Jan. 5, 1971 S. H. UPDIKE 3,552,876

PULSE SENSITIVE TURBINE NOZZLE

Filed June 12, 1968 2 Sheets-Sheet 1

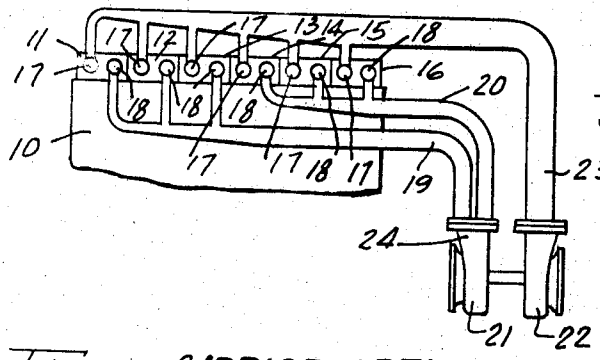


Fig. 1

Fig. 3 (PRIOR ART)

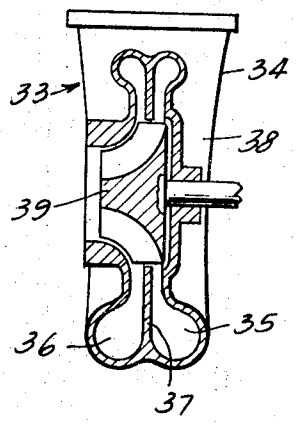


Fig. 2 (PRIOR ART)

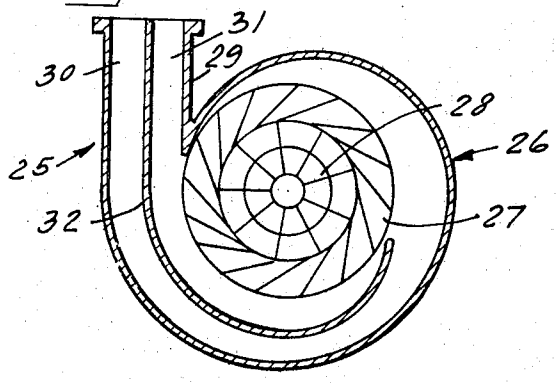


Fig. 4

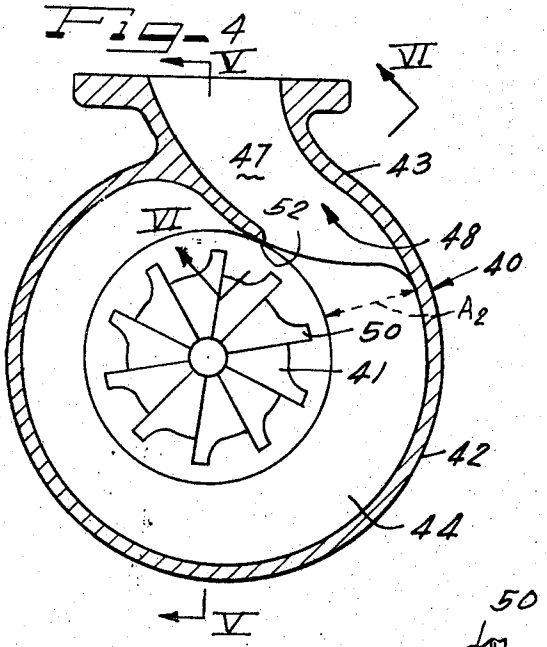


Fig. 5

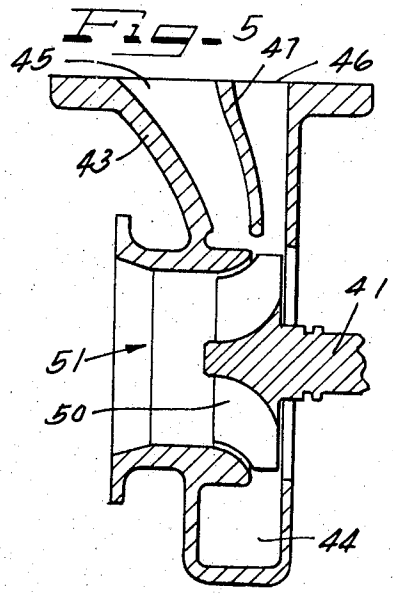
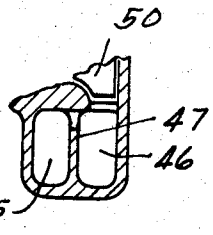


