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TURBINE CONTROL

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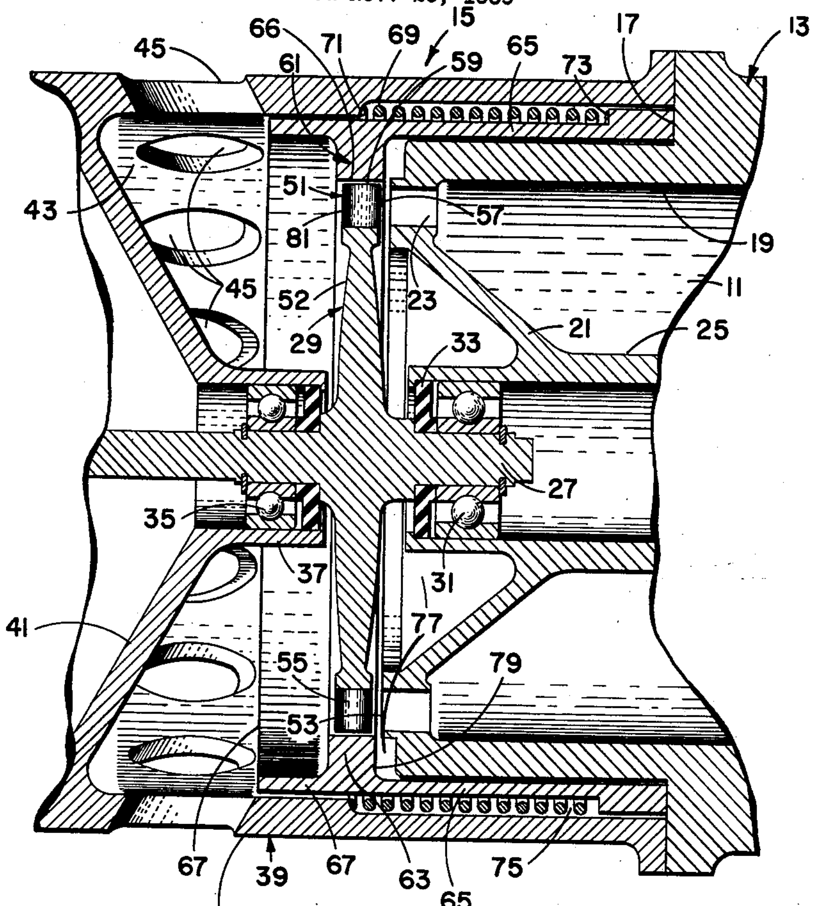

FIG. 1

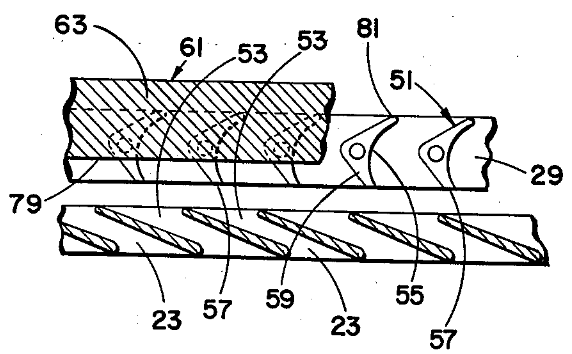

FIG. 2

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TURBINE CONTROL

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This invention relates to turbines and controls and more particularly concerns an axial-flow gas turbine and a speed-limiting control therefor.

In turbine devices, it is necessary to provide speed regulation and to prevent a turbine wheel from attaining the speed at which the turbine disc or blades will fail. A common method now used to limit the speed is that of absorbing power with a special turbine stage. This method has the disadvantage that efficiency losses result at normal operation conditions. Another method of speed control utilized a mechanical governor to detect excessive speed and this signal is used to actuate a control device which regulates the gas supply to the turbine. It is apparent that a control which is more simplified than a governor-regulator system is desirable.

The primary object of the present invention is to provide an improved simplified turbine control wherein the effective flow through the turbine is decreased in response to reaction pressure between the turbine wheel and nozzles so that the turbine speed is regulated and unsafe speed is avoided.

A further object is the provision of a turbine having peripheral blades and a movable shroud at the blade tips which is responsive to turbine reaction pressure above a predetermined turbine speed whereby speed regulation is achieved.

A further object is the provision of such a turbine having movable shroud which, after initial movement, is subject to the impingement of gases from the gas nozzles.

Another object is to provide such a turbine having a spring-biased shroud at the turbine blade tips whereby, at a predetermined speed, the shroud moves in response to reaction pressure forces and the gases can move radially to give less effective gas flow for speed reduction.

