Jan. 11, 1944. F. NETTEL 2,339,185

COMBUSTION TURBINE

Filed June 13, 1941 2 Sheets-Sheet 1

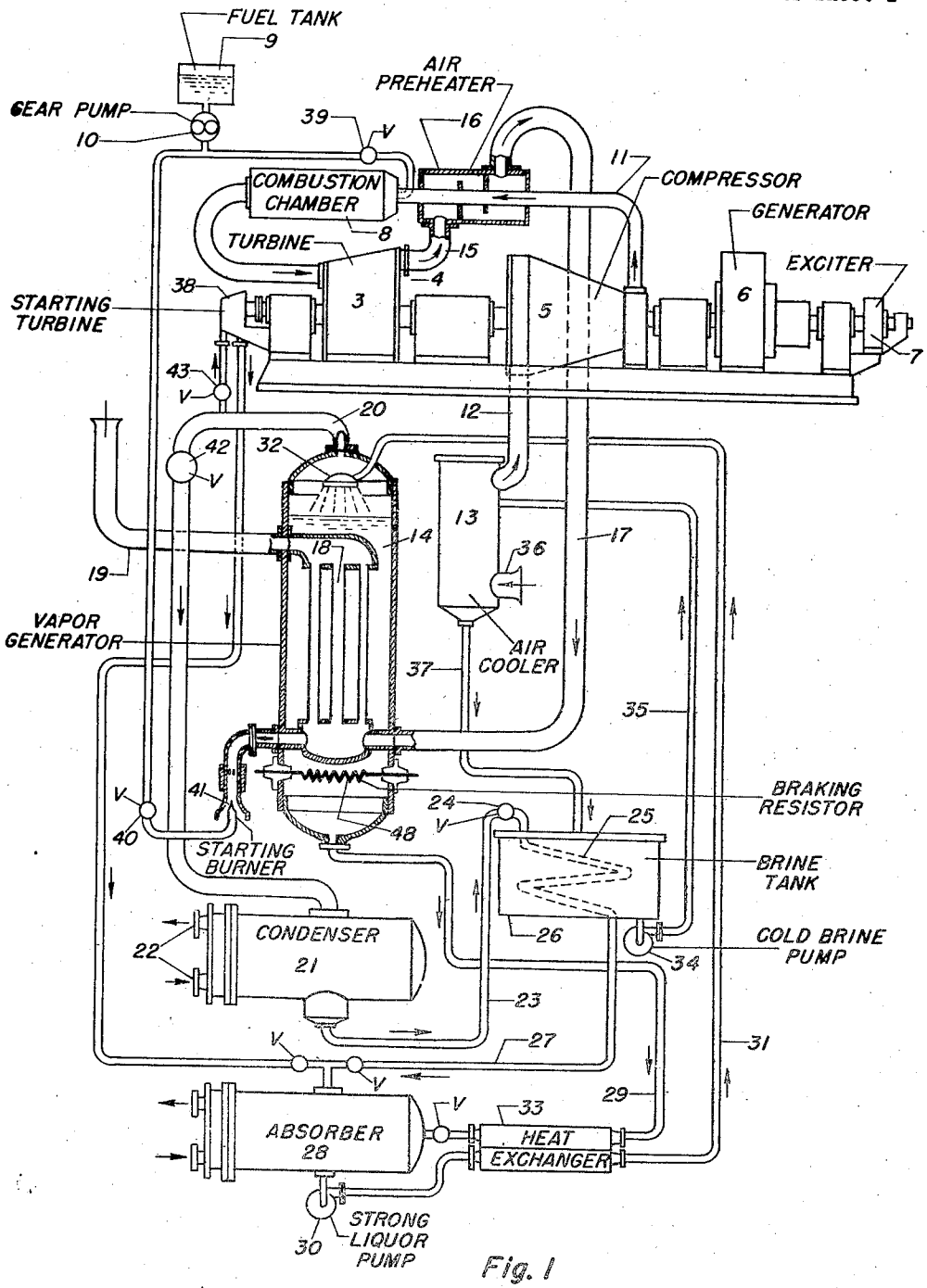


Fig. 1

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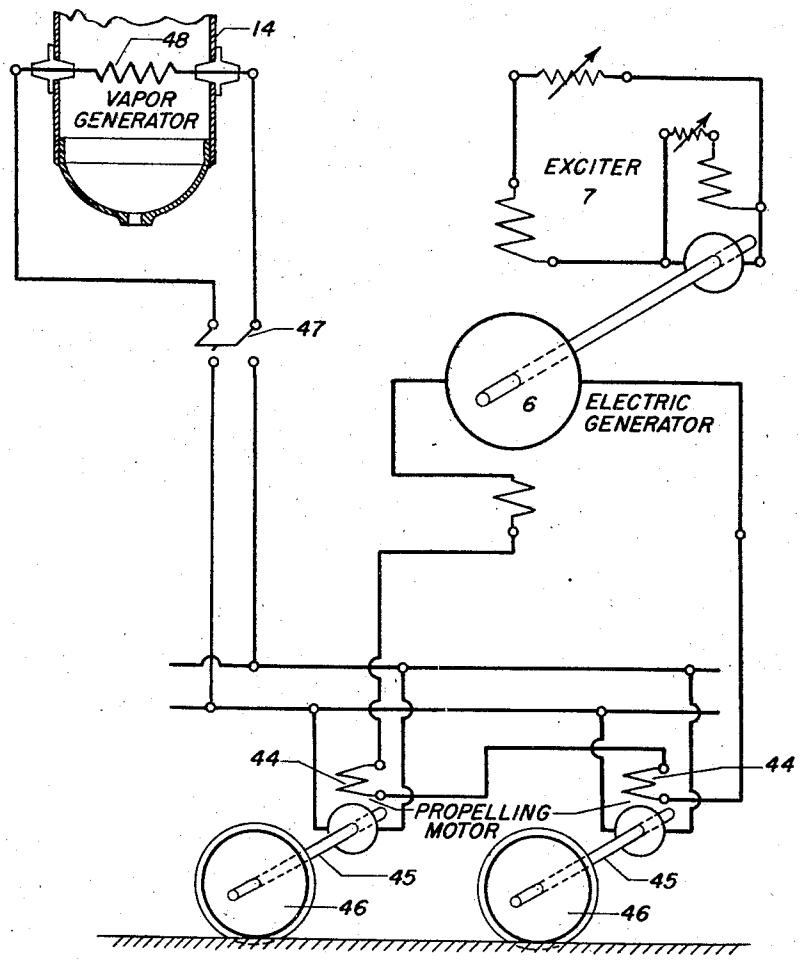


Fig. 2

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COMBUSTION TURBINE

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Application June 13, 1941, Serial No. 397,980

6 Claims. (Cl. 290—14)

This invention relates broadly to combustion turbines such as are shown in my copending applications Serial Nos. 309,359 and 330,801, filed December 15, 1939, and April 20, 1940, respectively, and more particularly to means to start the system and to utilize regenerative braking to increase the efficiency thereof.

Among the several objects of this invention are:

To provide simple and useful means for starting combustion turbines operating on a refrigeration cooling cycle;

To utilize the energy of regenerative braking in combustion turbine systems operating on a refrigeration cooling cycle without necessitating heavy resistors and to recover at least a part of the heat derived from electric current generated by the braking for use in operating the turbine.

In the drawings:

Fig. 1 is a schematic layout of a system that illustrates the present invention; and

Fig. 2 is a diagrammatic showing of the electrical circuits involved.

Combustion turbines cannot be set in operation from standstill without an outside power impulse. In this respect, the combustion turbine is in an even less favorable position than the reciprocating internal combustion engine for which a short cranking is generally sufficient for starting.

In combustion turbines as known in the art, it is generally necessary to bring the speed up to about twenty-five percent of the normal working speed before the air compressor begins to deliver sufficiently to permit the burner in the combustion chamber to be started. The power required for starting has been provided by either an electrical or a mechanical starting motor. While electric starting is convenient, a source of electric power is not always available and consequently the present invention has been made to avoid the necessity of such power source.

When turbo-electric drives are used in ship propulsion, locomotives or industrial drives, it is sometimes necessary to bring the motors driven by current from the turbo-electric set to a quick stop or to limit the number of revolutions per second as in regenerative braking. It is well known in the art to operate electric motors as generators, the power thus produced being consumed in resistors where it is converted into heat that is usually wasted. Moreover, such resistors are heavy and expensive and require considerable space, which may not always be available. The present invention avoids the use of heavy resistors by transferring the heat from the resistors to the fluid in the vapor generator or still of an absorption refrigeration system, that is used to cool the combustion air before compression.

