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Schwarz

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[54] GAS TURBINE SYSTEM WITH SUBTERRANEAN AIR STORAGE

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[51] **Int. Cl.** **F02c 3/10**
[58] **Field of Search** ..... 60/39.18 B, 39.07, 39.18 C, 60/39.09 P, 39.02; 290/52

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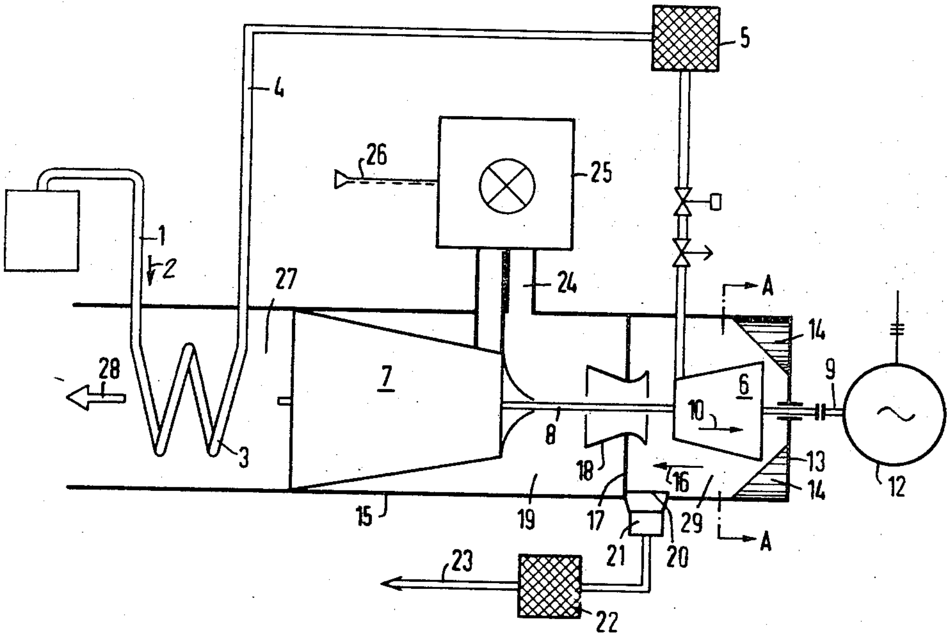
[57] ABSTRACT

In a gas turbine system with subterranean air storage such as in a cavern formed in a salt stratum, a hot-air decompression turbine stage for partially decompressing combustion air stored at high pressure, prior to the entry thereof into the combustion chamber of the gas turbine proper, after the combustion air has been delivered by suitable conducting means to a location at which it is heated by the exhaust gases of the gas turbine to a temperature below the melting temperature of any salt particles that may be present in the stored air.

7 Claims, 2 Drawing Figures



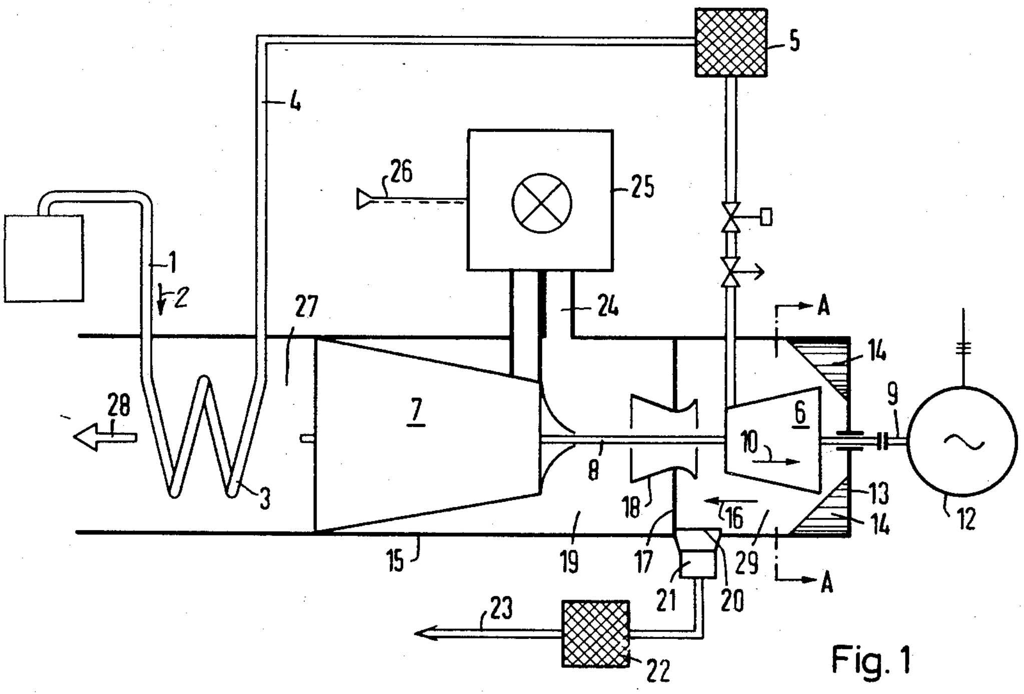

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Fig. 1

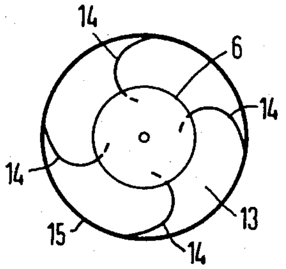
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Fig. 2

