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SAFETY DEVICE FOR STARTER TURBINE

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2 Sheets-Sheet 1

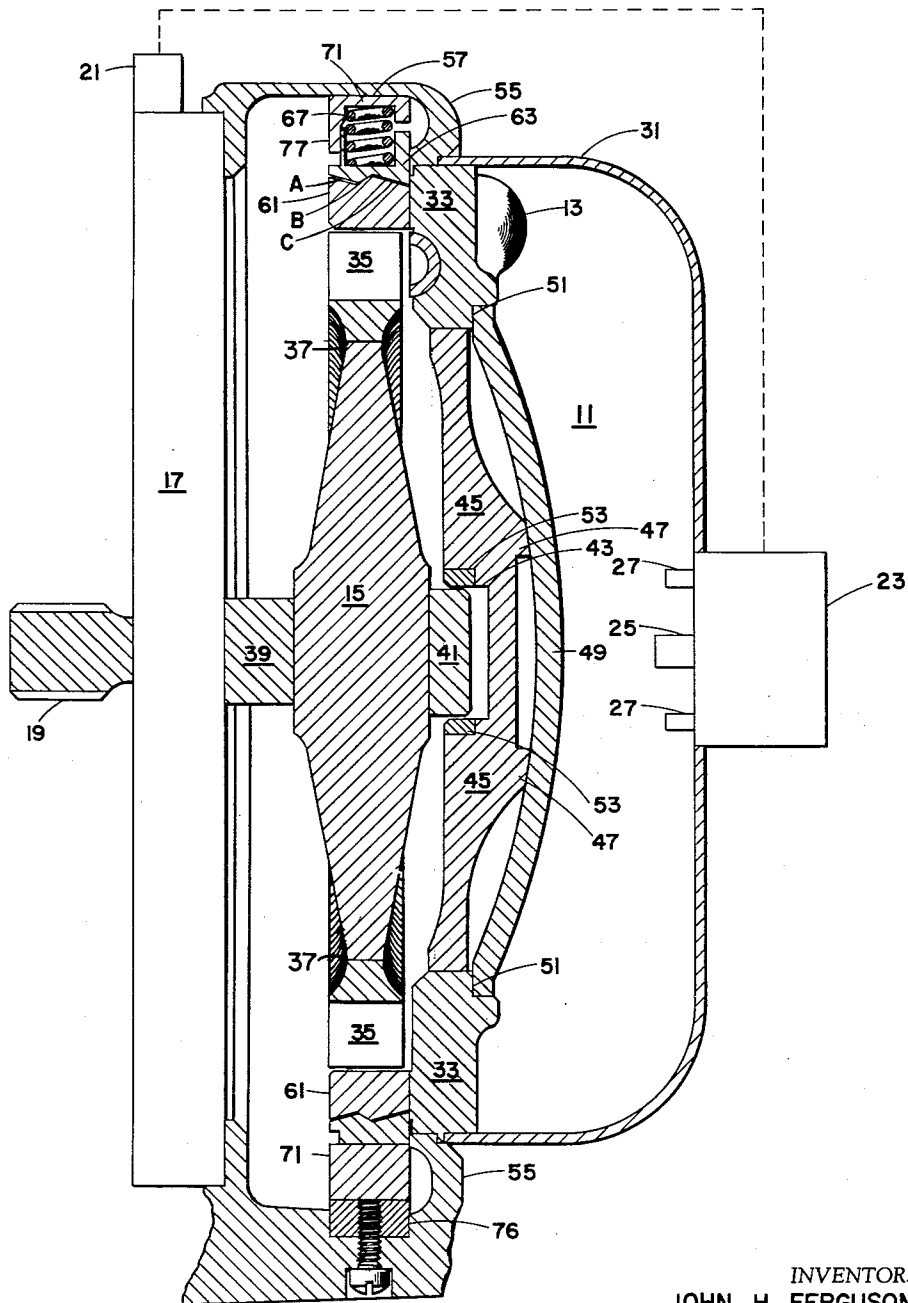


FIG. 1

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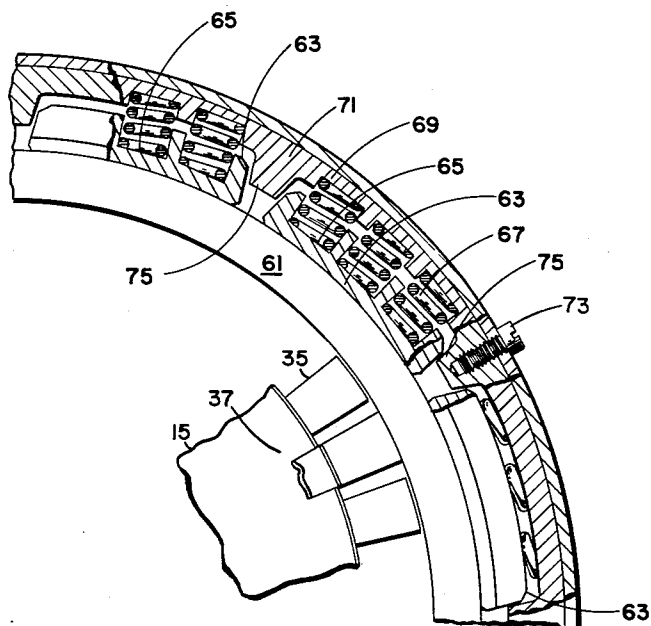


FIG. 2

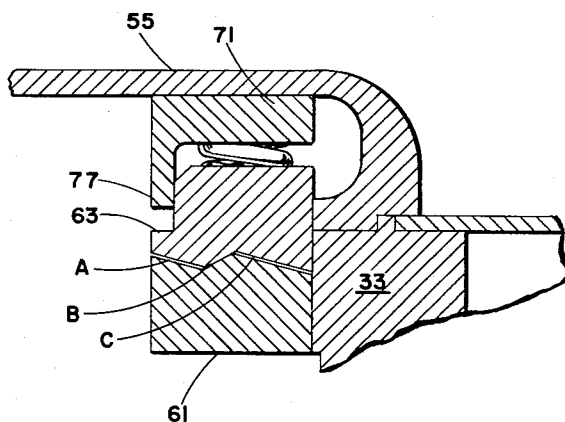


FIG. 3

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SAFETY DEVICE FOR STARTER TURBINE

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6 Claims. (Cl. 253-59)

The present invention relates to high speed turbine starters and more particularly concerns means for braking and containing the turbine wheel when the bucket segments thereof separate at a low strength section.

The separation of bucket segments from a high speed turbine in a starter has caused serious damage to the associated engine and engine accessories. Further, the bucket segments which pass through the starter housing have been known to injure personnel. The separation of bucket segments can occur at excess speeds when the speed responsive control malfunctions after the starter has reached starting speed and thus fails to cut-off the gas supply to the turbine. Such separation can also occur at lower speeds if a fault develops in the turbine wheel.

An object of the present invention is to provide brake means for a turbine wheel when bucket segments thereof separate whereby the segments are contained within the turbine section of the starter.

A further object is to provide improved means for gradually braking a turbine wheel after bucket segments thereof have separated.

An additional object is the provision in a high speed turbine starter of such braking means combined with means for preventing the separation of the turbine shaft.

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

FIG. 1 is a longitudinal cross-sectional view of the turbine section with associated parts shown schematically;

