July 19, 1960 C. B. McLURE 2,945,619

STAGE EXPANSION REACTION TURBINES

Filed Sept. 21, 1954 4 Sheets-Sheet 1

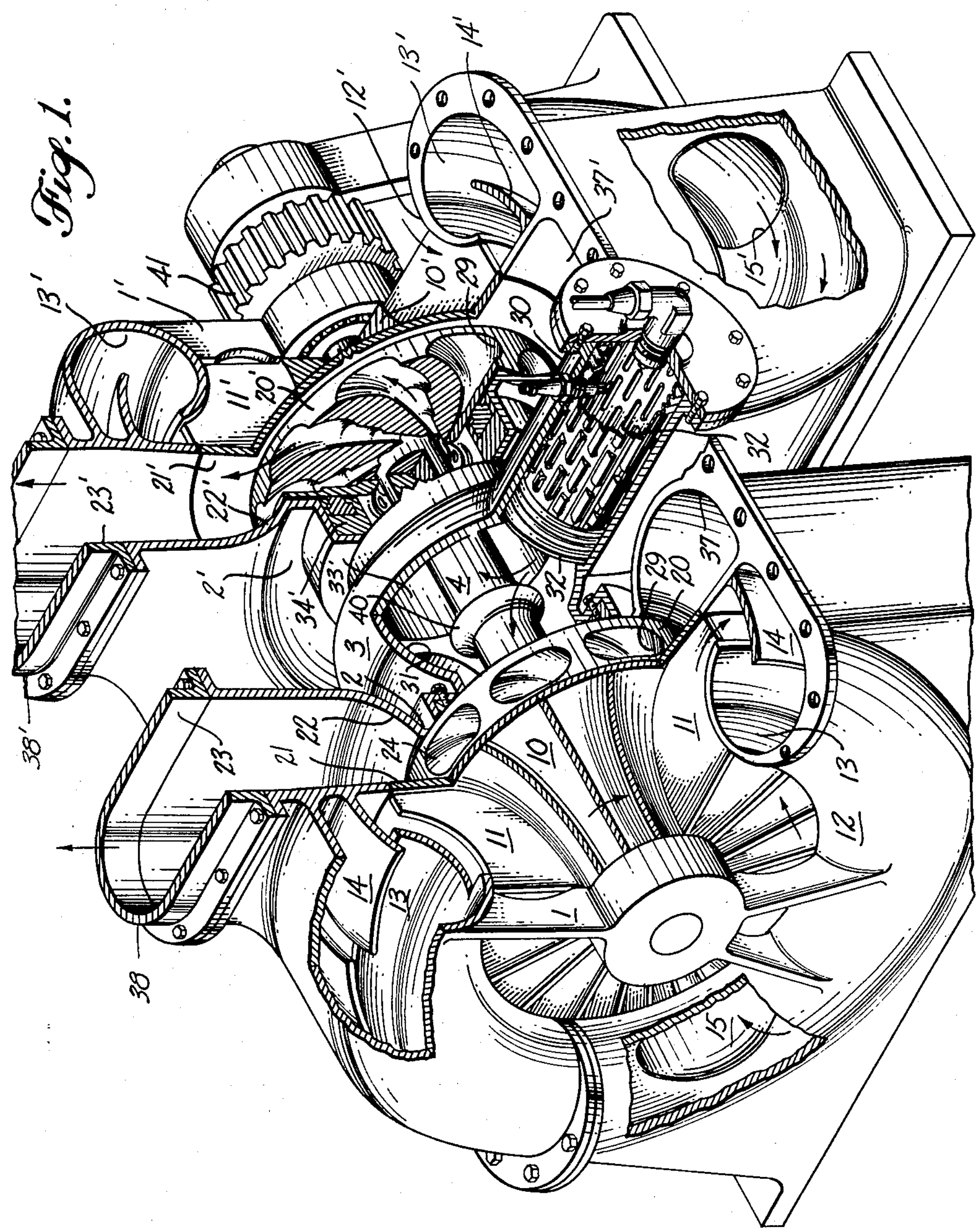

Fig. 1.

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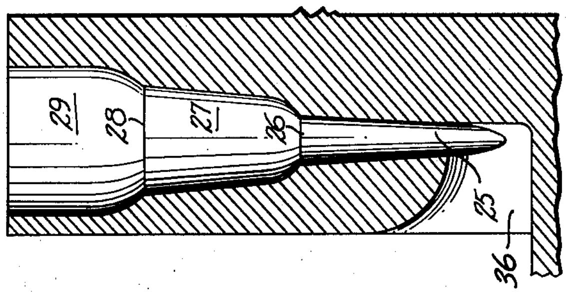

Fig. 8.

