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Walsh

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[54] **TURBINE WHEEL CONTAINMENT DEVICE**

[72] Inventor: **Richard E. Walsh,** Rockford, Ill.

[73] Assignee: **Sudstrand Corporation**

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[58] **Field of Search**.........................415/9, 55, 106, 213, 205

[56] **References Cited**

UNITED STATES PATENTS

1,488,931	4/1924	Marechal	415/106
3,175,804	3/1965	Bunger	415/9
3,506,373	4/1970	Danker et al.	415/106

FOREIGN PATENTS OR APPLICATIONS

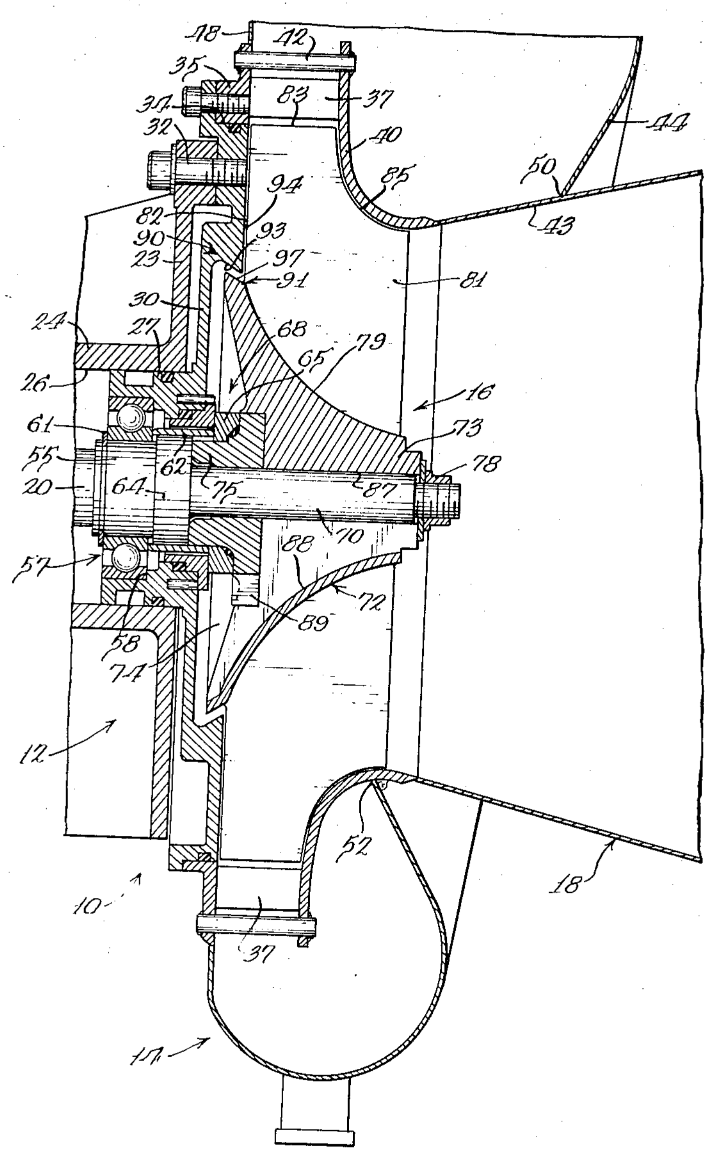
624,166	7/1961	Canada	415/9

Primary Examiner—Henry F. Raduazo
Attorney—Hofgren, Wegner, Allen, Stellman and McCord

[57] **ABSTRACT**

A containment construction for a radial turbine having a generally radially disposed inlet and an axially disposed outlet with a stationary back-plate disposed opposite the outlet that has a conically diverging recess therein that receives a complementary rotating diverging conical shoulder on the turbine wheel hub so that upon overspeed bursting of the turbine wheel, the conical recess assists in containing the turbine wheel, there also being provided stationary stator blades completely surrounding the turbine wheel which assist in containing the turbine wheel upon exceeding the burst speed.

