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(54) THERMALLY ACTUABLE DISCONNECT COUPLING

(71) We, SUNDSTRAND CORPORATION, a corporation organised and existing under the laws of the State of Delaware, United States of America, of 4751 Harrison Avenue, Rockford, Illinois 61101, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a thermally actuable disconnect coupling of the type such as may be utilized in an aircraft to provide the drive connection between the output shaft of the aircraft engine gearbox and the input drive shaft of the aircraft's constant speed drive. More particularly, the invention relates to a thermally actuable disconnect coupling which includes a fusible element such as a solder pellet located between parts of the coupling so that, when parts of the constant speed drive fail and become overheated, the pellet melts and the coupling disconnects from the gearbox thereby shutting down the constant speed drive to avoid causing excessive damage to the drive and other parts of the aircraft.

The invention provides a thermally actuable disconnect coupling for use to transmit a torque between drive and driven rotary members, comprising: a one-piece coupling shaft for providing a unitary drive path between the drive member and the driven member; means at one end portion of the coupling shaft for connecting the coupling shaft to one of the drive and driven members; helical splines at the other end portion of the coupling shaft for connecting the coupling shaft to the other of the drive and driven members and imparting a component of the torque as an axial force on the coupling shaft; and means including a fusible element for resisting axial movement of the coupling shaft while the fusible element is in the solid state but when the fusible element is melted permitting such axial movement to allow the coupling shaft to move under the said axial force to an axial position in which the means at the one end portion thereof no longer connect the coupling shaft to the one of the drive and driven members.

The invention enables couplings to be designed which are more compact and stronger for their size than prior similar couplings. The new couplings can be made capable of transmitting greater torque for their size and thus providing a stronger connection with the output shaft of the gearbox during normal in-service use than prior similar couplings. This is made possible by use of a helical spline connection within the coupling, the spline connection serving to transmit torque when the eutectic pellet is solid but causing the coupling to disengage completely when the pellet melts. Advantageously, the helical spline connection introduces a strong axially directed component of the force transmitted by the coupling shaft so that, when the pellet melts, the axial component of the force propels the coupling shaft in an axial direction to disconnect the drive. Preferably the drive is disconnected by disengaging both the outer end section of the coupling shaft from the drive shaft and the inner end section of the coupling shaft from the driven shaft.

According to the invention, the opposite end sections of the coupling shaft are integral with each other so as to require fewer separate operating parts in the coupling than are employed in prior similar couplings. A preferred feature resides in the size relationship between the helical spline connection and the axially straight spline connection so as to eliminate the need for means such as a spring for keeping parts of the coupling away from the drive shaft once the coupling has disconnected itself from the drive shaft.

The invention is hereinafter particularly described by way of example only, with reference to the drawings of which:

FIG. 1 is a fragmentary cross-sectional view of a thermally actuated disconnected coupling embodying the novel features of the present invention.

FIG. 2 is a cross-sectional view similar to FIG. 1 but showing parts of the coupling in moved positions.

FIG. 3 is a view taken substantially along line 3—3 of FIG. 1 with parts of the coupling being shown in phantom.

As shown in the drawings for purposes of illustration, the present invention is embodied in a thermally actuated disconnect coupling 10 particularly adapted for use in transmitting torque between a drive member 11 and a driven member 13 during normal in-service use. When the driven member becomes overheated, the coupling automatically disconnects from the drive member. Typically, a coupling of this type may be used in an aircraft to provide the connection between a drive member 11, such as the output shaft of the engine powered gearbox of the aircraft, and the input driven member 13 of a constant speed drive (not shown). In this environment, it is important that the torque transmitted to the constant speed drive be terminated in the event of a failure in the system so as to avoid overheating of the drive and perhaps serious damage to the drive and other parts of the aircraft.

Herein, the coupling 10 is mounted within the sidewalls of a housing 14 and includes the driven member 13 whose inner end portion is supported by bearings 15 within the housing. More particularly, the driven member 13 is in the form of a tubular shaft including an axially directed chamber 16 and a peripheral gear 17 disposed intermediate the ends of the shaft 13. Supporting the outer end portion of the driven shaft 13 radially and against axial movement out of the housing 14 are bearings 19 disposed within the side wall of the housing. Mor particularly, as shown in FIG. 1, the axial chamber 16 of the shaft telescopically receives a coupling shaft 20 normally extending between the drive shaft 11 and the input or driven shaft 13. Sealing between the sidewall of the housing and the driven shaft 13 is achieved through the provision of a sealing ring 21 which is captivated against the outer end 23 of the shaft 13 by a retaining ring 24 that, in turn, is held in place by a snap ring 25. O-rings 27 and 28 are disposed between the sealing ring 21 and retaining ring 24, and between the retaining ring 24 and the housing 14, respectively, to keep the operating fluid of the constant speed drive from leaking out of the housing 14.