FIG. 2 is a transverse partial cross-sectional view at the plane of the turbine with parts broken away and shows spring means for biasing the brake shoes against the brake ring; and

FIG. 3 is an enlarged longitudinal cross-sectional view at the location of the brake ring and shoe and shows the limited contact between the brake shoe and the brake ring.

In accordance with the embodiment of the invention, a starter turbine has a rotatable brake ring outwardly of the buckets of the turbine having low-strength section and the brake ring is constructed and supported so that initially it rubs against a limited surface to provide a gradual pick-up of the load from a separated turbine bucket segment which will move radially under centrifugal force and will be confined circumferentially by the adjacent parts of the turbine wheel. The limited surface arrangement also urges the brake ring axially against the annulus which has nozzles for directing gas to the buckets of the turbine so that brake ring does not move axially. The back-up means for the brake ring includes stationary spring-biased brake shoes having a limited inclined surface abutting a limited mating surface of the brake ring whereby the aforementioned gradual load pick-up and positioning of the brake ring occurs. Further, braking and containment of the turbine is achieved by the entire surfaces of the brake ring rubbing against the entire mating surfaces of the brake shoe surfaces after the initial loading wears down the limited surfaces which normally contacted each other. The turbine wheel has a shaft extension or hub from the front of the turbine wheel and a wall having a catch cavity closely surrounding the extension so that, if the turbine shaft is flexed due to a turbine wheel bucket segment separation and braking,

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the turbine wheel will be restrained to rotate generally on its axis. In this manner, severance of the turbine shaft due to flexing will be prevented while braking at the turbine wheel periphery continues.

