May 27, 1952 P. S. DICKEY 2,598,235

VAPOR GENERATOR OPERATION

Filed June 14, 1946 2 SHEETS—SHEET 1

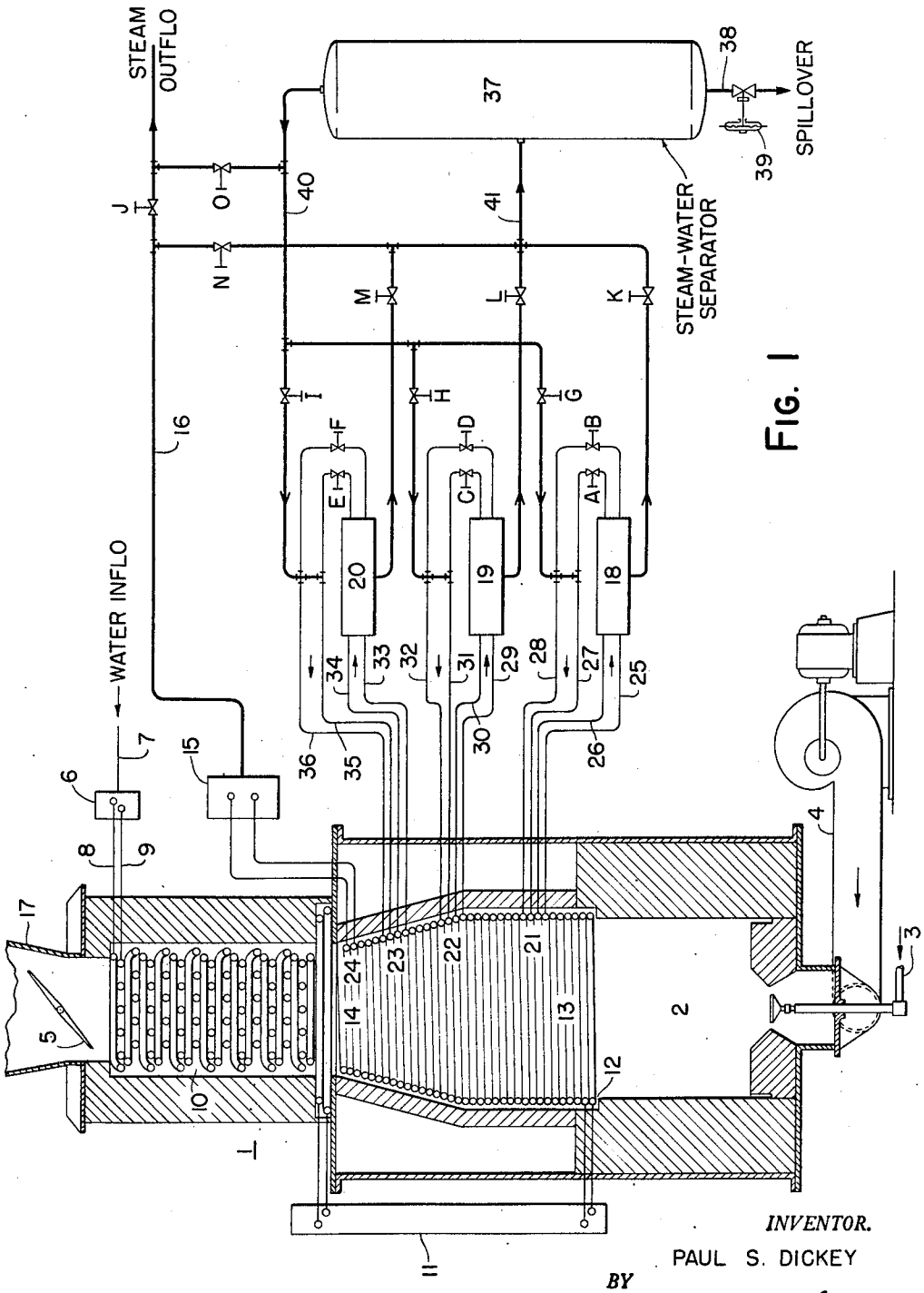


FIG. 1

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May 27, 1952 P. S. DICKEY 2,598,235

