

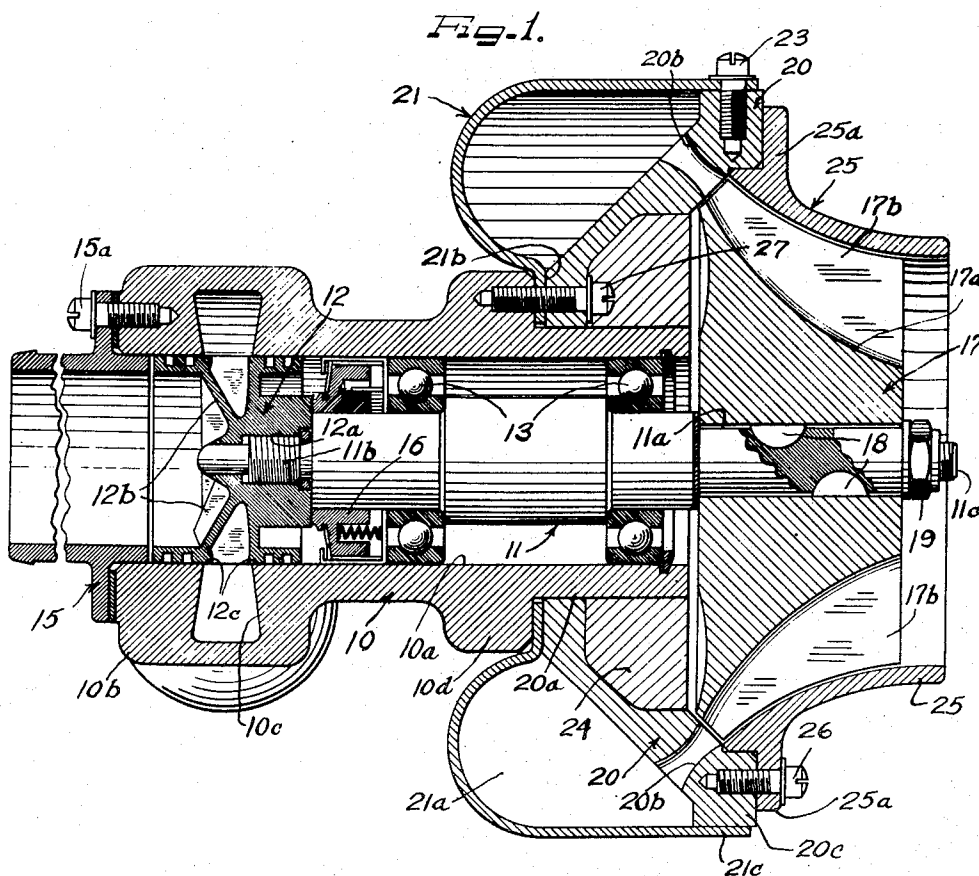
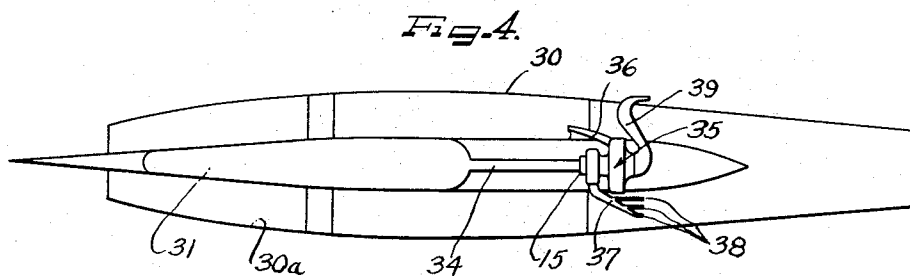
Feb. 8, 1955

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TURBINE DRIVEN FUEL PUMP

2,701,528

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig.-2.

