

[54] **SPECIAL THERMAL ELECTRIC
POWER GENERATING UNIT USING
PRESSURIZED HOT AIR TOGETHER
WITH SUPERHEATED STEAM**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 772,239, Oct. 31, 1968, Pat. No. 3,597,621.

[30] **Foreign Application Priority Data**

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[51] Int. Cl.**F16k 49/00**

[58] Field of Search137/340, 604; 138/42; 259/4

[56] **References Cited**

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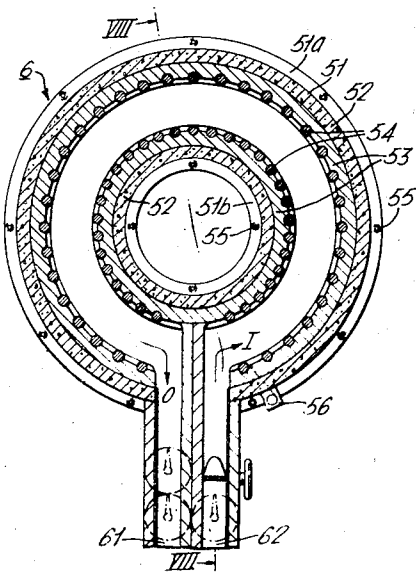
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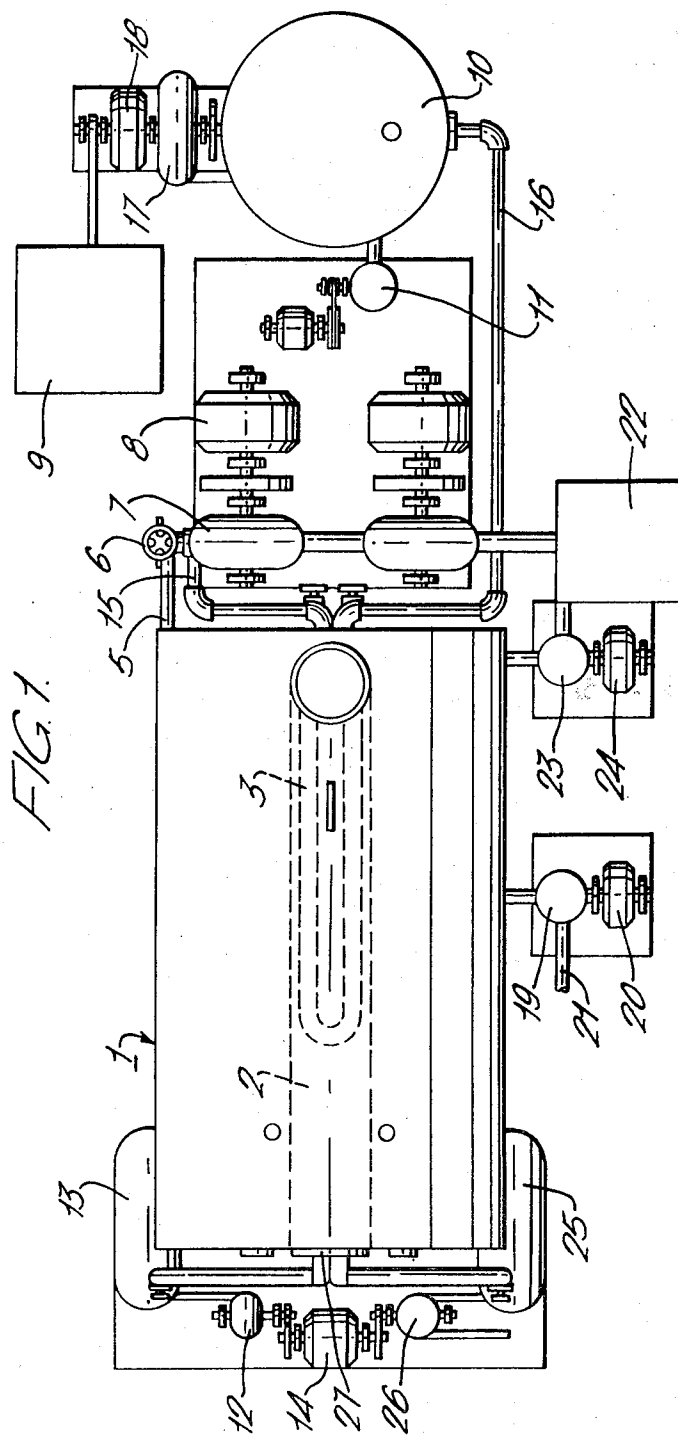
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[57] **ABSTRACT**

