The present invention relates to improvements in turbines and especially the type which are driven by hot high energy gases, such as products of combustion, from combustors or the like.

In one form of the invention illustrated, the hot high energy gases are directed to a turbine assembly which is constructed so as to direct the gases through a series of passages to act on a turbine wheel. The turbine wheel is preferably constructed of a substantially cylindrical shape with a first set of drag vanes provided around the peripheral surface by notching of the wheel. A second set of drag vanes are provided by notching one of the side faces of the turbine wheel, and a third set by notching the opposing side face. A cylindrical housing for enclosing the turbine wheel is provided in three sections with a first housing section having a peripheral inner surface with a gas flow channel opposite the drag vanes. At each side of the rotor are side housing sections, each provided with a gas flow channel opposite the drag vanes. The three housing sections are rigidly clamped together to form the rotor therein. Integral gas flow conduits connect the channels to direct the gases for successive passes at the succeeding sets of drag vanes with a first pass being made at the outer peripheral vanes, a second pass at one side of the rotor, and a third pass at the opposite side, and with each successive set of drag vanes being longer and with the gases being expanded adiabatically to obtain the added work of expansion from the gases.

Accordingly, it is an object of the present invention to provide an improved turbine which is driven by expandable gases or the like, and wherein the gases are fed to a turbine rotor with a succession of passes in an improved manner.

Another object of the invention is to provide an improved multiple pass drag turbine having improved rotor and improved housing construction to enhance the flow of gases and to enable improved simplified and simplified construction, and in which manufacturing tolerances and accuracy can be readily maintained.

A further object of the invention is to provide an improved multiple pass drag turbine adapted to be driven by hot high energy gases, such as products of combustion or the like, and wherein the flow passageways for each pass of gases past a turbine wheel permit adiabatic expansion of the gases to obtain added work of expansion.

A further object of the invention is to provide a multiple pass drag turbine for high energy gases with an improved gas flow conduit arrangement.

Other objects and advantages will become more apparent with the teachings of the principles of the invention in connection with the disclosure of the preferred embodiment thereof, in the specification, claims and drawings, in which:

FIGURE 1 is a side elevational view of a housing for a turbine taken from the direction indicated by the line II—II of FIGURE 1;
FIGURE 2 is a side elevational view of a housing for the turbine taken from the direction indicated by the line III—III of FIGURE 1;
FIGURE 3 is a vertical sectional view taken through the turbine along line IV—IV of FIGURE 1;
FIGURE 4 is a vertical sectional view taken through the turbine of FIGURE 1 along line IV—IV;
FIGURE 5 is an enlarged fragmentary elevational view taken along line V—V of FIGURE 4;
FIGURE 6 is an enlarged fragmentary sectional view taken along line VI—VI of FIGURE 2;
FIGURE 7 is an elevational view of the turbine wheel with a portion of the wheel shown in section;
FIGURE 8 is an enlarged end elevational view of a portion of the turbine wheel of FIGURE 7 taken from the direction indicated by the line VIII—VIII of FIGURE 7;
FIGURE 9 is a elevational view from the other end of the turbine wheel showing a portion thereof and taken from the direction indicated by line IX—IX of FIGURE 7;
FIGURE 10 is a sectional view taken along line X—X of FIGURE 1 and illustrates the inner surface of the end part of the housing for the third stage of the turbine and the housing illustrating an alternative form for the part shown in FIGURE 3.

The assembled turbine is illustrated in section in FIGURE 1 and includes a turbine wheel 10 as illustrated in detail in FIGURES 1, 3, 7, 8 and 9.

The turbine wheel is substantially cylindrical in shape and is supported for rotation on a shaft 12, held in driving relation thereto by a key 14.

Along the outer peripheral surface of the turbine wheel 10 are a plurality of notches or pockets 18. These pockets are spaced around the entire periphery of the wheel 10, and are preferably of equal size and equal spacing. The pockets provide drag vanes for action of the expansive gases in rotating the wheel 10. These peripheral pockets provide the first set of drag vanes of a plurality of sets.

The second set of drag vanes is provided by a plurality of notches or pockets 18 formed in the flat side face 20 of the wheel, as illustrated in FIGURE 9. These pockets are preferably of equal size and equal spacing and arranged in an annular pattern round the turbine wheel 10.

The third set of drag vanes is provided by a series of notches or pockets 22 formed in the opposite face 26 of the turbine wheel 10. These notches or pockets are spaced around the entire periphery of the wheel 10, and are preferably of equal size and equal spacing.

