

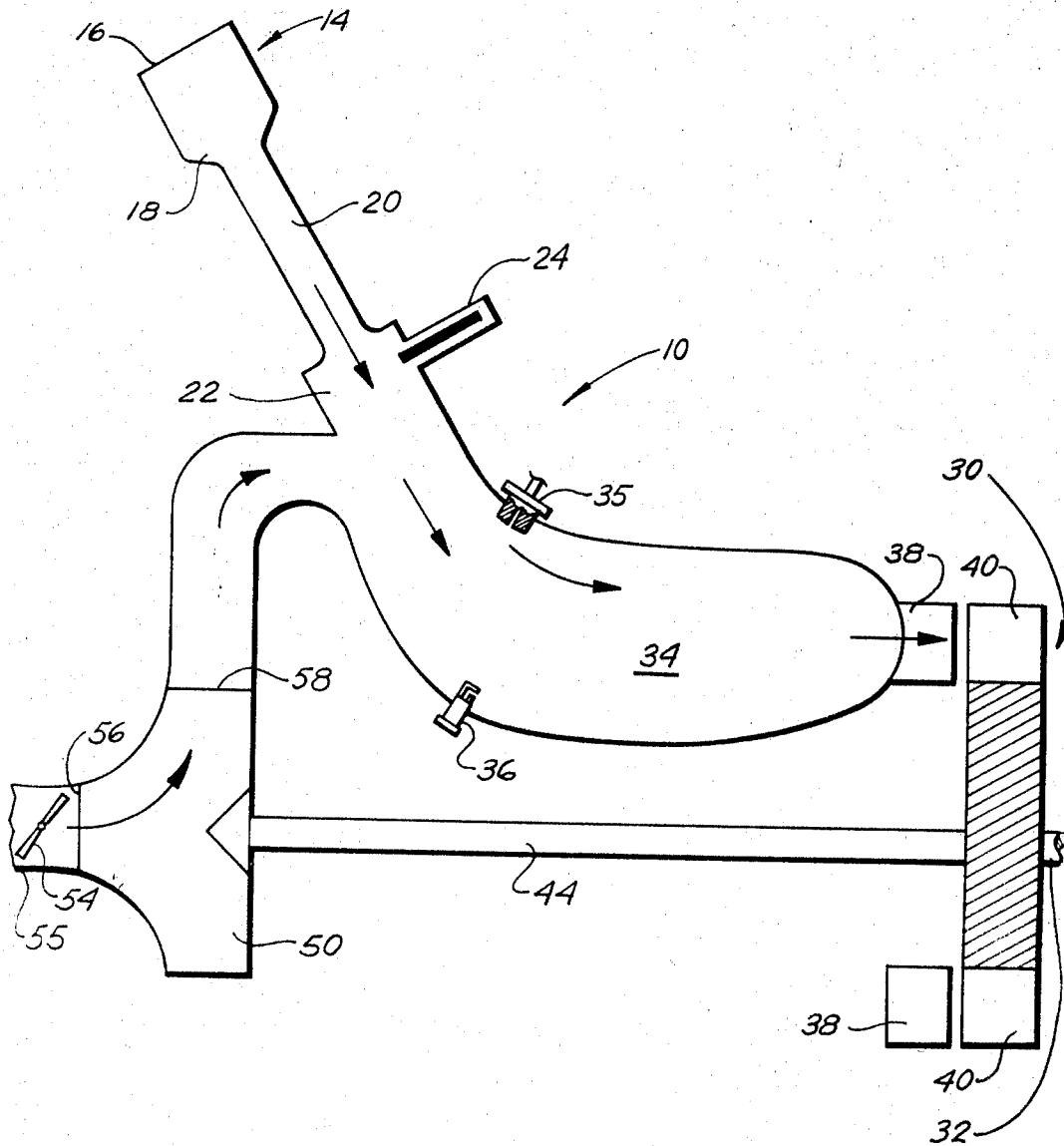
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RESONATING COMBUSTOR FOR DIRECTLY STARTING TURBINE ENGINE

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RESONATING COMBUSTOR FOR DIRECTLY STARTING TURBINE ENGINE

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8 Claims

ABSTRACT OF THE DISCLOSURE

A resonating or pulse jet-type combustor for discharging combustion product through a main burner directly to a main turbine. Hot starting gases from the resonant combustor pre-heat and pre-pressurize the burner while being passed directly to the turbine which in turn operates a compressor. As the turbine attains its self-sustaining level of power, external air is drawn by the compressor into the burner. Immediately thereafter, the resonant combustor is inactivated.