A thermal electric power generating unit using pressurized hot air together with superheated steam, which is useful for storing superfluous electric energy of thermal power plants in the form of compressed air during an off-peak load period, and for regenerating electric power by using the thus stored compressed air during succeeding peak load periods. The unit comprises a means for producing compressed air, a boiler to produce superheated steam, a drum within the boiler for heating the compressed air, a special injection nozzle to simultaneously inject said superheated steam and the pressurized heated air, a gas turbine to be driven by gaseous mixture jets from said nozzle, and an electric generator driven by said gas turbine. The injection nozzle comprises a hollow toroidal member having adjacent but separated input and output orifices, and having a heating coil disposed therein for maintaining the gas at a desired temperature as it is being discharged.

5 Claims, 8 Drawing Figures





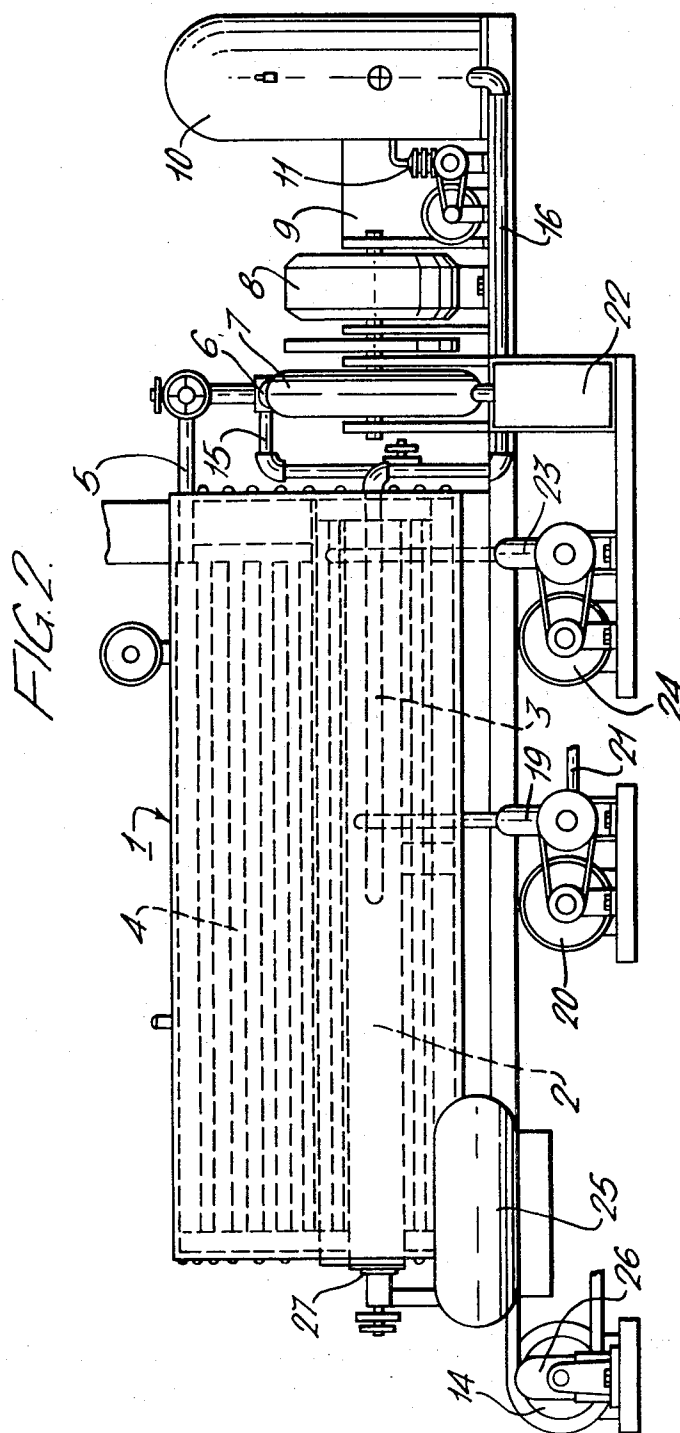


FIG. 3.