Fig. 6



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PULSE SENSITIVE TURBINE NOZZLE

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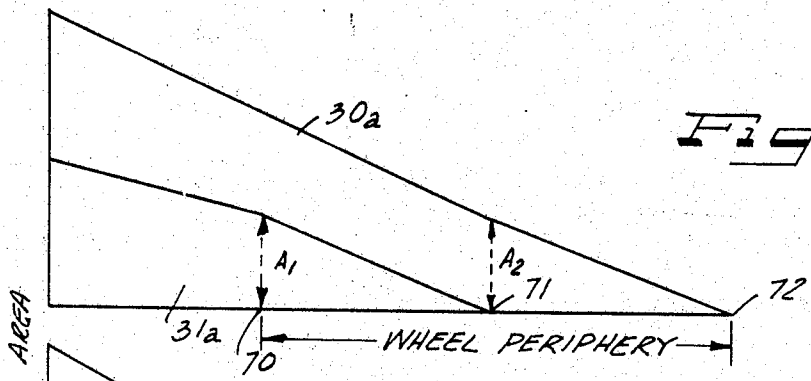


Fig. 7

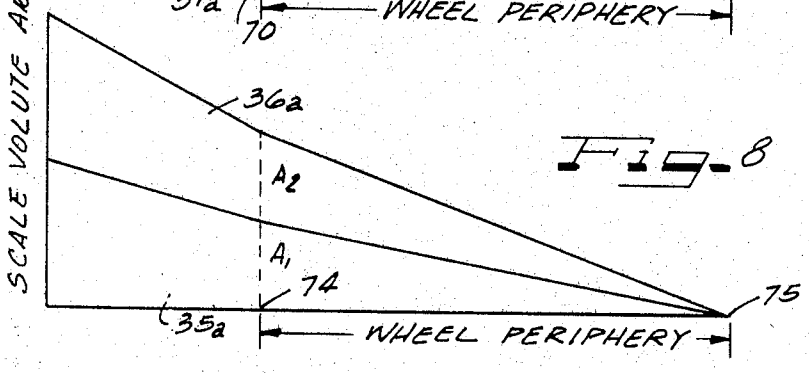


Fig. 8

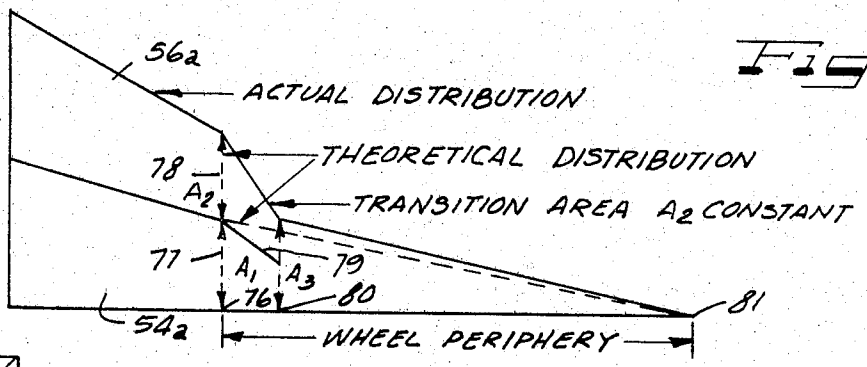


Fig. 9

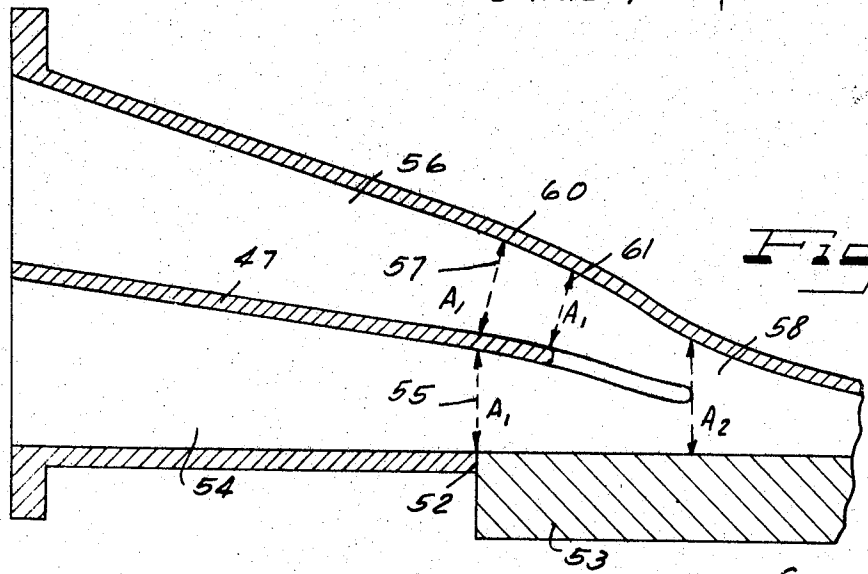


Fig. 10

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PULSE SENSITIVE TURBINE NOZZLE

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Int. Cl. F01d 9/02
U.S. Cl. 415—205 3 Claims

ABSTRACT OF THE DISCLOSURE

A radial inflow turbine effective to recover blowdown energy from the exhaust ports of an internal combustion engine which has two manifolds feeding from the exhaust ports to the turbine housing, the housing having an inlet throat divided by a wall only through the effective nozzle area to a point where exhaust gases have been accelerated to maximum tangential velocity prior to entry into the turbine wheel, the housing thereafter having an undivided single circumferential gas flow chamber sized to provide uniform distribution at constant tangential velocity to the turbine vanes.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to turbines and more particularly to a radial inflow turbine with a divided inlet throat.

Prior art

Radial inflow gas turbines driven by the exhaust gases of internal combustion engines are known to the prior art.

Because the cylinders of a multi-cylinder internal combustion engine are fired serially, the exhaust ports which provide the energy source for driving the turbine are opened at different times. This provides a pulsating flow to the turbine wheel. Further, when the exhaust port initially opens for each cylinder, there is released a surge of gas resulting from the pressure of the gas in the cylinder. This surge is of short duration and is followed by a gas flow of smaller energy created by the evacuation of the cylinder under pressure of the moving piston. The initial surge of energy, which is referred to as blowdown energy, is of great value in driving the turbine. However, in single exhaust manifold systems, it is possible that the surge pressure of one cylinder will interact during the scavenging process with the lower pressures of other cylinders. It has been known to prevent such interaction of cylinders during the scavenging process by dividing the engine exhaust system into a plurality of exhaust manifolds, each of which is connected to a different set of exhaust outlets from the cylinders.