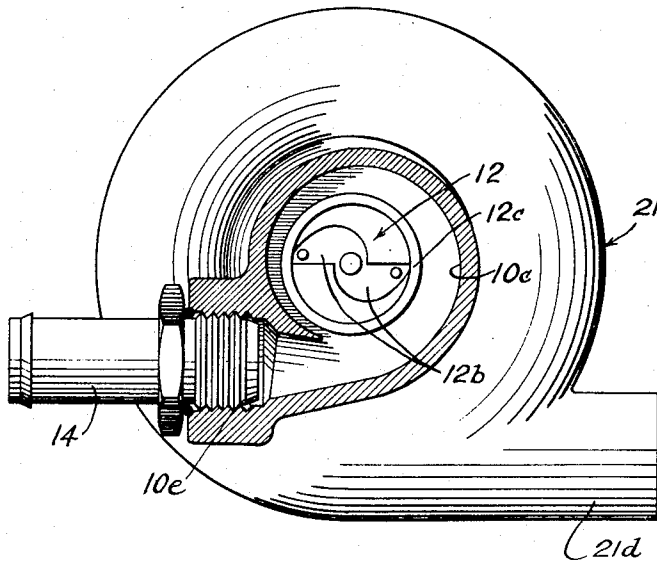
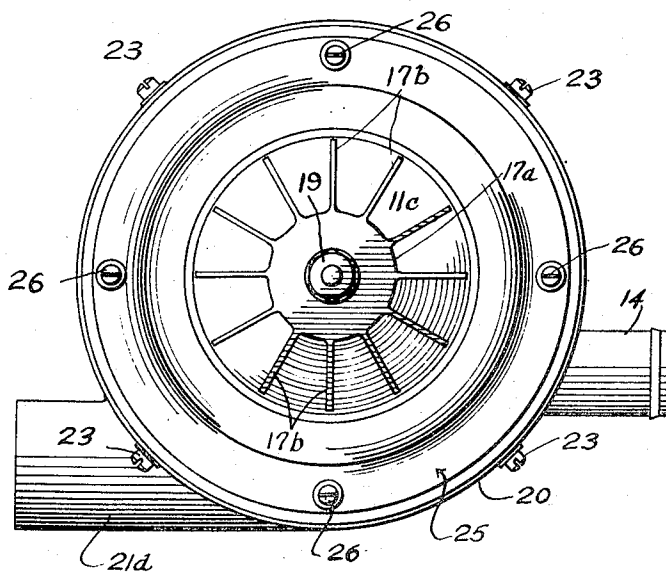


Fig.-3.



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TURBINE DRIVEN FUEL PUMP

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13 Claims. (Cl. 103—87)

This invention relates to an improved unitary turbine driven fuel pump unit particularly adaptable for use in jet engines or similar applications.

The recent widespread adoption of jet engines for aircraft propulsion has resulted in a demand for a light weight, compact and economical turbine driven pump unit which will function to pressure the fuel supplied to the jet engine and which may be driven by pressured air passing through the engine at a point in advance of the fuel combustion chamber. In such applications, it is essential that the turbine driven fuel pump unit be as light and as compact as is consistent with long life and reliable performance. Since it is generally desirable that such units be mounted directly within the path of air flow through the jet engine, it is particularly essential that the overall diameter of the unit be maintained at an absolute minimum.

Accordingly, it is an object of this invention to provide an improved unitary turbine driven fuel pump unit adaptable for incorporation in jet engines or the like.

Another object of this invention is to provide an improved turbine construction of unusual simplicity, lightness and compactness.

A particular object of this invention is to provide a turbine driven fuel pump unit wherein a single main casing and shaft will perform duplicate functions in both the turbine and pumping ends of the unit.

Still another object of this invention is to provide an improved configuration of a bladed turbine rotor characterized by employment of a rotor hub of axially tapering configuration decreasing in diameter from the inlet end of the turbine and thus providing increased interblade volume to accommodate the expansion of the driving fluid as it passes through the blades of the rotor, without substantially increasing the overall diameter of the turbine unit.

