

May 28, 1963

T. SHELLEY
GAS TURBINE ENGINES

3,091,382

Filed Sept. 15, 1961

2 Sheets-Sheet 1

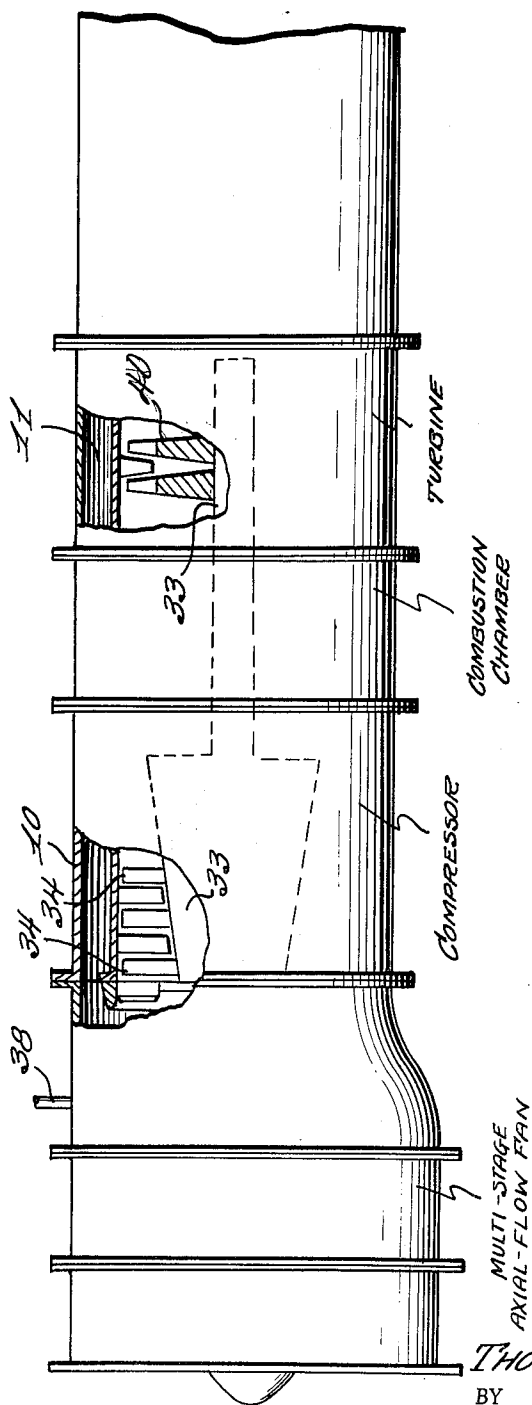


FIG. 1

INVENTOR.
THOMAS SHELLEY
BY

Cushman, Darby & Cushman
ATTORNEYS

May 28, 1963

T. SHELLEY
GAS TURBINE ENGINES

3,091,382

Filed Sept. 15, 1961

2 Sheets-Sheet 2

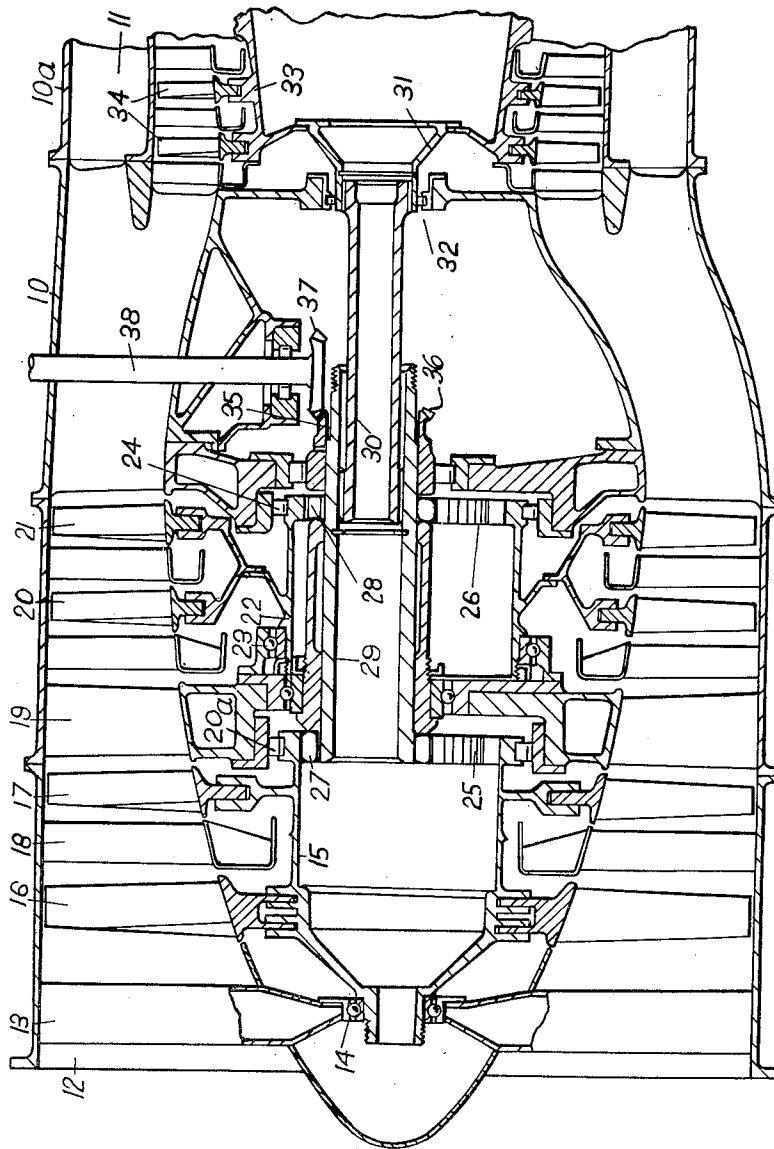


FIG. 2-

Inventor
Thomas Shelley
By
Cushman, Darby & Cushman
Attorneys

1

3,091,382

GAS TURBINE ENGINES

Thomas Shelley, Breaston, Derby, England, assignor to
Rolls-Royce Limited, Derby, England
Filed Sept. 15, 1961, Ser. No. 138,384

Claims priority, application Great Britain Sept. 29, 1960
11 Claims. (Cl. 230-116)

This invention relates to gas turbine engines and in particular, but not exclusively, to gas turbine engines having a single shaft connecting a turbine or turbines to the compressor or compressors or fan or fans.

In single shaft gas turbine engines it is important to maintain the tip speeds of the compressor or fan rotor blades within predetermined limits. Where a single shaft engine is designed to rotate a high pressure compressor and a low pressure compressor or fan the diameter of the blade tips of the low pressure compressor or fan is usually much larger than the diameter of the blade tips of the high pressure compressor, therefore, if the rotational speed of the engine rotor shaft is chosen to give the correct tip speed of the high pressure compressor rotor blades then the tip speeds of the low pressure compressor or fan rotor blades becomes too great, resulting in an increase in noise and a loss in efficiency.

It is, therefore, desirable to rotate the low pressure compressor or fan at a much lower rotational speed than the rotational speed of the high pressure compressor in order to obtain the correct tip speeds of the rotor blades.

It has previously been proposed to drive the low pressure compressor or fan from the engine rotor shaft through reduction gearing comprising a system of spur gears mounted on lay-shafts, both the engine rotor shaft and the low pressure compressor or fan rotor shaft being mounted on the same rotational axis.

Such gear systems suffer from the disadvantages of low mechanical efficiency and high bearing loading usually associated with systems employing lay-shafts and spur gears.

