

PATENT SPECIFICATION

(11)

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- (21) Application No. 53457/76 (22) Filed 22 Dec. 1976 (19)
(31) Convention Application No. 643253 (32) Filed 22 Dec. 1975 in
(33) United States of America (US)
(44) Complete Specification Published 11 Apr. 1979
(51) INT. CL.² F16D 23/00
(52) Index at Acceptance
F2C 1A11A4 1A1A3 1A1A4 1A3A1



(54) DISCONNECTABLE DRIVE TRANSMISSION

(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:-

The invention relates to disconnectable drive transmissions, and particularly to such transmission in which the disconnect mechanism is reliable at low speeds. This low speed reliability is particularly important in a constant speed drive system.

In many areas, and particularly in the aircraft industry, it is required to operate certain accessories with a constant frequency source of power. Accordingly, a generator or alternator must be driven at a constant speed. The source of the driving power is quite variable, due to demands for higher or lower speeds from the prime mover.

Between the prime mover and the constant speed drive transmission is a form of clutching arrangement which is adapted to connect the output of the prime mover to the input of the transmission in such a way that the driving train can be interrupted under certain conditions, for instance, upon overheating in the transmission, generator breakdown in the system, or the like, where the prime mover is still operating. This can best be handled by disconnecting the prime mover from the constant speed transmission so as to prevent damage to the transmission and/or to the generator.

It has been proposed to provide a disconnect mechanism in which a plunger-actuated gear element is moved into engagement with a worm splined to a coupling member, whereby the worm is moved along the gear element to disengage the coupling member

from the input shaft. Under normal high speed conditions, such a plunger-actuated gear element will clear the worm thread and pass behind the worm to hold the coupling member disengaged from the input member. When the speed of the input member is relatively low, the plunger-actuated gear element and worm are effective to disconnect the coupling member from the input shaft, but, even though the teeth of the coupling member are disengaged from the teeth on the input shaft, the space therebetween is relatively small and there is not sufficient speed or momentum in the coupling member to drive the worm off the end of the plunger-actuated gear element. As a result, vibration caused by the prime mover can cause the worm gradually to rotate back relative to the plunger-engaged gear until the teeth on the coupling member come into contact with the teeth on the coupling member come into contact with the teeth on the input shaft, causing damage to the teeth and, in some cases, reengagement of the coupling member to drive the constant speed transmission and the generator even though one or the other or both may have failed.

The invention provides a disconnectable drive transmission having an input shaft, coupling means axially aligned with and selectively driven by said input shaft, a driven member splined to the coupling means, an axially movable worm-threaded member splined to the coupling means, a first spring acting on the coupling means through the worm-threaded member to urge the coupling means into coupled relationship with the input shaft, a second spring acting on the coupling means to urge the coupling means out of coupled relationship with the input shaft after axial movement of the worm-threaded member has relieved the coupling means of the bias of the first spring, and rack means movable into engagement with the

worm-threaded member whereby the rotation of the input shaft and coupling means will thread the worm over the rack means first to compress the first and second springs and then to disconnect the coupling means from the input shaft, the second spring urging the coupling means away from the input shaft on disconnection of the coupling means from the input shaft. As a further improvement, axial movement of the worm-threaded member in a direction to relieve the coupling means of the bias of the first spring means causes engagement of the worm-threaded member with ratchet means for preventing rotation of the worm-threaded member in a sense such as to produce axial movement in the reverse direction. The ratchet means is such as to permit the worm-threaded member to rotate in a disengaging direction, but to prevent the worm-threaded member from rotating in a direction toward reengagement of the coupling means with the input shaft.