VAPOR GENERATOR OPERATION

Filed June 14, 1946 2 SHEETS—SHEET 2

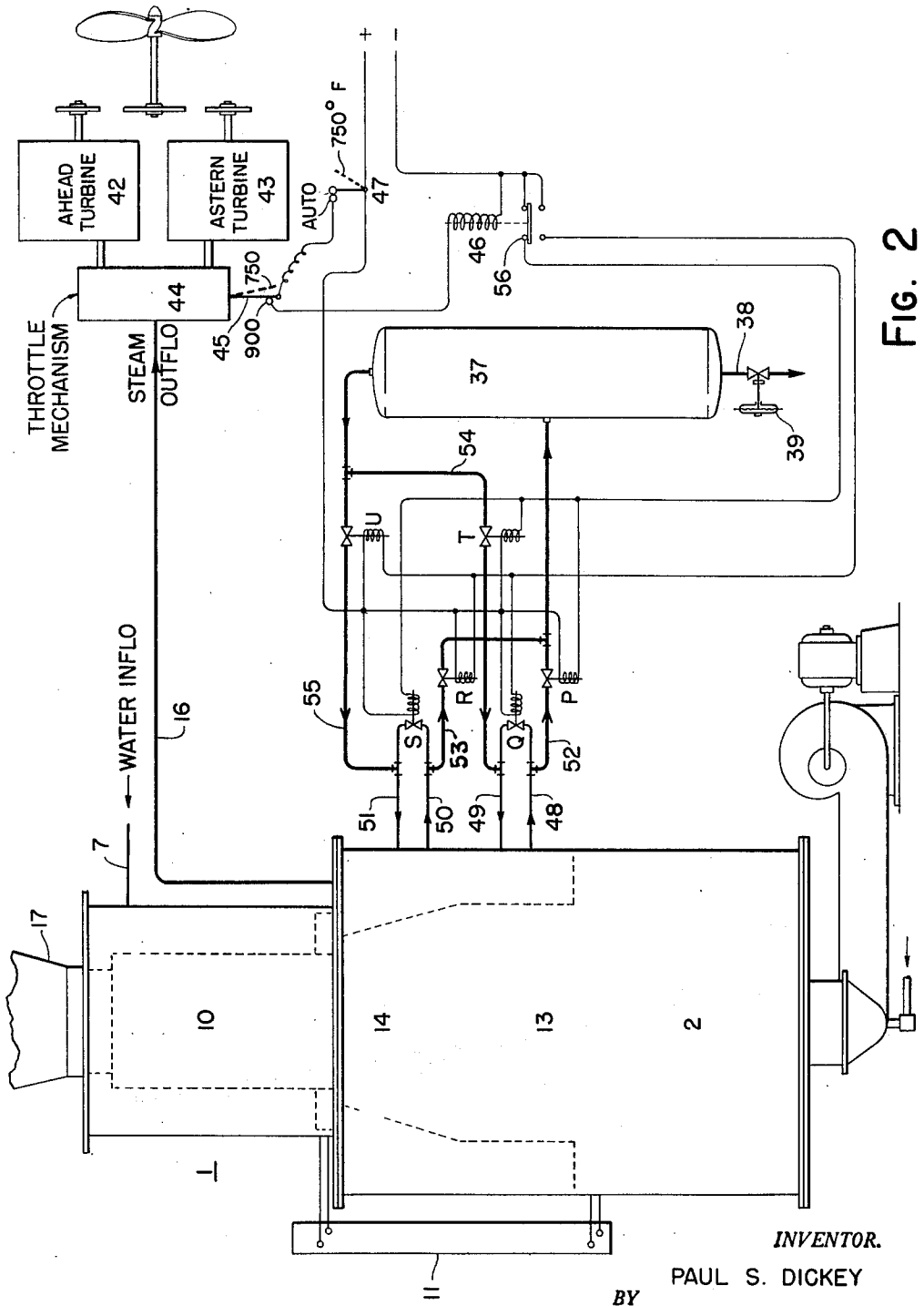


FIG. 2

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Patented May 27, 1952

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UNITED STATES PATENT OFFICE

2,598,235

VAPOR GENERATOR OPERATION

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6 Claims. (Cl. 60—102)

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This invention relates to a method and means for operating and controlling the operation of vapor generators; particularly vapor generators of the drumless, forced-flow type having a fluid flow path including one or more long small-bore tubes, in which the flow in the path is initiated by the entrance of liquid under pressure at one end and the exit of vapor only at the other end. Such vapor generators have a small liquid storage with a high rate of evaporation and are usually heated by the products of combustion.