Such multi-exhaust or divided exhaust systems have, in the prior art, been fed into internally divided turbine housings which provide separate, uninterrupted passages circumferentially around the turbine housing delivering such divided flow in close proximity to either a nozzle ring preceding the turbine wheel or directly to the turbine wheel itself. While these systems, such as that illustrated in the patent to J. M. Cazier, Pat. No. 3,292,364 are advantageous in decreasing the resisting back pressure during the scavenging period which would otherwise occur with a non-divided system, the divided housings are costly to manufacture due to the requirement of extended cast cores of precise shape, supporting chaplets to support the cores and increased weight due to wall length. Such castings are also difficult to clean of core sand, casting fins and chill blocks when used. A further disadvantage lies in the fact that the dividing wall presents a long juncture with the colder outer casing increasing potential for thermal cracking.

SUMMARY

My invention overcomes the deficiencies of the prior art by providing a divided exhaust system which is fed to a radial inflow turbine encased in a housing having a divided throat to receive the divided exhaust gas flow. The housing division extends only through the effective nozzle area and thereafter the gas flow channel of the housing is undivided, but is sized to maintain an approximate consistent or increasing tangential velocity around the periphery of the turbine wheel.

Theoretically the system is effective when the dividing wall extends only through the entrance neck of the turbine housing to a common specific nozzle area where each channel terminates. However, it is desirable for reasons of casting and efficient gas blending to extend the dividing wall beyond the effective nozzle area a short distance to provide a transition zone. In this zone, one of the channels is entirely open to the turbine wheel while the other is partially blocked from the wheel. The dividing wall is gradually reduced to the point of a common undivided volute where both gas streams are entirely open to the turbine wheel.

It is therefore an object of this invention to provide an improved and inexpensively manufactured radial inflow turbine for divided exhaust systems.

It is another object of this invention to provide a radial inflow turbine having a housing with an access throat therein, the throat being divided through the effective nozzle area and thereafter communicating to an undivided volute.