Background of the invention

The instant invention relates to a starting power system for starting a self-sustaining turbine engine and more specifically concerns a resonating or pulse-jet combustor whose hot gases are driven through the main burner to the main turbine.

The broad concept of positioning the exhaust portion of a pulse jet-type combustor in operative driving relationship with a turbine is known in the art. Such a power generating arrangement used as a supercharger for a vehicle internal combustion engine is disclosed in U.S. Patent No. 2,963,863 to Middlebrooks, Jr. It is also known in the art to use hot gases generated in a combustor, not of the pulse jet-type, for operating a turbine designed to "start," i.e., initiate motion of, an engine system (e.g., U.S. Patent No. 3,004,387 to Woodward, Jr.). A conventional technique for starting a main turbine contemplates drawing a charge of pressurized air from an external source into the main turbine or using a charge of stored compressed air against the turbine. In the case of using external air, a complex and space consuming supply device must be employed, especially when the turbine is relatively large and great starting energy is demanded. The storage container for compressed starting gas is bulky and complex. A compressor is needed to recharge the compressed air storage container. As shall be fully described, the instant invention contemplates employing a resonating combustor for starting a turbine that is integrally coupled with the combustor.

As disclosed in co-pending U.S. application, Ser. No. 576,726, filed Sept. 1, 1966 and Ser. No. 583,624, filed Oct. 3, 1966 (which applications are assigned to the assignee of this invention), the combustion product of a resonating or pulse jet-type combustor may be discharged through a plurality of exhaust tubes to the inlet side of a starter turbine designed to start a self-sustaining engine. This invention employs a combustor of the type described in these applications, using it to generate hot gases which rather than starting an intermediate turbine, are used to directly start the main turbine.

Summary of the invention

Briefly described, the instant invention contemplates combining a resonating or pulse jet-type combustor with a main turbine system so that both are incorporated in an economical, minimal-space package. Between the com-

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bustor and main turbine is a main burner through which the starting combustion product from the combustor passes as it is being discharged to the turbine. The combustion product is discharged directly to the main turbine without passing through any intermediate turbine, other rotating components, sliding parts, etc. The combustion product both preheats and pre-pressurizes the burner as the product is being driven directly to the turbine that is caused to rotate. Rotation of the turbine is transmitted through a drive-shaft to a compressor which, at a predetermined time, draws in external air through a check-valve and pumps it into the burner. At this time external air is mixed with fuel and ignited to produce sustaining or steady state combustion at constant pressure, the hot gases of which are used to further accelerate the turbine. The resonating combustor having achieved its purpose is then cut off.

A diffuser may be positioned adjacent the exhaust end of the combustor to increase the pressure of the combustion product before it is admitted into the burner.

The advantages and operation of the invention will be fully understood upon studying the detailed description in conjunction with the drawings.

Description of the drawing

The figure is a schematic illustration of the invention showing the pulse jet combustor and main turbine separated by a main burner through which the pulse jet exhaust is discharged to directly start the turbine.