The specific nature of the invention, as well as other objects and advantages thereof, will become apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which, by way of preferred example only, illustrate one specific embodiment of the invention.

On the drawings:

Figure 1 is a longitudinal cross section view, with parts in elevation, of a turbine driven fuel pump unit constructed in accordance with this invention;

Figure 2 is an end elevational view, partly in section, of the pump end or left hand end of the turbine fuel pump unit of Fig. 1;

Figure 3 is an end elevational view of the turbine end or right hand end of the unit of Fig. 1; and

Figure 4 is a schematic diagram of a ram type jet engine showing the manner in which a turbine driven fuel pump unit embodying this invention may be mounted therein.

As shown on the drawings:

Both the turbine and fuel pump elements of the combined unit embodying this invention are mounted in and supported by a generally tubular casing 10 which may conveniently comprise an integral casting and which defines an elongated cylindrical bore 10a therethrough. One end portion of the casing 10 is radially enlarged as indicated at 10b and such enlarged portion is provided with an annular spiral recess 10c which defines a pumping chamber communicating with the casing bore 10a. Axially spaced from the enlarged portion 10b is a radial mounting flange portion 10d which is employed to mount

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the various components of the turbine unit in a manner that will be described in more detail later.

A shaft 11 is suitably journaled within the casing bore portion 10a as by a pair of antifriction bearing units 13 which cooperate with spaced portions of the shaft. One end of the shaft 11 is of reduced diameter as indicated at 11a and projects out of the end of the casing 10 remote from the pumping chamber 10c. The other end 11b of the shaft 11 is likewise of reduced diameter and is threaded to mount thereon a centrifugal type pumping rotor 12. Pumping rotor 12 is of unitary construction, having a central threaded bore portion 12a, which cooperates with the threaded shaft end 12b, and a plurality of circumferentially spaced, radially extending vane portions 12b which are integrally connected at their outer ends to generally cylindrical sealing ring portions 12c. The vane portions 12b are, of course, disposed immediately adjacent the pumping chamber recess 10c in the casing 10 and cooperate therewith to pressure fuel which is supplied axially to the rotor 12 and discharged radially through a threaded outlet port 10e in the casing 10 in which is conventionally fastened a pipe fitting 14. The fluid fuel is supplied to the rotor 12 through a flanged fitting 15 which is secured as by bolts 15a to the axial end of the casing 10 adjacent the pumping chamber 10c.

To prevent fluid leakage along the casing bore 10a or the surface of shaft 11, a conventional seal unit 16 is mounted intermediate the rotor 12 and the adjacent antifriction unit 13 and cooperates with the surface of bore 10a and the peripheral surface of the shaft 11 in conventional fashion to minimize fluid leakage therealong.

To drive the shaft 11, a turbine rotor 17 is corotatably secured to the projecting end portion 11a of shaft 11 in any conventional fashion, as by keys 18 and a nut 19 threaded upon a still further reduced diameter threaded end portion 11c of shaft portion 11a. The turbine rotor 17 is of integral construction and embodies a hub portion 17a of generally frusto-conical configuration, decreasing in diameter in an outward direction, and a plurality of circumferentially spaced, radially extending vanes or blades 17b. The effective taper of the outer peripheral surfaces of the vanes 17b is substantially less than the taper of the root surfaces. Accordingly, the effective space or volume between any two adjacent vanes increases substantially in an axially outward direction, although the external periphery of rotor 17 is concurrently decreasing in diameter.

To supply pressured fluid to the turbine rotor 17 to effect its rotation, nozzle ring member 20 is provided which is of generally annular configuration and has a central recess 20a suitably proportioned to permit the nozzle member to be slipped over the end of casing 10 and secured to the radial flange 10d thereof in any conventional fashion as by bolts 27. The nozzle ring 20 is also of generally frusto-conical configuration and the large diameter end portion 20a thereof extends axially beyond the end of casing 10 and overlies the large diameter portion of the turbine rotor 17.