Referring now to Fig. 1, the combustion turbine 3 is connected to shaft 4 that transmits driving torque through air compressor 5, electric generator 6 and exciter 7. It will be understood that, if desired, the compressor 5 may be driven by a separate turbine. The hot gaseous working substance is produced by combustion of fuel in combustion chamber 8 where a suitable material such as oil supplied from fuel tank 9 by gear pump 10 is mingled with air conducted to combustion chamber 8 from compressor 5 through the pipe 11. The air intake to compressor 5 is through conduit 12 from air cooler 13 where the air is cooled before compression as will be hereinafter described.

The vapor generator, or still, 14 contains a refrigerant, such as ammonia gas, in a liquid carrier, such as water. The hot exhaust gases from turbine 3 pass through pipe 15 to air pre-heater 16, thence through pipe 17 to heat exchanging device 18 immersed in the liquid in vapor generator 14 where a considerable portion of the rejected heat from turbine 3 is transferred to the liquid and evaporates the ammonia gas, the discharge to atmosphere being through pipe 19.

The ammonia vapor driven off from the solution in vapor generator 14 passes through pipe 20 to condenser 21 where it is condensed by cooling water introduced and discharged through the openings 22. The condensed gas is carried through pipe 23 and expansion valve 24 to a brine coil 25 in brine tank 26 where the ammonia is expanded and takes up heat from the brine in the well known manner. The ammonia then passes through pipe 27 to absorber 28 where it mingles with weak ammonia solution carried from still 14 through pipe 29 with the result that the ammonia is absorbed and is then transferred by the strong liquor pump 30 through pipe 31 to sprayhead 32 in the vapor generator 14. Heat exchanger 33 transfers heat from the weak liquor in pipe 29 to the strong liquor in pipe 31.

The refrigerated brine is transferred from tank 26 by means of brine pump 34 through pipe 35 to a sprayhead (not shown) in the air cooler 13 where all the air drawn in at intake 36 must pass through the cold spray before going through pipe 12 to compressor 5. The brine is returned to tank 26 through pipe 37. When the turbine 3 is operating normally the rejected heat therefrom will be sufficient to provide the necessary refrigeration to cool the air taken into compressor 5 to reduce

the work required to compress the air, as is well known.

Starting from standstill is accomplished by a small ammonia vapor turbine 38 that may be coupled to shaft 4 by a clutch or continuously as shown in the drawings, or it may be connected separately to compressor 5. In the last mentioned case suitable clutches would be provided to connect compressor 5 to shaft 4. When it is desired to start the system, valve 39 is closed and valve 40 is opened so that fuel is carried to starting burner 41, from which the hot products of combustion are passed through heat exchange device 18 to generate ammonia vapor under pressure. The valve 42 is closed and valve 43 is opened so that the ammonia vapor is carried to turbine 38 to drive turbine 38 and impart sufficient speed to compressor 5 to deliver the necessary supply of air to combustion chamber 8 for starting the main turbine 3. After the compressor 5 has reached sufficient speed, valve 40 is closed and valve 39 is opened to supply fuel to combustion chamber 8. Also, valve 43 is closed and valve 42 is opened to permit the normal circulation of ammonia vapors from still 14 to condenser 21.

One common use of combustion turbine systems as herein disclosed is to power locomotives. Fig. 2 shows the electrical circuits adapted to practice one efficiency-increasing aspect of my invention when the system is incorporated in a locomotive. Current from the generator 6 is carried to electric propelling motors 44 fixed to the axles 45 upon which the driving wheels 46 are mounted. While the motors 44 are functioning as motors, the switch 47 is open. However, when the locomotive begins to descend a hill, the fuel supply to combustion chamber 8 is materially reduced or entirely cut off and the motors 44 then begin to operate as generators. The switch 47 being closed, the current from the motors 44 acting as generators will be carried to resistor 48, that is in heat exchanging relation with the fluid in vapor generator 14 so that ammonia vapor is driven off. This transfer of heat from resistor 48 makes it possible to use a much lighter resistor and, in addition, the evolved heat is usefully employed to evaporate ammonia which may be stored either as such or it may be used to reduce still further the temperature of the brine in tank 26 so that the system can easily take care of subsequent overloads.