In normal service use, the coupling shaft 20 is supported against axial movement by a fusible element such as a eutectic pellet 30 formed of solder. The pellet supports the coupling shaft so that the inner end section 31 thereof is connected with the driven member or shaft 13 and so that the outer end section 33 of the coupling shaft is connected to the drive shaft 11. Thus, if the drive shaft is rotated, torque is transmitted through the coupling shaft to the driven member 13. If for some reason during the operation of the constant speed drive the operating fluid becomes overheated, the solder pellet 30 will melt, thereby allowing the coupling shaft to slide in an axial direction to disconnect the drive and driven members 11 and 13.

In accordance with the primary aspect of the present invention, the coupling 10 is more compact and stronger for its size than prior similar couplings. This is achieved by constructing the coupling shaft 20 so that the opposite end sections 31 and 33 are integral with each other, thereby providing a continuous shaft, and through the provision of normally mating helical splines 34 and 35 formed on one of the sections 31 and 33 and one of the members 11 and 13 for transmitting torque between the coupling and the member. Advantageously, the helical splines provide a stronger connection between the coupling shaft and the drive or driven member and further allow the coupling shaft to be made as one continuous part thereby reducing the number of parts in the coupling and generally simplifying its construction.

In the present instance, the helical splines 34 and 35 are formed on the inner end section 31 of the coupling shaft 20 and the outer end portion of the driven shaft 13. In particular, the splines 34 are external splines while the splines 35 are formed internally of the driven shaft 13 so as to extend in a generally radial direction into the chamber 16 of the shaft. Preferably, the splines 34 and 35 are slanted helically in a direction so as to urge the coupling shaft 20 toward the pellet 30 during normal power-driven rotation of the shaft. Holding the coupling shaft against axial movement in the opposite direction is a clip-ring 32. More particularly, as shown in FIG. 3, the helical spline 34 slants in the normal direction of rotation of the shaft 20 upon progressing in an inward direction along the shaft and toward its inner end. With this arrangement, as torque is being transmitted through the coupling shaft 20, an axial force is introduced urging the coupling toward the pellet 30. As long as the pellet is in its solid state, the coupling shaft 20 is supported against axial movement into the chamber 16, but when solder liquifies, the axial force propels the shaft inwardly thereby disengaging the outer end of the shaft from the drive member 11.

As shown in FIG. 1, the outer end section 33 of the coupling shaft 20 is connected to the drive member 11 by means of axially straight splines 36 and 37. The splines 36 are external splines, being formed on the outside surface of the shaft 20, and the splines 37 are internal splines, defining in part an axially extending cavity 39 formed in the outer end portion of the drive member 11. Advantageously, the axial length of

the splines 36 is less than the axial length of the splines 34 so as to assure a complete disconnection of the outer end section 33 of the shaft 20 from the driven member 11. This is because when the pellet 30 melts the axially directed force is applied to the coupling shaft 20 over an extended period of time due to the axial length of the splines 36. Accordingly, when disconnecting, the coupling shaft 20 is accelerated axially inward with sufficient force for the inner end of the coupling shaft to strike the inner end of the chamber 16. As shown in FIG. 2, this completely disengages the helical splines 34 and 35, and, because the splines 34 and 35 have an engageable length greater than the length of the splines 36, the coupling 20 is retracted from the drive member 11 into a position spaced a substantial distance from the exposed end of the drive member 11. Also during disengagement, the helical splines cause the coupling shaft to rotate, with the splines 34 and 35 misalgining upon separation. This misaligning of splines 34 and 35 tends to keep the shaft 20 from vibrating back toward the drive member 11. Thus, it will be appreciated that by virtue of the unique size relationship between helical splines 34 and 35 and axially straight splines 36, the present construction avoids the need for means such as a spring member or the like for holding the coupling shaft 20 in a position disconnected from the drive member 11.