One form of forced circulation vapor generators is disclosed in my prior Patents 1,975,085–6 as having a once-through fluid path receiving liquid under pressure at one end and delivering superheated vapor only at the other end, with no addition to, or diversion from, the flow intermediate the ends of the path.

Another form of forced circulation vapor generators is disclosed in my prior Patents 2,170,344 and 2,170,346, characterized by having an inflow of liquid normally greater than the outflow of vapor, the difference being diverted from the path intermediate the ends thereof.

My present invention is concerned with structure embodying features of each of these forms, and with provision for selectively varying the operating arrangement of the vapor generator.

Particularly, I am concerned with providing an arrangement, as well as a method of operating the same, whereby the unit may be operated at a selected one of two or more predetermined outlet vapor temperature standards.

Such a vapor generator, having small liquid storage and operated with wide range combustion devices, forms a combination rendering practical extremely high heat release rates with the consequent ability to economically handle practically instantaneous load changes from minimum to maximum, and vice versa, without heavy standby expense, and is particularly suitable for operating conditions such as mobile service where load variations are of a wide range and are required to be met substantially instantaneously.

The generator has a minimum liquid storage capacity with a maximum heat absorbing surface so disposed and arranged as to be substantially instantaneously responsive to rapid changes and wide diversity in heat release rate in the furnace. The heat absorbing surface is arranged in relation to the path of the products of combustion and radiant heating so that the entering liquid is received at the cooler end of the path. Further, the vapor generator, insofar as the passage of combustion gases is concerned, has a continuously

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increasing resistance to gas flow throughout the length of the passage.

In vapor generators of the first mentioned form having a once-through fluid flow path without circulation, and wherein the liquid volume is always at a minimum, the liquid inflow must of necessity be continuous and at all times proportioned to the vapor demand or generator load. Furthermore, this type of unit, having no substantial reserve liquid capacity and the fluid in motion in the circuit varying from liquid to vapor with intermediate percentages of vapor and liquid mixture, cannot be equipped with any liquid level indicating device, such as the standard water glass, to establish a safe operating condition. Vapor is generated in the tubes as needed, and the liquid is fed to the tubes at such a rate that the desired proportion is held in a tube between liquid and vapor, so that vapor of the desired amount and quality may be obtained. My prior patents provide a method and means for operating such a vapor generator in accordance with desired vapor conditions.

In such a once-through fluid flow unit a constant predetermined quality or temperature of the vapor outflow may be insured regardless of the rate of outflow, through the maintaining substantially constant of the percentage of the fluid flow path within the boiler in which vapor alone exists. The point of conversion to complete vapor state, beyond which in the flow path the fluid exists as vapor only, tends during operation to move along the flow path through several causes, such, for example, as variation in the rate of liquid inflow relative to the rate of vapor outflow, and through variation in the rate of supply of the elements of combustion for heating or causing change of state or temperature of the fluid.

Prior boilers of this type have been operated to evaporate all of the liquid entering the relatively cold end of the forced circulation path and to produce a vapor outflow, either saturated or at a predetermined degree of superheat, depending upon an operation of the unit such that a preselected proportion of the total length of the path comprises liquid or mixture while the remaining preselected portion of the path comprises steam drying or superheating surface. It has not been too satisfactory to attempt to operate such a vapor generator at different selected values of total vapor temperature, and particularly where such values are quite far apart. For a given or fixed structural arrangement, the other variables in supply and operation of the unit preclude se-

lectively operating over a wide range in total vapor outflow temperature.

The second mentioned form of vapor generator in which more liquid is supplied at the entrance to the path than leaves as vapor at the exit of the path, with some of the liquid being diverted intermediate the ends of the path, presupposes a definite length of path for vapor generation before the point of diversion, and a predetermined length of path for vapor superheating after the point of excess liquid diversion.