8 Claims, 1 Drawing Figure



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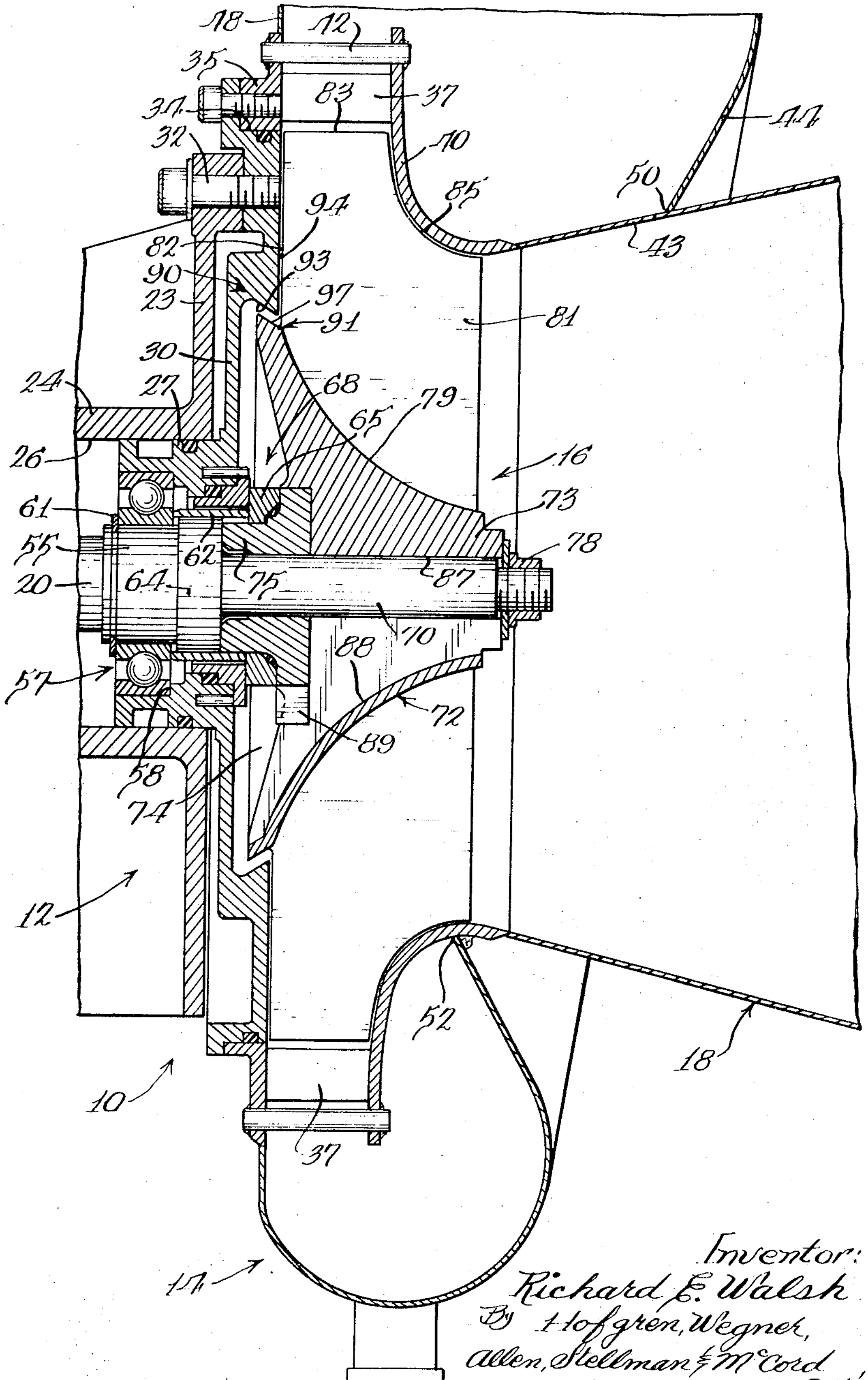

Inventor:
Richard E. Walsh
By Hofgren, Wegner, Allen, Stellman & McCord
Att'ys

TURBINE WHEEL CONTAINMENT DEVICE

BACKGROUND OF THE INVENTION

As is well known to those skilled in the turbine art, turbine power devices are most efficient at extremely high speeds, and the high centrifugal forces acting on the turbine sheet will, upon an excessive speed, cause disintegration of the turbine wheel under the resulting centrifugal forces.

It is extremely desirable both from a safety standpoint and for the protection of surrounding equipment that the turbine wheel be contained within the turbine housing upon burst and/or that the energy level of the fractured parts be reduced to a minimum.

This problem is particularly acute in radial turbines which are known to have radial inlets an axially disposed outlets defined by bell-shaped outlet plates. In such turbines it has been found that upon exceeding the burst speed there is a problem of radial containment since centrifugal forces naturally tend to throw the fragmented parts of the turbine wheel radially outwardly toward the turbine inlet. In some constructions, the turbine wheel fragments also have a tendency to move axially out the outlet at a high energy level, fracturing or causing severe damage to the outlet plate and also to associated equipment near the outlet.

