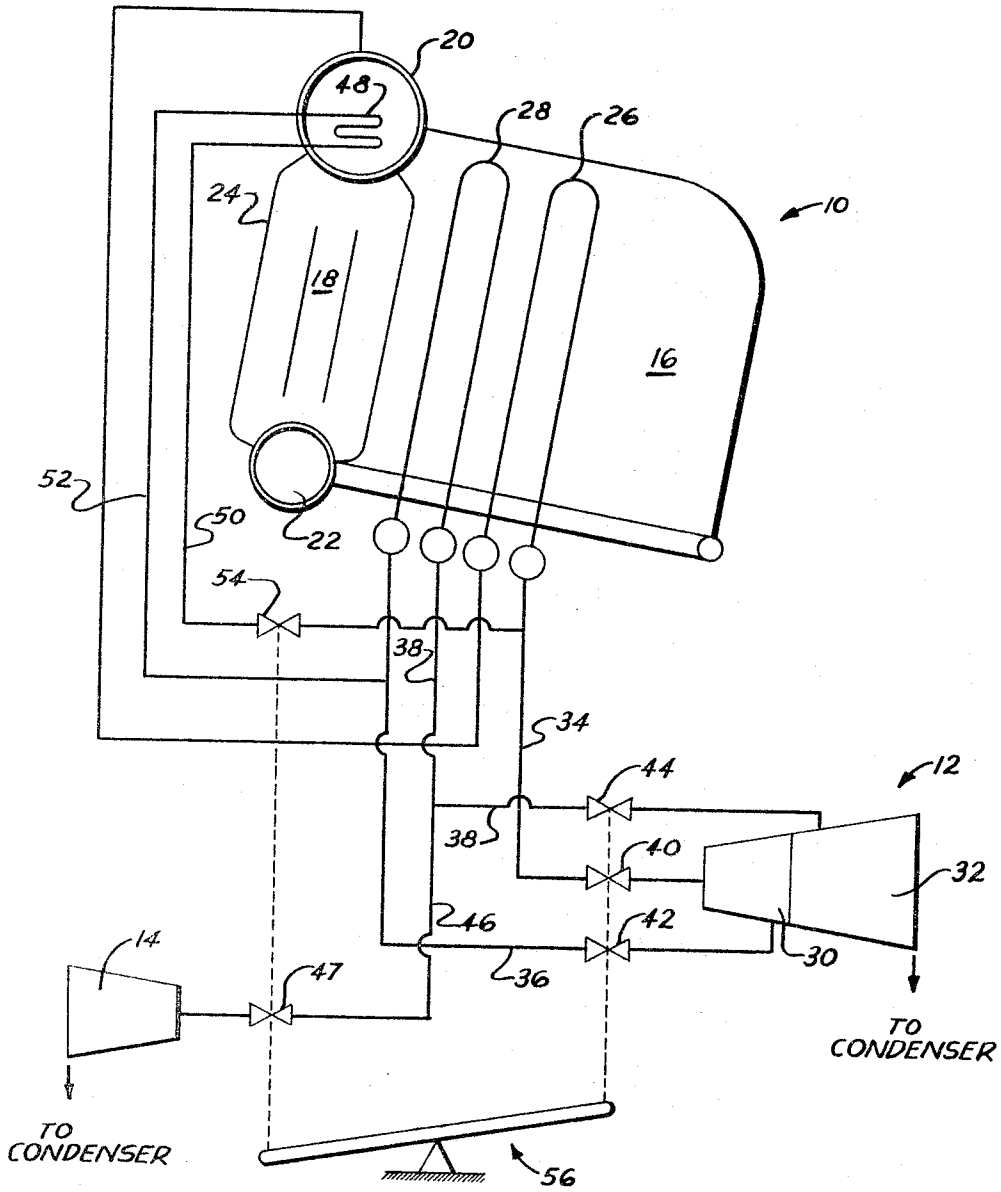
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MARINE REHEATER CYCLE

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# MARINE REHEATER CYCLE

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The present invention relates to marine power plant installations and their method of operation. More particularly, the invention relates to a marine power plant installation including separate turbines operable for ahead and astern operation and wherein the ahead turbine operates on a reheat steam cycle.