In such a unit, the heat absorbing surface, or flow path for the working medium, is comprised of one or more long small-bore tubes with an enlargement, preferably at the end of the generating section, which acts as a separator to divide liquid and vapor. The vapor is then passed through a superheater, while the excess liquid carried through the tubes for the purpose of wetness and preventing scale deposit is diverted out of the separator under regulated conditions. From the separator there is usually a continuous and an additional regulated spillover or diversion of a part of the liquid entering the economizer under pressure, so that there is always being fed to and through the economizer and vapor generating sections more liquid than can be converted into vapor in a single passage therethrough, although the proportion of such excess liquid represents but a small part of the total volume of fluid passing through the vapor generator, and is at most times only sufficient to insure tube wetness and to carry off scale forming material.

In vapor generators of this character, having small liquid and heat storage with high release capabilities, the liquid inflow must of necessity be continuous and at all times proportioned to the vapor outflow, at the same time taking into account the desired diversion of excess liquid from the flow path. My prior patents of the second mentioned group are directed to the control and operation of such a vapor generator.

The particular arrangement provided by the present invention includes certain structural features of the two mentioned forms of forced circulation vapor generator, and the invention provides a method of operation having advantageous features over prior vapor generators of the type mentioned. Principally, such a construction and method of operation provides for a wide temperature range of operation. The arrangement permits the selective interposition of a separator into the flow path at a selected one of several locations along the path, or the separator may selectively be omitted from the flow path. By such operation the ratio of vapor generating to vapor superheating surface may be modified for the purpose of securing different ranges of superheat temperature or of total temperature of the vapor leaving the unit.

Specifically, I provide a structural arrangement which may be operated selectively at one or more total temperature values of the vapor outflow while maintaining the desired vapor outflow pressure and proper combustion conditions for efficiency.

In the drawings:

Fig. 1 illustrates diagrammatically an embodiment of my invention.

Fig. 2 illustrates diagrammatically a somewhat similar embodiment to Fig. 1, but including certain automatic provisions for use in connection with ship propulsion.

Referring now in particular to Fig. 1, I have

illustrated a steam generator 1 having a furnace 2 for heating fluid passed through a plurality of parallel conduits in heating relation with the combustion and products of combustion. The elements of combustion, such as fuel and air for example, are fed to the furnace 2 in regulated amounts through the conduits 3 and 4 respectively. Inasmuch as the present invention is not directed to the regulation of the rate of supply of the elements of combustion or of the uptake damper 5, I have not herein disclosed any means for regulating the same, but refer to my various patents aforementioned.

In like manner my present invention is not directed to any control of the rate of water inflow, or of vapor outflow, or of the specific value of vapor outflow temperature or pressure. As previously mentioned, the present invention is concerned particularly with selectively varying the relative proportion of vapor generating surface to vapor superheating surface within the unit, and with the consequent result of preselected vapor outflow total temperatures.

Liquid to be converted into vapor under pressure is fed to a header 6 through a conduit 7 by a pump (not shown). From the header 6 originate two parallel conduits 8, 9, each of which are of small diameter and great length, being formed sinuously in layers by suitable bending in a water heating or economizer section 10 of the flow path, the lower portions of which having much greater length than the upper portions and which extend outwardly into the walls of the flue passage for support. It will be understood that two parallel circuits are shown in the fluid path by way of example only, and that this might equally as well as a single circuit or more than two circuits in parallel.

From the economizer section 10 the parallel conduits lead to a header 11 and from the header 11 enter the furnace at 12, whereafter they are coiled upwardly surrounding a secondary combustion space of the furance. A certain portion of the surrounding conduit wall may normally comprise a steam generating portion 13, while the uppermost portion of the surrounding conduits comprise a superheating section 14, from which the parallel conduits lead to a header 15, and thence through a conduit 16 to a turbine or other utilizing apparatus. It is a particular feature of the present invention to selectively vary the proportion of the heating surface 13 to the surface 14, namely, the proportion between vapor generating surface and vapor superheating surface.

The products of combustion pass from the furnace 2 in series heating contact with the vapor generating portion 13, the superheating portion 14, and the economizer portion 10, to a stack 17 whose draft is controlled by the positioning therein of the damper 5.