I propose to split the low pressure compressor or fan rotor into two components each with its own drive. By splitting the drive pinion into two, each pinion only has to handle half the power required and this enables the dimensions of the gearing itself and associate bearings and housings to be kept sufficiently small as not to have any appreciable effect on the size of the aerodynamic passage through the compressor or fan. The gearing does not employ lay-shafts and spur gears.

According to the present invention a gas turbine engine includes a compressor, a turbine, a first shaft drivingly interconnecting the compressor and turbine, a multi-stage axial-flow fan, an additional shaft and reduction gearing, said additional shaft drivingly interconnecting said first shaft through said reduction gearing and said multi-stage axial-flow fan, the longitudinal axis of said multi-stage axial-flow fan being displaced laterally with respect to the longitudinal axis of said first shaft, said reduction gearing comprising a first part which drives at least one stage of the multi-stage axial-flow fan and a second part which drives at least one other stage of the multi-stage axial-flow fan.

Preferably there are four stages of rotatable blades in the additional fan and two stages are driven by one part of the reduction gear, and the other two stages by the other part of the reduction gear.

In one arrangement of the invention the pinion is split into two portions of different size or different number of teeth and co-operating with an appropriate internally toothed annulus so that the two portions of the fan, which are separately rotatable, are made to rotate at different speeds.

The gear teeth may be helical with opposite angles of

2

helix on each of the pinion halves so as to balance pinion thrust.

If the power requirements are small, the gears can have conventional straight teeth.

One embodiment of the present invention, to which the invention is in no way limited, will now be described with reference to the accompanying drawing which is a section through the front portion of a gas turbine engine with a four stage front fan.

FIGURE 1 is a schematic side-elevational view, partly in section, and illustrating one preferred form of gas turbine engine according to the present invention; and

FIGURE 2 is an enlarged vertical sectional view of the forward portion of the gas turbine of FIGURE 1 and illustrating in detail the multi-stage axial-flow fan and its relationship to the compressor of the gas turbine engine.