Nozzle ring 20 is provided with a plurality of circumferentially spaced nozzle apertures 20b which have their discharge openings arranged immediately adjacent the end face of the turbine rotor blades 17b. To supply pressured fluid concurrently to all of the nozzle apertures 20b, a shroud member 21 is provided of annular configuration which is arranged to cooperate with the rear face, or inlet face of the nozzle ring 20 to define a generally toroidal inlet chamber 21a therewith. Shroud member 21 may be secured to the assembly by having its radially innermost edge 21b clamped between the nozzle ring 20 and the casing flange 10d by the bolts 27 and its outermost edge 21c secured to a cylindrical face 20c of the nozzle ring 20 by suitable bolts 23. As is best shown in Figs. 2 and 3, the shroud member 21 is provided with an integrally formed tangentially disposed inlet conduit 21d which communicates with a suitable source of pressured fluid in a manner that will be described in more detail later.

From the foregoing description, it is apparent that the frusto-conical configuration of the nozzle ring 20 will permit such ring to be economically fabricated by stamping or similar large quantity production processes. How-

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ever, such configuration will also result in a substantial annular space being defined between the inner face of the nozzle ring 20 and the end portions of the casing 10 which are overlaid by the nozzle ring 20. This annular space must, of course, be filled in order to complete a proper pumping chamber for the turbine rotor 17 to operate in. In accordance with this invention, the annular space is filled by casting in a deposit of a relatively light weight, low melting point metal indicated at 24. In addition to serving to define the pumping chamber for the rotor 17, the cast metal insert 24 obviously serves to substantially strengthen and rigidify the frusto-conically shaped nozzle ring 20.

A second shroud member 25 of annular configuration is provided to closely surround the frusto-conical periphery of the turbine blades 17b. Such member is provided with an integral, radially projecting flange 25a by which it may be conveniently secured to the front face of the nozzle ring 20 by a plurality of bolts 26.

From the foregoing description, it is apparent that when pressured fluid is supplied to the tangential inlet conduit 21d of the first shroud member 21, the pressured fluid will be supplied through the nozzles 20b to the blades 17b of turbine rotor 17 and effect a driving of the turbine rotor 17 and hence the shaft 11. Rotation of the shaft 11 results in driving of the fuel pump rotor 12 and, when the axial inlet fitting 15 is connected to a suitable source of fuel, fuel will be drawn into the pump 12 and pressured in the pumping chamber 10c to be radially discharged through the outlet fitting 14. Hence, this invention provides an unusually compact, light weight, yet economically manufacturable combined turbine and pump unit.

Referring to Fig. 4, there is schematically illustrated one manner in which the described combination turbine and pump unit may be advantageously employed in a jet engine of the ram jet type. In this figure, the numeral 30 represents the external casing of the ram jet engine. A fuel bag 31 is conventionally supported in the front portion 30a of the casing 30 and this portion of the casing, in cooperation with the fuel bag 31 defines a diffuser section wherein the high velocity air entering the open front of the casing 30 is converted into a substantial static pressure. A combined turbine and fuel pump unit 35 is then centrally mounted within the casing 30 to the rear of the fuel bag 31 and an annular, axially disposed conduit 34 is provided in communication between the fuel bag 31 and the inlet fitting 15 of the fuel pump end of the combined turbine and fuel pump unit.

A sheet metal conduit 36 is provided which connects with the tangential inlet 21d of the first shroud member 21 and the conduit 36 has its mouth portion disposed in the air stream through the jet casing 30 to bleed off a small volume of the air passing therethrough to supply to the turbine rotor 17. Outlet piping 37 is provided which connects between the fuel outlet opening 10e of the fuel pump portion of the combined unit 35 and supplies pressured fuel to a plurality of circumferentially spaced fuel ejection nozzles 38 by which the pressured fuel may be injected into the air stream through the jet casing for combustion therein. If desired, the relatively low velocity fluid discharged from the turbine rotor 17 may be led into a turbine exhaust conduit 39 and directed to atmosphere exteriorly of the jet casing 30.