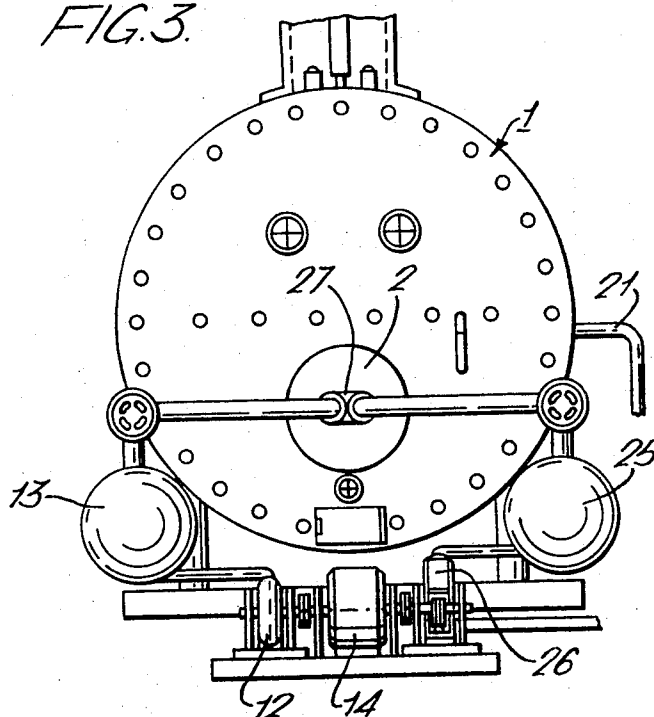
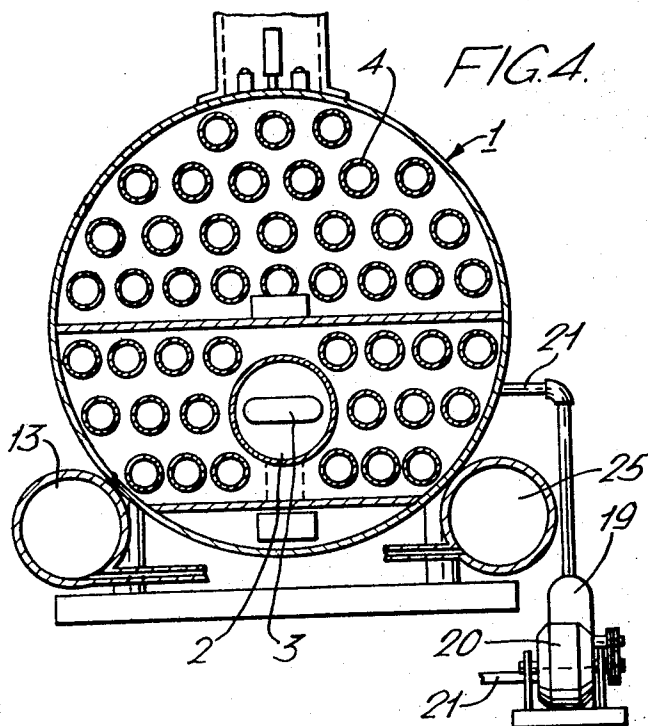
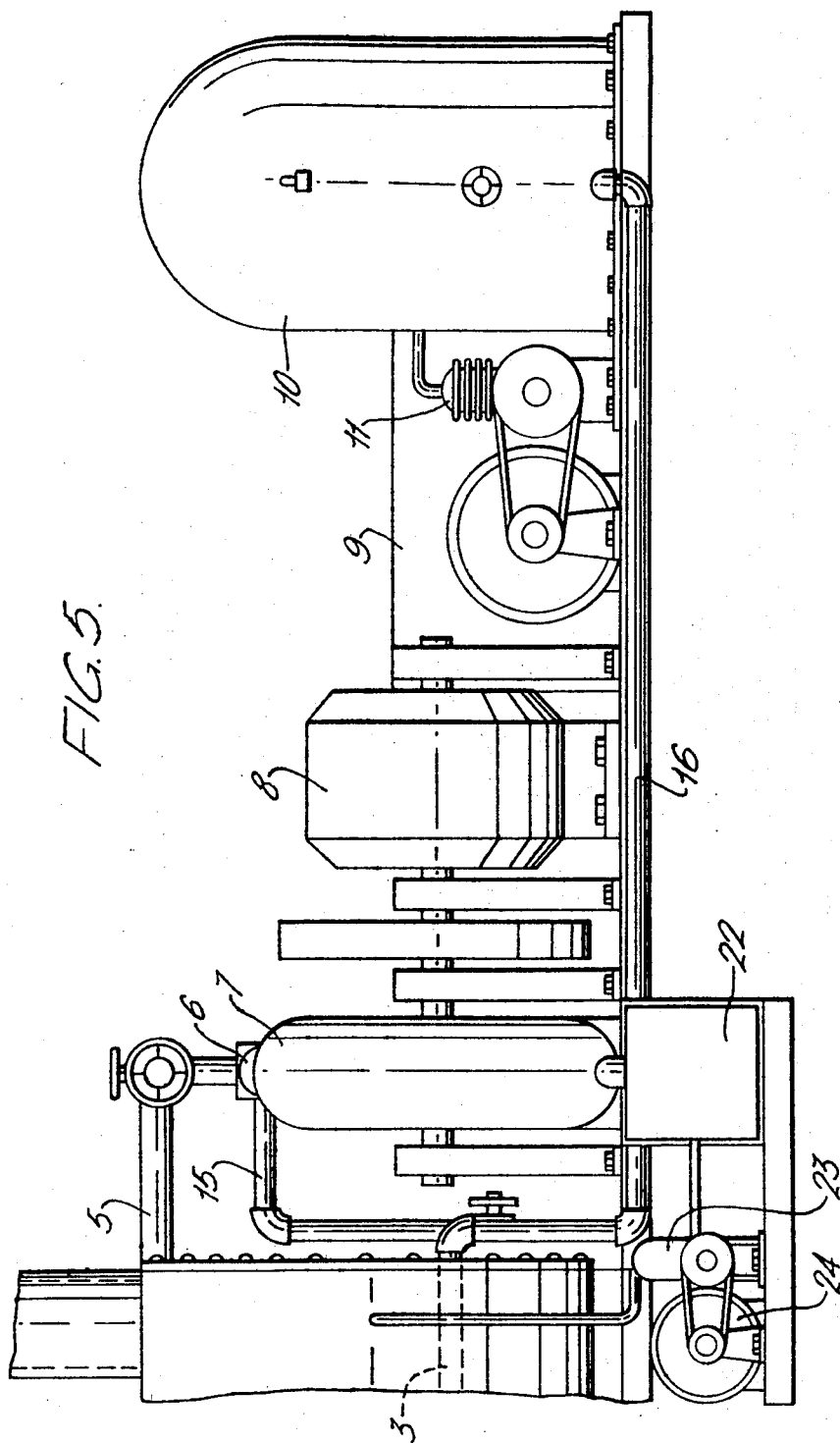