There have in the past been provided devices for reducing the problem of turbine burst damage. For example, there have been devised speed responsive brakes which act upon a predetermined turbine overspeed to brake the turbine wheel either to a complete stop or within its operating range. There are several disadvantages to such constructions, one being that the speed sensing and braking mechanisms add significantly to the weight and complexity of the turbine assembly. Another is that the burst speed of a specific turbine wheel is difficult to determine without test, and after test obviously too late, so that there is a considerable difficulty in selecting the predetermined overspeed at which the turbine overspeed brake becomes activated. The only solution to this problem is to select a turbine overspeed well below the estimated burst speed of the turbine wheel. It is apparent this seriously limits the usefulness of the turbine itself since it may shut down on overspeed conditions which are not at all within the danger range.

SUMMARY OF THE INVENTION

In accordance with the present invention, a turbine assembly is provided for a radial turbine that contains the fragmented turbine wheel within the turbine housing upon burst and reduces the destructive energy level of the fragmented pieces to a safe value. The containment device according to the present invention has an advantage over the various braking devices of the prior art in that the former does not become effective until after turbine wheel fragmentation.

Radial flow turbines are known generally to include a relatively flat back-plate and a bell-shaped exhaust plate together defining a generally radial inlet and an axially extending outlet. The turbine wheel, disposed between the two plates, turns the radial inlet flow axially towards the centrally disposed outlet, as it is driven by the expanding gases. The turbine wheel is formed by an axially curved hub from which the turbine blades extend radially with the outlet sides of the blades being generally free.

One means according to the present invention for assisting containment of the turbine wheel is the provision of a knife-edged annular recess in the back-plate that cooperates with an annular knife-edged shoulder on the turbine hub which extends into the recess so that upon turbine fragmentation, the knife-edged recess tends to hold the fragmented pieces radially inwardly as well as resist axial movement of the fragmented pieces toward the outlet, it being understood that the back-plate is on the opposite side of the turbine wheel from the outlet. Thus, the knife-edged recess, which is in fact a conically diverging recess in the back-plate, delays the movement of the fragmented parts toward the turbine inlet and outlet. As a result of this delay, the destructive energy level of the fragmented parts is reduced to a level significantly reducing to damage to the inlet and the outlet as well as the potential damage to surrounding equipment.

To assist in containing the radial movement of the fragmented pieces in addition to the recess noted above, the present turbine is provided with stationary inlet stator blades completely surrounding the tips of the turbine blades. With sufficient strength, the stator blades acting in conjunction with the recess in the back-plate noted above can completely contain the fragmented parts in the turbine housing.

A further feature of the present invention is in the provision of a tri-burst hub which includes three equally spaced radial slots in the turbine wheel. This has the advantage of providing more uniform fracture upon turbine burst and reduces the fragmented particle size thus reducing the energy level of any given piece of the turbine wheel. Additionally, the weakening slots provide predictable burst configurations which must be contained.

It should be understood that the problem of containment involves not only the features described above, but also other parameters such as the configuration of the turbine wheel, the thickness of the back-plate, the thickness of the exhaust plate, the length of the exhaust plate, and the number of fastening elements interconnecting the back-plate to the exhaust plate.

BRIEF DESCRIPTION OF THE DRAWING

The drawing illustrates a fragmentary section of a radial turbine incorporating the containment means of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, a radial turbine **10** is illustrated generally including a housing **12**, an inlet scroll **14**, a turbine wheel **16**, an outlet shroud **18** and an output shaft **20**.

As is well known to those skilled in this art, hot gases entering the inlet scroll **14** flow radially inwardly across and against the blades of the turbine wheel **16** rotating the turbine wheel with the exhaust gases flowing out the outlet shroud **18**. The turbine wheel **16** is drivingly connected to shaft **20** and rotates the same providing a mechanical output which may drive a suitable reducing gear box.

One application for the turbine assembly **10** is as a prime mover in an emergency hydraulic power supply system such as shown in the copending application of Richard W. Reynolds entitled "Emergency Hydraulic Power System," Ser. No. 16,841 filed Mar. 5, 1970, assigned to the assignee of the present invention. It should be understood, however, that the turbine burst containment means according to the present invention are applicable to turbines in a wide variety of applications.

Referring in more detail to the construction of the present turbine, a generally annular frame plate **23** is provided which may be the primary support for the turbine assembly. The frame member **23** has a cylindrical central portion **24** with a central bore **26** therethrough which supports an axially extending annular flange **27** on a turbine back-plate **30**.

