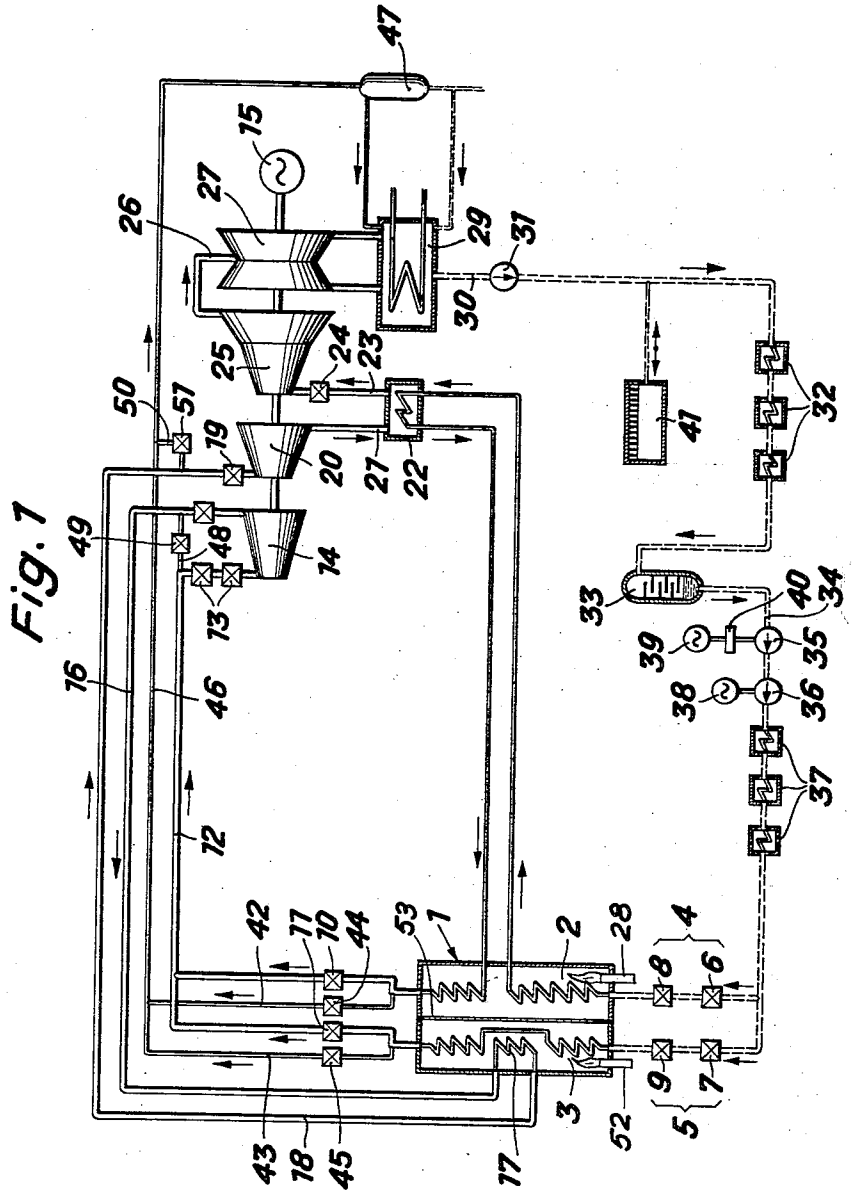
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STEAM POWER PLANT COMPRISING A STEAM GENERATOR AND A PLURAL STAGE STEAM CONSUMING MACHINE