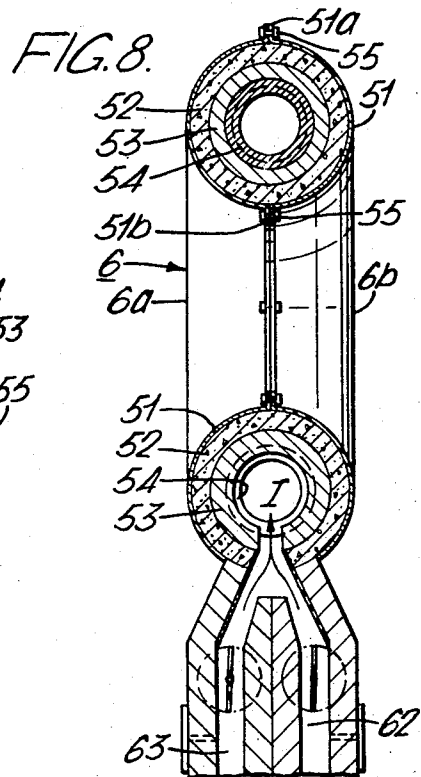
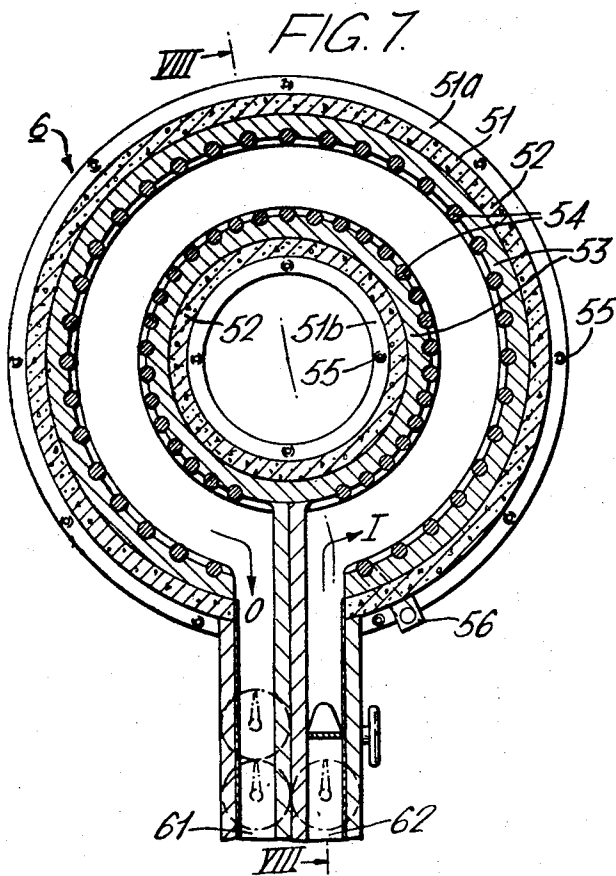
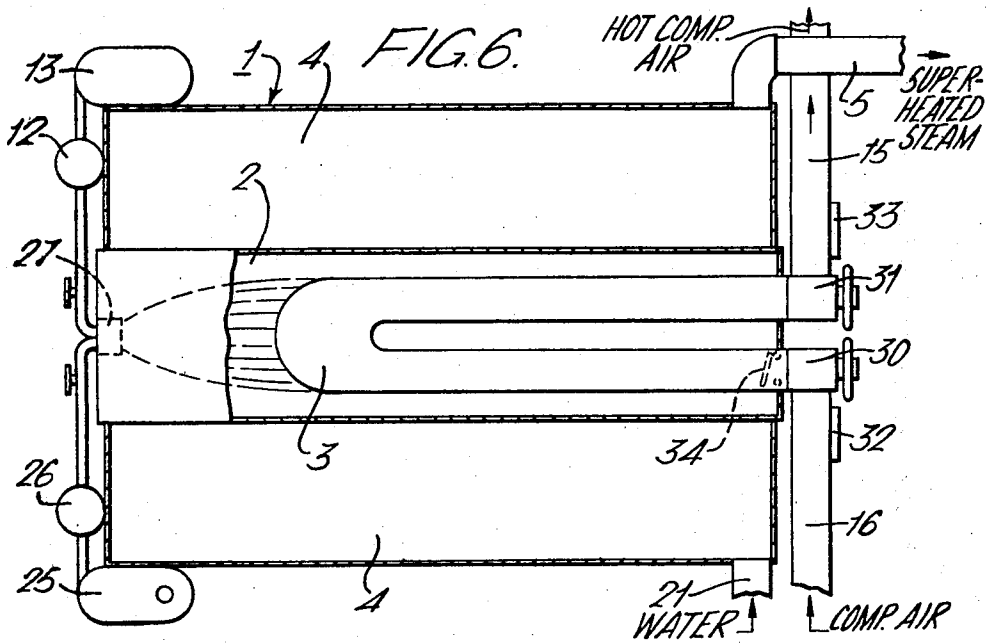


