

SPECIFICATION

An integrated drive-generator assembly

5 This invention pertains to an integrated drive-generator system as usable in aircraft wherein an aircraft engine is used as a power source for an electrical generating system for the aircraft.

10 In the conventional system, a drive shaft connectable to an output shaft driven by an aircraft engine is connected to a mechanical differential, with the differential having an output connected to drive the generator. A
15 variable speed transmission, such as a hydrostatic transmission, is associated with the mechanical differential and controlled to modify the output of the differential, as required, whereby the input speed to the generator
20 remains constant even though the speed of the drive shaft may vary. Previous systems have incorporated a differential that spanned the length of the units of the hydrostatic transmission resulting in longer length shaft-
25 ing and has required accessory drive jack shafts.

Examples of prior art systems are shown in a number of patents owned by the assignee of this application, including U.S. Patent No.
30 3,576,143 and U.S. Patent No. 3,786,696. These patents show a variety of structural arrangements for a constant speed drive and generator system, but which have the components structurally related to require a longer
35 length unit and a total package having a corresponding weight disadvantage.

The invention provides an integrated drive-generator assembly comprising a housing mounting a drive input shaft, a variable speed
40 transmission, a generator transversely spaced from the transmission and a mechanical differential, also transversely spaced from the transmission and positioned adjacent the transmission and the generator, wherein the
45 mechanical differential comprises a first drive input connection from the drive input shaft, a first drive output connection to the variable speed transmission, a second drive input connection from the variable speed transmission
50 and a second drive output connection to the generator, and wherein the drive connections to and from the variable speed transmission are at the same end of the transmission and the second and optionally the first drive input
55 connections and the first and second drive output connections are grouped in a narrow working zone at an end of the housing. The novel disposition of drive connections in the assembly of the invention enables integrated
60 drive generator assemblies to be designed which have new and improved size, weight, and mounting characteristics. In such assemblies the variable speed transmissions (such as a hydrostatic transmission) extends alongside
65 the differential and the drive input shaft, and

the generator is also positioned alongside the differential and the drive input shaft.

Advantageously the variable speed
70 transmission is a hydrostatic transmission with a pair of coaxial units hydraulically connected to each other. The units are connected to the differential by the first drive output and second drive input connections respectively, of which each connection comprises a gear asso-
75 ciated one with each of a pair of shafts which are connected to their respective units. Both of the gears are disposed at one end of the hydrostatic transmission within the narrow working zone at an end of the housing.
80 The mechanical differential preferably has a carrier mounting a pair of intermeshing pinion gears and a pair of ring gears associated one with each of the pinion gears. The carrier is connected to the drive input shaft to define
85 the first drive input connection and is geared to the variable speed transmission to define the first drive output connection. One of the ring gears is gear-connected to the generator to define the second drive output connection,
90 while the other ring gear is connected to the variable speed transmission to provide the second drive input connection. The carrier preferably comprises a ring of external gear teeth which are located between the two ring
95 gears and which mesh with an input gear of the variable speed transmission.

With the foregoing construction, all of the drive connections and gear ring structure may be located at one end of the housing of the
100 system, and the structure can be mounted generally vertically, with the gears positioned away from the sump of the unit to avoid oil churning losses for better efficiency of operation.

105 The assembly of the invention lends itself particularly to the use of multiple hydrostatic transmissions to share the torque through the variable speed transmission. For example, a second variable speed transmission can be
110 provided in the housing, alongside the first variable speed transmission and sharing the first drive output connection and the second drive input connection. It follows therefore that the drive connections to and from the
115 second and any additional variable speed transmissions (which are also preferably hydrostatic transmissions) are at the same end of the transmission within the narrow working zone. According to the invention the compo-
120 nents can be positioned close to a mounting pad for the housing to minimize structural loading with resulting weight reduction.

More particularly, past systems have generally had a length in the order of 48 to 56 cms
125 (19 to 22 inches) while the system disclosed herein can have a length of approximately 33 cms (13 inches), with this reduced length being critical in some uses of the system.

The invention is illustrated in the drawings
130 of which:

Figure 1 is a plan section of the integrated drive-generator system, taken generally along the line 1-1 in Fig. 2; and

Figure 2 is a vertical section on a slightly enlarged scale, taken generally along the line 2-2 in Fig. 1.