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Fig. 1



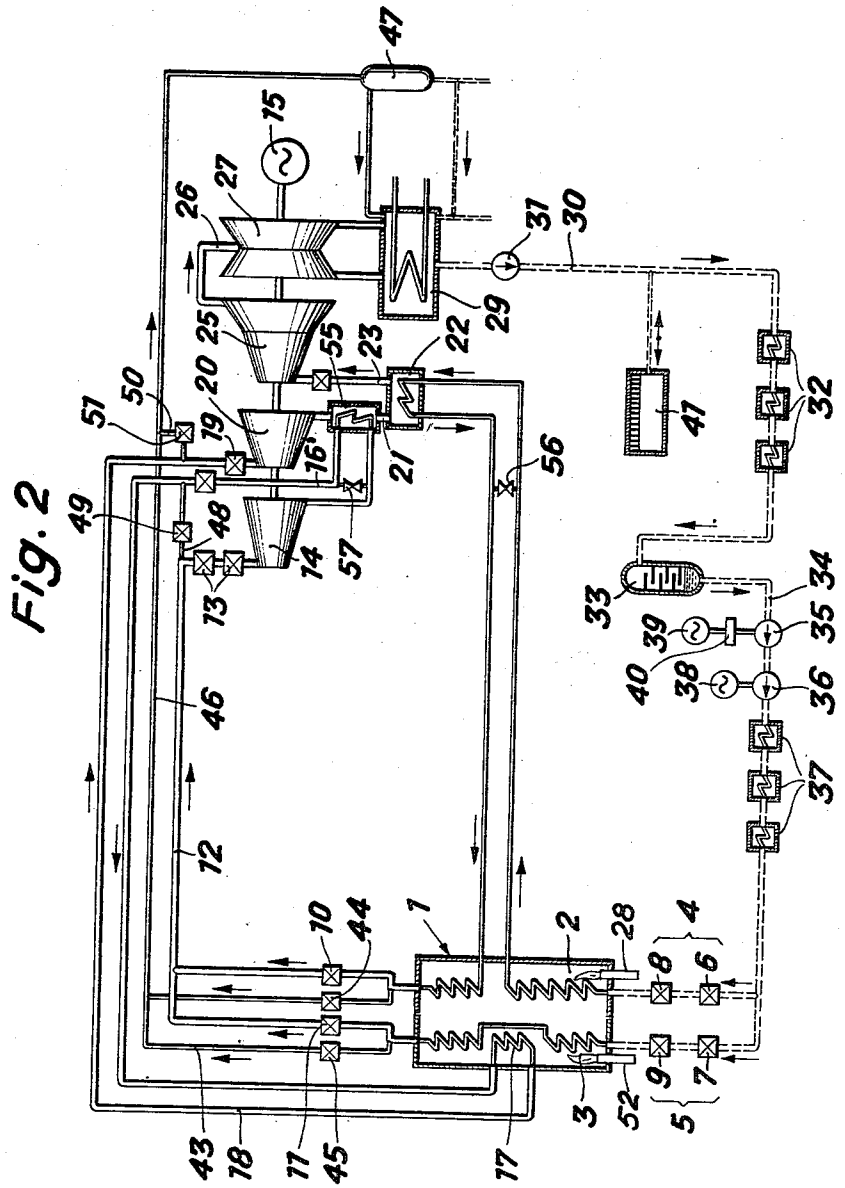
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STEAM POWER PLANT COMPRISING A STEAM GENERATOR AND A PLURAL STAGE STEAM CONSUMING MACHINE

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Fig. 2



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3,105,357

STEAM POWER PLANT COMPRISING A STEAM GENERATOR AND A PLURAL STAGE STEAM CONSUMING MACHINE

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4 Claims. (Cl. 60—73)

This invention relates to a steam power plant comprising a steam generator and plural stage steam consuming machine or prime mover with at least double interstage reheating of the partially expanded working medium emerging from the various stages of the prime mover.

Attempts have been made in the past in starting up steam generators having flue-gas-heated reheaters to leave the reheaters dry so as to prevent any possible leakage of water into the turbine. However, leaving the reheaters dry poses the danger of their burning out. To overcome these difficulties, the use of steam-heated rather than flue-gas-heated reheaters has been restorted to. These reheaters have been usually located near the turbine installation. However, such reheaters are high in capital cost since they represent inclusion of extra heating surfaces in the boiler that are additional to the regular boiler heating surface. Also, this arrangement is costly in operation because of the double heat transfer—first from flue gas to high-pressure steam, and then from the latter to the expanded steam that is to be reheated.

The problem which the invention has sought to solve is to find ways and means for placing a steam power plant, and particularly one for high-pressure steam having at least two-stage reheating, on line rapidly and safely while keeping the capital cost and operating costs down. In accordance with the invention, my novel steam power plant is characterized by the fact that at least one flue-gas-heated reheater is provided for one stage of reheating, and at least one steam-heated reheater is provided for another stage of reheating, and by the fact that the steam generator is divided into two sections, one of which contains the flue-gas-heated reheater while the other supplies the steam for the steam-heated reheater. This arrangement permits a steam power plant to be started up rapidly and without danger to the flue-gas-heated reheater since the boiler section having the working medium which heats the steam-heated reheater is placed on line first, while the other boiler section containing the flue-gas-heated reheater is cut in only after the first boiler section has begun to supply steam of the desired condition, which upon warming up of the turbine, flows through the flue-gas-heated reheater and thus cools it.