GAS TURBINE SYSTEM WITH SUBTERRANEAN AIR STORAGE

The invention relates to a gas turbine system with subterranean air storage of the type which is formed of a storage cavern in a salt stratum or the like, from which combustion air stored at times of low current demand is fed to the combustion chamber of a gas turbine at times of higher current demand. The stored air is subjected in such installations to fluctuating changes of state, depending on the volumetric efficiency of the storage reservoir. These changes in state occur virtually adiabatically while the reservoir is being filled and during removal of the air from the reservoir.

Such subterranean cavities, which are produced, for example, especially in salt deposits by washing the salt out, further contain a sump formed of saturated salt water, numerous impurities partly containing silica, and insoluble rock residues. During the frequent changes in state of the air, which occur relatively rapidly, the moisture content of the air also changes. As a result of these continual changes in pressure, temperature and humidity, it must be taken into account that salt particles from the cavern will be held in suspension in the enclosed air and entrained when a large amount of the stored air is withdrawn from the cavern. When these dust particles formed primarily of sodium chloride or potassium chloride enter the gas turbine combustion chamber, they melt there and precipitate subsequently on the colder turbine blades. The deposit formed thereby can cause not only a narrowing of the gas channels in the blading and therefore produce an increased tangential loading or stress on the thrust bearing, but can also cause a reduction of power. Moreover, the salt deposit endangers the strength of the rotor blading due to intercrystalline corrosion.

The need therefore arises to free the combustion air of salt dust as completely as possible by suitable filters or dust separators prior to the entry of the air into the combustion chambers. Equipment for this purpose, which must be designed for total air through-put and the highest operating air pressure is very costly.

It is accordingly an object of the invention to provide a gas turbine system with subterranean air storage which reduces in part the technical expenditure for the apparatus which is indispensable for separating salt dust or other impurities and to use in this connection other measures which permit this reduction without exposing the gas turbine system to the dangers described hereinbefore.

With the foregoing and other objects in view, there is provided in accordance with the invention, gas turbine system with subterranean air storage space, for example, in a cavern formed in a salt stratum, wherefrom combustion air stored at high pressure during periods of low output current demand from the gas turbine is fed, during periods of higher current demand, to the gas turbine combustion chamber, includes means for conducting the highly compressed stored air to a location at which it is heatable by exhaust gas of the gas turbine to a temperature below the melting temperature of any salt particles present in the stored air, and a hot-air decompression turbine stage for partly decompressing the highly compressed heated stored air prior to entry of the latter into the gas turbine combustion chamber.

The combustion air is stored at high pressure, as noted hereinbefore. When air is withdrawn, the air flow is heated exclusively in surface heat exchangers by the exhaust gas heat from the gas turbine, and is then fed to the hot-air decompression turbine stage through a coarse filter. The temperature of the air can be selected at about 350° C and is therefore far below the melting temperature of the salts.

In accordance with another feature of the invention, the decompression turbine stage is mounted to particular advantage on the same shaft as that on which the associated gas turbine proper is mounted, but with a flow passage therein opposite in direction to that of the gas turbine. Moreover, both the decompression turbine stage and the gas turbine are located with a common outer casing.

In accordance with a further feature of the invention, at the discharge end of the decompression turbine, radially disposed swirl or vortex vanes for setting the air stream into rotational flow without jolting by using the outlet energy of the discharging hot air flow, the air being deflected through an angle of 180° C and flowing around the casing of the decompression turbine stage in direction toward the gas turbine. On this path, the air flow performs a torsional displacement, the helical advance of the flow being terminated by a ring-shaped partition. The particles to be separated are removable thereat from the air flow.

In accordance with yet another feature of the invention, the purified air then flows through a diffuser-like overflow tube, which surrounds the common turbine shaft from the region in which the rotational air flow is located to an antechamber located upstream of the combustion chamber.

Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in gas turbine system with subterranean air storage, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatic axial view of the gas turbine system with subterranean air storage space according to the invention; and

FIG. 2 is a sectional view of FIG. 1 taken along the line A—A in the direction of the arrows.