It is a further object of this invention to provide a radial inflow turbine for use in connection with divided exhaust systems having an intake throat which is divided only through the effective nozzle area and which communicates to an undivided volute which is sized to maintain an approximate constant or increasing tangential velocity from the throat around the periphery of the turbine wheel.

Other objects, features and advantages of the present invention will be readily apparent from the following detailed description of certain preferred embodiments thereof taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of an internal combustion engine equipped with a divided exhaust system driving a turbine which in turn drives an air compressor or supercharger.

FIG. 2 is a transverse section of a prior art divided turbine.

FIG. 3 is a cross-sectional view of another type of prior art divided turbine.

FIG. 4 is a transverse section of the turbine of this invention.

FIG. 5 is a cross-section of the turbine of this invention taken along the lines V—V of FIG. 4.

FIG. 6 is a fragmentary cross-sectional view taken along the lines VI—VI of FIG. 4.

FIG. 7 is a schematic diagram illustrating the area distribution of the turbine of FIG. 2.

FIG. 8 is a schematic diagram illustrating the area distribution of the turbine of FIG. 3.

FIG. 9 is a schematic diagram illustrating the area distribution of the turbine of this invention.

FIG. 10 is a diagrammatic view of the throat section and effective nozzle area of the turbine of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates an internal combustion engine **10** having six cylinders **11**, **12**, **13**, **14**, **15** and **16**, each of which has an intake port **17** and an exhaust port **18**. The exhaust ports **18** are connected through two manifolds

19 and 20 to a radial inflow turbine 21 which drives an air compressor 22 which supplies air through an intake manifold 23 to the intake ports 17.

The engine 10 may be considered as a standard six-cylinder four-stroke engine which fires the cylinders in sequence such as 11, 15, 13, 16, 12, 14. Therefore the exhaust ports 18 open at different times providing a pulsating gas flow. As has been described, the provision of two different exhaust manifolds 19 and 20 provides a divided exhaust system to decrease manifold back pressures. The manifolds 19 and 20 are connected to the exhaust ports 18 of the different cylinders in such a manner that the pulsating flow created by the opening of the exhaust ports 18 alternates between the manifolds.

The exhaust ports 19 and 20 are connected to the turbine 21 through the neck 24 thereof.

FIG. 2 illustrates one form of a prior art divided turbine 25. The turbine 25 consists of a housing 26, a stationary nozzle ring 27 therein and a rotatable turbine wheel 28 fed from the nozzle ring. The housing 26 has an entrance neck 29 thereon which admits exhaust gases to the interior of the turbine. The neck 29 has two passages 30 and 31 divided by a dividing wall 32. The dividing wall extends through the neck and approximately 180 degrees around the nozzle ring 27 and turbine wheel 28. In this manner, gases entering the chamber 30 are directed to the second half of the nozzle ring circumference where gases entering the chamber 31 are directed to the first half. The gases pass through the chambers 30 and 31 into the nozzle ring 27 where they are directed to the turbine wheel 28 at such an angle to cause the turbine wheel 28 to rotate.

FIG. 3 illustrates another form of prior art divided turbine 33. The turbine 33 has an entrance neck 34 which is divided into two chambers 35 and 36 by a dividing wall 37. The dividing wall 37 extends continuously around the housing 38 of the turbine 33 and extends inwardly towards the turbine wheel 39 from the inside of the radially outermost wall of the housing. Both chambers 35 and 36 communicate to the turbine wheel 39 along their inner peripheries. In this manner, gases entering the chambers 35 and 36 are directed to the turbine wheel 39 throughout the 360 degrees of the turbine wheel, but the chambers are kept separate by the dividing wall 37.

In casting the housings 26 and 38 of the prior art divided turbines 25 and 33, care must be used to create the dividing walls 32 and 37. The casting methods utilizable to create the dividing walls are expensive and difficult to use.

FIG. 4 illustrates the divided turbine 40 of my invention. The turbine 40 is a radial inflow turbine in which the exhaust gases are tangentially directed against a rotatable turbine wheel 41 contained in a housing 42.

The housing 42 has an entrance neck 43 therein which is connectable to the exhaust manifolds 19 and 20. A single volute 44 extends around the turbine wheel 41 interiorly of the housing 42. The neck 43 of the housing 42 contains two separate passages 45 and 46 which are divided by a dividing wall 47. The chambers 45 and 46 are connected to the exhaust manifolds 19 and 20, such that chamber 45 may be connected to exhaust manifold 19 while chamber 46 is connected to exhaust manifold 20.