The turbine wheel 10 is contained in a cylindrical chamber formed within the housing 28. The housing 28 is formed of three parts, 30, 32, and 34, which are clamped together to form a fixed, rigid enclosure for the turbine wheel 10.

The first housing part 30, as shown in FIGURES 1 and 3, is substantially rectangular in outer shape, and has a circular bore through the center for forming the chamber containing the turbine wheel. The circular bore forms an inner annular surface 36. Formed in the center of this annular surface 36 is a channel 38 which is exposed to the pockets 16 to conduct gas around the periphery of the turbine wheel 10.

Gas is conducted to the channel 38 from a gas inlet conduit 40. Means are provided to supply hot high energy combustible gases to this conduit 40 for driving the turbine wheel 10.

Various sources of gases may be used, and a combustor normally will be provided for supplying the gases. Further, various types of fluids or gases may be used with the flow passageway preferably constructed in ac-
cordance with the gas used. The design of the turbine and flow passages therethrough is such as to obtain adiabatic expansion of the gases for the plurality of passage 30 of the turbine and in order to maintain the velocity of the gases at the desired level. As the gases make their series of passes at the turbine rotor, they expand to reduce in pressure and density, but maintain the velocity of the turbine surfaces which they drive.

As illustrated in FIGURE 3, the gases flow around the turbine wheel, after being supplied thereto from the first gas conduit 40. They exhaust through a second gas conduit 42. This conduit has a first section 42a formed integrally within the housing part 30 which extends substantially tangential to the wheel. The section 42a leads to an axial section 42b which communicates with another section 42c extending in the same direction, and is formed integrally within the part 32 of the housing.

As shown in FIGURE 3, the section 42a of the passageway 42 may be manufactured by boring the housing part 30 from the outside and closing the bored opening with a cap 56. The gases being exhausted from the first stage of the turbine, or the first set of drag vanes, will then be restrained to flowing through the first section 42a of the passageway and subsequently through the second section 42b and the third section 42c.

As illustrated in FIGURE 11, the intermediate or central part of the housing can be formed with the gas flow passageways having a different construction. The central housing part, 30a, is provided with the first conduit 40a for the admission of the gas. The gas exhausts in the same manner, from the first stage, as in FIGURE 3 but at the conduit 42 of FIGURE 3, which leads to the second stage, is formed differently. In FIGURE 11, this conduit is labeled 42' and 42a and 42b are essentially the same conduit or passageway. This conduit is formed by cutting a channel directly into the inner annular surface 36a of the part and this channel or conduit 42' will then communicate directly with the conduit section 42c which leads to the second stage and is positioned as shown in FIGURE 4. This construction of part 30a avoids the necessity of boring two meeting holes as shown in FIGURE 3, and avoids the necessity of providing the cap for closing the outer end of the passageway 42.

It will be understood that the conduits shown through parts 32 and 34 may similarly be formed of simplified construction with the conduits formed by meeting bored holes and the necessity of providing caps or plugs for closing the holes at the outer surface of the parts can be avoided. The housing parts 32 and 34 are illustrated in the drawings as being formed with closing plugs and in the alternative forms with internal passageways that do not open through the housing. Parts are not illustrated, since the construction will be apparent from the above description.

Returning to the description of the centrally located housing part 30, as shown in FIGS. 1 and 3, or 30a, the gas will leave the first housing part to flow into the second housing through the conduit 42.

As shown in FIGURES 4 and 5, the section 42c joins section 42d with the gas flowing in the direction indicated by the arrows to flow into the annular channel 54 formed in the face 56 of the housing part 32. The section 42d of the gas conduit may be constructed by boring a circular hole into the housing part 32, and closing the opening with a plug 58. As above mentioned a construction may be adopted wherein this conduit is formed of sections which do not break through the outer surface of the housing part and therefore no plugs will be necessary. Thus, the gas flows through the conduit 42 from the first set of drag vanes 16 to the second set 18. The conduit 42 is comprised of the sections 44a, 42b, 42c, and 42d.

As illustrated in FIGURE 1, the part 32 of the housing is clamped against a side face 60 of the part 30 of the housing, and in this position, the annular channel 54 in the face 56 of the housing part 32 will be directly opposite the pockets 18, so as to guide the gas along the drag vanes in the second pass around the turbine wheel 10. The housing part 32 has a small annular rib 62 outside of the channel 54 to provide a shoulder 64 which seats within the annular surface 36 of the housing part 30 to thereby align the two housing parts 30 and 32 into accurate coaxial relative positions.