If the speed of the input shaft and coupling means is sufficient to run the worm-threaded member off the end of the rack means movable into engagement therewith, the said rack means will engage behind the worm-threaded member and lock the coupling means out of engagement with the input shaft as heretofore. However, in the event that the speed of the input shaft and coupling means is not sufficient to run the worm thread completely off the rack means the coupling means will advance relative to the ratchet means as long as the drive is engaged or there is sufficient momentum, but when the coupling means stop rotating, the ratchet means will prevent the coupling means from rotating backwardly and therefore will prevent the coupling means from reengaging the input shaft. Clutch teeth on the coupling means are thus retracted out of contact with the input shaft to a fully retracted position by the second spring. In this way, the connection between the input shaft and the coupling means will be held disengaged in a positive fashion until the rack means is disengaged, and the likelihood of damage to the constant speed drive or to the auxiliary equipment connected thereto will be prevented.

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

Figure 1 is a fragmentary axial section through a disconnect mechanism of a transmission according to the invention, with the transmission in its engaged condition;

Figure 2 is an axial section similar to that of Figure 1, showing the coupling between the input member and the coupling member disengaged; and

Figure 3 is a transverse section taken along the line 3-3 of Figure 1.

The drawings show a disconnect mechanism provided in a constant speed drive of the type described in our U.S. Patents 3,576,143 and 3,365,981. The constant speed drive, most of which is not shown, has a housing 10 through one wall of which extends an input shaft 12. The external part of the input shaft 12 has splines on the outer surface thereof for engagement with the output of a prime mover, such as an aircraft engine, not shown. The input shaft 12 is mounted in bearings 14 in the housing so as to be freely rotatable about an axis 15 of the input shaft. The axially inwardly projecting end portion of the input shaft 12 has a plurality of angularly spaced clutch teeth 16 formed in a circular pattern concentric about the axis 15 of the input shaft.

Mounted on the inside of the housing and in axial alignment with the input shaft 12 is a coupling member 18 which is externally splined at 20 and 22 at each end portion thereof. The axial end of the coupling member facing the input shaft 12 has a plurality of circumferentially spaced clutch teeth 24 which are adapted to mesh with the clutch teeth 16 formed on the input shaft 12. The spline teeth 20 on the left end portion of the coupling member 18 engage with internal spline teeth 26 on the interior end portion of a driven member 28 of a constant speed drive transmission. The driven member 28 is mounted in bearings 30 in a torque tube 32 rotatably supported on the inside of the housing 10 so that the driven member 28 is free to rotate about its axis, which axis coincides with the axis 15 of the input shaft 12. With the clutch teeth 16 on the input shaft 12 in engagement with the clutch teeth 24 on the coupling member 18, the driven member 28 is driven with the same speed of rotation as the input shaft 12. The constant speed transmission downstream from the disconnect mechanism converts the different speeds of rotation of the input shaft 12 to a constant output speed of rotation as is taught by the above-mentioned patents.

A sleeve 34 is disposed concentrically about the right end portion of the coupling member 18 and has internal spline teeth 36 engaging with the spline teeth 22 on the right end of the coupling member whereby the sleeve 34 will rotate with the coupling member 18 and is axially slidable relative to said coupling member 18. In order to withdraw the clutch teeth 24 from the clutch teeth 16, the sleeve 34 has an inwardly directed annular flange 37 engageable with the end of spline 22 on the coupling member 18.

The sleeve 34 has a worm thread 38 formed around one end portion thereof and has a plurality of axially facing ratchet teeth 40 projecting from the opposite end portion

thereof. A snap ring 42 is seated in an internal groove 44 formed on the inner surface of the left end portion of the sleeve 34. A stop washer 45 is positioned within the sleeve 34 and is located between the snap ring 42 and a shoulder 43 on the outer surface of the coupling member 18. An annular ring member 46 having an axially extending collar 47 on one face thereof is positioned inside the sleeve 34 and is urged against the ring 42 by one end of a first compression spring 48 which has its other end urged against an annular spring seat 50 on the end of the driven member 28. The collar 47 on the member 46 separates the first spring 48 from a second spring 52 which has one end bearing against the ring member 46 and has its other end bearing against an annular spring seat 54 on the outer surface of the coupling member 18.