It is thus apparent that my present invention provides a system having means to utilize at least a portion of the rejected heat from the turbine and also to convert regenerative braking energy into heat and usefully employ the same in the system. Also, it is apparent that my invention contemplates broadly the utilization of rejected heat from a heat engine in a thermo-electric system and the utilization of heat from regenerative braking to increase the output of useful work from such engine, the heat from both sources being applied in the same apparatus.

I claim:

1. A motive power system, including a combustion turbine, an air compressor to compress air for combustion, absorption refrigeration apparatus to cool the air before compression, and an electric generator connected to be driven by said turbine, said apparatus comprising a closed shell to contain a refrigerant absorbed in a liquid carrier, means in said shell to transfer heat from exhaust gases from said turbine to evaporate said refrigerant, means to burn fuel and pass the gases of combustion through said means in said shell to evaporate refrigerant when said turbine is not operating, a second turbine connected to drive said compressor, means to conduct evaporated refrigerant from said shell to drive said second turbine, a vehicle whereon said system is mounted having electric propelling motors connected to be driven by current from said generator, said motors being operable as generators for regenerative braking, and resistor means connected to consume the current generated by said regenerative braking and disposed to transfer heat to the liquid in said shell.

2. A motive power system, including a combustion turbine, an air compressor to compress air for combustion, and absorption refrigeration apparatus to cool the air before compression, an electric generator connected to be driven by said turbine, said apparatus comprising a closed shell to contain a refrigerant absorbed in a liquid carrier, means in said shell to transfer heat from exhaust gases from said turbine to evaporate said refrigerant, means to burn fuel and pass the gases of combustion through said means in said shell to evaporate refrigerant when said turbine is not operating, a second turbine connected to drive said compressor, means to conduct evaporated refrigerant from said shell to drive said second turbine, a vehicle whereon said system is mounted having an electric propelling motor connected to be driven by current from said generator, said motor being operable as a generator for regenerative braking, and means to utilize current generated by said regenerative braking to evaporate refrigerant in said shell.

3. A thermo-electric power system, comprising means to release heat and produce hot working substance, a prime mover drivable by said hot working substance, vapor generator means connected to utilize at least a portion of the rejected heat from said prime mover to produce a gasiform fluid, means to utilize said fluid to increase the work output of said prime mover, an electric generator connected to be driven by said prime mover, a vehicle upon which said system is mounted having an electric propelling motor driven by electric current from said generator, said motor being operable as a generator for regenerative braking and means to convert the current generated by said regenerative braking into heat in said vapor generator means to produce gasiform fluid for use in said fluid utilizing means whereby to employ usefully at least a significant portion of said regenerative braking energy in said system.

4. A thermo-electric power system, comprising means to release heat and produce hot working substance, a prime mover drivable by said hot working substance, vapor generator means connected to utilize at least a portion of the rejected heat from said prime mover to produce a gasiform fluid, means to utilize said fluid to increase the work output of said prime mover, an electric generator connected to be driven by said prime mover, a vehicle upon which said system is mounted having an electric propelling motor driven by electric current from said generator, said motor being operable as a generator for regenerative braking, means to convert into heat the energy generated by said regenerative braking, and means usefully to employ in said system at least a portion of the heat thus derived from regenerative braking.

5. A motive power system, comprising thermo-electric power mechanism including a combustion

device, a prime mover driven by hot fluid generated by said combustion device, an electric generator driven by said prime mover, means to compress air for use in said combustion device, means to cool said air before compression including a refrigeration system having a vapor generator, a vehicle upon which said system is mounted, said vehicle having an electric propelling motor driven by current from said electric generator and operable as a generator for regenerative braking, and means to convert current generated by said regenerative braking into heat in said vapor generator.

6. A motive power system, comprising thermoelectric power mechanism including a combustion device, a prime mover driven by hot fluid generated by said combustion device, an electric generator driven by said prime mover, means to cool said air before compression including a refrigeration system operable by energy from said power mechanism, a vehicle upon which said system is mounted, said vehicle having an electric propelling motor driven by current from said electric generator and operable as a generator for regenerative braking, and means to utilize the current generated by said regenerative braking to supply energy to operate said regfrigeration system.

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