In the theoretically best embodiment of this invention, the dividing wall 47 extends throughout the length of the neck 43 as in the prior art devices, but terminates at a common effective nozzle area 48 where the chambers 45 and 46 communicate with a common volute 44. In this theoretically best embodiment, the effective nozzle area would then be determined as the point where the gases are first allowed to contact the turbine wheel.

As is illustrated in FIG. 5, the chambers 45 and 46 are constricted in the throat 43 of the housing 42. It is this constriction of the chambers which gives rise to the effective nozzle area 48. The constriction has an advantageous effect on the energy of the gases flowing through the chambers 45 and 46, and increases the velocity of the gas to the desired point while decreasing the static pressure. Because of the reduction in static pressure, gas passing through the nozzle area of one chamber will continue on to the turbine blade without adversely affecting the scavenge period low pressure of the gases passing through the other nozzle. In the type of turbine illustrated, the effect of the gases upon the turbine wheel is accounted for primarily by reason of their velocity, and not by reason of a high pressure.

In the theoretically best embodiment, the common volute 44 is further constricted after the effective nozzle area to continue to provide uniform distribution at constant or even increasing tangential velocity to the turbine wheel 41 of the gases in the volute.

While, as has been described above, the theoretically best embodiment terminates the dividing wall at the effective common nozzle area, it has been determined that it is desirable to provide a short transition period after the effective common nozzle area to facilitate blending of the gases into the common volute. Therefore, as is shown in FIG. 10, the dividing wall 47 extends past the point 52 which marks the beginning of the turbine discharge area 53. The point 52, being the narrowest point in the throat of one of the channels 54 prior to the turbine discharge area, therefore becomes the effective nozzle area for that channel. This effective nozzle area for the channel 54 is illustrated by the arrowed line 55.

If the other channel 56 were to be terminated in accordance with the theoretically best embodiment, its narrowest portion would be measured by the broken line 57 which would be co-planar with the line 55. The dividing wall 47, in the theoretically best embodiment, would also terminate at the point 52 co-planar with the lines 55 and 57.

Both channels 54 and 56 would then immediately discharge into a common combining area equal to or greater in size than the combining channels at the start of the common volute.

It has been found, however, that in order to provide a transition zone to facilitate blending of the gas in the channels 54 and 56 into the common volute area 58 with a minimum of static pressure rise due to turbulence, the combining wall 47 may be extended a short distance beyond the common nozzle area 52. The extension of the dividing wall beyond the common nozzle area does not affect the nozzle area, inasmuch as the dividing wall is terminated at the point 52 on its radially innermost side and thereafter tapers to the point A_2 where it merges into the radially outer wall of the turbine housing. This is best shown in FIG. 4. The extension of the dividing wall 47 is so spaced from the wall 60 and so formed that the areas A_1 are equally diminished throughout the transition zone until their total combined area equals A_2. This diminishing of the areas A_1 through the transition zone continues or increases the velocity of the gas passing therethrough. The common volute thereafter tapers beyond the point A_2 to continue the high velocity of the gases.

FIGS. 7, 8 and 9 graphically illustrate the area distribution of the turbines of FIGS. 2 and 3 of the present invention.

FIG. 7 illustrates the area distribution of the turbine of FIG. 2, showing the area of the chamber 31 in the area 31*a* and the chamber 30 in the area 30*a*. The gases from the area 31*a* contact the wheel periphery between the points 70 and 71, and the gas from the area 30*a* contacts the wheel periphery between the points 71 and 72. The area at the point 70(A_1) of the area 31*a* is approximately the same as the area at the point 71(A_2) of the area 30*a*.

FIG. 8 illustrates the area distribution of the turbine of FIG. 3 with the area 35*a* representing the chamber 35 and the area 36*a* representing the chamber 36. Both chambers contact the wheel periphery between the points 74 and 75, with the areas in the channels 35(A_1) and 36(A_2) being approximately equal at the point 74.