The realization of the above objects along with the features and advantages of the present invention will be apparent from the following description and the accompanying drawing in which:

FIG. 1 is a longitudinal cross-sectional view of an embodiment of the invention and shows a movable shroud at the blade tips of a turbine wheel and

FIG. 2 is a diagrammatic flat-projected view of the shroud, turbine blades and nozzles with the nozzle-to-blade space enlarged and illustrates how the gases can radially move and can impinge on the radial side of the shroud after it has moved.

Referring to FIG. 1, air or other gas is supplied to annular passage 11 formed by inlet housing member 13 of housing 15. Inlet housing member 13 includes radially-extending limit shoulder 17 and a tubular axially-extending wall 19 extending to the left from shoulder 17. A radial wall 21 of member 13 extends inwardly from tubular wall 19 and has a ring of nozzles 23 adjacent wall 19. At the inner end of radial wall 21, an axially-extending shaft-support wall 25 is formed and supports the turbine wheel shaft 27 of turbine wheel 29 at the right by means of ball bearing 31. A gas-tight seal 33 is provided at the left of bearing 31 between wall 25 and shaft 27. Turbine wheel shaft 27 is supported at the left by ball bearing 35 which is carried by the axially-extending shaft-support wall 37 of outlet housing member 39 of housing 15. Member 39 also includes a radially-extending wall 41 connected to wall 37 and an axially-extending outer wall 43 which has a ring of exhaust outlets 45. Outer wall 43

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extends to the right and is suitably connected to inlet housing member 13 so that housing means for encasing the turbine wheel 29 are provided.

The turbine wheel 29 has peripheral blades 51 at the periphery of disc 52 facing the outlets 53 of nozzles 23 (shown schematically). Blades 51 have concave surfaces 55 for impingement of gases and inlet edges 57 which are adjacent the surface of wall 21 having nozzles 23. At the tips 59 of blades 51, an axially-movable tubular shroud 61 is provided. Shroud 61 has a radially-inwardly-projecting shoulder 63 and an axially-extending support wall 65. Shoulder 63 terminates adjacent the tips 59 of blades 51 and provides an axial surface 66 which normally confines gases to the axial flow paths between blades 51 by blocking at the full periphery of the blade tips 59. Shroud 61 also includes an annular extension 67 extending to the left from shoulder 63. This extension 67 when the shroud 61 is moved to the left will block the exhaust outlets 45. Shroud 61 is biased to the right by coil spring 69 which is confined between the inwardly-projecting shoulder 71 of outer wall 43 and the outwardly-projecting shoulder 73 of wall 65. The shroud 61 and spring 69 around the shroud are mounted in an annular cavity 75 formed by housing means. Shroud 61 is slidably-mounted on the outer annular surface of axially-extending wall 19 so that restriction to gas flow and hence pressure loss is minimized.

It is apparent that, if shroud 61 is moved to the left, peripheral flow-confining surface 66 will permit radial movement of gas at the blade tips 59 resulting in less effective gas flow and a lower turbine speed.

An annular reaction pressure chamber 77 is formed by shroud 61, and inlet housing member 13. Spring 69 is selected to provide a low force which opposes leftward movement of the shroud. It is apparent that a predetermined pressure in chamber 77 will result in an axial force on the annular shroud surface 79 of shoulder 63 and will overcome spring 69 and move shroud 61 to the left uncovering the right portions of the tips 59 of the blades 51.

It is to be noted that the turbine blade area for the design speed and inlet conditions provides impulse turbine operation at and below design speed but, above design speed the turbine operates as a reaction turbine. With impulse turbine operation, there is no static pressure differential across the turbine blade flow path. With increased speed (such as with reduced loading), the flow through the sonic nozzles remains constant but to maintain continuity of flow the pressure builds up across the turbine to pass the fixed-weight flow through the turbine area. Thus, a pressure differential develops or a reaction pressure builds up with increased speed and this pressure exists in chamber 77. The spring 69 and shroud pressure surface 79 are so related that the shroud 61 is moved to the left at a predetermined pressure in chamber 77. It is to be noted that the shroud 61 is arranged so that it can move to the left to the extent necessary to position radial surface 79 of shoulder 63 at the outlet edges 81 of blades 51.