Description of the preferred embodiment

Turning now to the detailed description of the instant invention, as schematically illustrated in the figure, an engine assembly 10 is shown having a pulse jet-type or resonating combustor 14 and a turbine wheel 30. Resonating combustor 14 may be constructed in accordance with the combustors disclosed in the applications previously referred to. Extending from the exit end 18 of combustor 14 is an exhaust tube 20 that communicates with a diffuser 22. Diffuser 22 is characterized by an abrupt expansion relative to the size of exhaust tube 20. Diffuser 22 functions to convert the kinetic energy of the starting combustion product issuing through exhaust tube 20 into increased potential energy or gas pressure so that the combustion product will be increased to a desired pressure. In the situation where it is desired to increase the mass flow rate of the starting combustion product from combustor 14 while reducing its pressure then a conventional air augmeter would be used rather than diffuser 22. The augmeter would serve to pull in external air. Preferably the augmeter would be characterized by a tube positioned downstream of resonator combustor exhaust tube 20, the augmeter tube being of larger diameter and spaced from exhaust tube 20 so as to constitute an annular inlet for admitting the external air.

The combustion product under the desired pressure is discharged into a main burner 34 and then through a plurality of turbine engine nozzles 38, that may be aligned circularly in a conventional nozzle ring. The combustion product eventually impinges on the turbine blades 40 of turbine engine 30. At this juncture no combustion of a fuel air mixture is being experienced in burner 34. In the typical manner, the hot gases being impinged against blades 40 impart spin to turbine 30 that in turn transmits torque and rotation to a drive shaft 44 rigidly secured to an air compressor 50. Turbine wheel 30 is secured to a power take-off shaft 32.

During the initial turbine engine starting operation as described above an inlet check-valve 54 inside a conduit 55 positioned adjacent the inlet end 56 of compressor 50 is closed. Additional combustion product generated in resonating combustor 14 continues to be discharged

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through burner 34 to turbine blades 40 of turbine wheel 30. After a short time rotation of compressor 50 attains a predetermined rate causing the ambient or atmospheric pressure outside of check-valve 54 to exceed the pressure at the inlet end 56 of compressor 50. When this condition is achieved check-valve 54, which may be actuated by a pressure differential sensor (not shown), opens to admit a charge of ambient air through compressor 50 into burner 34.

As air is admitted through check-valve 54 into burner 34, fuel is injected into the burner from a conventional injector 35 and the resulting fuel-air mixture is then ignited by an igniter 36 to produce sustaining or steady state combustion. The generated combustion product issues through the ring of nozzles 38 to spin turbine 30 at an accelerated rate. In turn the increased rotational rate of compressor 50 causes increased charges of ambient air to be drawn into burner 34 where a continuous combustion occurs. When an air augments is employed, there may be sufficient air in burner 34 to commence its initial combustion cycle before check-valve 54 is opened. Immediately after engine assembly 10 attains self-sustaining power combustor 14 is cut off and potential leakage from it into burner 34 is prevented by actuating a shut-off valve 24 which may be in the form of a gate valve. Due to the fact that combustor 14 supplies starting gas through burner 34, engine assembly 10 can achieve self-sustaining operation earlier than in conventional related systems. Since the combustion product of resonating combustor 14 serves the dual purpose of initiating spin of the main turbine 30 and preparing burner 34 for combustion, engine assembly 10 can be regarded as "boot strapping" itself to achieve a quicker start.

It should be noted that the resonant combustors disclosed in the two previously referred to applications are arranged to actuate a starter turbine which in turn through a power output shaft initiates movement of some desired self-sustaining engine. In contrast, the combustion product generated in resonating combustor 14 is discharged directly to main turbine 30 without passing through any intermediate turbine, i.e.; a starter turbine. Thus the torque produced as a direct consequence of gases from resonant combustor 14 striking the blades of turbine engine 30 are directly convertible into torque applied to main drive-shaft 44. By eliminating the need of a starter turbine or the like, there is a concomitant elimination of complex gears, bearings, etc. that would be required to couple together the starter and main turbines. The instant invention excludes the need of rotating, sliding and other types of moving parts between resonating combustor 14 and turbine 30. Thus, the risk of mechanical failure and need for maintenance are significantly minimized.

In addition to the hot gases from resonating combustor 14 being used to directly start main turbine 30, the gases also function to preheat burner 34 so that the time required for engine assembly 10 to attain its full self-sustaining power is diminished.