Problems arise with the application of a reheat cycle to marine power plants due to the fact that turbines are required to operate a vessel both in the ahead direction and in the astern direction. The need for a separate turbine to operate the vessel in the astern direction creates much difficulty and in most cases even prevents the use of a reheater due to the fact that when steam flow to the astern turbine is commenced the supply to the ahead turbine must be discontinued and this in turn means that steam flow to the reheater is also discontinued thereby starving the reheater tubes of cooling fluid. With no cooling fluid flowing through the reheater the tubes are subject to deterioration by burnout. Therefore, it has been the practice when employing reheaters in such installations either to locate them in a low temperature region of the steam generator such as in the gas pass behind the boiler bank or to employ independently heated heat exchangers such as separately fired reheaters or those in which line steam is employed as a heating medium.

The location of a tubular reheater in the gas pass is undesirable due to the fact that the presence of relatively low gas temperatures requires an excessive amount of heating surface in the reheater therefore necessitating a reheater of tremendous proportions that is high in initial cost and low in operational efficiency. The latter two of the above methods of reheat are also undesirable in that they require duplication of feed and firing controls and other ancillary equipment necessary for the operation of a reheater separate from the main steam generator.

By means of the present invention there is provided a marine power plant installation wherein the ahead turbine is operated on a reheat steam cycle and in which the reheater is permitted to be located in a high temperature region of the steam generator thereby increasing the overall efficiency of the steam cycle and reducing the initial cost of manufacturing the reheat equipment. In general terms, the invention provides for a marine power plant installation including a multi-stage ahead turbine and an astern turbine both of which are supplied with steam from a steam generator including an evaporator section, a superheater and a reheater located in a high gas temperature region of the steam generator. The installation also includes a desuperheater located in the system between the superheater and the inlet to the astern turbine such that steam supplied by the superheater to the astern turbine is first reduced in temperature in the desuperheater and then raised to the desired turbine temperature in the reheater thereby permitting full steam flow through the reheater during operation of the astern turbine.

The objects and the attendant advantages of the instant invention will become apparent when considered in connection with the accompanying description including the drawings of which:

The single figure is a schematic representation of a marine power plant installation employing the invention.

Referring now to the figure there is shown a marine power plant installation including a steam generator **10**



and a turbine **12** operable for ahead operation of the vessel and a turbine **14** operable for astern operation thereof. The vapor generator **10** comprises a furnace chamber **16** and a boiler bank **18** including upper drum **20**, lower drum **22** and a bank of interconnecting tubes **24**. Interposed between the furnace section **16** and the boiler bank **18** are a superheater **26** and a reheater **28** in open gaseous communication with both the furnace chamber **16** and the boiler bank **18**. The ahead turbine **12** is of the multistage type including a high pressure section **30** and a low pressure section **32**. However, it is to be understood that the number of stages in the turbine employed can be increased without departing from the spirit of the invention. A plurality of steam conduits connect the steam generator equipment to the turbines **12** and **14** for their operation on a reheat cycle. These conduits include steam line **34** connecting the outlet of the superheater **26** to the inlet of the high pressure stage **30** of the ahead turbine **12**, line **36** connecting the exhaust of the high pressure stage **30** to the inlet of the reheater **28** and line **38** connecting the reheater outlet to the inlet of the low pressure stage **32** of the turbine **12**. The steam lines **34**, **36** and **38** are equipped with valves **40**, **42** and **44** that are operable to admit or discontinue flow of steam to the turbine **12**. In order to pass steam from the vapor generator **10** to the astern turbine **14** there is provided a steam line **46** that connects between the line **38** between the outlet of the reheater **28** and the valve **44** and the inlet to the astern turbine **14**. Valve **47** is located in line **46** to control the flow of steam to the astern turbine **14**.

According to the invention a desuperheater **48**, shown in FIGURE 1 as being of the indirect type, is submerged below the water level in the upper drum **20**. The desuperheater **48** may be located in other water containing parts of the steam generator such as the lower drum **22** without departing from the spirit of the invention. It is connected in the system by inlet and outlet lines **50** and **52**, respectively, that connect the desuperheater between the steam line **36** intermediate the valve **42** and the inlet of the reheater **28** and the line **34** intermediate the valve **40** and the inlet of superheater **26** such that, when desired, steam can be caused to flow from the superheater, through the desuperheater and thence through the reheater. A valve **54** is provided in the desuperheater discharge line **52** for placing the desuperheater **48** either in or out of service.