In FIG. 2 which diagrammatically shows the turbine blades 51, nozzles 23 and shoulder 63 of shroud 61 in a flat projection, the shroud 61 is shown as being moved to the left so that somewhat more than one-fourth of the blade tips 59 is uncovered. The inclination of the nozzles 23 which are parallel to the turbine wheel axis is twenty degrees from the transverse plane of the inlet edges 57 of the blades 51. It is apparent that the gas moving at this angle in straight lines and impinging on surface 79 of shoulder 63 will result in an axial force on the shroud 61 tending to move it to the left. After the shroud 61 has moved so that about one-fourth or more of the blade tips 59 is uncovered, the axial force developed by impingement is such as to significantly augment the axial force derived from the reaction pressure. Prior to shroud movement during normal operation, impingement does not occur since the gas leaving the nozzles 23 in a straight line pattern is confined to the flow paths or passages formed by the blades 51 and shroud surface 66. From FIG. 2, it can be realized that, with the shroud shoulder 63 not covering the blade tips 59, gas radially escapes and spills over the tips 59. A loss in efficiency results since the gas from nozzles 23 is not turned in the turbine blades 51 whereby less torque is imparted to the turbine wheel.

In operation under normal conditions, a gas or air is supplied to the annular passage 11 and is discharged from nozzles 23 so that the turbine wheel 29 is driven by the flow through the axial passages which are formed by the blades 51 and the shroud surface 66. During this operation before actuation of the shroud 61, the impulse turbine performs in the usual manner with its normal efficiencies. Normal operating speed of the turbine will be maintained while normal loading exists. However, when the load on the turbine decreases, the turbine wheel speed will tend to increase. This increase in speed will result in a reaction pressure build-up in chamber 77 due to a pressure differential through the turbine. The same effect results with an increase in the energy level of the turbine-powering gas. Thus, with speed increase of the turbine wheel 29 as when the connected load decreases, pressure builds up in chamber 77 between the turbine wheel 29, shroud pressure surface 79 and the nozzles 23. When a predetermined pressure level is reached in chamber 77 at a predetermined speed, the shroud 61 is moved to the left against spring 69 due to the axial force on the radial pressure surface 66 of shoulder 63. Movement of shroud 61 away from nozzles 23 uncovers turbine blade tips 59 which reduces the turbine efficiency and speed because the gas moves radially outward at and spills over the blade tips 59 without being turned in the turbine blades 51 to impart torque to the turbine. After initial movement of shroud 61, gas impinges on surface 79 and augments the axial force due to pressure so that the shroud 61 moves more rapidly to provide speed reduction. In the case of no load, the shroud 61 is moved farther to uncover most of the width of the turbine blade tips 59 and to partially block the exhaust outlets 45 so that turbine efficiency is further reduced and equilibrium positioning with the surface 66 in a plane adjacent the outlet edges of the blades 51 results whereby an unsafe turbine speed is avoided. For conditions which tend to give small increases in turbine speed, small decreases in efficiency due to limited uncovering of the blade tips 59 by the shroud 61 will provide the desired speed reduction so that the turbine speed is maintained below the desired limit. The balancing of the axial forces derived from spring 69 and the opposing effects on surface 79 will variably position shroud 61 as turbine speed varies so that the turbine is maintained at constant speed. When normal loading or input exists, the shroud 61 will move to its original position, thereby restoring normal efficiency, since surface 66 will peripherally confine the gas flow through blades 51.

It is to be understood that changes in the disclosed embodiment can be made by persons skilled in the art without departing from the invention as set forth in the following claims.

What is claimed is:

1. A turbine and control comprised of a turbine wheel having peripheral impulse blades, said blades having impingement surfaces, nozzle means arranged to direct gas to said impingement surfaces, axially-movable shroud means at the periphery of said blades normally arranged to prevent radial escape of gas from the periphery of said blades, spring means biasing said shroud means toward said nozzle means, a pressure chamber radially outward

of said nozzle means and said blades in communication with the space between said nozzle means and said blades, said shroud means having a presure surface subject to the pressure in said pressure chamber and constructed so that pressure in said chamber will exert an axial force on said shroud means which will tend to urge said shroud means away from said nozzle means, said shroud means being constructed so that the periphery of said blades is uncovered as said shroud means is moved away from said nozzle means, said spring means and said shroud pressure surface being so related that said shroud means is moved when a predetermined pressure is reached in said pressure chamber as a result of a predetermined speed of said turbine wheel whereby gas flow radially from said blades and said turbine speed is reduced.