It is known in the art to supply a change of external air or compressed air to start a main turbine. To provide this compressed air, a compressor or other space consuming device is required. The container for storing compressed air also consumes space and requires energy for recharging. As distinguished from these conventional techniques for starting a main turbine, the instant invention is self-contained, i.e., resonant starting combustor 14 is integrally coupled with main turbine 30 to achieve a compact, efficient engine assembly 10 that conserves on space and is capable of rapid starting. The necessary start-air supply, pressurized fuel and igniter occupy only minimal space.

The location of resonant combustor 14, rather than being positioned adjacent the upstream end of burner 34 could, alternatively, be positioned adjacent the downstream end of combustor 34 near the ring of nozzles 38. In this case, the combustion product would be directed to

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turbine 30 without first passing through burner 34. Also diffuser 22 could be eliminated in cases where the increment of increased pressure that it achieves could be dispensed with. It is contemplated that in most embodiments of engine assembly 10 the increment of pressure build-up attributed to diffuser 22 would not be critical. Inlet check-valve 54 would be replaced by any suitable device capable of admitting ambient air at the predetermined demand time and preventing backflow when closed. It will be appreciated that the components employed in constructing the embodiment of the instant invention illustrated in the figure are readily available on the market.

Having described the chief components of the instant invention and having explained its operation, it can now be understood that engine assembly 10 incorporates an economical and practical starting system involving no intermediate turbines or other rotating parts, bearings, gears, etc. Also the starting energy required is substantially below that required in a conventional geared starting system because of the early energy boost that is directly transmitted from resonant combustor 14 to main turbine 30.

What is claimed is:

1. A starting power system for rapidly starting a self-sustaining main turbine engine, the system comprising:
 - a turbine,
 - a main burner for generating sustaining combustion product to drive the turbine, and
 - a resonating combustor in communication with the burner for discharging starting combustion product through a portion of the burner directly to the turbine, the combustor operating to start the turbine and directly assist the turbine engine in obtaining self-sustaining power.
2. The structure according to claim 1 wherein the combustor is positioned so that its combustion product passes substantially from end to end through the burner prior to its being discharged to the turbine.
3. The structure according to claim 2 further comprising a diffuser positioned adjacent the exhaust side of the combustor to increase the pressure of the combustion product prior to its admission into the burner.
4. The structure according to claim 2 further comprising a compressor connected to the turbine by a drive shaft for forcing external air into the burner, the air being used to form sustaining combustion product.
5. The structure according to claim 4 further comprising an inlet conduit adjacent the compressor through which the external air may be drawn into the compressor, and
 - a check-valve positioned in the conduit which is closed when the combustor initially operates and is opened to achieve steady state combustion in the burner.
6. A process for starting a self-sustaining turbine engine characterized by a turbine positioned adjacent a main burner and a resonant combustor in communication with the burner, comprising the steps of:
 - exhausting the combustion product of the resonant combustor through the main burner directly to the turbine, and
 - preheating and prepressurizing the burner with the combustion product prior to the time when steady state combustion commences in the burner.
7. The process of claim 6 further comprising the steps of admitting external air to be combusted into the burner, and
 - shutting off the combustor after the turbine engine has attained self-sustaining power.
8. A starting power system for rapidly starting a self-sustaining main turbine engine, the system comprising:
 - a turbine,
 - a main burner for generating sustaining combustion product to drive the turbine,
 - a resonating combustor for generating starting combustion product supplied directly to the turbine, the

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combustor operating to start the turbine and directly assist the turbine engine in obtaining self-sustaining power,
 a compressor connected to the turbine by a drive shaft for drawing in external air to be supplied to the main burner,
 a check valve positioned adjacent the conduit which is closed when the combustor is initially operated and is opened to achieve steady state combustion in the burner,
 means for supplying fuel to the burner,
 an igniter for igniting the fuel air mixture in the burner to produce sustaining combustion product, and

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a valve for closing the exhaust outlet of the combustor when the turbine engine attains self-sustaining power.

References Cited**UNITED STATES PATENTS**

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