The first spring 48 bears against the ring member 46 to urge the washer or ring 45 against the shoulder 43 formed on the coupling member 18 such that the spring force retains the clutch teeth 24 on the coupling member in engagement with and in mesh with the clutch teeth 16 on the input shaft 12. In this way, the drive from the shaft 12 is transmitted through the coupling member 18 to the driven member 28.

An annular bearing support 60 surrounds the sleeve 34 and a portion of the coupling member 18, and the support 60 is mounted to the housing 10 by means of screws 61. A bearing 62 surrounds the support 60 and rotatably supports the torque tube 32 of the transmission. The left end of the annular bearing support 60 has a pair of axially extending slots 63 formed inwardly from one end thereof. An annular ratchet 64 is mounted in the annular bearing support 60 and has one-way detent teeth 66 projecting axially toward the ratchet teeth 40 formed on the left end of the sleeve 34. An annular spring seat 68 is retained by a snap ring in the left end of the annular bearing support 60 and retains the left end of a third compression spring 70, with the other end of the third spring 70 bearing against the ratchet 64. The ratchet 64 is retained against rotation relative to the annular bearing support 60 by means of lugs 72 which project radially outwardly from the ratchet 64 and engage in the axially extending slots 63 in the end portion of the bearing support 60 as shown more clearly in Figure 3. The arrangement of the lugs 72 within the slots 63 in the bearing support 60 makes it possible for the ratchet 64 to be moved toward the left as viewed in Figures 1 and 2 relative to the support 60 against the force of the third spring 70. With the sleeve 34 rotating and being moved toward the ratchet 64, the ratchet teeth 40 on the sleeve engage with the detent teeth 66 whereupon the sleeve 34

is permitted to rotate in one direction relative to the bearing support 60 but the one-way teeth 66 on the ratchet 64 prevent the sleeve 34 from rotating in the opposite direction. The spring-urged ratchet 64, due to its mounting relative to the bearing support 60 will permit the sleeve 34 to move the ratchet 64 to the left relative to the bearing support against the compressive force of the third spring 70.

A small segment of rack gear teeth 76 is adapted to mate with the worm thread 38 and is formed on the inner end of a plunger assembly 78. The assembly 78 is structurally the same and operates the same as disclosed in our U.S. Patents mentioned above and is designed to move the teeth 76 into engagement with the worm thread 38 on the sleeve 34. The plunger assembly 78 may be actuated either manually from the cockpit of an airplane or automatically upon overheating of the transmission, upon overload of the generator, or the like. Upon actuation of the plunger assembly 78, the gear teeth 76 engage with the worm thread 38 whereupon the rotation of the sleeve 34 by the input shaft 12 will cause the sleeve 34 and the coupling member 18 to be moved to the left to disconnect the meshed teeth 24 on the coupling member 18 from the teeth 16 on the input shaft 12. The detailed operation of the disconnecting of the coupling member from the shaft will be described in more detail hereinafter. The plunger assembly 78 has a reset handle or reset mechanism which permits the manual or automatic resetting of the assembly 78 to move the gear teeth 76 out of engagement with the worm thread 38, whereupon the spring 48 will drive the teeth 24 on the coupling member 18 into mesh with the teeth 16 on the input shaft 12.

When, as has been the case heretofore, the input shaft 12 is rotating at a moderate or high speed, e.g. approximately 4,000 rpm, actuation of the plunger assembly 78 will drive the gear teeth 76 into engagement with the worm thread 38, whereupon the rotation of the input shaft 12 and the coupling member 18 will cause the sleeve 34 to progress axially relative to the rack teeth 76 and relative to the coupling member 18 in a position (not shown) where the inwardly directed flange 37 on the sleeve engages the spline 22 on the coupling member positively to move the coupling member axially toward the left to a position (not shown) where the teeth 24 on the coupling member 18 disengage the teeth 16 on the input shaft 12. At this stage the second spring 52, which has been compressed during relative movement of the sleeve 34 relative to the coupling member 18, becomes effective to move the coupling member 18, (now freely axially movable) further to the left well clear of the teeth 16. When such moderate or high