2. A turbine and control comprised of a turbine wheel having peripheral impulse blades, said blades having concave impingement surfaces, nozzle means arranged to direct gas to said impingement surfaces, axially-movable shroud means at the periphery of said blades normally arranged to prevent radial escape of gas from the periphery of said blades, spring means biasing said shroud means toward said nozzle means, a pressure chamber radially outward of said nozzle means and said blades in communication with the space between said nozzle means and said blades, said shroud means having a pressure surface subject to the pressure in said pressure chamber and constructed so that pressure in said chamber will exert an axial force on said shroud means which will tend to urge said shroud means away from said nozzle means, said shroud means being constructed so that the periphery of said blades is uncovered as said shroud means is moved away from said nozzle means, said spring means and said shroud pressure surface being so related that said shroud means is moved when a predetermined pressure is reached in said pressure chamber as a result of a predetermined speed of said turbine wheel whereby gas moves radially from said blades and turbine speed is reduced, said shroud means including a shoulder having an axially-extending surface providing for said prevention of gas escape from the periphery of said blades and a radially-extending wall at the inlet edges of said blades which provides said pressure surface.

3. A turbine and control comprised of an axial-flow turbine wheel having a disc and impulse blades at the periphery of the disc, said turbine wheel having a shaft, housing means encasing said turbine wheel and rotatably mounting said shaft, a ring of nozzles spaced from said blades and arranged to direct gas to said blades, an axially-movable tubular shroud slidably mounted in said housing, said shroud having a radially-inwardly-extending shoulder which terminates at the tips of said blades and encases the tips of said blades to confine gases, said shoulder and said turbine wheel together with said housing means providing a pressure chamber in communication with the space between said nozzles and said blades, said shoulder having an annular radial surface subject to the pressure in said pressure chamber, spring means urging said shroud axially in a direction toward said nozzles, said housing means having stop structure arranged to limit the movement of said shroud due to the urging of said spring means, said spring means and said shroud being so constructed that when the speed of said turbine wheel exceeds a predetermined value and a predetermined pressure builds up in said pressure chamber said shroud will move to away from said nozzles and permit radial movement of air at the tips of said blades.

4. A turbine and control comprised of an axial-flow turbine wheel having a disc and impulse blades having concave impingement surfaces at the periphery of the disc, said turbine wheel having a shaft, housing means encasing said turbine wheel and rotatably mounting said shaft, a ring of inclined nozzles spaced from said blades and arranged to direct gas to said blade surfaces, and axially-movable tubular shroud slidably mounted in said housing,

said shroud having a radially-inwardly-extending shoulder which terminates at the tips of said blades and encases the tips of said blades to confine gases, said shoulder and said turbine wheel together with said housing means providing a pressure chamber in communication with the space between said nozzles and said blades, said shoulder having an annular radial pressure surface exposed to said pressure chamber, spring means urging said shroud axially in a direction toward said nozzles, said housing means having stop structure arranged to limit the movement of said shroud due to the urging of said spring means, said spring means and said shroud being so constructed that when the speed of said turbine wheel exceeds a predetermined value and a predetermined pressure builds up in said pressure chamber said shroud will move to away from said nozzles and permit radial movement of air at the tips of said blades, said nozzles and said shroud shoulder being arranged so that gas impinges on said radial surface of said shoulder after said shroud is moved to uncover the tips of said blades, said shroud being arranged to uncover the entire axial width of said blade tips.

5. A turbine and control comprised of an axial-flow turbine wheel having a disc and impulse blades having concave impingement surfaces at the periphery of the disc, said turbine wheel having a shaft, housing means encasing said turbine wheel and rotatably mounting said shaft, said housing means providing exhaust outlets and an annular shroud cavity, a ring of inclined nozzles spaced from said blades and arranged to direct gas to said blade surfaces, an axially-movable tubular shroud having support wall slidably mounted in said housing cavity, said shroud having a radially-inwardly-extending shoulder which terminates at the tips of said blades and encases the tips of said blades to confine gases, said shoulder and said turbine wheel together with said housing means providing a pressure chamber in communication with the space between said nozzles and said blades, said shoulder having

an annular radial surface at the inlet edges of said blades exposed to said pressure chamber, coil spring means around said shroud support wall confined by said housing means and said support wall and urging said shroud axially in a direction toward said nozzles, against the bottom of said cavity, said shroud shoulder including a tubular extension arranged to move over said exhaust outlets when said shroud is moved from its normal position encasing said blade tips, said spring means and said shroud being so constructed that when the speed of said turbine wheel exceeds a predetermined value and a predetermined pressure builds up in said pressure chamber said shroud will move to away from said nozzles and permit radial movement of air at the tips of said blades, said nozzles and said shroud shoulder being arranged so that air impinges on said radial surface of said shoulder when said shroud is moved away from said nozzles to uncover said blade tips, and said shroud being movable so that said radial surface can be positioned adjacent the outlet edges of said blades.

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