

SPECIFICATION

Combination no-back brake and torque limiter assembly**DESCRIPTION:**

The invention relates to an assembly utilizing a single brake which functions to provide no-back brake operation as well as torque limiting operation, with the brake being progressively released intermediate the aforesaid two conditions to permit non-braked rotation of the output shaft.

In various types of actuators, such as an actuator for aircraft components, it is necessary to have structure to perform no-back braking of the drive train as well as limiting the applied torque. In such installations, the space and weight requirements are limiting and with the structure disclosed herein both types of brake operation are accomplished by use of a single brake and, more particularly, by the use of a single set of brake elements or plates which provide both braking functions.

The invention provides a combination no-back brake and torque limiter assembly comprising a casing, a rotatable input shaft, a rotatable output shaft, a pair of confronting spaced apart torque transmitting discs connected one for rotation with the input shaft and one for rotation with the output shaft, brake means associated with the torque transmitting discs, the brake means comprising a brake surface on the casing and a brake element engageable therewith and rotatable with one of the shafts, spring means urging the brake element toward the brake surface and into no-back braking pressure engagement, the torque transmitting discs having a plurality of pairs of opposed ball ramps formed therein, each ball ramp having a bottom and first and second ramp sections at different angles to the face of the disc in which it is formed, a ball being accommodated between each pair of opposed ball ramps, whereby upon creation of a predetermined torque difference between the input and output shafts the space between the torque transmitting discs is increased causing the spring means first to reduce and then to release the pressure engagement of the brake means, and whereby as the torque difference between the input and output shafts approaches a predetermined maximum value the space between the torque transmitting discs is further increased causing force to be exerted on the brake means to obtain torque limiting braking pressure engagement.

The invention is illustrated by the drawings of which:

Figure 1 is a central, vertical sectional view through a combination no-back brake and torque limiter assembly according to the invention;

Figure 2 is a vertical sectional view taken

about the line 2-2 in Fig. 1;

Figure 3 is a vertical sectional view taken about the line 3-3 in Fig. 1;

Figure 4 is a transverse sectional view through one of the ball ramps shown in Fig. 2;

Figure 5 is a graph showing the static characteristics of operation with input torque plotted against the brake plate travel;

Figure 6 is a diagrammatic view, exaggerated for the purposes of clarity, of the torque-responsive structure positioned in no-back brake operation;

Figure 7 is a view similar to Fig. 6, but showing the torque-responsive structure in null position with the brake released; and

Figure 8 is a view similar to Fig. 6, but showing the torque-responsive structure in torque limiting position.

With reference to Fig. 1, a combination no-back brake and torque limiter assembly has a casing 10 with an end closure member 11 which houses an elongate input shaft 15 having an input gear 16 and a tubular output shaft 17 having an output gear 18. The input shaft is rotatable mounted at one end by a bearing (not shown) in the end closure member 11 and a bearing 21 carried by the tubular output shaft 17. The latter shaft has a casing mounted bearing 22.

An input disc 30 is keyed to the input shaft 15 and is mounted in opposing relation to an output disc 31 having a central opening to provide for keying thereof, as indicated at 32, to the output shaft 17. The output disc 31 is urged toward the input disc 30 by spring means 35 in the form of a series of disc springs which surround the output shaft and are confined within a cup-shaped member 36 rotatable with the output shaft. This spring means acts through a brake, indicated generally at 40, to urge the output disc 31 toward the input disc 30.

The brake 40 has a series of brake elements in the form of annular plates associated with the casing 10 and the output shaft 17. More specifically, a first series of plates 41 have their outer periphery keyed to the interior of the casing while a second series of plates 42 are interleaved with the first series and have their inner periphery keyed to the exterior of the output shaft. The brake plates have pressure pads provided on the adjacent faces thereof.

The spring means 35 reacts at one end against the base of the cup-shaped member 36 and at the other end against a ring 45 which abuts an end brake plate 46 keyed to the casing and which exerts pressure engagement on all of the interleaved brake plates and through to the output disc 31.

With the parts positioned as shown in Fig. 1, the input disc 30 and output disc 31 are relatively close to each other and the brake plates are in pressure engagement to provide

the no-back brake operation.

Upon delivery of input torque by the input shaft 15, torque sensing means are operative to control the condition of the brake 40. This torque sensing means includes several pairs of ball ramps provided on the adjacent faces of the input and output discs. All of the ramps are of the same configuration, with the input disc 30 having the ramps 50, 51, and 52 which form pairs with ramps 54, 55 and 56, respectively, of the output disc 31. Each pair of ramps has a ball 61 positioned there-between.