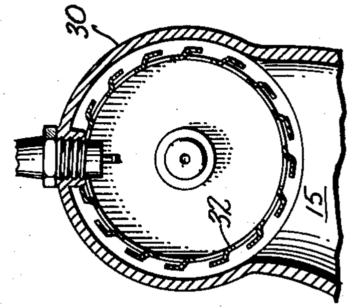

Fig. 9.

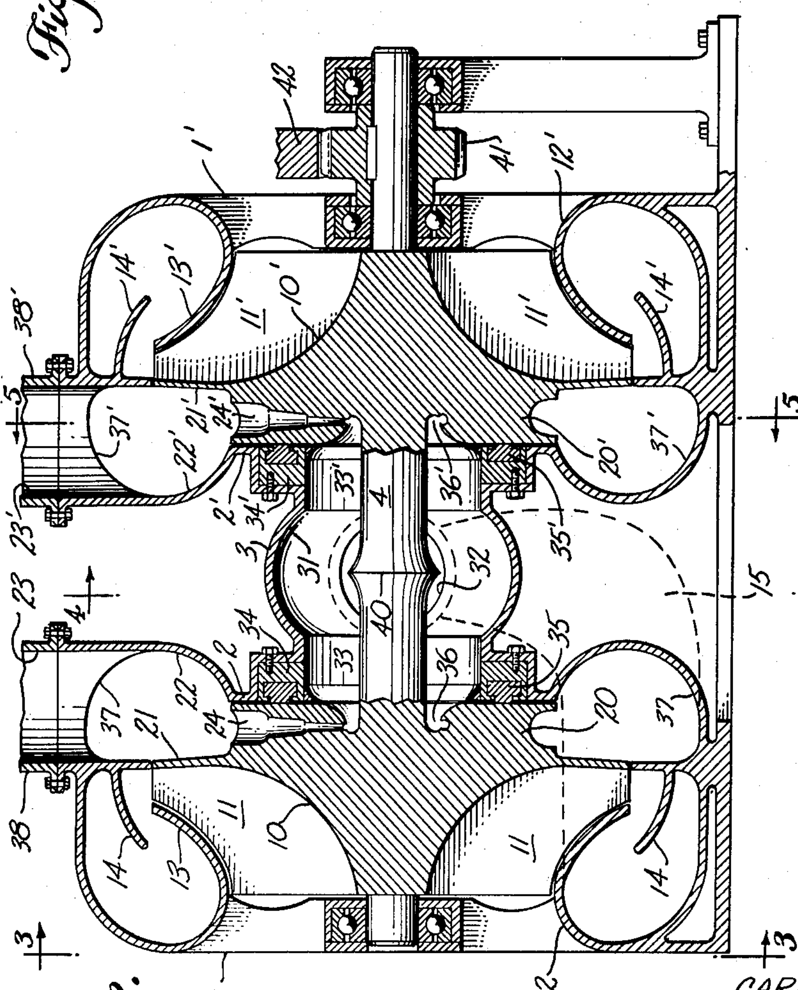

Fig. 2.

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Fig. 3.