Reference is made to the drawings in which two preferred embodiments of my invention are disclosed and wherein;

FIG. 1 is a diagrammatic illustration of a steam plant having a flue-gas-heated reheater and a steam-heated reheater; and,

FIG. 2 is a diagrammatic illustration of a steam plant similar to FIG. 1 except that it has an additional stage for reheating the working medium by partially expanded steam.

Referring to the drawings in which similar parts are denoted by the same reference numeral, and in particular to FIG. 1, a once-through forced circulation boiler 1 is illustrated and which is divided into two sections 2 and 3 which in turn can be heated individually as by means of burners 28 and 52. This may be done either by separating the two sections by a wall 53 which may be formed of boiler tubes and providing in each section at least one furnace that can be fired independently of the other one, or by dispensing with a partition wall and providing a

furnace that is composed of a plurality of swiveling burners capable of being regulated and adjustable with respect to the tube systems. In the last-mentioned arrangement, at least some of the burners are directed against the tube system in boiler section 2, shown at the right in FIG. 1, during the starting-up period while in normal operation all burners are adjusted so that the tube systems of both sections are fired uniformly.

The tube systems of the boiler sections 2 and 3 are provided with feed regulator units 4 and 5, respectively, comprising, respectively, the usual feed regulator elements 6 and 7 and pressure-differential valves 8 and 9. The tube systems of the two boiler sections 2 and 3 are further provided with separate steam-pressure regulator units 10 and 11. Upstream of feed regulator units 4 and 5 and also downstream of the steam-pressure regulator units 10 and 11, the tube systems of the two boiler sections are combined into a common steam line 12.

The common steam line 12 runs by way of a turbine governor unit 13 to the first pressure stage 14 of a multi-stage turbine installation driving an electric generator 15. A line 16 leads from the outlet of first pressure stage 14 to the flue-gas-heated reheater 17 located in boiler section 3. The outlet of the flue-gas-heated reheater is connected by a line 18 through a valve 19 to the second pressure stage 20 of the turbine installation. A line 21 runs from the outlet of second stage 20 to the steam-heated reheater 22, located near the turbine installation and heated with high-pressure steam from the tube system of boiler section 2. The outlet of reheater 22 is connected by a line 23 with a valve 24 to the third pressure stage 25 of the turbine installation. From stage 25, a line 26 runs to the last pressure stage 27 of the turbine installation. The stage 27, designed on the double-flow principle, is connected to a condenser 29 from which condensate line 30 leads, by way of a condensate pump 31 and three condensate preheaters 32, to a degasifier 33. Degasifier 33 is connected by a line 34 to the two feed regulator units 4 and 5 of steam generator 1.

Inserted in series in line 34 are two feed pumps 35 and 36 and three feedwater preheaters 37. Feedwater preheaters 37 and condensate preheaters 32 are heated with steam bled from the turbine installation. For the sake of clarity, the connecting lines therefor are not shown in the drawing. Feed pump 36 is driven by a constant-speed electric motor 38 whereas pump 35 is driven by an electric motor 39 through a gear transmission 40 permitting the rotative speed of pump 35 to be varied. A condensate equalizer tank 41 is connected to condensate line 30 between condensate pump 31 and the first condensate preheater 32.

The tube systems of the two boiler sections 2 and 3 are provided with separate bypass lines 42 and 43, respectively, which combine downstream of the associated bypass valves 44 and 45 into a common line 46 leading, by way of a precondenser 47, to condenser 29. Between lines 12 and 16, there is a bypass line 48 which, with a valve 49, bypasses the first pressure stage 14 of the turbine installation. Between line 18 and line 46, a bypass line 50 with a valve 51 is provided for bypassing the other pressure stages 20, 25 and 27 of the turbine installation.