As shown in Fig. 1, the integrated drive-generator system has a housing, indicated generally at 10, with an enclosing top cover 11 secured thereto, as by a series of fastening devices 12.

Components of the system include an electrical generator, indicated generally at 15, which is to be operated at a constant speed by means of a drive applied to a drive input shaft 16. The drive does not go directly to the generator, since the speed of the input shaft 16 may vary, dependent upon the speed of the prime mover, such as an aircraft engine to which the system is connected.

The system includes a mechanical differential, indicated generally at 17, and two variable speed transmissions, each indicated generally at 18 and each preferably in the form of a hydrostatic transmission.

The generator 15 has a pair of stators 20 and 21 associated with rotors 22 and 23 and which have electrical windings associated therewith. The rotors 22 and 23 are mounted on a shaft 25 which has a pair of bearings 26 and 27 positioned at opposite ends thereof and supported within the housing 10 whereby the rotors are mounted for rotation relative to the stators.

The drive input shaft 16 receives its drive from a connecting shaft 30 having a splined section 31 located externally of the housing 10 for connection to an output drive from a prime mover, such as an aircraft engine. Rotation of shaft 30 is imparted to the drive input shaft 16 through a quick-disconnect structure, indicated generally at 35.

Generally, the quick-disconnect structure includes a disconnectable clutch 36 between the drive input shaft 16 and the shaft 30 and a quick-disconnect operator 37 which may be moved from the position shown in Fig. 2 toward the axis of the drive input shaft to cause engagement between gear teeth 38 and 39 and which causes movement of the drive input shaft 16 toward the left, as viewing in Fig. 2, against the action of a spring 40 to release clutch 36 which stops the drive of the drive input shaft 16.

The mechanical differential has a carrier 50 and a pair of annular spaced-apart ring gears 51 and 52. The carrier 50 has a tubular end 53 with an internal spline relation with an end of the drive input shaft 16 permitting axial movement of the drive input shaft while maintaining a drive relation thereof to the carrier.

The carrier rotatably mounts a pair of intermeshing pinion gears 55 and 56 which are associated, one with each of the ring gears 51 and 52, respectively. Additionally, the carrier

has a series of external gear teeth 57 positioned in the space between the ring gears 51 and 52.

The components of the mechanical differential are supported relative to the housing and each other by a series of bearings, including a bearing 60 surrounding the ring gear 52 and supported by an internal frame member 61 which is secured to the housing 10. A bearing 62 is interposed between a cylindrical section 63 of the ring gear 52 and the carrier 50 for support of the carrier at one end thereof. The carrier extends to the opposite end of the differential and has a bearing 65 interposed between it and a cylindrical end of the ring gear 51. An additional bearing 66 surrounds the cylindrical end of the last-mentioned ring gear and is supported by a cylindrical section of the cover 11. Additional bearings 70 and 71 are positioned between the interior surfaces of the ring gears 51 and 52 and the exterior surface of the carrier 50 and immediately to either side of the external teeth 57 on the carrier.

The pinion gear 55 meshes with internal gear teeth 80 on the ring gear 51 and the mesh between ring gear 52 and pinion gear 57 is by internal teeth 81 on the ring gear 52.

Each variable speed transmission 18 is a hydrostatic transmission having hydraulically-connected coaxial units. These units are axial piston units and one unit is a fixed displacement motor 90 while the other unit is a variable displacement pump 91. Each of the units is of the same basic structure, including rotatable cylinders 92 and 93, respectively, in which pistons reciprocate under the control of a swash plate.

The motor 90 has pistons 95 under the control of a swash plate 96 which is at a fixed angle while the pump 91 has pistons 97 whose stroke is controlled by a swash plate 98 which is mounted to have its angle varied by control structure, not shown. The cylinder 93 of the pump 91 is driven through an element of the mechanical differential which is connected to a tubular quill shaft 100 which is splined to the cylinder 93, as shown at 101. The fixed displacement motor 90 drives an element of the differential through a shaft 105 which is splined to the cylinder 92 of the motor and which extends through the tubular quill shaft 100 to a point of drive connection to the mechanical differential.