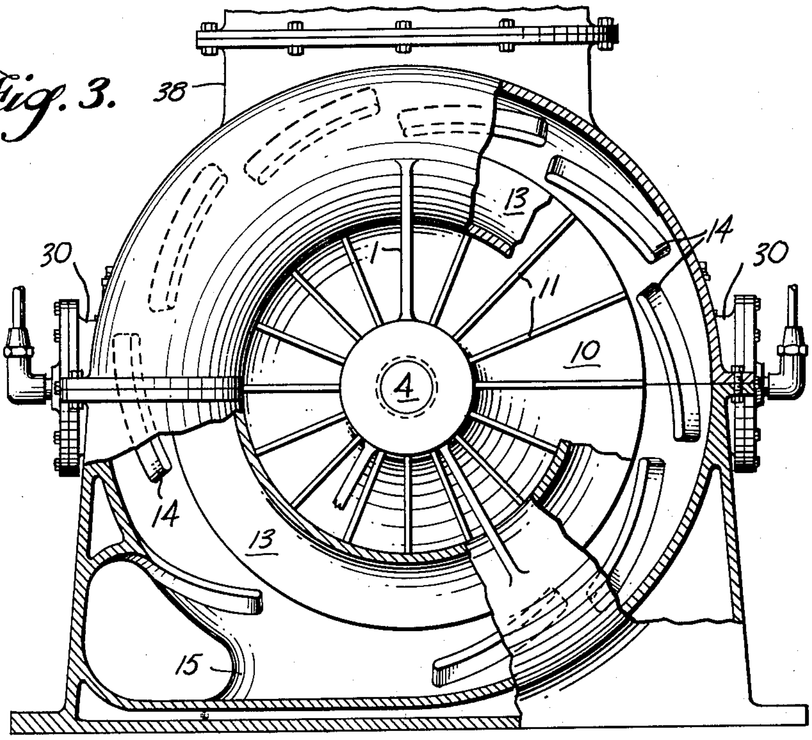

Fig. 4.

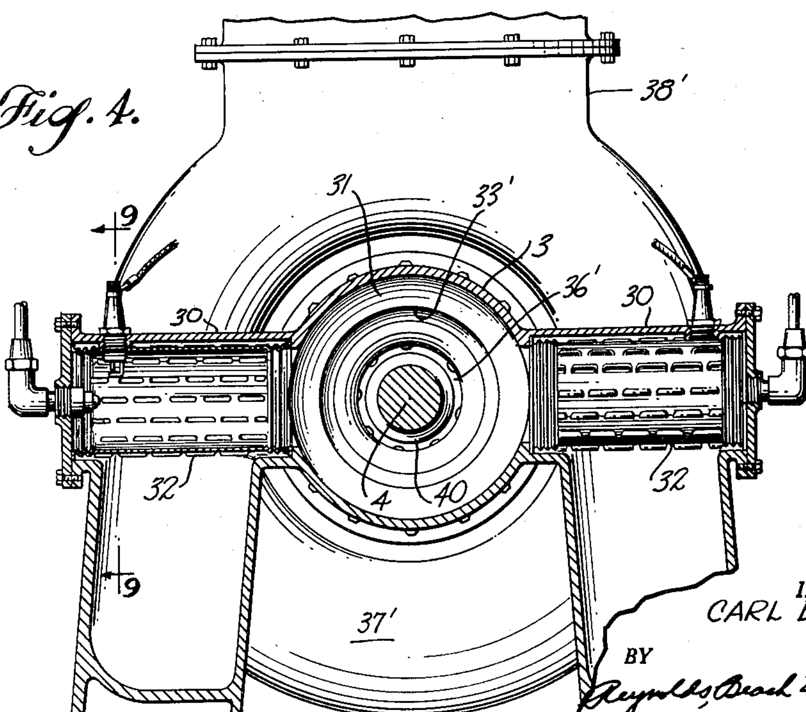

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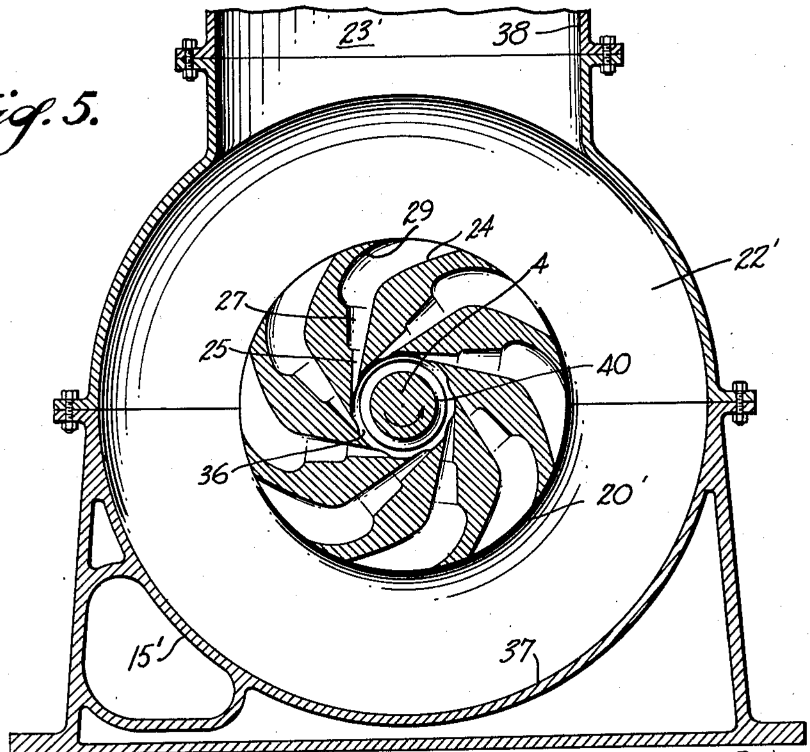
Fig. 5.