FIG. 9 illustrates the area distribution in the turbine of the present invention with the area **54***a* representing the channel **54** of FIG. 10, and the area **56***a* representing the channel **56**. The effective nozzle area of both channels is determined at the point **76** where the gas from the channels begins to contact the wheel periphery. In the theoretically best embodiment, the effective nozzle areas would be that shown by the lines **77**(A_1) and **78**(A_2) which would be equal. At this point the dividing wall **47** would terminate. However, because of the extension of the dividing wall **59**, a transitional area or zone indicated by the line **79** is provided. The line **79** begins from the point **76** and terminates at point **80**. Because of the termination of the radially innermost portion of the dividing wall extension **47** at the point **52** in FIG. 10, equivalent to the point **76** in FIG. 9, the effective nozzle area for both the area **54***a* and the area **56***a* remains, as in the theoretically best embodiment, at the point **76**. Between the point **76** and the point **80**, the areas of the channels **54***a* and **56***a* are both equally reduced during the transition zone and are combined smoothly by the angular dividing wall **79**, thus permitting the high velocity low static pressure gas of one volute to combine slowly with the low velocity high static pressure gas of the second volute and provide effectively an ejector type of function without creating undesirable turbulence. Both areas A_1 and A_2 have been combined at the point **80** into an area A_3 which is always greater than or equal to the area indicated by the line **77**(A_1). After the point **80**, the common volute decreases in area to point **81** where the volute is terminated around the periphery of the wheel.

It can thus be seen that in the divided housing of my invention, the gases from each of the chambers **45** and **46** of FIGS. 4 through 6 or the chambers **54** and **56** of FIG. 10, are allowed to contact the turbine wheel **41** substantially throughout its entire 360-degree periphery. Further, due to the sizing of the volute **44** from the throat around the periphery, the gases are maintained at approximately constant or increasing tangential velocity to the vanes **50** of the turbine wheel **41**.

Extending the dividing wall **47** only through the throat **43** to the effective nozzle area **48** of the turbine **40** substantially decreases the complexity and cost of casting the housing **42** without decreasing the advantages which flow from the use of a divided turbine. Although it is sometimes desirable to extend a part of the dividing wall **47** beyond the common effective nozzle area **48** in order to provide a transition zone to facilitate blending of the gases, the extension **59** of the dividing wall **47** can be kept quite short and does not affect the common nozzle area. It is anticipated that the extension in most cases will be no more than approximately 10 degrees.

The gases in the volute **44** escape from the turbine **40** through an axial discharge opening **51** after passing the turbine wheel **41**.

It can therefore be seen from the above that my invention provides for an improved radial flow divided turbine in which the division wall extends only through the throat of the turbine housing and terminates approximately at a common effective nozzle area.

Although I have herein set forth by invention with respect to certain specific principles and details thereof, it will be understood that these may be varied without departing from the spirit and scope of the invention as set forth in the hereunto appended claims.

I claim as my invention:

1. A partial division radial flow turbine adapted to be connected to a plurality of sources of serially pulsating gas flows comprising: a housing, a turbine wheel disposed in said housing, an entrance throat in said housing tangential to said turbine wheel, a dividing wall in said entrance throat adapted to divide the said entrance throat into two gas flow chambers, said gas flow chambers constricting to define nozzles at the areas of greatest constriction, said chambers having a common nozzle point, said chambers opening to the periphery of the turbine wheel at the common nozzle point, a portion of said dividing wall extending beyond the said nozzle point, and said chambers communicating to a common volute extending around the periphery of the turbine wheel.

2. The turbine of claim **1** wherein the said portion of the said dividing wall decreases in area beyond the said nozzle point.

3. A turbine adapted to be connected to a plurality of sources of serially pulsating gas flows comprising: a housing, a turbine wheel axially disposed in said housing, an entrance throat in said housing, a dividing wall in said entrance throat dividing the said entrance throat into a plurality of gas flow conduits, said conduits adapted to receive gas from different sources, said conduits constricting in said throat and terminating in a nozzle at the point of greatest constriction, said conduits having a common effective nozzle area, a portion of said dividing wall terminating at said common effective nozzle area, said conduits communicating to a common volute extending around the turbine wheel periphery, and said volute sized to produce constant or increasing tangential velocity of the gases from the conduits to the periphery of the turbine wheel, other portions of said dividing wall extending beyond the said common effective nozzle area, partially separating said conduits beyond the said nozzle area, and the extension of said dividing wall diminishing in area beyond the said nozzle area whereby a transition zone is provided past the said common nozzle area to facilitate the blending of the gas flows from each of said conduits.

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