Control means here shown as being a simple bar linkage **56** are employed to operate the valves **40**, **42**, **44**, **47** and **54**. The arrangement is such that the valves **40**, **42** and **44** that control the supply of steam to the ahead turbine **12** are arranged to operate in unison as are the valves **47** and **54** that effect the supply of steam to the astern turbine **14**. The arrangement shown is such that actuation of the valves **40**, **42** and **44** to an open position at the same time closes valves **47** and **54** and vice versa. The control means **56** can embody any means for controlling the operation of the valves in the system such as means that are electrically, pneumatically or hydraulically actuated. In the alternative, the two groups of valves, **40**, **42**, **44** and valves **47**, **54** can be arranged to operate in unison with the valves of the same group but independently of those of the other group without departing from the spirit of the invention.

The operation of the herein described power plant installation is as follows. Fuel and water are admitted to the vapor generator **10** wherein combustion of the fuel in the furnace section **16** effects a transfer of heat from the combustion gases through the water contained in the pressure parts of the vapor generator wherein saturated steam is created and collected in the upper drum **20**. The saturated steam is passed to the superheater **26** where it is increased to about 1000° F. When it is desired to

perate the vessel in the ahead direction the control means **56** are actuated to open the valves **40**, **42** and **44** hat admit steam to the ahead turbine **12** and to close he valves **47** and **54** thereby to bypass the desuperheater **8** and the astern turbine **14**. Superheater steam is then permitted to pass from the outlet of the superheater **26** hrough line **34** to the inlet of the high pressure stage **0** of the turbine **12**. The exhaust steam from the high pressure stage then passes through line **36** to the reheater where its temperature is raised to 1000° F. This lower pressure steam then passes through line **38** to the inlet of the low pressure stage **32** of the turbine **12** and then o a condenser (not shown).

When it is desired to operate the vessel in the astern direction flow of steam to the ahead turbine **12** is discontinued by the control means **56** closing the valves **40**, **42** and **44** and admitted to the astern turbine **14** by opening the valves **47** and **54**. In this manner steam emerging from the outlet of the superheater **26** at 1000° F. is caused to flow through the desuperheater inlet line **50** to the desuperheater **48** where the temperature is reduced to about 700° F. and thence through the desuperheater outlet line **52** to the reheater **28** where its temperature is raised to 1000° F. From the reheater the steam passes through line **46** to the inlet of the turbine **14**. Exhaust steam from the turbine **14** is passed to a condenser (not shown).

By means of the present invention there is provided a simple and effective means for permitting the use of a conventional reheater located in a high gas section of a steam generator. The invention permits the full flow of steam through the reheater during astern operation of the vessel thereby enabling the reheater to be cooled at all times during the operation of the steam generator. By locating the reheater in a high gas temperature section of the steam generator the size of its heat exchange surface is kept to a minimum thereby lowering the initial cost of the equipment and the heat transfer efficiency is raised to a maximum thereby increasing the over-all efficiency of the steam cycle.

It will be understood that various changes in the details, materials, and arrangements of parts which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims. For example, while the disclosed arrangement embodies a desuperheater of the indirect type it should be understood that a spray type desuperheater could be employed without departing from the spirit of the claims.

What is claimed is:

**1.** A method of operating a marine power plant installation comprising a two-stage ahead turbine, an astern turbine, a steam generator including a superheater, a desuperheater and a reheater, the steps comprising sequentially flowing steam from said superheater to the first stage of said ahead turbine, to the reheater and to the second stage of said ahead turbine during ahead operation of said power plant installation; discontinuing steam flow to said ahead turbine and sequentially flowing steam from said superheater to said desuperheater, to said reheater to said astern turbine during astern operation of said power plant installation.

**2.** A method of operating a marine power plant installation comprising a two-stage ahead turbine, an astern turbine, a steam generator including a superheater, a desuperheater and a reheater, the steps comprising flowing steam from said superheater in direct sequence to the first stage of said ahead turbine, to said reheater and to the second stage of said ahead turbine in bypass relation to said desuperheater and said astern turbine during ahead operation of said power plant installation; flowing steam from said superheater in direct sequence to said desuperheater, to said reheater and to said astern turbine in bypass relation to said ahead turbine during astern operation of said power plant installation.



**3.** A marine power plant installation comprising a multi-stage ahead turbine; an astern turbine; a steam generator including an evaporator section, a superheater, a desuperheater, and a reheater; means operable to connect said evaporator section, said superheater, said ahead turbine and said reheater for series steam flow and to bypass said desuperheater and said astern turbine during ahead operation of said power plant installation; means operable to connect said evaporator section, said superheater, said desuperheater, said reheater and said astern turbine for series steam flow and to bypass said ahead turbine during astern operation of said power plant installation.