To support the coupling shaft 20 in its normal operating position, the pellet 30 is telescoped into a cylinder 40 disposed within the drive shaft chamber 16 and a plunger 41 extends between the pellet and the coupling shaft 20 (see FIG. 1). Herein, the plunger includes an elongated body extending axially outward from within the cylinder 40 and into an axial recess 45 formed in the inner end section 31 of the shaft 20. Formed on the body is an enlarged inner end portion 43 having a diameter slightly less than the internal diameter of the cylinder thereby leaving a gap between the enlarged end of the plunger and the interior sidewalls of the cylinder. The gap provides a passage through which the liquid solder may flow when the pellet is melted. In addition, flow passages 44 are provided through the cylinder adjacent the inner end thereof for permitting liquid solder to flow through the cylinder and into the chamber 16. Opposite the inner end of the plunger body is a rounded outer end portion 46. In particular, the outer end portion is hemispherical in shape and engages a radially extending bearing surface 47 of a bearing disk 49 so that the plunger is articulated with respect to the coupling shaft 20. In this way, the enlarged end of the plunger is kept from wobbling against and cold working the outer end of the pellet 30 should there be a slight axial misalignment between the drive and driven shafts 11 and 13.

From the foregoing, it is apparent that the present invention brings to the art a new improved thermally actuated disconnect coupling 20 which is more compact, stronger for its size and includes fewer parts than prior similar couplings. Herein, these advantages are achieved by utilizing the unique mating helical splines 34 and 35 on the coupling shaft 20 and the driven member 13, respectively, and by taking advantage of the axial force created by the helical splines to disconnect the coupling shaft from the drive shaft 11 when the pellet 30 melts. Moreover, by virtue of the unique size relationship between the axial lengths of the helical splines 34 and 35 and the axially straight splines 36 and 37 complete disconnection of the coupling shaft from the drive shaft is assured when the solder melts.

WHAT WE CLAIM IS:—

1. A thermally actuable disconnect coupling for use to transmit a torque between drive and driven rotary members, comprising: a one-piece coupling shaft for providing a unitary drive path between the drive member and the driven member; means at one end portion of the coupling shaft for connecting the coupling shaft to one of the drive and driven members; helical splines at the other end portion of the coupling shaft for connecting the coupling shaft to the other of the drive and driven members and imparting a component of the torque as an axial force on the coupling shaft; and means including a fusible element for resisting axial movement of the coupling shaft while the fusible element is in the solid state but when the fusible element is melted permitting such axial movement to allow the coupling shaft to move under the said axial force to an axial position in which the means at the one end portion thereof no longer connect the coupling shaft to the one of the drive and driven members.

2. A thermally actuable disconnect coupling for use to transmit a driving torque between a drive member and a driven member, said coupling including a coupling shaft having opposite end sections integrally formed with each other so said shaft is continuous form one end to the other, means for connecting one of said end sections to one of said members normally to transmit torque between said one member and said shaft while permitting axial movement of said shaft relative to said one member when disconnecting the driven member from the drive member, nordmally mating helical splines formed on the other one of said members and the other one of said end sections of said shaft, means for sup-

the splines 36 is less than the axial length of the splines 34 so as to assure a complete disconnection of the outer end section 33 of the shaft 20 from the driven member 11. This is because when the pellet 30 melts the axially directed force is applied to the coupling shaft 20 over an extended period of time due to the axial length of the splines 36. Accordingly, when disconnecting, the coupling shaft 20 is accelerated axially inward with sufficient force for the inner end of the coupling shaft to strike the inner end of the chamber 16. As shown in FIG. 2, this completely disengages the helical splines 34 and 35, and, because the splines 34 and 35 have an engageable length greater than the length of the splines 36, the coupling 20 is retracted from the drive member 11 into a position spaced a substantial distance from the exposed end of the drive member 11. Also during disengagement, the helical splines cause the coupling shaft to rotate, with the splines 34 and 35 misalgining upon separation. This misaligning of splines 34 and 35 tends to keep the shaft 20 from vibrating back toward the drive member 11. Thus, it will be appreciated that by virtue of the unique size relationship between helical splines 34 and 35 and axially straight splines 36, the present construction avoids the need for means such as a spring member or the like for holding the coupling shaft 20 in a position disconnected from the drive member 11.