It is therefore apparent that the turbine driven fuel pump unit embodying this invention may be advantageously employed in applications such as jet engines wherein the overall dimensions and the weight of the unit must be maintained at a minimum. Furthermore, unusual operating efficiency of the turbine portion of the turbine driven fuel pump unit is achieved by the described configuration of the rotor 17 wherein the effective cross sectional area of the space defined between adjacent blades 17b of the turbine rotor 17 increases substantially in the direction of fluid flow along the rotor, thereby automatically compensating for the expansion of the driving fluid during its operation upon the rotor blades.

It will, of course, be understood that various details of construction may be modified through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

I claim as my invention:

1. A unitary fuel pump and turbine comprising a

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hollow casing defining an elongated bore, a shaft journaled in said bore and having one end thereof projecting out of said casing, a bladed turbine rotor secured to said projecting shaft end, a centrifugal fuel pump rotor secured to a portion of said shaft lying within said casing, said casing having a recess therein surrounding said fuel pump rotor to define a pumping chamber, a frusto-conical annular nozzle ring secured to said casing adjacent the turbine end thereof and projecting axially beyond said casing to adjoin said blades of said turbine rotor, said nozzle ring having a plurality of circumferentially spaced nozzle apertures formed therein, a first annular shroud overlying the inlet face of said nozzle ring remote from said turbine rotor to define a generally toroidal chamber for supplying pressured fluid to said nozzles, and a second annular shroud secured to the nozzle ring to extend from the discharge face of said ring opposite said inlet face around the rotor blades to define a discharge chamber for said turbine rotor blades.

2. The combination defined in claim 1 wherein said frusto-conical nozzle ring is secured to said casing at a point axially displaced from the turbine end of said casing, thereby defining an annular space between said casing and said nozzle ring, and a deposit of relatively low melting alloy cast in said space, thereby reinforcing said nozzle ring.

3. A unitary fuel pump and turbine comprising a hollow casing defining an elongated bore, a shaft journaled in said bore and having one end thereof projecting out of said casing, a bladed turbine rotor secured to said projecting shaft end, a centrifugal fuel pump rotor secured to a portion of said shaft lying within said casing, said casing having a recess therein surrounding said fuel pump rotor to define a pumping chamber, a frusto-conical annular nozzle ring secured to said casing adjacent the turbine end thereof and projecting axially beyond said casing to adjoin said blades of said turbine rotor, said nozzle ring having a plurality of circumferentially spaced nozzle apertures formed therein, a first annular shroud cooperating with the inlet face of said nozzle ring remote from said turbine rotor to define a generally toroidal chamber for supplying pressured fluid to said nozzles, and a second annular shroud secured to the opposite discharge face of said nozzle ring and surrounding the turbine rotor to define a discharge chamber for said turbine rotor, said turbine rotor having an outer configuration concentrically adjacent radially coextensive portions of said second shroud to form an expansion chamber increasing the interblade volume of said rotor in the direction away from said nozzles.

4. A turbine comprising a hollow casing, a shaft journaled in said casing and having an end thereof projecting out of said casing, a bladed turbine rotor secured to said projecting shaft end, a frusto-conical annular nozzle ring secured to said casing adjacent the turbine rotor end thereof and projecting axially beyond said casing to adjoin said blades of the turbine rotor, said nozzle ring having a plurality of circumferentially spaced nozzle apertures formed therein, a first annular shroud cooperating with the face of said nozzle ring remote from said turbine rotor to define a generally toroidal chamber for supplying pressured fluid to said nozzles, and a second annular shroud disposed around said rotor and secured to the opposite face of said nozzle ring to define an expansion chamber for said turbine rotor.