The back-plate **30** is generally annular in configuration and is rigidly fixed to the frame member **23** by a plurality of annularly arrayed fasteners **32**. Fixed to the periphery of the back-plate **30** in annular recess **34** is an annular stator blade ring **35** that has a plurality of turbine inlet stator blades **37** machined thereon. Stator blades **37** are not radially disposed with respect to the axis of the turbine wheel, but are angularly related toward the direction of rotation of the turbine wheel as is known to those skilled in the art. The stator blades **37** extend completely around the turbine wheel **16** and are of sufficient strength to assist in providing the radial containment of the turbine wheel **16** upon burst. The free, or right ends, of the turbine blades **37** fit and may be welded in suitable recesses in a bell-shaped exhaust plate **40**. The exhaust plate **40** is fixed to the nozzle ring 35 by a plurality of pins 42 extending through both the exhaust plate 40 and the stator blade ring 35. Pins 42 are welded to plate 40 and ring 35 and are preferably equal in number to one-half the number of stator blades 37. The number of pins 42 is of importance since the exhaust plate 40 does provide an axial containment function. Moreover, the thickness of exhaust plate 40 is sufficient to prevent fracture upon turbine burst when employed with the other containment features of the present invention.

The outlet shroud 18 is a generally conical sheet metal exhaust duct 43 fixed to the open end of the bell-shaped exhaust plate 40. The inlet scroll 14 also has a sheet metal member 44 connected at one side as at 48 to the stator blade ring 35 and at the other side of the outlet shroud 43 as indicated at 50 and the outlet plate 40 as indicated at 52.

The turbine output shaft 20 has a first enlarged portion 55 rotatably supported in a main bearing 57. Another bearing may be provided for supporting shaft 20 spaced from the bearing shown. Bearing 57 is seated within recess 58 in the back-plate flange 27 and is retained at its left side by snap ring 61 in enlarged portion 55 of shaft 20, which limits rightward movement of the shaft 20 with respect to the frame plate 23. For locating the opposite side of bearing 57 with respect to the shaft, sleeve 62 is provided surrounding a further enlarged portion 64 on shaft 20. The left end of the sleeve engages the inner race of bearing 57 and the right end engages a sealing ring 65 of shaft seal assembly 68. Extending from the enlarged portion 64 of the output shaft is a reduced cantilevered portion 70 which supports the turbine wheel 16.

The turbine wheel 16 is seen to include a bell-shaped hub member 72 with its small end 73 adjacent the outlet, and large end 74 adjacent back-plate 30. The hub 72 receives an adapter ring 75 which supports sealing ring 65 and has an annular nose engaging the enlarged flange portion 64 on the output shaft. Suitable means are provided for keying hub 72 to shaft portion 70. A threaded fastener 78 on the threaded end of shaft portion 70 locates the hub 72 axially on the output shaft.

Hub 72 has a concave exterior surface 79 that turns the expanding inlet gases from a radial direction to an axial direction as is well known to those skilled in the turbine art. Extending radially with respect to surface 79 and formed integrally with the hub 72 are a plurality of turbine blades 81 that have free ends 82 adjacent the back-plate, free ends 83 adjacent the stator blades 37, and arcuate free ends 85 adjacent the exhaust plate 40. While not apparent from the view of the turbine shown, the blades 81 lie generally in a radial plane, i.e., a plane including the axis of shaft 20, adjacent the inlet thereof, and then turn in a direction opposite the direction of flow adjacent the outlet portions thereof.

To provide a somewhat uniform predictable burst configuration, the hub 72 has three radial slots as at 88 that assist in providing a clean tri-segment failure of the turbine wheel. The slots are equiangularly related, and as illustrated, each extends longitudinally completely through the hub 72 and radially outwardly from bore 87, but the slots are insignificant enough to maintain the integrity required of the hub 72. The adapter provides a seal on shaft 70 against loss of pressure through slots 88, and each slot receives an adapter projection 89, locking the adapter and wheel for rotation together. The tri-burst slotted hub increases the likelihood of the hub failing in three reasonably uniform segmented pieces, thus reducing the possibility of a very large piece of the turbine fragmenting which would have a higher destructive energy level because of its greater mass.

The primary containment means according to the present invention is an annular recess 90 in the back-plate 30, facing and partially encapsulating a projecting shoulder 91 on the turbine hub 72. The recess 90 is defined in part by a frustoconical surface 93 extending axially rearwardly from back-plate surface 94 and radially outwardly. Frusto-conical surface 93 has approximately a thirty degree relationship with the axis of turbine wheel 16. The surfaces 93 and 94 define generally what is termed a "knife edge," which assists in holding the fragmented turbine parts radially as well as axially, upon burst, against the tendency of the turbine fragments to move radially and axially toward the inlet and outlet ducting. The shoulder 91 also has a frusto-conical surface 97 adjacent and complementary to the recess surface 93. Shoulder 91 and surface 97 project radially outwardly and axially rearwardly into the recess 90 as is apparent from the drawing. The outer diameter of surface 97 is preferably smaller than the inner diameter of surface 93 in order for the projection on the wheel to enter the recess in the housing.