The housing part 34 is clamped against a side face 66 of the first housing part 30. The housing part 34 also has an annular rib 68 providing an annular shoulder 70 which seats inside of the annular surface 36 of the housing part 30 to insure coaxial relative positions of the housing parts.

The housing part 34 has an annular channel 72 which faces the drag vanes or pockets 22 to guide the gas therearound in its third pass past the wheel 10.

The gas is conducted from the second set of drag vanes 18 to the third set 22 through a gas conduit 74, FIGURES 2, 4, 6, and 10. As the gas leaves the channel 54 from the second set of drag vanes, it flows into a first section 74a of the conduit 74. This first section 74a joins a lateral section 74b, which is bored into the housing part 32. 74b continues with part 74c which passes axially through the center part 30 of the housing, 74c joins 74d which continues in the housing part 34, FIGURE 6. 74d joins the section 74e which angles to join the channel 72, which annularly around to gases through the third pass of the turbines, FIGURE 10.

After making the third pass, the gases are exhausted through the diverging gas exhaust passageway 76. The exhaust passageway is formed as shown in FIGURE 11. The exhaust passages 30, 32 and 34 are held together such as by bolts 78, 79, 80 and 81, which extend through aligned openings through each of the housing parts, and receive tightening nuts such as 82 and 84, received by bolts 78 and 79, FIGURE 1.

As illustrated in FIGURES 1 and 7, seals 86 and 88 are provided extending peripherally around the turbine wheel at each side of the first pass pockets 16. These seals are of any suitable type, and are shown schematically as being formed of a plurality of grooves to establish a labyrinth seal. These seals mate with the close surface 36 on the inside of the housing part 30, and provide a seal between the first and second drag vanes 16 and 18, and between the first and third, 16 and 22. The turbine wheel has an axial bore 90 through the center, FIGURE 7, to receive the reduced end 92 of the shaft 12, which is driven by the turbine wheel 10. The housing part 34 has a recess 94 for the shaft to project beyond the turbine wheel.

The shaft and turbine wheel are supported in a bearing sleeve 96 which contains ball bearing sets 98 and 100 to support the shaft 12. The bearing sleeve 96 is supported by bolts 102 and 104 which extend through an annular flange 106 projecting from the stepped opening 108 in the center of the housing part 32.

In operation, the hot, high-energy gases, such as products of combustion from a combustor or like, are delivered to the turbine through the first conduit 43, FIGURE 4. The gases flow through the first pass of the turbine through the channel 38 to react against the first set of drag vanes formed by the pockets 16.

The gases expand adiabatically to maintain a constant velocity and pass to a second gas conduit 43, to be directed to the channel 54 in the housing part 32. In this channel 54, they are expanded to the second stage of the turbine formed of the drag vanes supplied by the pockets 18.

Leaving the second stage, the gases flow through the third conduit 74 and cross over to the other side of the turbine wheel 10 to flow through the channel 72, and act on the drag vane provided by the pockets 22. After
flowing through the third stage, the gases pass out through the fourth conduit 76 which is the exhaust conduit. The flow conduits or passageways through the turbine are designed to cause adiabatic expansion of the gases to obtain the added work of expansion. The passageways are made on the same integral wheel and the flow passageways are short to provide a minimum loss of heat and energy. The first pass of the gases, when they have minimum volume, is made at the outer peripheral surface of the turbine wherein the highest velocity is obtained. The succeeding passes are at the sides of the turbine where more space is available for the drag vanes which are of a larger size. The velocity at these locations is slightly less than at the periphery of the turbine wheel.

Thus, it will be seen that I have provided an improved triple pass drag turbine especially for use with hot, high energy gases, such as products of combustion. The invention embodies the objectives and advantages hereinafter set forth, and provides improved features for turbines of this type obtaining advantages over turbines hereinafter used.

I have, in the drawings and specifications, presented a detailed disclosure of the preferred embodiment of my invention, and it is to be understood that I do not intend to limit the invention to the specific form disclosed, but intend to cover all modifications, changes and alternative constructions and methods falling within the scope of the principles taught by my invention.