The mechanical differential has two drive input connections and two drive output connections. The first drive input connection is that of the carrier 50 to the drive input shaft 16. The second drive input connection is from the fixed displacement unit 90 of each hydrostatic transmission by rotation of the shaft 105 which has a gear 120 which meshes with teeth of an external gear 121 on the ring gear 51. The first drive output connection



from the mechanical differential is from the external gear teeth 57 on the carrier which mesh with a gear 125 on the tubular quill shaft 100 to provide a direct input from the input drive shaft 16 to each variable speed unit 91. The second drive output connection is from the ring gear 52 which has an external gear 130 which meshes with a gear 131 carried by a member 132 which is internally splined to the rotor shaft 25 of the generator 15.

With the disclosed structure, the speed of drive input shaft 16 can be monitored and, as necessary, the displacement of each variable displacement unit 91 varied whereby there is a constant speed of rotation of the ring gear 52 to provide a constant speed drive of the rotors of the generator 15. The structure for monitoring the input speed and controlling the hydrostatic transmissions is well known in the art and does not form a part of the present invention.

The structural arrangement disclosed herein enables placement of both the variable speed transmissions and the generator alongside the drive input shaft 16 and the mechanical differential 17. As shown in Fig. 1, it is thus possible to have two of the transmission units 18 associated with and sharing the torque from the mechanical differential whereby each of the transmissions can be of a smaller size for more efficient operation. Location of the gears 120 and 125 associated with the hydrostatic transmission at one end thereof enables the use of a relatively short mechanical differential, with its length determined by only the necessary gear and bearing span requirements. Resultingly, there is a short length integrated drive-generator system which requires smaller space for installation and which results in lighter weight. All of the motion-transmitting gearing lies in a relatively narrow gear plane which can be located at the top of the unit for minimizing losses due to churning of lubricating and cooling oil. Also, all components are positioned close to the mounting pad for the structure of the system to minimize structural loading which also results in weight reduction because of reduced structural loading, both within the housing as well as on the supporting structure for the system.

CLAIMS

1. An integrated drive-generator assembly comprising a housing mounting a drive input shaft, a variable speed transmission, a generator transversely spaced from the transmission and a mechanical differential, also transversely spaced from the transmission and positioned adjacent the transmission and the generator, wherein the mechanical differential comprises a first drive input connection from the drive input shaft, a first drive output connection to the variable speed transmission, a second drive input connection from the

variable speed transmission and a second drive output connection to the generator, and wherein the drive connections to and from the variable speed transmission are at the same end of the transmission and the second drive input connection and the first and second drive output connections are grouped in a narrow working zone at an end of the housing.

2. An assembly according to claim 1, wherein the variable speed transmission is a hydrostatic transmission.

3. An assembly according to claim 2, wherein the hydrostatic transmission comprises a pair of hydraulically-connected coaxial units with one unit having a variable displacement and being connected to the first drive output connection, and the other unit being connected to the second drive input connection.

4. An assembly according to claim 3, wherein each of the units has a separate rotatable shaft associated therewith, and one of the shafts is tubular and has the other shaft positioned therein to provide the connections with the mechanical differential at the same end of the transmission.

5. An assembly according to any preceding claim, further comprising a second variable speed transmission in the housing, alongside the first-mentioned transmission and sharing the first drive output connection and the second drive input connection to share the torque through the first-mentioned transmission.

6. An assembly according to claim 5, wherein the second variable speed transmission is a hydrostatic transmission comprising a pair of hydraulically-connected coaxial units each having a separate rotatable shaft associated therewith and one of the shafts is tubular and has the other shaft positioned therein to provide the connection with the mechanical differential at the same end of the transmission.

7. An assembly according to any preceding claim wherein the mechanical differential comprises a carrier carrying a pair of intermeshing pinion gears, and a pair of ring gears associated one with each of the pinion gears, the carrier being connected to the drive input shaft to define the first drive input connection and being geared to the variable speed transmission to define the first drive output connection, one of the ring gears being geared to the variable speed transmission to define the second drive input connection, and the other of the ring gears being geared to the generator to define the second drive output connection.