5. A turbine comprising a hollow casing, a shaft journaled in said casing and having an end thereof projecting out of said casing, a bladed turbine rotor secured to said projecting shaft end, a frusto-conical annular nozzle ring secured to said casing adjacent the turbine rotor end thereof and projecting axially beyond said casing to adjoin said bladed turbine rotor, said nozzle ring having a plurality of circumferentially spaced nozzle apertures formed therein, a first annular shroud cooperating with the inlet face of said nozzle ring remote from said turbine rotor to define a generally toroidal chamber for supplying pressured fluid to said nozzles, and a second annular shroud secured to the discharge face of said nozzle ring adjacent said rotor and surrounding the blades of the rotor in coextensive relation therewith to define an expansion chamber for said turbine rotor, said rotor having an axially tapering hub configuration reducing in diameter inwardly from the second annular shroud in the direction away from said nozzles and forming together

therewith interblade recesses increasing in volume in the direction away from said nozzles.

6. A fuel pump and turbine drive unit comprising a hollow casing, a shaft journaled within said casing, a fuel pump rotor secured to one end of said shaft, said casing defining a pumping chamber for said fuel pump rotor, a turbine rotor secured to the other end of said shaft, a frusto-conically shaped nozzle ring defining a plurality of circumferentially spaced nozzles having discharge openings adjacent the inlet side of said turbine rotor, an annular shroud member defining a toroidal chamber secured to said casing and said nozzle ring on the inlet side of said nozzles for supplying pressured fluid to said nozzles, and a frusto-conically shaped shroud member secured to said nozzle ring on the discharge side of said nozzles and surrounding said turbine rotor to define a discharge chamber for said turbine rotor.

7. In a turbine unit having a rotor shaft a casing surrounding the rotor shaft and a bladed rotor secured to said shaft and having an inlet and outlet side, the improvements comprising means mounted on said casing defining a nozzle having a discharge opening adjacent the inlet side of said turbine rotor, a first shroud element secured to said casing on the inlet side of said nozzle to define a chamber for supplying pressured fluid to said nozzle, and a second shroud member secured to said nozzle defining means on the discharge side of said nozzle and forming together with the hub of said rotor and the blades thereof an expansion chamber providing an exhaust chamber for the outlet side of said turbine rotor.

8. In a turbine unit having a rotor shaft, a casing surrounding the rotor shaft and a bladed rotor secured to said shaft, the improvements comprising an outwardly extending annular nozzle ring on the casing defining a plurality of circumferentially spaced nozzles having discharge openings adjacent the inlet end of said rotor, a first annular shroud on the casing for cooperating with the face of said nozzle ring remote from said turbine rotor and forming together therewith a generally toroidal chamber around said casing for supplying pressured fluid to said nozzles, and a second annular shroud secured to the opposite face of said nozzle ring and surrounding said rotor and forming with the hub of said rotor and the blades thereof an expansion chamber for the rotor.

9. In a turbine unit having a rotor shaft a casing surrounding the rotor shaft and a bladed rotor secured to said shaft, the improvements comprising an annular nozzle ring defining a plurality of circumferentially spaced nozzles having discharge openings adjacent said rotor, a first annular shroud secured on said casing and cooperating with the face of said nozzle ring remote from said turbine rotor to define a generally toroidal chamber for supplying pressured fluid to said nozzles, and a second annular shroud secured to the opposite face of said nozzle ring adjacent and surrounding said rotor to define an exhaust chamber for said rotor, said rotor having an axially tapering hub configuration reducing in diameter in a direction away from said nozzles and with the blades on the hub and said second annular shroud having an outer and inner configuration, respectively, of less taper than the hub whereby the interblade volume of said rotor increases in the direction away from said nozzles.