**4.** A marine power plant installation comprising a multi-stage ahead turbine; an astern turbine; a steam generator including an evaporator section, a superheater, a desuperheater, and a reheater; first valve means operable to connect said evaporator section, said superheater, said ahead turbine and said reheater for series flow; second valve means operable to connect said evaporator section, said superheater, said desuperheater, said reheater and said astern turbine for series steam flow; means for actuating said first valve means to an open position and said second valve means to a closed position for ahead operation of said power plant installation; and means for actuating said first valve means to a closed position and said second valve means to an open position for astern operation of said power plant installation.

**5.** A marine power plant installation comprising a two-stage ahead turbine; an astern turbine; a steam generator including an evaporator section, a superheater, a desuperheater and a reheater; first conduit means connecting said superheater and the first stage of said ahead turbine; a first valve in said first conduit means; second conduit means for passing exhaust steam from said first stage to said reheater; a second valve in said second conduit means; third conduit means for passing steam from said reheater to said second stage of said ahead turbine; a third valve in said third conduit means; fourth conduit means including a desuperheater connecting said first conduit means upstream of said first valve with said second conduit means downstream of said second valve; a fourth valve in said fourth conduit means; fifth conduit means for passing steam from said reheater to said astern turbine; a fifth valve in said fifth conduit means; control means including means for opening said first, second and third valves and closing said fourth and fifth valves for ahead operation of said power plant installation, and means for closing said first, second and third valves and opening said fourth and fifth valves for astern operation of said power plant installation.

**6.** The organization of claim **5** wherein said desuperheater comprises indirect heat exchange means submerged in a water section of said steam generator.

**7.** A marine power plant installation comprising a two-stage ahead turbine; an astern turbine; a steam generator including a furnace chamber, an evaporator section comprising an upper drum, a lower drum and a bank of interconnecting tubes, a superheater disposed between said furnace chamber and said tube bank, a desuperheater, a reheater disposed between said superheater and said tube bank; first conduit means connecting said superheater and the first stage of said ahead turbine; a first valve in said first conduit means; second conduit means for passing exhaust steam from said first stage to said reheater; a second valve in said second conduit means; third conduit means for passing steam from said reheater to said second stage of said ahead turbine; a third valve in said third conduit means; fourth conduit means including a desuperheater connecting said first conduit means upstream of said first valve with said second conduit means downstream of said second valve; a fourth valve in said fourth conduit means; fifth conduit means for passing steam from said reheater to said astern turbine; a fifth valve in said fifth conduit means; control means including means for opening said first, second and third valves and closing said

fourth and fifth valves for ahead operation of said power plant installation, and means for closing said first, second and third valves and opening said fourth and fifth valves for astern operation of said power plant installation.

8. The organization of claim 7 wherein said desuperheater comprises indirect heat exchange means submerged in a water section of said steam generator.

9. The organization of claim 8 wherein said desuperheater comprises indirect heat exchange means submerged in a water section of said upper drum.

10. A marine power plant installation comprising a two-stage ahead turbine; an astern turbine; a steam generator including a furnace chamber, an evaporator section comprising an upper drum, a lower drum and a bank of interconnecting tubes, a superheater and a reheater located intermediate said furnace chamber and said tube bank and a desuperheater; first conduit means connecting said superheater and the first stage of said ahead turbine; a first valve in said first conduit means; second conduit means for passing exhaust steam from said first stage to said reheater, a second valve in said second conduit means; third conduit means for passing steam from said reheater to said second stage of said ahead turbine; a third valve in said third conduit means; fourth conduit means including a desuperheater connecting said first



conduit means upstream of said first valve with said sec ond conduit means downstream of said second valve; a fourth valve in said fourth conduit means; fifth conduit means for passing steam from said reheater to said astern turbine; a fifth valve in said fifth conduit means; control means including means for opening said first, second and third valves and closing said fourth and fifth valves for ahead operation of said power plant installation, and means for closing said first, second and third valves and opening said fourth and fifth valves for astern operation of said power plant installation.

11. The organization of claim 10 wherein said desuperheater comprises indirect heat exchange means submerged in a water section of said steam generator.

12. The organization of claim 11 wherein said desuperheater comprises indirect heat exchange means submerged in a water section of said upper drum.

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