8. An assembly according to claim 7, wherein the first drive output connection comprises a ring of external carrier teeth on the carrier meshing with an input gear of the variable speed transmission, and the ring

from the mechanical differential is from the external gear teeth 57 on the carrier which mesh with a gear 125 on the tubular quill shaft 100 to provide a direct input from the input drive shaft 16 to each variable speed unit 91. The second drive output connection is from the ring gear 52 which has an external gear 130 which meshes with a gear 131 carried by a member 132 which is internally splined to the rotor shaft 25 of the generator 15.

With the disclosed structure, the speed of drive input shaft 16 can be monitored and, as necessary, the displacement of each variable displacement unit 91 varied whereby there is a constant speed of rotation of the ring gear 52 to provide a constant speed drive of the rotors of the generator 15. The structure for monitoring the input speed and controlling the hydrostatic transmissions is well known in the art and does not form a part of the present invention.

The structural arrangement disclosed herein enables placement of both the variable speed transmissions and the generator alongside the drive input shaft 16 and the mechanical differential 17. As shown in Fig. 1, it is thus possible to have two of the transmission units 18 associated with and sharing the torque from the mechanical differential whereby each of the transmissions can be of a smaller size for more efficient operation. Location of the gears 120 and 125 associated with the hydrostatic transmission at one end thereof enables the use of a relatively short mechanical differential, with its length determined by only the necessary gear and bearing span requirements. Resultingly, there is a short length integrated drive-generator system which requires smaller space for installation and which results in lighter weight. All of the motion-transmitting gearing lies in a relatively narrow gear plane which can be located at the top of the unit for minimizing losses due to churning of lubricating and cooling oil. Also, all components are positioned close to the mounting pad for the structure of the system to minimize structural loading which also results in weight reduction because of reduced structural loading, both within the housing as well as on the supporting structure for the system.

CLAIMS

1. An integrated drive-generator assembly comprising a housing mounting a drive input shaft, a variable speed transmission, a generator transversely spaced from the transmission and a mechanical differential, also transversely spaced from the transmission and positioned adjacent the transmission and the generator, wherein the mechanical differential comprises a first drive input connection from the drive input shaft, a first drive output connection to the variable speed transmission, a second drive input connection from the

variable speed transmission and a second drive output connection to the generator, and wherein the drive connections to and from the variable speed transmission are at the same end of the transmission and the second drive input connection and the first and second drive output connections are grouped in a narrow working zone at an end of the housing.

2. An assembly according to claim 1, wherein the variable speed transmission is a hydrostatic transmission.

3. An assembly according to claim 2, wherein the hydrostatic transmission comprises a pair of hydraulically-connected coaxial units with one unit having a variable displacement and being connected to the first drive output connection, and the other unit being connected to the second drive input connection.

4. An assembly according to claim 3, wherein each of the units has a separate rotatable shaft associated therewith, and one of the shafts is tubular and has the other shaft positioned therein to provide the connections with the mechanical differential at the same end of the transmission.

5. An assembly according to any preceding claim, further comprising a second variable speed transmission in the housing, alongside the first-mentioned transmission and sharing the first drive output connection and the second drive input connection to share the torque through the first-mentioned transmission.

6. An assembly according to claim 5, wherein the second variable speed transmission is a hydrostatic transmission comprising a pair of hydraulically-connected coaxial units each having a separate rotatable shaft associated therewith and one of the shafts is tubular and has the other shaft positioned therein to provide the connection with the mechanical differential at the same end of the transmission.

7. An assembly according to any preceding claim wherein the mechanical differential comprises a carrier carrying a pair of intermeshing pinion gears, and a pair of ring gears associated one with each of the pinion gears, the carrier being connected to the drive input shaft to define the first drive input connection and being geared to the variable speed transmission to define the first drive output connection, one of the ring gears being geared to the variable speed transmission to define the second drive input connection, and the other of the ring gears being geared to the generator to define the second drive output connection.

8. An assembly according to claim 7, wherein the first drive output connection comprises a ring of external carrier teeth on the carrier meshing with an input gear of the variable speed transmission, and the ring



gears are positioned one on each side of the ring of external carrier teeth and carry external teeth meshing with, respectively, an output gear of the variable speed transmission and an input gear of the generator.

- 5 9. An integrated drive-generator assembly substantially as described herein with reference to the drawings.

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