I claim as my invention:

1. A rotary gas turbine driven by an expansible gas or the like comprising a cylindrically shaped turbine rotor, a rotary shaft supporting the turbine rotor in rotation and driven thereby, a first set of gas receiving pockets in the outer peripheral surface of the turbine rotor, a second set of gas receiving pockets in one radial face of the rotor, a third set of gas receiving pockets in the opposite radial face of the rotor, a first housing part for the rotor having an annular inner surface and closely surrounding the rotor, a second housing part positioned axially of the rotor and in engagement with a side of said first housing part and having a flat surface closely adjacent a side of the rotor, a third housing part positioned on the opposite side of said rotor and said first housing part having a flat surface closely adjacent the other side of said rotor, means clamping said three housing parts together in a gas-proof manner with the rotor housed therein, a gas flow channel in the first housing part directing gas to the pockets in the outer peripheral surface of the rotor, a gas flow channel in the flat face of said second housing part directing said gas to the pockets at the side of the rotor, a gas flow channel in the flat face of the third housing part directing gas to the pockets at the opposite side of the rotor, first gas conduit means connecting to said channel in the first housing part to direct gas to the turbine rotor, a second gas conduit extending through the first and second housing parts and communicating between the channel in the first housing part and the channel in the second housing part whereby expanded gas will flow from said first to said second set of pockets, a third gas conduit means extending through said second, first and third housing parts and communicating between the channels of said second and third parts to direct expanded gas from the second set of pockets to the third set of pockets, and a fourth gas conduit leading through said third housing part and directing expanded gas from said third set of pockets to be exhausted from the turbine rotor.

2. A turbine driven by an expansible gas comprising a circular turbine rotor to be driven in rotation by a gas, a housing enclosing the rotor, a plurality of sets of rotor driving surfaces carried by the rotor with each set being of a different size to accommodate the gas as it expands through different stages and each extending for 360° around the rotor, one set being on the periphery of the rotor, another set on a side of the rotor, another set being on the other side of the rotor, arcuate channels in the housing for directing gas to the driving surfaces on the rotor with each channel having an inlet end and an outlet end with the outlet for one channel leading to the inlet for the next channel, the outlet for each channel being spaced substantially 360° from the inlet for the channel, and individual gas supply conduits connected to supply gas to said channels, said conduits connecting the outlet end of the first channel to the inlet end of the second channel and connecting the outlet end of the second channel to the inlet end of the third channel.

3. A turbine driven by an expansible gas comprising a circular turbine rotor adapted to be driven in rotation by a gas, a housing surrounding the rotor, a plurality of sets of rotor driving surfaces carried by the rotor with each set being of a different size to accommodate gas of different density, a first of said sets being the smallest and located on the periphery of the rotor, a second of said sets being the next in size and located on the side of the rotor, a third of said sets being the largest and being located on the other side of the rotor, each of said sets positioned to drive the rotor in the same direction, first, second and third gas supply channels in the housing respectively facing each of the sets of rotor driving surfaces and each having an inlet and an exhaust end, and individual gas supply conduits connected to supply gas to said channels, said conduits connecting the exhaust end of the first channel to the inlet end of the second channel and connecting the exhaust end of the second channel to the inlet end of the third channel.

4. A rotary gas turbine driven by an expansible gas or the like comprising a cylindrically shaped turbine rotor, a rotary shaft supporting the turbine rotor in rotation and driven thereby, first, second and third sets of closed outwardly opening gas-receiving pockets in the outer surfaces of the turbine rotor, one set being in the outer peripheral surface of the turbine rotor, another set of gas-receiving pockets being in one radial face of the rotor, another set of gas-receiving pockets being in the opposite radial face of the rotor, the first of said sets being the smallest in size, the second of said sets being the next in size, the third of said sets being the largest, each of said sets positioned to drive the rotor in the same direction, a housing for the rotor having an annular inner surface closely surrounding the rotor, having a flat surface closely adjacent a side of the rotor, and having another flat surface closely adjacent the other side of the rotor, first, second and third gas flow channels formed in the annular inner surface and in said flat surfaces of the housing respectively facing the first, second and third sets of pockets in the rotor, each of said channels having an inlet end and an outlet end, and individual open gas supply conduits connected to supply gas to said channels, said conduits connecting the outlet end of the first channel to the inlet end of the second channel and connecting the outlet end of the second channel to the inlet end of the third channel.

References Cited in the file of this patent

UNITED STATES PATENTS

728,232 Hewlett ----------- May 19, 1903
751,209 Schwarze ------- Feb. 2, 1904
855,009 Kelly ---------- May 28, 1907
945,742 Boeckel et al. --- Jan. 11, 1910
1,258,552 Fraser -------------- Mar. 5, 1918