During startup of the steam power plant, only boiler section 2, shown on the right in the drawing, is placed on line. The feedwater in this section of the boiler will then flow by way of feed regulator unit 4 into the preheater section, evaporator section and presuperheater section of the tube system, then through the second reheater 22, the final superheater section, bypass lines 42 and 46 and precondenser 47 into condenser 29 and from there through lines 30 and 34 back to the boiler. When boiler section 2 reaches superheat temperature, part of the steam from line 12 is utilized to heat up the first pressure stage 14 of the

turbine installation, while at the same time boiler section 3 is placed on line. The steam exhausted from stage 14 then cools, together with the remaining steam flowing through bypass line 48, the flue-gas-heated reheater 17 in boiler section 3. The steam emerging from reheater 17 may then be used to heat up the other stages of the turbine installation; or all or part of it may be conducted through bypass lines 50 and 46 to precondenser 47. When the left-hand boiler section 3 has reached superheat temperature, then the turbine installation can be brought up to its rated speed.

The steam power plant shown in FIG. 2 is constructed in substantially the same way as the plant of FIG. 1, except that a reheater 55 is inserted in line 21 coming from the second pressure stage 20 of the turbine installation. This reheater is heated with partially expanded steam from the first pressure stage 14 of the turbine installation. The partially expanded steam, cooled in reheater 55, passes through line 16' to the flue-gas-heated reheater 17 in boiler section 3. Insertion of reheater 55 makes it possible to equalize the reheat temperatures between the first and second, and between the second and third pressure stages at the same loads of the two boiler sections 2 and 3. The primary sides of the two steam-heated reheaters 22 and 55 are provided with bypass valves 56 and 57, respectively, which permit improved regulation of the reheat temperatures by variation of the quantity of steam flowing to the reheater involved. Under certain conditions, the entire quantity of steam may be made to bypass the turbine installation through bypass lines 48 and 50 during startup or when similar conditions prevail and the generator is uncoupled.

It is thought that the invention and its attendant advantages will be understood from the foregoing descriptions and it will be apparent that various changes may be made in the form, construction and arrangement of the parts without departing from the scope of the invention which is to be limited only by the appended claims.

I claim:

1. A steam power plant comprising a plural stage steam consuming machine, a condenser, a plurality of tube systems connected in parallel between said condenser and one stage of said machine for delivery of steam to said one stage, each of said tube systems including evaporating and superheating portions, separate firing means associated with each of said tube systems, and a plurality of reheaters, one of said reheaters being heated by steam from one of said tube systems and another of said reheaters being heated by flue gases from the firing means associated with the other of said tube systems.

2. A steam power plant comprising a steam consuming machine having at least three stages operated at successively declining steam pressures, a condenser, a plurality of tube systems connected in parallel between the condenser and the highest pressure stage of said machine for delivery of steam to said highest pressure stage, each of said tube systems including evaporating and superheating portions, a separate firing means associated with each of said tube systems, and a plurality of reheaters each connected between a different pair of stages of said machine, one of said reheaters being heated by steam drawn from one of said tube systems at a point within the superheating portion of said one tube system, another of said reheaters being heated by flue gases from the firing means associated with the other of said tube systems.

3. A steam power plant comprising a steam consuming machine having at least three stages operated at successively declining steam pressures, a condenser, a plurality of tube systems connected in parallel between the condenser and the highest pressure stage of said machine for delivery of steam to said highest pressure stage, each of said tube systems including evaporating and superheating portions, a separate firing means associated with each of said tube systems, and a plurality of reheaters each connected between a different pair of stages of said machine, one of said reheaters being heated by steam drawn from one of said tube systems at a point within the superheating portion of said one tube system, another of said reheaters being heated by flue gases from the firing means associated with the other of said tube systems, said flue gas heated reheater being connected between a pair of stages of said machine of higher pressure than the pair of stages between which is connected said steam-heated reheater.

4. A steam power plant comprising a steam consuming machine having at least three stages operated at successively declining steam pressures, a condenser, a plurality of tube systems connected in parallel between the condenser and the highest pressure stage of said machine, each of said tube systems including evaporating and superheating portions, a separate firing means associated with each of said tube systems, and a plurality of reheaters each connected between a different pair of stages of said machine, one of said reheaters being heated by steam drawn from one of said tube systems at a point within the superheating portion of said one tube system, another of said reheaters being heated by flue gases from the firing means associated with another of said tube systems, said flue gas heated reheater being connected on its secondary side between a pair of stages of said machine of higher pressure than the pair of stages between which is connected said steam-heated reheater, and a further reheater connected in series with said steam-heated reheater, said further reheater being heated with steam exhausted from a stage of said machine of higher pressure than either of those between which said steam-heated and further reheaters are connected.

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