FIG. 4.







SPECIAL THERMAL ELECTRIC POWER GENERATING UNIT USING PRESSURIZED HOT AIR TOGETHER WITH SUPERHEATED STEAM

This application is a continuation-in-part application based on my copending U.S. Patent application, Ser. No. 772,239, filed on Oct. 31, 1968 now Pat. No. 3,597,621.

This invention generally relates to a thermal electric power generating unit, and more particularly to a special thermal electric power generating unit using pressurized hot air together with superheated steam.

It is an object of the present invention to provide a special electric power generating unit, which enables the storage of superfluous electric power from conventional thermal power plants, such as midnight output, by using such power to compress air, by storing the compressed air in a tank, and by subsequently driving a pneumatic turbine with the stored air to regenerate electric power during daytime hours when the demand for electric power is high. With the electric power generating unit according to the present invention, the stored compressed air is conveyed to a special blind drum in the firebox of a boiler, while its pressure and flow rate are suitably regulated so that pressurized hot air can be produced. Superheated steam delivered from a boiler, or a superheated steam generating chamber thereof, is injected through a special nozzle together with said pressurized hot air, so as to produce a superheated gaseous mixture jet which strikes the runner of a gas turbine to rotate the turbine at a high speed. By driving an electric generator by such gas turbine, electric power can be produced. It is, of course, possible to generate electric power not only during daytime but also at night by using the special thermal electric power generating unit using pressurized hot air together with superheated steam according to the present invention.