It will be observed that the grouping of the parallel conduits 8, 9 is definitely segregated into three sections, namely, an economizer section 10, a vapor generating section 13 and a superheating section 14, wherein the fluid flowing through the conduit is continuously in heating relation with the products of combustion passing from the furnace. Equalizing headers or mixing boxes 18, 19 and 20 are shown in the flow path to cause the fluid of the several parallel conduits to commingle and for equalization of temperature and distribution, whereafter they again separate into the respective flow conduits. Obviously, in the present diagrammatic showing the

mixing boxes 18, 19 and 20 are for clarity shown at a disproportionate distance from the generator 1. Likewise, the conduits 8, 9 where they join the surfaces 10, 13 and 14 with the headers 6, 11, 15 and the mixing boxes 18, 19 and 20 are shown diagrammatically in single line.

It will be seen that the grouping of the respective portions of the conduits is such that each represents a continuous fluid path of great length and small diameter from liquid entrance to vapor outlet with some portion thereof having a fluid flow countercurrent to the hot gases passing thereover, while other portions thereof have fluid flow with the gases passing thereover concurrently.

The grouping of the conduit sections and their arrangement with respect to the furnace, secondary combustion chamber and flue, is such that insofar as arrangement is considered the heat absorbed by any one conduit is substantially equal to the heat absorbed by any other conduit, with the result that heat input to each conduit for a given combustion condition is approximately constant, and the furnace and flue are constructed so that the heat stored therein is at a minimum.

Referring particularly to the arrangement of Fig. 1, it will be observed that the parallel circuits 8, 9, entering the furnace at 12, comprise the lowermost coils of the vapor generating portion of the path. I have diagrammatically indicated that at some location 21 I bring the two circuits as pipes 25, 26 outwardly to the mixing box 18, and from the mixing box return the circuits as pipes 27, 28 to again enter the heating chamber. Again at some location 22 I bring the circuits out as pipes 29, 30 to the mixing box 19 and return them to the heating chamber as pipes 31, 32. Again at a location 23 I bring the circuits out as pipes 33, 34 to the mixing box 20 and return them to the flow path as pipes 35, 36. The two tubes then leave the upper portion of the heating chamber as at 24 to the header 15.

Interposed between the pipes 26—27, 25—23, 30—31, 29—32, 34—35, and 33—36 are valves A, B, C, D, E and F respectively. The valves are located in the pipes at the outlet side of the respective mixing boxes 18, 19 and 20; between the mixing box and the reentrant point of the parallel circuits to the heating chamber.

In each instance, between the valves and said reentrant point the two circuits are joined together with a pipe which leads through a valve G, H or I to join the steam takeoff of a steam-water separator 37.

As disclosed in my prior patents, when a liquid-vapor mixture is diverted from the flow path it tangentially enters a bulge in the fluid flow path in the form of a separating chamber 37 for dividing the fluid into liquid and vapor, the vapor of which may then be returned to a superheating portion of the path and the excess liquid being diverted from the path through a pipe 38 to the hot well or to waste. There may be a normally continuous spillover, or a variable spillover under the control of a valve 39.

Joining the separator 37 with the mixing boxes 18, 19 and 20 are pipes in which are located respectively valves K, L and M. The pipe by which steam leaves the separator 37 I have designated at 40, while the pipe by way of which a steam-water mixture may enter the separator 37 I designate at 41. It will be observed that the pipe 41 may be joined to the pipe 16 through the agency of a valve N, while the pipe 40 may be joined to

the pipe 16 through a valve O. A sectionalizing valve J is located in the pipe 16 intermediate said joining points.

From the description, and from a study of the drawing, it will be seen that I have provided the necessary structure and apparatus wherein I may, by proper manipulation of the various valves, selectively vary the proportion of the vapor generating surface 13 to the vapor superheating surface 14, i. e. by preselecting the location 21, 22, 23 or 24 where the fluid is withdrawn from the heating chamber and/or returned thereto.

By way of example it will be seen that if I desire to operate the unit as a once-through forced circulation vapor generator without using the liquid-vapor separator 37 I would operate with valves A, B, C, D, E, F and J open and with valves G, H, I, K, L, M, N, O closed.

On the other hand, if I desire to operate with a maximum of superheating surface within the heating chamber I would so adjust the valves that the steam-water mixture would leave the flow path at 21, enter the mixing chamber 18 and pass to the separator 37. The water from the mixture would be discharged through the pipe 38, while the steam would leave through the pipe 40, and re-enter the heated flow path through the pipes 27, 28. This would be accomplished by having the valves C, D, E, F, G, K and J open with valves A, B, L, H, M, I, N and O closed.