As seen in FIG. 1, the basic components of the starter are a combustion chamber 11 or other source of turbine-powering gases, a ring of turbine nozzles 13 for directing the gases against the buckets of turbine 15, a suitable power train 17 for transmitting the energy of the turbine to an associated turbine engine, not shown, which is connected to splined shaft 19. The power train 17 conventionally has reduction gearing and means arranged so that the associated engine does not drive the starter after the starter brings the engine up to starting speed and the turbine gas supply is cut off.

A speed responsive control 21 is suitably connected as indicated by a dashed line to control means 23 which stop the supply of combustion air and the limited supply of fuel to the combustion chamber 11. This control device 23, when actuated by control 21, cuts off the supply of fuel to the axial fuel nozzle 25 and the supply of air through air nozzles 27 at the sides of the fuel nozzle 25. This functioning occurs when the speed of the turbine exceeds a predetermined speed. This predetermined speed is sensed through suitable gearing in power train 17 by the control 21. Control 21 then closes valves for the fuel and air by electrical connections. In some instances, the control 21 malfunctions and the turbine 15 under no load rapidly is rotated at speeds which exceed the speeds for which the designed strength holding the turbine bucket segments on to the turbine 15 was made. At other times, faults in the turbine wheel structure cause the bucket segments to separate before the starter cut-off speed is reached.

The combustion chamber 11 has a bowl-shaped wall member 31 which is attached at its left end to the outer circumference of an annular nozzle ring 33. Ring 33 contains a plurality of equally-spaced nozzles 13 for directing the combustion gases against peripheral buckets 35 of the turbine 15 for rotating it. The turbine 15 is fabricated by welding the bases of peripherally-abutting structures having buckets 35 to a hub section and machining in such a manner that a low strength section 37 is formed at the weld location which is necked or of reduced width, interiorly of the buckets, to provide bucket segments upon failure. The turbine wheel 15 is mounted on a shaft 39 which has an extension 41 extending towards the combustion chamber 11. This shaft extension or hub 41 is partially encased by the annular surface of an axial recess 43 in the transverse wall 45 which extends radially inwardly from the nozzle ring 33. Wall 45 is brazed to the inner surface of nozzle ring 33 and is further supported by an annular ring extension 47 which centrally abuts the forward wall 49 of the combustion chamber 11. The forward combustion wall 49 is mounted in an inner annular recess 51 in the nozzle ring 33 and is suitably attached to ring 33. The outer part of the axial recess or hub catcher 43 has a ring insert 53 which is made of a hard and high-strength alloy. It is to be noted that the surface of the hub catcher is slightly spaced from the surface of the hub 41. Extending to the left from the nozzle ring 33 is an exhaust shroud 55. The shroud or housing 55 surrounds a turbine and extends to the right edge of the power train 17. Suitable exhaust discharge means, not shown, are provided in the bottom of housing 55 for exhausting the combustion gases. It is to be noted that housing 55 has an interior, horizontally-extending cylindrical surface 57 adjacent the nozzle ring 33 along upper half of the housing 55 and outward of the turbine buckets 35. Surface 57 provides upper support for a braking

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device which extends radially inward to adjacent the turbine buckets 35.

With reference to FIGS. 1, 2 and 3, the details of the above-mentioned braking device will be described. An annular brake ring 61 is rotatably mounted against nozzle ring 33 by means of a plurality of spring-biased brake shoes 63. The outer surface of the brake ring 61 has three inclined surfaces A, B and C. Surfaces A and C are inclined about fifteen degrees with respect to the axis of the turbine in a direction away from the front of the turbine while surface B is inclined thirty degrees in a direction toward the front of the turbine. As can be seen more readily in the enlarged view of FIG. 3, the limited surface B is in contact (about one-eighth inch) with a mating surface of the brake shoes 63 while the surfaces A and C are not in contact with mating surfaces on the brake shoes, although closely spaced thereto. The annular brake ring 61 is made of stainless steel as a ring forging having reasonably good strength. The brake shoes 63 are formed from a reasonably good strength steel but can be made from brass or a sintered alloy. The brake shoes 63 are equally spaced and in the disclosed embodiment twelve shoes are provided. The brake shoes 63 each have three outwardly-opening recesses 65 which contain springs 67 for tensioning the surfaces of the brake shoe into contact with surfaces of the brake ring 61 which is frictionally restrained. The other end of the springs 67 are retained in inwardly-opening recesses 69 in positioning ring 71 which abuts the inner surface 57 of the housing 55. Positioning ring 71 is suitably attached to the housing 55 by screws 73 uniformly spaced around the housing. The screws 73 project into an inwardly extending ridge 75. The axially-extending ridges 75 extend radially inwardly so that they separate and position the brake shoes 63. In this manner, the brake shoes 63 are restrained from rotation. Ring 71 is supported at the bottom thereof by an arcuate plate 76. In the disclosed embodiment, the inner surface of the brake ring is about .020 of an inch from the tips of the turbine buckets.