speeds are transmitted to the coupling member 18, the momentum of the coupling member and the sleeve 34 will continue to move the coupling member 18 to the left after the teeth 24 and 16 have separated until the worm 38 runs off the rack teeth 76 on the plunger assembly 78, whereupon the plunger assembly 78 will drive the rack teeth 76 behind the right end of the sleeve 34 to hold the coupling member 18 locked against reengagement with the input shaft 12. When it is desired to reconnect the transmission to the input shaft 12, the plunger assembly 78 is retracted to pull the rack teeth 76 out of alignment with the coupling member 18, whereupon the first spring 48 will drive the coupling member 18 to the right until the teeth 24 again mesh with the teeth 16 on the input shaft 12.

When the input shaft 12 is running at low speeds and the plunger assembly 78 is actuated to drive the rack teeth 76 into mesh with the worm thread 38, there is sometimes not sufficient momentum to move the coupling member 18 sufficiently to the left to cause the rack teeth 76 to latch behind the sleeve 34 on the coupling member 18. Heretofore, with the gear teeth 76 still engaged with the worm thread 38 and the coupling member 18 not rotating, it was possible for the vibration from the engine to cause the coupling member 18 slowly to rethread the worm thread 38 relative to the gear teeth 76 until the teeth 24 remeshed or partially remeshed with the teeth 16, thereby causing damage not only to the teeth 24 and 16, but also to any of the downstream transmission or auxiliary equipment which may have overheated.

With the illustrated embodiment, when the input shaft 12 is rotating at low speeds, for example 1 rpm, and the plunger assembly 78 is actuated to engage the rack teeth 76 with the worm thread 38, the sleeve 34, rotating with the coupling member 18, threads its way axially along the coupling member 18 to a position (not shown) where the inwardly directed flange 37 engages the right end of the splines 22 on the coupling member. Axial movement of the sleeve 34 in the manner described moves the snap ring 44 away from the input member, so that there is no force applied by the ring 45 against the shoulder 43 on the coupling member. Thus, the bias of the spring 48 is no longer applied to urge the coupling member toward the input shaft. Also the initial axial movement of the sleeve 34 has compressed the normally relatively uncompressed second spring 52 in a manner to load the second spring to urge the coupling member 18 away from the input shaft 12. Continued rotation of the worm thread 38 positively moves the clutch teeth 24 to a position (not shown) out of contact with the

input clutch teeth 16. Thereupon the second spring 52 moves the coupling member 18 to the position shown in Figure 2 where the shoulder 43 on the coupling member engages the ring 45 in the sleeve, with the latter in the left-most position illustrated in Figure 2.

Before the clutch teeth 24 disconnect from the clutch teeth 16, the ratchet teeth 40 on the end of the sleeve 34 will engage with the one-way detent teeth 66 on the ratchet 64. If there is sufficient momentum to continue to turn the sleeve 34, it will be moved further to the left as shown in Figure 2, moving the lugs 72 on the ratchet 64 in the guide slots 63 and against the compression of the third spring 70. The third spring 70 urges the lugs 72 on the ratchet member 64 to the right in the slots 63 formed in the bearing support 60. Once the ratchet teeth 40 on the sleeve 34 engage with the one-way detent teeth 66 on the ratchet 64, the sleeve 34 is permitted to continue to rotate in one direction only, and to move axially relative to the bearing support 60 by compressing the third spring 70 as the ratchet 64 is moved to the left. Assuming the momentum from the input member 12 to the coupling member 18 and sleeve 34 is insufficient to cause the plunger assembly 78 to seat the rack teeth 76 behind the sleeve 34 and, accordingly, the coupling member 18 comes to rest with the worm thread 38 still in engagement with the rack teeth 76 as shown in Figure 2, the teeth 24 will continue to be held disengaged from the teeth 16, and no further rotational forces will be transmitted from the input shaft 12 to the driven member 28. The detent ratchet 64 with the one-way teeth 66 in engagement with the clutch teeth 40 will prevent the sleeve 34 and the coupling member 18 from moving back toward the right and thereby will prevent reengagement of the teeth 24 with the teeth 16.