In general, the operation in accordance with the arrangement of Fig. 1 provides the following conditions of operation.

Condition 1.—The unit operated as a once-through vapor generator without using the steam-water separator. Temperature of the vapor outflow depends upon the rate of water inflow and firing.

Condition 2.—Produces saturated steam moisture-free by use of the separator and wets the entire length of the heated flow path.

Condition 3.—The unit includes the separator and minimum superheating surface.

Condition 4.—The unit includes the separator and medium superheating surface.

Condition 5.—The unit includes the separator and maximum superheating surface.

These conditions of operation would be attained by:

Condition	Valves Open	Valves Closed
1	A, B, C, D, E, F, J	K, G, H, I, L, M, N, O.
2	A, B, C, D, E, F, N, O	K, G, H, I, L, M, J.
3	A, B, C, D, I, M, J	K, G, H, E, F, L, N, O.
4	A, B, L, H, E, F, J	K, G, C, D, I, M, N, O.
5	K, G, C, D, E, F, J	A, B, H, I, L, M, N, O.

By way of specific example, I may desirably select to operate the unit with a vapor outflow of saturated condition or of a total temperature, for example of 750° F., 850° F., or 950° F. It will be appreciated that the embodiment being described and the examples given are by way of illustration only, and that other proportioning of the fluid flow paths and other desirable vapor outflow temperatures may be used.

Referring now to Fig. 2, I show an embodiment of my invention directed particularly to marine use, althought the general features of the invention are equally adapted to stationary power plants.

In marine service it is know to equip a ship with propellers, gear connected to an ahead and

to an astern turbine each pair of turbines exhausting to one or more surface condensers. The ahead turbine normally operating at relatively uniform and most efficient load may utilize high temperature steam, for example in a range of 900° F., and will extract sufficient work from the steam so that the exhaust to the condenser will be at a safe low temperature for which the condenser is designed. The astern turbine, normally idling backwards, is given no opportunity to warm up when a signal for backing operation is had. Furthermore, the design of the infrequently operating astern turbine is one which will not extract from the steam as great an amount of work as will the normally loaded ahead turbine. Thus the steam exhausting from the astern turbine to the condenser will be at a relatively higher percentage of the initial temperature than that steam exhausting from the ahead turbine. The surface condenser normally designed for the steam exhausted from the ahead turbine is in danger of being damaged by the relatively higher temperature steam exhausted from the astern turbine. It is, therefore, usually desirable to design and operate the astern turbine at a different temperature standard than the ahead turbine.

In the docking of all vessels and in the maneuvering of such high speed vessels as destroyers and the like, it is not uncommon to have an immediate change in load of 80% to 90% of maximum output and/or to have a sudden and immediate reversal of direction or alternate use of the ahead and the astern turbines. The danger to the condenser of such a shift in operation is apparent.

It is a principal feature of my invention to provide a method and apparatus for properly controlling the total temperature of the steam supplied to the ahead and to the astern turbines from the vapor generator. It is a further object to provide a system for automatically varying the temperature standard to which the vapor generator works, so that the proper temperature standard may be attained for the ahead turbine and for the astern turbine, or in fact for any combination of the two or range in operation of either.

The present invention, as depicted in Fig. 2, while directed particularly to a steam temperature control at different standards for marine service, is nevertheless adapted to stationary boiler service. Stationary boilers in central stations, for example, are often so designed that they feed a single turbine with steam at relatively high temperature and pressures, for example 950° F. and 1200 p. s. i. g. It is also possible to use the same vapor generator to supply steam alternatively to a second turbine at relatively lower temperature and pressure, for example a temperature of 700° F. and a pressure of 600 p. s. i. g. If, for example, the high pressure-temperature turbine loses its load suddenly it becomes immediately desirable, and perhaps necessary, to switch the output of the vapor generator to the lower pressure-temperature turbine, and this at a new standard of both temperature and pressure for the control of the vapor generator.

The invention, as depicted in Fig. 2, while shown specifically in connection with an ahead turbine and an astern turbine, may equally as well be adapted to the operation of a high temperature and a low temperature turbine in a stationary power plant. Specifically, the throttle mechanism for the marine installation, or the load control mechanism for the stationary plant, is so arranged that when the steam is desired to

be changed from high total temperature to low total temperature, or vice versa, the necessary valving is automatically actuated to vary the proportionality between vapor generating and vapor superheating surface in the vapor generator to thereby and thereafter operate the vapor generator at the preselected total temperature standard corresponding with the demand.