With reference to FIG. 3, it is to be noted that surface B is relatively limited and contacts a limited portion of the brake shoes 63. The inclination of surface B and the surface which it contacts is such as to urge the brake ring 61 against the adjacent transverse surface of the nozzle ring 33. An inwardly projecting flange 77 of the positioning ring 71 confines the brake shoes axially against an inward extension of the housing 55 and the outer edge of nozzle ring 33.

From the foregoing construction, it is apparent that brake ring 61 is rotatable by a separated bucket segment and that its surface B and the stationary mating surfaces of the brake shoes will rub against each other and initially dissipate energy. After a limited time with such rubbing and wearing down, surfaces A, B and C will then contact the stationary mating surfaces of the brake shoes 63.

In operation, it is apparent that, when the starter turbine wheel fails at the low strength section 37 due to either a fault in the low strength section 37 or at predetermined speeds above starter cut-off speed, a bucket segment will separate with circumferential confinement and contact the brake ring 61. When a bucket segment under centrifugal force rotates brake ring 61, there is a limited braking action for a limited period of time so that a limited amount of energy is first dissipated. This results because limited surface B only contacts the limited mating surfaces on the brake shoes 63 until they wear off or are removed. After this initial energy dissipation due to this limited surface contact, all surfaces A, B and C of the brake ring 61 will be rubbing against the mating surfaces of the brake shoes 63 and more rapid braking of the failed turbine wheel 15 will result. A gradual dissipation of energy is thus provided in the process of stopping the turbine. It is to be noted that the

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right edge of the rotating brake ring 61 will also be rubbing against the outer part of the nozzle ring 33 and that the ring 61 will be prevented from moving axially to the left by the central-inclined surfaces of the brake shoes 63 and brake ring 61.

During this braking caused by separated bucket segments having buckets 35 contacting brake ring 61, the shaft 39 of the turbine 15 is put under bending moments and would normally tend to be broken adjacent its connection to the power train 17. Excessive bending of the shaft 39 is prevented by the journalling of the hub extension 41 of the turbine shaft in the hard insert 53 of the hub catcher recess or cavity 43. In this manner, the damaged turbine wheel is braked when the turbine wheel bucket segments separate and, at the same time, resulting forces tending to sever the turbine shaft 39 are offset by the support provided the turbine hub extension 41 by the encasing recess 43.

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

What is claimed is:

1. In a turbine engine starter, the improvement comprising in combination a turbine wheel having peripheral buckets and a low strength section inwardly of said buckets to provide bucket segment separation, peripheral brake means extending around the circumference formed by said buckets, said brake means including an annular brake ring adjacent the outer ends of said buckets and a back-up means having brake shoes spring-biased against said brake ring, and said brake ring being slidable over said brake shoes to rotate circumferentially, whereby, when a bucket segment of said turbine wheel separates at said low strength section, it will contact said brake ring and cause the brake ring to rotate and to rub against the brake shoes thereby dissipating the energy of the turbine wheel and braking the turbine wheel.

2. In a turbine engine starter, the improvement comprising in combination a turbine wheel having peripheral buckets and a low strength section inwardly of said buckets, peripheral brake means extending around the circumference formed by said buckets, said brake means including an annular brake ring adjacent the outer ends of said buckets and a back-up means having arcuate brake shoes spring-biased against said brake ring, said brake ring being slidable on said brake shoes to rotate circumferentially, said brake shoes and said brake ring having facing surfaces with limited surfaces in contact, the remainder of the surfaces on said brake ring and said brake shoes being slightly spaced from each other and constructed so that, when a bucket segment of said turbine wheel separates at said low strength section, it will contact said brake ring and cause the brake ring to rotate and to rub against and to remove the limited surfaces of the brake shoes and then to rub against the remainder of the surfaces of the brake shoes, thereby gradually dissipating the energy of the turbine wheel and braking the turbine wheel.

3. In a turbine engine starter, the improvement comprising in combination a turbine wheel having peripheral buckets and a low strength section inwardly of said buckets, a shaft extending from one side of said turbine wheel for supporting said wheel, peripheral brake means having a rotatable brake ring extending around the circumference formed by said buckets, said brake means including spring-biased brake shoes frictionally contacting and restraining said brake ring and arranged to brake said turbine wheel when a bucket segment separates and rotates said ring, a short hub extending axially from the other side of said turbine wheel and means including a cavity having an annular surface slightly spaced from the surface of said hub for radially confining said hub when said shaft is flexed and thereby preventing excess bending of said turbine shaft during braking.