When it is desired to recouple the coupling member 18 to the input shaft 12, the same operation as previously described takes place, namely withdrawal of the plunger assembly 78 to retract the rack teeth 76 from their engagement with the worm thread 38. Immediately upon disconnecting the rack teeth 76 from the worm thread 38, the first spring 48 will be reapplied to the coupling member 18 by driving the collar 46, ring 42 and washer 45 against the shoulder 43 to drive the sleeve 34 and coupling member 18 to the right to remesh the teeth 24 on the coupling member with the teeth 16 on the input shaft 12.

From the above, it can be seen that the disconnect mechanism prevents the constant speed drive transmission from reengaging accidentally with the input shaft 12 until some affirmative action is taken to reengage

the drive therebetween.

WHAT WE CLAIM IS:-

1. A disconnectable drive transmission having an input shaft, coupling means axially aligned with and selectively driven by said input shaft, a driven member splined to the coupling means, an axially movable worm-threaded member splined to the coupling means, a first spring acting on the coupling means through the worm-threaded member to urge the coupling means into coupled relationship with the input shaft, a second spring acting on the coupling means to urge the coupling means out of coupled relationship with the input shaft after axial movement of the worm-threaded member has relieved the coupling means of the bias of the first spring, and rack means movable into engagement with the worm-threaded member whereby the rotation of the input shaft and coupling means will thread the worm over the rack means, first to compress the first and second springs and then to disconnect the coupling means from the input shaft, the second spring urging the coupling means away from the input shaft on disconnection of the coupling means from the input shaft.
2. A drive transmission according to claim 1, wherein the rack means movable into contact with the worm-threaded member comprises a rack gear on a plunger and adapted to be driven into meshing relationship with the worm-threaded member.
3. A drive transmission according to either preceding claim, wherein axial movement of the worm-threaded member in a direction to relieve the coupling means of the bias of the first spring means causes engagement of the worm-threaded member with ratchet means for preventing rotation of the worm-threaded member in a sense

such as to produce axial movement in the reverse direction.

4. A drive transmission according to claim 3, wherein the ratchet means comprise one-way ratchet teeth on an axially movable member that is secured against rotation and cooperating detent teeth on the worm-threaded member.
5. A drive transmission according to claim 4, wherein the axially movable member is movable against the bias of third spring means so as to yield to axial movement of the worm-threaded member.
6. A drive transmission according to any preceding claim, wherein the worm-threaded member is an externally screw-threaded collar splined to the coupling means.
7. A drive transmission according to any preceding claims, wherein the coupled relationship between the coupling means and the input shaft is one in which axially extending teeth on an end face of the coupling means engage corresponding axially extending teeth on an end face of the input shaft.
8. A drive transmission according to any preceding claim, wherein the first spring is provided between the driven member and the worm-threaded member.
9. A drive transmission according to claim 8, wherein the second spring is provided between the coupling means and the worm-threaded member.
10. A disconnectable drive transmission substantially as particularly described herein with reference to the drawings.

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2. A drive transmission according to claim 1, wherein the rack means movable into contact with the worm-threaded member comprises a rack gear on a plunger and adapted to be driven into meshing relationship with the worm-threaded member.
3. A drive transmission according to either preceding claim, wherein axial movement of the worm-threaded member in a direction to relieve the coupling means of the bias of the first spring means causes engagement of the worm-threaded member with ratchet means for preventing rotation of the worm-threaded member in a sense

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9. A drive transmission according to claim 8, wherein the second spring is provided between the coupling means and the worm-threaded member.
10. A disconnectable drive transmission substantially as particularly described herein with reference to the drawings.

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