Referring now specifically to Fig. 2, I show the vapor generator of Fig. 1 having a furnace **2**, a vapor generating surface **13**, a vapor superheating surface **14**, and an economizer section **10**. Water is admitted to the cold end of the flow path through a conduit **7**, and steam leaves the unit at the other end of the flow path through a conduit **16**. The conduit **16** joins either an ahead turbine **42** or an astern turbine **43** selectively through throttle mechanism **44**. The throttle mechanism **44** is of any commercial type, usually hand operated, for switching the admission of steam from the conduit **16** selectively to one or the other of the two turbines, **42**, **43**.

The particular example illustrated in Fig. 2 utilizes steam from the boiler **1** at 900 F. for the ahead turbine **42** and at 750° F. for the astern turbine **43**. Inasmuch as neither the astern turbine nor the condenser to which both of the turbines exhaust is adapted to withstand the application of relatively high temperature steam it becomes advisable, and in fact necessary for safety, to change the temperature of the steam supplied to the throttle mechanism through the conduit **16** when operation is switched from the ahead turbine to the astern turbine, and vice versa. Such switching operation is accomplished by the throttle mechanism **44**, which through its position and/or movement automatically changes the temperature standard to which the boiler **1** is operating.

For example, the arrangement of Fig. 2 provides a switch **45** connected to the throttle mechanism **44** in such manner that if the throttle is moved to admit steam to the ahead turbine the contact arm **45** closes circuit with the contact marked **900**, energizing the relay **46**; whereas when the throttle mechanism **44** is so positioned as to divert the steam from conduit **16** to the astern turbine, then the contact **45** assumes the position shown in dotted line and marked 750. Under this latter condition electrical connection to the relay **46** is broken and the relay is deenergized.

I show the circuit for the relay **46** controlled in series through a hand positionable switch **47**, which allows automatic selection of temperature standard operation of the boiler **1**, or in its alternate position dictates that the boiler **1** will be operated at the lower temperature, namely, in this example 750° F. Thus for docking and certain maneuvering conditions the hand switch **47** may be moved to the position marked 750° F., and such total temperature steam would be available at both the ahead and the astern turbines. While this leads to somewhat inefficient operation of the ahead turbine (designed for 900° F. steam), nevertheless under frequent reversing, such as is encountered in docking or high speed maneuvering, the efficiency of operation or safety of the ship, rather than the thermal efficiency of turbine operation, assumes greater importance.

In Fig. 2 I have shown quite diagrammatically the fluid flow path being brought out of the vapor generator through a circuit **48** and returned through a circuit **49**, and again being

brought out through a circuit 50 and returned through a circuit 51. Interposed between the circuits 48 and 49 is a solenoid actuated valve Q, and between the circuits 50, 51 is a solenoid actuated valve S.

The circuit 48 is joined to the separator 37 by a conduit 52, in which is located a solenoid actuated valve P. In similar manner the circuit 50 is joined to the separator 37 by a conduit 53 in which is positioned a solenoid actuated valve R.

The steam returned to the unit from the separator 37 joins the conduit 49 through a pipe 54, in which is located a solenoid actuated valve T; while the solenoid actuated valve U is located in the conduit 55 joining the separator 37 with the pipe 51.

In operation assume (as shown in Fig. 2) that the throttle mechanism 44 is so positioned as to direct steam from the conduit 16 to the ahead turbine 42. The switch 45 engages the contact 900, thereby energizing the relay 46 and closing contact 56. The various solenoid valves previously enumerated are normally closed and must be electrically energized to open. Thus with the contact 56 close circuited (or a desire of 900° F. steam) the valves P—T—S are opened and valves Q—R—U are closed. Under this condition it will be apparent that the conduit 48 is connected through the pipe 52 and valve P to discharge into the separator 37. Valve Q being closed, and valve T being opened, the separated steam from the separator 37 passes through the conduit 54 to reenter the vapor generator through the pipe 49. With valves U and R closed and valve S open the circuit then passes through 50, S, 51 without diversion. Under this condition a maximum of superheating surface of the unit 1 is utilized, and the unit operates at a preselected high total steam temperature, in this example 900° F.