All of the ramps, as viewed in plan, are curved to have a contour following the curved path of a ball as a ball moves in response to relative movement between the discs. Additionally, each of the ramps has the same longitudinal contour, as shown for the ramp 52 in Fig. 4. The ramp has a slightly curved bottom 75 wherein a ball 60 is positioned against the bottoms of a pair of ramps to provide minimum spacing between the discs 30 and 31. The ramp then has a first inclined section 76 which, in a preferred embodiment, is at an angle of approximately 5° to the face of the disc, followed by a second inclined ramp section 77 which is at a greater angle. In a preferred embodiment, this greater angle is approximately 13°. The ramp sections are gradually curved into the adjacent part of the ball ramp.

Referring particularly to Figs. 6-8, the no-back brake operation is shown in Fig. 6. Input torque is transmitted by the input shaft 15 to the input disc 30 and from the ramps 50-52 thereof through the balls 60 to the output disc ramps. The torque difference sensed by the input and output discs with their ramp and ball structure is vectorially changed into an axial force as the torque is transmitted to the output shaft 17 by movement of the balls 60 onto the ramp sections 76. This acts to initially reduce the axial pre-load caused by the spring means 35 and, at the end of the ramp sections 76, the brake has been moved to a null position where there will be no torque resistance by the brake.

This movement of the output disc is longitudinal of the output shaft 17, as permitted by the key relation therebetween, and is transmitted to the spring-urged ring 45 by a series of motion-transmitting pins 80 around the output shaft and which extend lengthwise thereof and engage between the ring 45 and a face of the output disc 31.

With the discs related as shown in Fig. 7, the brake 40 is completely released. As the torque increases toward a predetermined maximum value, the balls 60 will move onto the second ramp sections 77 and progressively therealong to increase the spacing between the discs and shift the brake structure toward the left to have the end brake plate 46

engage against an end of the cup-shaped

member 36 defining a reaction means for the brake structure in torque limiting operation. This disc movement, at the same time, acts through the motion transmitting pins 80 to further compress the spring means 35. With the parts positioned as shown in Fig. 8, the brake is fully active to limit the torque.

These various stages of operation are shown in Fig. 5 with the ball ramp section angles given as preferred values, but not as required values.

The direction of rotation of the input shaft 15 has been shown as to the right in Figs. 7 and 8. However, if shaft rotation were reversed, there are additional ramp sections 90 and 91 functioning the same as ramp sections 76 and 77, respectively, in the opposite direction of shaft rotation.

All of the forces acting longitudinally of the assembly are applied against the input disc 30 and a bearing 90 is positioned between the input disc 30 and the end closure member 11 to permit free rotation of the input disc.

The casing 11 has hydraulic fluid therein to dissipate heat generated by the brake 40.

CLAIMS

1. A combination no-back brake and torque limiter assembly comprising a casing, a rotatable input shaft, a rotatable output shaft, a pair of confronting, spaced apart torque transmitting discs connected one for rotation with the input shaft and one for rotation with the output shaft, brake means associated with the torque transmitting discs, the brake means comprising a brake surface on the casing and a brake element engageable therewith and rotatable with one of the shafts, spring means urging the brake element toward the brake surface and into no-back braking pressure engagement, the torque transmitting discs having a plurality of pairs of opposed ball ramps formed therein, each ball ramp having a bottom and first and second ramp sections at different angles to the face of the disc in which it is formed, a ball being accommodated between each pair of opposed ball ramps, whereby upon creation of a predetermined torque difference between the input and output shafts the space between the torque transmitting discs is increased causing the spring means first to reduce and then to release the pressure engagement of the brake means, and whereby as the torque difference between the input and output shafts approaches a predetermined maximum value the space between the torque transmitting discs is further increased causing force to be exerted on the brake means to obtain torque limiting braking pressure engagement.

2. An assembly according to claim 1 wherein the bottom of each ball ramp is aligned with the bottom of the opposing ball ramp and the balls are positioned on the ramp



16

- bottom when there is zero or low torque transmitted between the shifts to have brake pressure engagement, the balls move onto the transmitted between the shafts increases towards
- 5 the predetermined torque difference progressively to move the discs apart and progressively to release brake pressure engagement with complete release when the balls are at the ends of the first ramp section, and the
- 10 balls move onto the second ramp sections as the torque transmitted between the shafts increases towards the predetermined maximum torque progressively to move the discs further apart and progressively to reapply
- 15 brake pressure engagement with full pressure engagement as the balls reach the ends of the second ramp sections.
3. An assembly accordingly to claim 1 or claim 2 wherein the first ramp sections are at an angle of approximately 5° to the faces of the discs and the second ramp sections are at an angle of approximately 13° to the faces of the discs.
4. An assembly to any preceding claim
- 25 wherein the spring means acts on an annular member, a motion-transmitting member between the annular member and the torque transmitting disc connected for rotation with the output shaft, and the brake element is
- 30 carried by the motion transmitting member.
5. An assembly according to any preceding claim in which the output carries a reaction member for pressure engagement by the brake elements for torque limiting.
- 35 6. A combination no-back brake and torque limiter assembly substantially as described herein with reference to the drawings.