Upon turbine burst, the shoulder 91 enters and engages the recess 90 with the surfaces 97 and 93 frictionally engaging and braking the rotating material. Because of the angular relationship of these surfaces there is an inward retention of the fragmented pieces tending to hold the pieces both away from the inlet blades 37 and away from the outlet or exhaust plate 40. While the primary tendency is for the material to fly radially outward on rupture, the retention shoulder 93 constrains the material to pivot about the shoulder, thus applying some axial component in the movement.

While the recess 90 in shoulder 91 will not completely contain the axial movement of the fragments toward the inlet 37 and the outlet 18 in all cases for an indefinite time, there is a braking function in the recess which delays the egress of the fragments axially until the destructive energy level is dissipated so low that for all essential purposes containment is achieved.

The angular diverging configuration of the recess 90 is of significance since tests, in which the surfaces 93 and 97 were not undercut by cylindrical and parallel to the shaft axis, resulted in a failure in exhaust plate 40 as well as an outward bulging of the back-plate 30. The fragments more promptly pivot about the shoulders of the cylindrical surfaces and move toward the inlet before sufficient dissipation of energy. The decrease in the effectiveness of such a modified recess 90 was substantiated by a reduced scraping of the hub segments on the cylindrical step on the back-plate.

I claim:

1. A rotary turbine comprising; a turbine wheel having a hub and a plurality of blades extending therefrom, housing means surrounding said wheel, inlet nozzle means associated with the blades, exhaust passage means associated with the blades, and means to assist in containment of the turbine wheel upon exceeding the burst speed thereof including an annular recess on said housing means that increases in diameter axially away from the turbine wheel, said turbine wheel being formed with a shoulder extending toward said recess, said recess being generally conical and diverging away from said turbine wheel, said shoulder being generally conical and complementary to said recess.

2. A radial flow turbine assembly, comprising: a rotary turbine wheel having a hub with blades extending from the hub, housing means surrounding said turbine wheel and defining generally radially disposed turbine inlet means and generally axially disposed turbine outlet means, containment means for minimizing turbine wheel burst damage including annual recess means within said housing having a first portion of predetermined diameter and a second portion of greater diameter spaced axially further from said turbine wheel than said first diameter portion, and projection means on said turbine wheel extending into said recess means.

3. A radial flow turbine assembly as defined in claim 2, wherein said projection means on said turbine wheel is a continuous annular projection on the turbine hub, said projection being spaced a substantial radial distance from the tips of the turbine blades, said recess means being closely adjacent said annular projection and being located in the housing means on the side of the turbine wheel opposite said outlet means.

4. A radial flow turbine assembly as defined in claim 2, wherein said recess means is generally conical and diverges away from said first diameter portion and is located in the housing means on the side of the turbine wheel opposite said outlet means.

5. A radial flow turbine assembly as defined in claim 4, wherein said projection means is conical and diverges into said recess means, and the conical surfaces on the projection and in the recess define braking means for dissipating energy of the turbine wheel on rupture.

6. A radial flow turbine as defined in claim 2, including means surrounding the inlet portion of the turbine blades for assisting in containment of the turbine wheel.

7. A radial flow turbine as defined in claim 6, wherein said means surrounding the inlet portion of the turbine blades includes a plurality of stationary stator blades extending completely toward said turbine wheel blades.

8. A radial flow turbine assembly, comprising: a rotary turbine wheel having a hub with blades extending from the hub, housing means surrounding said turbine wheel and defining generally radially disposed turbine inlet means and generally axially disposed turbine outlet means, containment means for minimizing turbine wheel burst damage including annular recess means within said housing means having a first portion of predetermined diameter and a second portion of greater diameter spaced axially further from said turbine wheel than said first diameter portion, projection means on said turbine wheel extending into said recess means, said projection means on said turbine wheel being a continuous annular projection on the turbine hub, said projection being spaced normally a substantial distance from the tips of the turbine blades, said recess means being closely adjacent said annular projection and being located in the housing means on the side of the turbine wheel opposite said outlet means, said recess means being generally conical and diverging away from said first diameter portion, said projection means being conical and diverging into said recess means, and means surrounding the inlet portion of the turbine blades for assisting in containment of the turbine wheel.

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