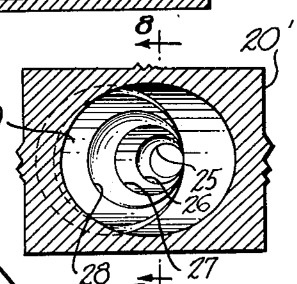


Fig. 7.

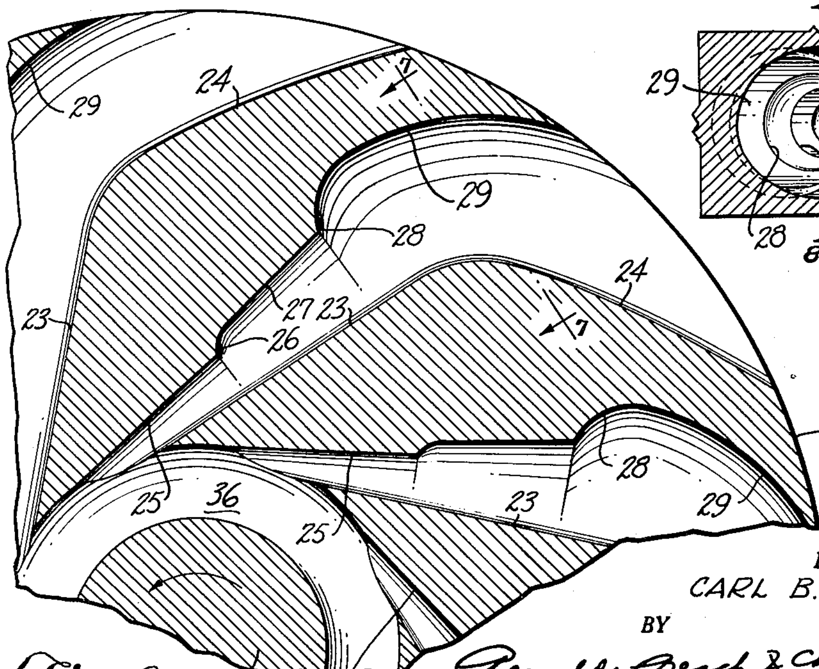


Fig. 6.

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STAGE EXPANSION REACTION TURBINES

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2 Claims. (Cl. 230—116)

The present invention relates to power plants of the turbine type and is concerned particularly with a reaction type of turbine providing stage expansion which is especially suitable for internal combustion applications.

An important object of the invention is to provide a turbine having good efficiency and a high power output for its size. The design of the turbine is compact, and the parts are integrated so as to afford maximum strength for minimum weight.

A particular object of the invention is to provide a unique type of abrupt stage expansion of the combustion gases passing through reaction wheel ducts to increase the power output and efficiency of the turbine. The design further contemplates utilizing twin reaction wheels to provide a high power output for a small and compact power plant.

An additional object is to locate twin compressor units and twin turbine wheels compactly on a common shaft with burners located between the two turbine wheels.

A specific object is to provide stage expansion ducts of unique character in a reaction turbine wheel.

The foregoing objects can be achieved in a turbine unit having a casing defining at opposite ends chambers for reception of centrifugal blower rotors, and passages leading from the blowers to a burner or burners in the central portion of the casing. From such central casing portion passages lead in opposite directions to expansion turbine wheels. Such turbine wheels and the compressor rotors are mounted on a common shaft extending through the casing. The turbine wheels have generally radially directed passages, each including several portions which are interconnected, but between which shoulders are provided to enable gases to expand abruptly as they flow outwardly from one passage portion to the next. Such radiating expansion passages in the reaction wheels discharge into exhaust ducts.

A preferred design of turbine construction is shown in the accompanying drawings.

Figure 1 is a top perspective view of the turbine with parts broken away to show internal structure.

Figure 2 is a longitudinal sectional view through the turbine.

Figure 3 is an end elevation view of the turbine viewed from line 3—3 of Figure 2, parts being broken away.