Referring now to the drawing and first, particularly to FIG. 1 thereof, there is shown therein the inventive gas turbine system wherein combustion air stored at high pressure travels from a non-illustrated subterranean storage space or reservoir in a cavern of a salt stratum, for example, through a line **1** in direction of the arrow **2** and is heated in a heat exchanger **3** by the hot exhaust gas of a gas turbine **7**. The heated air flow is then fed through a line **4** to an air filter **5** and from there to a hot-air decompression turbine stage **6**. The turbine stage **6** is mounted on the same shaft **8** on which the gas turbine **7** is mounted, the shaft **8** being coupled with a shaft **9** of a generator **12**.

The flow through the decompression turbine stage **6** is axial, in direction of the arrow **10.** The partially decompressed quantity of air leaving the turbine stage **6** arrives at the region of swirl or vortex vanes **14** which are secured at the end wall **13** of the casing **15,** which commonly encloses both turbines **6** and **7.** In FIG. **2,** which represents a cross-sectional view taken along the line A—A in FIG. **1,** the disposition of these swirl or vortex vanes **14** is shown more clearly.

The swirl vanes **14** set the deflected air flow into additional rotational motion virtually without jolting by using the outlet energy or velocity of the hot air flow, when the air flow passes through the annular space **29** between the outer casing **15** and the decompression turbine stage **6** in the direction of the arrow **16.**

The helically advancing air flow produced thereby is bounded by a circular partition **17.** The entire or predominent part of the combustion air is conducted from the central region of the rotational air flow and directed through a diffuser **18,** which extends through a central opening in the partition **17** and surrounds the turbine shaft **8,** into an ante-chamber located upstream of the combustion chamber **19,** in the flow direction of the combustion air.

The outer or marginal zone of the air flow travels axially in direction toward the partition **17,** is baffled thereat and deflected radially inwardly. A zone of turbulence formed thereby rotates simultaneously in the rotary direction of the main air flow set by the swirl vanes **14.** Salt particles and other impurities are thereby thrown into the outer zone of the air flow and travel therewith in direction toward the partition **17.**

In the lower part of the partition **17** suitable deflectors or baffles **20** cause a deflection into a collecting chamber **21** of the part of the air flow that is entrained or laden with impurities. Salt particles and foreign bodies thus accumulate in the collecting chamber **21.**

In order to attain a well-defined flow, the partial air flow conducted through the collecting chamber **21** is re-fed through an air filter **22** and the pipe line **23** connected thereto, into the main air flow at a suitable non-illustrated point. The line **23** can, for example, discharge into the region of the cross-sectional constriction of the diffuser **18.** It is, of course, also possible to discharge the partial quantity of air into the exhaust gas flue of the gas turbine, in order to have available a greater pressure difference for drawing off the impurities.

From the ante-chamber **19** located upstream of the combustion chamber **25,** the combustion air now passes through the passage **24** to the combustion chamber **25,** to which fuel **26** is fed in a conventional manner shown schematically, together with the combustion air.

The combustion chamber **25** is located upstream of the gas turbine **7,** which is provided with an exhaust gas channel **27** wherein the aforedescribed heat exchanger **3** is disposed. The exhaust gases leave the system at lower temperature in direction of the arrow **28.**

I claim:

1. Gas turbine system arranged for connection to a supply of high pressure air containing salt particles for feeding said high pressure air during periods of high output current demand, comprising a gas turbine having an exhaust means, a combustion chamber feeding hot gases to said gas turbine, a heat exchanger in said exhaust means of said gas turbine for heating said supply of high pressure air containing salt particles below the melting temperature of any salt particles present in said supply, a hot-air decompression turbine stage for reducing the pressure of the high pressure supply of air, means for delivering air from said heat exchanger to said decompression turbine stage, and means for delivering said air supply from said decompression turbine stage to said combustion chamber.

2. System according to claim **1** wherein said hot-air decompression turbine stage and the gas turbine are located within a common outer casing; said hot-air decompression turbine stage having a fluid flow passage therein opposite in direction to that of the gas turbine.

3. System according to claim **2** including a shaft disposed in said outer casing, both said hot-air decompression turbine stage and said gas turbine being mounted in common on said shaft.

4. System according to claim **2** wherein said hot-air decompression turbine stage has a discharge end for decompressed hot air flow and including radially extending vortex vanes operative by the outlet energy of the discharging hot air flow for setting the hot air flow into rotation substantially free of jolting.

5. System according to claim **4** including an antechamber upstream of the combustion chamber in flow direction of the hot air, and a circular ring-shaped partition located between said ante-chamber and the region in which the rotational flow of the hot air is located.

6. System according to claim **5** wherein said partition is formed with a central opening, and a diffuser-like overflow tube extends through said opening and forms a passage for air from the region in which the rotational flow thereof is located to said antechamber.

7. System according to claim **6** including a shaft disposed in said outer casing, both said decompression turbine stage and said gas turbine being mounted in common on said shaft, said diffuser-like overflow tube surrounding said common shaft.

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