10. A unitary pump and turbine comprising a hollow casing defining an elongated bore, a shaft journaled in said bore, a centrifugal pump rotor secured to one end of said shaft, a peripherally bladed turbine rotor secured to the other end of said shaft, said casing bore having a recess therein surrounding said pump rotor to define a pumping chamber, an annular nozzle ring secured to said casing adjacent the turbine rotor end thereof, said nozzle ring having a plurality of circumferentially spaced nozzles formed therein and extending from an inlet face to a discharge face of the nozzle ring, said nozzles having discharge apertures in the discharge face of the nozzle ring adjacent to the periphery of said turbine rotor to direct fluid to the blades of said turbine rotor, said nozzles also having inlet apertures in the inlet face of said nozzle ring, a first annular shroud element secured to the inlet face of said nozzle ring to define a generally toroidal chamber for supplying pressured fluid to said inlet apertures of the nozzles, and a second annular shroud member secured to the discharge face of said nozzle ring and surrounding said turbine rotor in coextensive relation with the blades of said turbine rotor and forming with the hub of

said turbine rotor and the blades thereof an expansion chamber for the rotor receiving fluid from the discharge apertures of the nozzles.

11. A unitary pump and turbine comprising a hollow casing defining an elongated bore, a shaft journaled in said bore, a centrifugal pump rotor secured to one end of said shaft, a peripherally bladed turbine rotor secured to the other end of said shaft, said casing bore having a recess therein surrounding said pump rotor to define a pumping chamber, an annular nozzle ring secured to said casing adjacent the turbine rotor end thereof, said nozzle ring having a plurality of circumferentially spaced nozzles formed therein, said nozzles having discharge apertures in the discharge face of said nozzle ring adjacent to the periphery of said turbine rotor to direct fluid to the blades of said turbine rotor, said nozzles also having inlet apertures in the opposite inlet face of the nozzle ring, a first annular shroud element secured to the inlet face of said nozzle ring to define a generally toroidal chamber for supplying pressured fluid to the inlet apertures of said nozzles, and a second annular shroud member secured to the discharge face of said nozzle ring and surrounding said turbine rotor in coextensive relation with the blades of said rotor to form an expansion chamber receiving fluid from the discharge apertures of said nozzles, and the external shape of said turbine rotor and the radially coextensive portions of said second annular shroud with respect to the outer configuration of said rotor together forming an expansion chamber having an increasing interblade volume in the direction away from the nozzles.

12. A fuel pump and turbine drive therefor comprising a hollow casing, a shaft journaled within said casing, a fuel pump rotor secured to one end of said shaft, means in said casing defining a pumping chamber for said fuel pump rotor, a turbine rotor having a hub and blades secured to the other end of said shaft, outwardly extending means mounted on said casing defining a nozzle having a discharge opening adjacent said turbine rotor, a first shroud element surrounding the casing and secured on one side of said nozzle to said nozzle defining means and to said casing and covering the inlet side of said nozzle to define a chamber for supplying pressured fluid to said nozzle, and a second shroud member secured to said nozzle defining means on the opposite discharge side of said nozzle and surrounding the turbine rotor, said second shroud member together with the hub and the blades of said turbine rotor forming an expansion chamber providing an exhaust chamber for said turbine rotor.

13. A fuel pump and turbine drive therefor comprising a hollow casing, a shaft journaled within said casing, a fuel pump rotor secured to one end of said shaft, said casing having a recess around said fuel pump rotor to define a pumping chamber, a turbine rotor secured to the other end of said shaft and having a hub and blades, a ring secured to said casing defining a plurality of circumferentially spaced nozzles having discharge openings adjacent the inlet side of said turbine rotor, a first shroud element secured to said casing on one side of said ring and surrounding said ring on the inlet side of said nozzles to define a chamber for supplying pressured fluid to said nozzles, and a second shroud member secured to said ring on the discharge side of said nozzles and surrounding said turbine rotor to form together with said hub and said blades of said turbine rotor an expansion chamber providing a discharge chamber for said turbine rotor.

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