For better understanding of the invention, reference is made to the accompanying drawings, in which:

FIG. 1 is a schematic plan view of a thermal electric power generating unit according to the present invention;

FIG. 2 is a side view of the unit;

FIG. 3 is a rear view of a boiler used in the unit;

FIG. 4 is a vertical sectional view of the boiler;

FIG. 5 is an enlarged schematic side view of an electric generator portion of the unit;

FIG. 6 is a more detailed schematic illustration of the drum means shown in FIGS. 1-5;

FIG. 7 is a lateral cross-section of a nozzle used in the generating unit according to the present invention; and

FIG. 8 is a sectional view taken along the line VII-VII of FIG. 7.

Referring to the figures, wherein like parts are designated by like reference numerals, a boiler 1 has a firebox 2 and blind drums 3 disposed in the firebox 2, which blind drums 3 are used for heating compressed air. The boiler 1 also has chambers 4 for generating superheated steam at a certain pressure and at a certain temperature. The blind drums 3 act to generate pressurized hot air of the same pressure and the same temperature as those of said superheated steam. The superheated steam is delivered to a pipe 5, which conveys the superheated steam to special nozzle 6 where the superheated steam is mixed with the pressurized hot air to produce a superheated gaseous mixture. The special

nozzle 6 injects both the superheated steam and the pressurized hot air at a suitable rate toward a runner of gas turbine 7, so as to rotate the gas turbine 7 at a high speed. By connecting the gas turbine 7 to an electric generator 8, electric energy can be generated in response to the rotation of the turbine 7.

When compressed air is heated to 300°C, the compressed air is expanded to a volume more than twice as large as its original volume, and becomes pressurized hot air. In a preferred embodiment of the present invention, the pressure and the temperature of such pressurized hot air are so adjusted as to become the same as the corresponding pressure and the temperature of the superheated steam from the pipe 5, and the pressurized hot air thus adjusted is then fed to the special nozzle 6 and it is mixed with the superheated steam therein.

The inventor disclosed a special prime mover, in his Japanese Patent No. 192,668, titled "A Special Intensive Prime Mover of Offset Output Type," which prime mover is generally designated as 9 in FIG. 1. By rotating a pneumatic turbine with such special prime mover connected thereto, compressed air can be produced at a very low cost, because an extremely inexpensive energy source is available. The compressed air thus produced is stored in a compressed air tank 10. A known air compressor 11 is provided for producing compressed air by using surplus power from thermal power plants during low-load hours, so as to effectively store the surplus energy in the form of compressed air within the tank 10. In the illustrated embodiment of the invention, both the special prime mover 9 and the known air compressor 11 are used, but it is also possible to dispense with one of them in the unit of the invention.

If the compressed air stored in the tank 10 is used for generating electric power during daytime hours when the demand for electric power is high, the thermal power plant can be efficiently operated day and night with full output, so that the equipment of the thermal power plant is fully utilized and the cost of the electric power generated can be reduced.

The illustrated embodiment of the present invention further comprises a blower 12, another compressed air tank 13, a motor 14, pipes 15, 16 for feeding the pressurized hot air, a pneumatic turbine 17, another motor 18, a water pump 19 driven by a motor 20, a water supply pipe 21, a steam condenser 22, another water pump 23 driven by a motor 24, a fuel tank 25, an oil pump 26, and an injection nozzle 27.

As shown specifically in FIG. 6, the air heating drum 3 is disposed within the firebox 2 of the steam generating boiler 1. Compressed air is supplied to the drum means 3 through the inlet pipe 16 connected to the tank 10, while the heated, pressurized air is discharged from the drum through the outlet pipe 15. Pressure adjusting valves 30 and 31 are disposed, respectively, at the inlet and outlet to the drum 3, and a manometer-thermometer assembly 32 is mounted in the inlet pipe 16, for monitoring the pressure and temperature of the incoming compressed air. Similarly, a second manometer-thermometer assembly 33 is mounted in the outlet pipe 15 for monitoring the pressure and temperature of the air as it is coupled to the nozzle 6. The drum means 3 also includes a check valve 34, disposed adjacent its inlet, for preventing the heated, pressurized air from being coupled back to the tank 10.