Figure 4 is a central transverse sectional view through the turbine on line 4—4 of Figure 2.

Figure 5 is a transverse sectional view through the turbine at the location of a reaction wheel, as designated by line 5—5 in Figure 2.

Figure 6 is an enlarged fragmentary section through a reaction wheel, taken along a radial plane, and Figure 7 is a sectional view on line 7—7 of Figure 6. Figure 8 is a sectional view through the turbine wheel on line 8—8 of Figure 7.

Figure 9 is a transverse sectional view through a turbine burner taken on line 9—9 of Figure 4.

The compact arrangement of the turbine of the present invention is shown best in Figures 1 and 2. The casing at opposite ends has housings **1** and **1'**, and between these are the casing portions **2** and **2'** alongside the turbine reaction wheels. In the central portion is the housing **3** accommodating the burners. Thus the compressor housings and the turbine wheel enclosing portions of the casing are located in symmetrical arrangement at opposite sides of the burner housing. Moreover, the generally cylindrical shells **30** for the burners extend diametrically oppositely from the central portion **3** of the casing so as to promote the symmetrical arrangement of the parts.

A shaft **4** extends axially through the turbine casing, and centrifugal blower rotors **10** and **10'**, respectively, are formed on its opposite ends and received in the housings **1** and **1'**. These blower rotors carry radial vanes **11** and **11'**, respectively, which draw air inward through the air inlet apertures **12** and **12'** in the ends of the casing and discharge such air centrifugally under pressure into the ducts **13** and **13'**, respectively. These compressors individually are of conventional type, but the arrangement of such centrifugal compressors with other components of the turbine assembly is unique. In the passages **13** and **13'** are guide vanes **14** and **14'** which are spirally inclined and assist in guiding air compressed by the compressor into the discharge passages **15** and **15'**, respectively.

The turbine reaction wheels **20** and **20'** are formed integral with the compressor rotors **10** and **10'**, respectively, and with the shaft **4**. In addition, the webs **21** and **21'** forming the bottoms of the grooves between the compressor blades **11** and **11'**, respectively, constitute parts of one side of each of the exhaust collector rings **22** and **22'**, respectively. From these collector rings exhaust discharge ducts **23** and **23'** may extend. Undoubtedly there will be some pressure differential between the compressed air passages **13**, **13'** and the exhaust collector rings **22** and **22'**, but the fit of the webs **21** and **21'** with the casing is sufficiently close so that there will be little interchange between these spaces.

Also, an advantage of forming the blower rotors, the turbine wheels and the interconnecting shaft as a single structure is that any pressure differential between the blower and turbine sections at one end of the shaft, which tends to produce a thrust on the shaft is exactly balanced by an equal and opposite pressure differential in the blower and turbine combination at the other end of the shaft. Thus the thrust on the shaft is exactly equalized to avoid subjecting the shaft bearings to any appreciable thrust load. The thrust forces on the shaft will be reflected only in tension or compression forces in the shaft itself. Warpage of the parts can be avoided, and clearances kept at a uniform minimum despite the high temperature at which the turbine operates by making all the parts of the same material such as Inconel metal.

Within the central portion of the turbine casing is the combustion chamber **31** within the casing part **3**. The shells **30** for housing the burners **32** are shown as extending diametrically oppositely from the combustion space **31**, so that the burners **32** open into such space, but it is not essential that the burners be located in this position so long as the products of combustion are discharged into this space. The shaft **4** extends centrally through the combustion space and has a peaked ridge **40** located centrally of such space, which serves as a flame spreader as the shaft rotates to divide the flow of combustion gases in opposite directions along the shaft into passages **33** and **33'** for flow into the ducts of the reaction turbine wheels.

The ducts of the turbine wheels which are the most important part of the present invention are shown best in Figures 6, 7 and 8. While these ducts are disposed generally radially of the turbine wheels **20** and **20'**, preferably their major portions are offset forwardly in the direction of rotation of the turbine wheel from the respective radii with which they are parallel. Such disposition of the major portions of three of the ducts is shown in Figure 6. The trailing side **23** of such major portion of the duct is straight and parallel with a radius from which it is offset, and such trailing side merges with the trailing side **24** of an outer duct portion inclined rearwardly in the direction of turbine wheel rotation to the major duct portion.