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4. In a turbine engine starter, the improvement comprising in combination a turbine wheel having peripheral buckets and a low strength section inwardly of said buckets, peripheral brake means extending around the circumference formed by said buckets, said brake means including an annular brake ring adjacent the outer ends of said buckets and a back-up means having brake shoes spring-biased against said brake ring, said brake ring being slidable on said brake shoes to rotate circumferentially, said back-up brake shoes and said brake ring having facing surfaces with limited surfaces in contact, said limited surfaces being inclined outwardly to the axis of the turbine wheel in a direction toward the front of the turbine wheel, the remainder of the surfaces on said brake ring and said back-up brake shoes being slightly spaced from each other and constructed so that, when a bucket segment of said turbine wheel separates at said low strength section, it will contact said brake ring and initially cause the brake ring to rotate and to rub against the limited surfaces of the back-up means and then to rub against the remainder of the surfaces of the back-up means, thereby gradually dissipating the energy of the turbine wheel and containing any separated bucket segment of the turbine wheel, said remainder of the surfaces of said brake shoes and said brake ring being mating surfaces at each side of said limited contacting surfaces, said mating surfaces being uniformly spaced apart and inclined slightly outwardly with respect to the axis of the turbine wheel in a direction away from the front of the turbine wheel, a nozzle annulus abutting the side of said brake ring and cooperating with said limited surfaces for axially positioning said brake ring.

5. In a turbine engine starter, the improvement comprising in combination a turbine wheel having peripheral buckets and a low strength section inwardly of said buckets, peripheral brake means extending around the circumference formed by said buckets, said brake means including an annular brake ring adjacent the outer ends of said buckets and a back-up means having brake shoes spring-biased against said brake ring, said brake ring being slidable on said brake shoes to rotate circumferentially, said back-up brake shoes and said brake ring having facing surfaces with limited surfaces in contact, said limited surfaces being inclined outwardly to the axis of the turbine wheel in a direction toward the front of the turbine wheel, the remainder of the surfaces on said brake ring and said back-up brake shoes being slightly spaced from each other and constructed so that, when a bucket segment of said turbine wheel separates at said low strength section, it will contact said brake ring and initially cause the brake ring to rotate and to rub against and to remove the limited surfaces of the back-up means and then to rub against the remainder of the surfaces of the back-up means, thereby gradually dissipating the energy of the turbine wheel and containing any separated bucket segment of the turbine wheel, said remainder of the surfaces of said brake shoes and said brake ring being mating

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surfaces at each side of said limited contacting surfaces, said mating surfaces being uniformly spaced apart and inclined slightly outwardly with respect to the axis of the turbine wheel in a direction away from the front of the turbine wheel, a nozzle annulus abutting the side of said brake ring and cooperating with said limited surfaces for axially positioning said brake ring, a positioning ring outwardly of said brake shoes, said positioning ring having axially-extending ridges between said brake shoes for circumferential positioning thereof and having a radial flange arranged to axially confine said brake shoes.

6. In a turbine engine starter, the improvement comprising in combination a turbine wheel having peripheral buckets and a low strength section inwardly of said buckets, peripheral brake means extending around the circumference formed by said buckets, said brake means including an annular brake ring adjacent the outer ends of said buckets and a back-up means having brake shoes spring-biased against said brake ring, said brake ring being slidable on said brake shoes to rotate circumferentially, said back-up brake shoes and said brake ring having facing surfaces with limited surfaces in contact, said limited surfaces being inclined outwardly to the axis of the turbine wheel in a direction toward the front of the turbine wheel, the remainder of the surfaces on said brake ring and said back-up brake shoes being slightly spaced from each other and constructed so that, when a bucket segment of said turbine wheel separates at said low strength section, it will contact said brake ring and initially cause the brake ring to rotate and to rub against and to remove the limited surfaces of the back-up means and then to rub against the remainder of the surfaces of the back-up means, thereby gradually dissipating the energy of the turbine wheel and containing any separated bucket segment of the turbine wheel, said remainder of the surfaces of said brake shoes and said brake ring being mating surfaces at each side of said limited contacting surfaces, said mating surfaces being uniformly spaced apart and inclined slightly outwardly with respect to the axis of the turbine wheel in a direction away from the front of the turbine wheel, a nozzle annulus abutting the side of said brake ring and cooperating with said limited surfaces for axially positioning said brake ring, a shaft extending from one side of said turbine wheel for supporting said wheel, a short hub extending from the other side of said wheel, means including a cavity encasing said hub with the side surface of the cavity slightly spaced from the hub whereby the hub is radially confined to limit the bending of said shaft.

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