To support the coupling shaft 20 in its normal operating position, the pellet 30 is telescoped into a cylinder 40 disposed within the drive shaft chamber 16 and a plunger 41 extends between the pellet and the coupling shaft 20 (see FIG. 1). Herein, the plunger includes an elongated body extending axially outward from within the cylinder 40 and into an axial recess 45 formed in the inner end section 31 of the shaft 20. Formed on the body is an enlarged inner end portion 43 having a diameter slightly less than the internal diameter of the cylinder thereby leaving a gap between the enlarged end of the plunger and the interior sidewalls of the cylinder. The gap provides a passage through which the liquid solder may flow when the pellet is melted. In addition, flow passages 44 are provided through the cylinder adjacent the inner end thereof for permitting liquid solder to flow through the cylinder and into the chamber 16. Opposite the inner end of the plunger body is a rounded outer end portion 46. In particular, the outer end portion is hemispherical in shape and engages a radially extending bearing surface 47 of a bearing disk 49 so that the plunger is articulated with respect to the coupling shaft 20. In this way, the enlarged end of the plunger is kept from wobbling against and cold working the outer end of the pellet 30 should there be a slight axial misalignment between the drive and driven shafts 11 and 13.

From the foregoing, it is apparent that the present invention brings to the art a new improved thermally actuated disconnect coupling 20 which is more compact, stronger for its size and includes fewer parts than prior similar couplings. Herein, these advantages are achieved by utilizing the unique mating helical splines 34 and 35 on the coupling shaft 20 and the driven member 13, respectively, and by taking advantage of the axial force created by the helical splines to disconnect the coupling shaft from the drive shaft 11 when the pellet 30 melts. Moreover, by virtue of the unique size relationship between the axial lengths of the helical splines 34 and 35 and the axially straight splines 36 and 37 complete disconnection of the coupling shaft from the drive shaft is assured when the solder melts.

WHAT WE CLAIM IS:—

1. A thermally actuable disconnect coupling for use to transmit a torque between drive and driven rotary members, comprising: a one-piece coupling shaft for providing a unitary drive path between the drive member and the driven member; means at one end portion of the coupling shaft for connecting the coupling shaft to one of the drive and driven members; helical splines at the other end portion of the coupling shaft for connecting the coupling shaft to the other of the drive and driven members and imparting a component of the torque as an axial force on the coupling shaft; and means including a fusible element for resisting axial movement of the coupling shaft while the fusible element is in the solid state but when the fusible element is melted permitting such axial movement to allow the coupling shaft to move under the said axial force to an axial position in which the means at the one end portion thereof no longer connect the coupling shaft to the one of the drive and driven members.

2. A thermally actuable disconnect coupling for use to transmit a driving torque between a drive member and a driven member, said coupling including a coupling shaft having opposite end sections integrally formed with each other so said shaft is continuous form one end to the other, means for connecting one of said end sections to one of said members normally to transmit torque between said one member and said shaft while permitting axial movement of said shaft relative to said one member when disconnecting the driven member from the drive member, nordmally mating helical splines formed on the other one of said members and the other one of said end sections of said shaft, means for sup-

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porting said shaft normally against axial movement so torque may be transmitted by said splines from said shaft to said other one of said members, said means including a fusible element adapted to melt and thereby release said shaft for axial movement under the urging of an axial force introduced in the coupling by said mating helical splines whereby said shaft is propelled in an axial direction to disconnect said drive and driven members from each other.

3. A coupling according to claim 1 or claim 2, wherein the helical splines are for connecting the coupling shaft to the driven member.

4. A coupling according to any preceding claim, wherein the means for connecting the coupling shaft to the one of the drive and driven members comprise splines formed on the coupling shaft, the splines having an axial length less than the axial length of the helical splines.

5. A coupling according to claim 4, wherein the splines and the helical splines are both external splines.

6. A coupling according to any preceding claim, wherein the means for normally resisting axial movement of the shaft comprises a cylinder that is open at one end and contains the fusible element in the form of a solder pellet, and a plunger abutting, at its ends, the solder pellet and the coupling shaft but movable into the cylinder on melting of the solder pellet.

7. A coupling according to claim 6, wherein the plunger has a rounded end portion abutting the coupling shaft.

8. A coupling according to claim 6 or claim 7, wherein the coupling shaft is formed with a blind axial recess in which the plunger is received, and a bearing disc forms a bearing surface for the plunger across the blind end of the axial recess.

9. A coupling according to any of claims 6 to 8, wherein the end of the plunger abutting the solder pellet has a diameter less than the diameter of the cylinder, for melted solder to flow between the plunger and the cylinder, and a passage is formed through the side wall of the cylinder at the end remote from the plunger for melted solder to flow from the interior of the cylinder.

10. A thermally actuable disconnect coupling substantially as particularly described herein with reference to the drawings.

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