The alternate condition of operation, when the switch 45 assumes the position marked 750 in Fig. 2, results in valves Q, R and U being opened and valves P, T and S being closed. Under this condition the steam-water mixture passes directly through 48, Q, 49 and is diverted through the pipes 50, 53 to the separator 37, the steam therefrom reentering the vapor generator through the pipes 55, 51 to utilize the lesser of the two predetermined steam superheating surfaces.

From the description just given of the arrangement shown in Fig. 2 it will be seen that I provide the necessary apparatus and method of operation whereby the vapor generator is automatically shifted from one to another predetermined temperature operating standard under the dictates of the demand of a vapor utilizer. While illustrated specifically in connection with a marine installation having an ahead and an astern turbine, it will be clearly seen that a similar arrangement is adaptable to stationary operation. Furthermore, it will be apparent that the invention is not limited to selective operation at the mentioned temperatures, or even as between two temperature standards only. It might equally as well be adapted to the showing of Fig. 1, which provides more than two temperature standards or preselected proportioning between vapor generating and vapor superheating surface in the vapor generator. In any event the disclosure which I have shown quite diagrammatically, and the description pertaining thereto, is to be considered as illustrative only and not as limiting.

What I claim as new, and desire to secure by Letters Patent of the United States, is:

1. The method of operating a power plant comprising a vapor generator and two vapor consuming prime movers, each requiring vapor of a different total temperature and connected to the generator for independent operation, which includes, continuously operating the vapor generator to maintain either a first or a second predetermined vapor temperature standard, shifting the operation of the vapor generator from one to the other of said standards through varying the proportion of vapor generating surface to vapor superheating surface, and shifting simultaneously the operation from one prime mover to the other.

2. The method of operating a power plant comprising a vapor generator and two vapor consuming prime movers, each requiring vapor of a different total temperature and connected to the generator for independent operation, which includes, continuously operating the vapor generator to maintain either a first or a second predetermined vapor temperature standard, varying the areas of vapor generating and superheating surfaces for maintaining said temperature standards, and shifting the vapor supply from one prime mover to the other simultaneously with the varying of the surface areas.

3. In combination, a power plant including a vapor generator and two vapor consumers connected thereto, one of the vapor consumers requiring vapor at a predetermined total temperature and the other consumer requiring vapor at a different predetermined temperature, a common throttle mechanism for switching the supply of vapor coming from the vapor generator from one to the other of said consumers, said vapor generator having a fluid flow path providing superheating surface and remaining fluid heating surface subject to heat and to which liquid is supplied under pressure, adjustable means for removing excess liquid at any one of several points along said path to vary the ratio of vapor superheating surface to the remaining fluid heating surface, and control means positioned by and with said throttle mechanism for adjusting said adjustable means to vary the ratio of vapor superheating surface to the remaining fluid heating surface in the vapor generator so as to establish the proper related total vapor temperature for the connected vapor consumer.

4. In combination, a power plant including a vapor generator and at least two vapor consumers connected thereto for independent operation, each of the consumers requiring vapor of an optimum total temperature, the vapor generator comprising serially connected economizer, vapor generating and vapor superheating surfaces forming a fluid flow path, means supplying liquid under pressure to one end of the path, means for heating the path, mechanism for switching the supply of vapor from one to another of said consumers selectively, and control means positioned by and with said mechanism properly proportioning the vapor superheating portion of the path to the other heating portion of the path to establish the optimum total temperature for the vapor consumer being then supplied.

5. The combination of claim 4 wherein two vapor consumers which are selectively connected

to be supplied from the vapor generator are namely an ahead turbine and an astern turbine for a ship.

6. The combination with a vapor generator of the drumless forced-flow type having a plurality of parallel circuits receiving liquid under pressure at one end of the path and delivering superheated vapor only at the other, means for heating the path, a liquid-vapor separator, mixing boxes at locations along the path where the parallel circuits are brought together and then separated, valve means in the circuits adjacent the mixing boxes, and means for selectively diverting the fluid from the path to the separator and returning vapor only from the separator to the path on opposite sides of said valve means at each of said locations.

PAUL S. DICKEY.

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