The sides and leading wall of the duct portion generally parallel to a radius of the turbine wheel expands in steps of which there are several, three being shown. The leading wall **25** of the innermost step diverges gradually outward relative to the trailing wall **23** of the gas discharge duct and is joined by an abrupt shoulder **26** with the next outward step **27**. The leading wall of this step gradually diverges relative to the trailing wall **23** and the side walls of such steps also diverge gradually outward. At the outer end of step **27** is a further abrupt shoulder **28** joining the step **27** with the leading wall **29** of the outermost step. In this portion or step the side walls do not diverge appreciably, as is shown in Figure 8.

In order to direct the flow of burning gas from the combustion space passages **33** and **33'** into the radiating reaction passages of the turbine wheels the space alongside the turbine wheels between them and the casing is sealed. Thus, as shown best in Figure 2, support rings **34** and **34'** are bolted to the inside of the casing and carry sealing carbon rings **35** and **35'**, respectively. Such carbon rings can withstand high temperatures and seal the space between the turbine wheels and the casing effectively while producing a minimum of friction.

In operation air is drawn into the intakes **12** and **12'** by the blades **11** and **11'** of the centrifugal turbine rotors **10** and **10'**. Air compressed by these blowers passes into the collector passages **13** and **13'**, respectively, from which the air flows into the passages **15** and **15'** and thence into their respective casings **30** around the shells **32** of their respective burners. Fuel is projected into the interior of these shells through nozzles **33**, and the combustible mixture is ignited by spark plugs **34**. The burning gas passing longitudinally inward through the burner shells **32** impinge upon the peaked ridge **40** of the shaft **4** and are divided into the passages **33** and **33'** and the annular manifolds or header passages **36** and **36'** of the turbine wheels.

From the manifold or header passages **36** and **36'** the burning gases are distributed evenly to the first steps **25** of the radiating reaction turbine wheel passages. During flow outward through these passages the combustion gases expand gradually in the first step and then abruptly as they reach the shoulder **26** into the second step **27**, gradually again as they pass through this second step, and once more abruptly as they pass shoulder **28** into the final step **29**. As the gases pass beyond the inner generally radial portion of each duct the flow of gas is deflected into the portion **24** of the duct, directed rearwardly with respect to the direction of wheel rotation so as to produce a final thrust on the turbine wheel in a direction generally tangential to the periphery of the wheel. The reaction produced by the burning gases expanding in their travel through the turbine wheel passages and ejected in a trailing direction from the outer ends of such passages causes the turbine wheels to rotate.

The gas discharged from the turbine wheel passages is collected in the exhaust manifold **37** and **37'** and passes out through the exhaust stacks **38** and **38'**. Power developed by rotation of the turbine wheels to a considerable extent is absorbed directly by the blower rotors **10** and **10'** to compress the air used to support combustion of the fuel. The useful power developed drives gear **41** keyed to one end of the shaft, which may mesh with a gear **42** of any suitable gear train used for transmitting the power developed by the turbine wheels to the mechanism to be driven.

The various parts of the turbine can be cast to approximate shaft, and the clearance portions such as the outer edges of blades **11** and **11'** and the outer edges of webs **21** and **21'** with the correspondingly adjacent portions of the casing **1** and **1'** can be machined accurately to the desired shape. The step portions **25** and **27** of the turbine wheel reaction passages are of circular cross section and can be ground by a rotating tool of special shape to the desired configuration. The structure of the burners is conventional and conventional accessories (not shown) as may be required are utilized for supplying the fuel and the spark.

I claim as my invention:

1. In an internal combustion reaction turbine, a unitary rotor having on one side thereof generally radial centrifugal blower vanes with outlets from the spaces between their outer ends and on the same side of said rotor an air inlet leading to the spaces between said blower vanes, and said rotor having on the other side thereof a plurality of tubular reaction turbine passages extending generally radially of said rotor having inlet means at their inner end portions and with their outer end portions directed rearwardly in the direction of rotation of said rotor, and said tubular reaction turbine passages flaring from inner portions toward outer portions.

2. In an internal combustion reaction turbine, a unitary rotor having on one side thereof generally radial centrifugal blower vanes with outlets from the spaces between their outer ends and on the same side of said rotor an air inlet leading to the spaces between said blower vanes, and said rotor having in the other side thereof a pluarality of tubular reaction turbine passages extending generally radially of said rotor having inlet means at their inner end portions and with their outer end portions directed rearwardly in the direction of rotation of said rotor and said tubular reaction turbine passages having shoulders spaced lengthwise thereof forming said passages flaring in steps from inner portions toward outer portions.

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