GEARING

The present invention relates to gearing, and in particular relates to epicyclic gearing having single helical teeth.

Few large gearboxes are designed using single helical teeth because the transmission of torque between the gear wheels through teeth lying at an angle to the axis of rotation of the wheels produces an end load on the wheels. This end load applied on opposite sides of a gear wheel in a gear train produces a tipping moment on the wheel, which is in proportion to the loads transmitted between the teeth of the wheels.

In order to avoid these tipping moments, large gear boxes are usually made with gear wheels having double helical teeth, that is, each wheel has two sets of helical teeth with helix angles of opposite senses, so that the end loads produced on opposite ends of the wheels are balanced and the tipping moment is eliminated.

However, in the manufacture of double helical teeth it requires very accurate machining to produce opposite tooth pairs which can mesh correctly together.

The object of the present invention is to produce a single helical gear train in which the tipping moments are substantially reduced or eliminated.

According to the present invention a gear train comprises first and second gears with an intermediate gear meshing between the two , all the gears having single helical teeth, the first and second gears being arranged to mesh with different axial portions of the teeth of the intermediate gear so that in operation the radial components of the tooth loads on the intermediate gear due to the pressure angles of the teeth, produce a couple which opposes the tipping moment on the intermediate gear due to the helix angle of the teeth.

By omptimizing the helix angle, tooth sizes and widths of the gears, the tipping moment can be eliminated without the intermediate gear becoming impractically long.

Also according to the present invention an epicyclic gear train comprises a sun wheel, a plurality of planet wheels and a surrounding annulus gear, all of which have single helical teeth, each of the planet wheels being mounted on a bearing pin, the sun wheel and the annulus gear being arranged to mesh with different axial portions of the teeth on each of the planet wheels so that in operation the radial components of the tooth loads on the planet wheels due to the pressure angles of the gear teeth produce couples acting on the planet wheels in opposition to the tipping couples on the planet wheels due to the helix angle of the gears.

The invention will now be described in more detail, merely by way of example, with reference to the accompanying drawings in which :

FIG. 1 illustrates diagrammatically a gas turbine engine incorporating the gear box of the present invention, and,

FIG. 2 is a half-section through the gear box of the engine of FIG. 1.

Referring now to the drawings, FIG. 1 illustrates one application of the invention in a gas turbine engine **1**, which comprises a gas generator **2** arranged to drive a fan **3** through a gear box **4**. The gas generator **2**,which produces the power to drive the fan, may be of any desired type, since the type of the gas generator used is not relevant to the invention. The gas generator will, however, include a compressor **5**, combustion equipment **6**, and one or more turbines **7**, for driving the compressor and the fan.

FIG. 2 illustrates the gearbox **4** in greater detail, and referring now to this figure, there is illustrated an epicyclic gear train comprising a sun wheel, **10**, which meshes with a plurality of planet wheels **11** which are supported on bearing pins **12** in a cage for rotation about their own axes. The sun wheel is driven via a shaft **14** from the forward end of the gas generator **2** and the planet wheel cage is connected by a shaft **15** to the fan for driving the fan.

The planet wheels mesh in turn with a stationary annulus gear **18** which causes the planets to rotate about the axis of the engine as well as around their own axes.

The planet cage comprises a plurality of bearing sleeves **20** sandwiched between annular flanges **21** and **22**, flange **21** being formed on the end of the shaft **15**, and flange **22** being formed on one end of a ring **23** which has at its other end the radially inner race **24** of the main bearing **25** for the cage. Each of the sleeves **20** are splined at **27** to the bearing pin **12** which is formed with several accurately machined diameters to provide an accurate fit in the sleeve **20**, and the assembly of sleeves and flanges is clamped by means of a nut **28** which screws onto the end of the pin. The outer race **29** of the bearing **25** is connected to fixed structure **30** which is supported from the outlet guide vanes of the fan.

In the epicyclic gear train described above, all the gear teeth are of single helical form in order to simplify the manufacture of the teeth. This results in there being an end load produced on the various elements in the gear train, and the end forces on opposite sides of the planet wheels (indicated by the arrows A A) cause a tipping moment on the wheels, which tends to tip each wheel in a radial plane about the center of its bearing.

In order to counteract this, the length of the planet wheel is increased and the centers of the sun wheel and annulus gear are offset along the axis of the planet, which results in the sun wheel and annulus gear meshing with different axial portions of the teeth on each of the planet wheels. The portions of teeth on the planet wheels with which the annulus gear and the sun wheel mesh may be totally different or may include a common portion.

By this means the radial components of the tooth loads due to the pressure angles of the teeth on both the sun wheel and annulus gear become offset axially of the planet wheel, and these loads, shown by arrows B B, produce a couple which opposes the tipping couple on the planet wheel.

In order to make sure that the offset between the sun wheel and the annulus gear is kept to a small value so that the planet wheel does not become impractically long, certain criteria are employed in the design of the planet wheel.

First of all an overlap ratio between the teeth of unity is used. This means that only one tooth is in mesh with another tooth at any one time, and this in turn fixes a maximum helix angle for a given wheel.

The second feature employed is to keep the tooth height to a minimum practicable figure and employ more teeth. This brings the teeth closer together so that for the given overlap ratio the helix angle is reduced.

Thirdly, the teeth are made as long as possible, preferably equal to the diameter of the wheel, so that once again the helix angle is kept down.