The specific details of the injection nozzle 6 are illustrated in FIGS. 7 and 8. The nozzle 6 comprises a hollow toroidal member or casing 51 formed in two halves 6a and 6b, each half having an outer peripheral flange 51a and an inner peripheral flange 51b, both sets of flanges being respectively joined together by a plurality of nut-and-bolt combinations 55. The inside of the casing 51 defines a toroidal passage for the gases to be mixed and is lined with a firebrick layer 52 and a heat-insulating layer 53. An electric heating coil 54 is disposed on the heat-insulating layer, which coil is connected to a junction box 56. Two tubes or pipes 62 and 63 are connected to an inlet opening of the casing 51 for delivering superheated steam and compressed air thereto, respectively. Adjusting valves 57 and 57a are mounted on the pipes. Temperature and pressure indicating gauges 58, 58a are also mounted on the two pipes, respectively. Another pipe 61 is connected to the outlet opening of the casing 51, on which are mounted a pressure gauge 59 and a thermometer 60. All the pipes 61, 62 and 63 are lined with heat-insulating layers 64. Thus, the steam and heated air are coupled to the nozzle 6 through the tubes 62 and 63, respectively; and, such steam and air are simultaneously mixed and heated as they travel around the entire internal cavity of the toroidal casing, whereupon they are discharged by the tube 61. All of the inlet and outlet tubes 61-63 are provided with valve means for regulating the various pressures at the nozzle.

For storing electric energy, storage batteries have heretofore been utilized. In addition, for effectively utilizing the surplus "midnight" output power from thermal power plants, hydraulic pumping-up power stations have been constructed. However, such pumping-up power stations have numerous difficulties in the equipment thereof. In comparing the electric power generating unit according to the present invention with known thermal power generating units, the amount of steam to be used in the former unit is less than one half of that in the latter unit. Thus, the fuel for power generation, such as heavy oil and coal, can be saved by more than 50 percent. Furthermore, the electric power generating unit according to the present invention can be constructed together with known thermal power plants as a compound plant. The unit of the present invention can be constructed in a short period of time, and accordingly, its construction cost is low. As compared with any known steam power plants, and the electric power generating unit of the present invention is superior in safety, economy, and freedom from public nuisance.

At the present, electric utility organizations in many countries operate their generating facilities at full

capacity during daytime hours, in order to meet the demand for electric power, but more than 50 percent of the generating facilities become idle at night. Recently, such idle generating facilities have been operated at night to run hydraulic pumping-up power stations, but such hydraulic pumping-up power stations have a considerable amount of inherent energy loss. In addition, the construction of hydraulic pumping-up power stations requires a rather enormous capital investment. On the other hand, the unit according to the present invention serves the purpose of efficiently storing and regenerating energy at a much lower cost. Thus, it is an important feature of the invention that the superfluous output from thermal power plants can be stored and regenerated at a limited capital expenditure.

It is, of course, possible to incorporate suitable relay means in the unit of the invention, so that each offpeak load is detected for automatically actuating the air compressor for storing energy and each peak load is detected for regenerating power out of the compressed air.

What I claim is:

1. An injection nozzle for mixing and discharging gases delivered from two separate sources comprising: a toroidal member having a hollow interior defining a toroidal passage for the gases and having first and second inlet ports disposed adjacent each other for providing immediate intermixing of gases delivered to said inlet ports and an outlet port disposed adjacent said inlet ports, means separating said inlet ports from said outlet port, and heating means disposed within said toroidal member for heating gases passing therethrough, whereby gases introduced at said inlet ports must traverse the entire hollow volume of said toroidal member prior to discharge from said outlet port.

2. An injection nozzle as set forth in claim 1, further comprising a firebrick layer lining said hollow interior, and heat-insulating means lining said firebrick layer.

3. An injection nozzle as set forth in claim 1, in which said toroidal member comprises two halves defined by a plane normal to the axis of said toroid, each said half having an inner and outer peripheral flange abutting said flanges of the other half, and means connecting together said respective inner and outer flanges.

4. An injection nozzle as set forth in claim 3, further comprising a firebrick layer lining the inner surface of each said toroidal half, and heat-insulating means lining each said firebrick layer.

5. An injection nozzle as set forth in claim 4, wherein said heating means comprises a plurality of heating coils imbedded in said heat-insulating means for heating said gases passing through said nozzle.

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