In FIGURES 1 and 2 of the drawings, the gas turbine engine of the present invention is shown with an engine outer casing 10 which also acts as the outer wall 10a of a by-pass duct 11. The engine has an intake 12 and inlet guide vanes 13 which support a ball thrust bearing 14 on which is mounted a rotor shaft 15 of drum type. The rotor shaft 15 carries two rows 16 and 17 of rotating fan blades between which is a row of fixed blades 18. Downstream of the rotating blades 17 is a row of fixed vanes 19 which support a roller bearing 20a on which the downstream end of the shaft 15 is rotatably mounted.

Two more rows of rotating blading 20 and 21 are attached to a second fan rotor shaft 22 which is supported by a ball thrust bearing 23 at its front end and a roller bearing 24 at its rear end. The rear portions of rotor shafts 15 and 22 each have respective internally toothed annular gears 25 and 26 formed integrally on them.

The two rotor shafts are driven through the annular gears by means of two parts 27 and 28 of a split helically toothed pinion, the two parts being splined on to a rotor driven shaft or pinion shaft 29. This shaft is in turn driven by a connecting shaft 30 which is splined to the shaft 29. The shaft 30 is splined to member 31 mounted in roller bearings 32 and attached to a drumlike main shaft 33 which carries rows 34 of rotatable compressor blades driven by a turbine 40.

The shaft 29 also drives, through a sleeve 35 and gears 36 and 37, accessory drive shaft 38.

It will be seen that the shafts 15 and 22 are coaxial but their longitudinal axes are offset laterally with respect to the longitudinal axis of the connecting shaft 30 and the main shaft 33.

With the arrangement described any desired tip speed of the fan rotor blades can be obtained and by varying the size of pinions 27 and 28, or by varying the number of teeth on those pinions or on the annular gears 25 and 26, the pairs of rotor blades 16, 17; 20, 21 can be made to rotate at different speeds if desired.

By having the pinions split in the manner shown the size of the pinion and of the adjacent bearings and shaft can be kept small enough so as to enable a construction of this type to be housed in a small area thus not interfering with the aerodynamic passage through the fan.

What I claim is:

1. In a gas turbine engine: compressor means and turbine means arranged in series and having a common axis of rotation; shaft means drivingly connecting said compressor means to said turbine means; a multi-stage axial-flow fan arranged in series with said compressor means and said turbine means, said multi-stage axial-flow fan having an axis of rotation displaced laterally from and parallel to the common axis of rotation of said compressor means and said turbine means; and means drivingly connecting said multi-stage axial-flow fan to said

shaft means, said last-mentioned means including reduction gearing having a first part for driving at least one stage of said multi-stage axial-flow fan and a second part for driving at least another stage of said multi-stage axial-flow fan.

2. The gas turbine engine as claimed in claim 1 in which said multi-stage axial-flow fan includes four stages of rotatable blades, said first part of said reduction gearing driving two of said stages and said second part driving the other two stages.

3. The gas turbine engine as claimed in claim 1 wherein said first part of said reduction gearing has a gear ratio different from the gear ratio of said second part so that said at least one stage of said multi-stage axial-flow fan rotates at a different speed from said at least another stage of said multi-stage axial-flow fan.

4. The gas turbine engine as claimed in claim 1 wherein said reduction gearing includes helical gear teeth, said gear teeth of said first part having an opposite angle of helix to an angle of helix of said gear teeth of said second part whereby pinion thrust is balanced.

5. In a gas turbine engine: compressor means and turbine means arranged in series and having a common axis of rotation; shaft means drivingly connecting said compressor means to said turbine means; a multi-stage axial-flow fan arranged in series with said compressor means and said turbine means, said multi-stage axial-flow fan having an axis of rotation displaced laterally from and parallel to the common axis of rotation of said compressor means and said turbine means; a first rotor shaft for carrying at least one stage of said multi-stage axial-flow fan, a second rotor shaft for carrying at least another stage of said multi-stage axial-flow fan; and means operatively connecting said first rotor shaft and said second rotor shaft to said shaft means.

6. The gas turbine engine as claimed in claim 5 wherein said last-mentioned means includes a first internally-toothed annular gear carried by said first rotor shaft

and a second internally-toothed annular gear carried by said second rotor shaft, a shaft operatively connected to said shaft means, and a first pinion gear carried on said last-mentioned shaft and meshing with said first internally-toothed annular gear and a second pinion gear carried on said last-mentioned shaft and meshing with said second internally-toothed annular gear.

7. The gas turbine engine as claimed in claim 6 wherein said first and second internally-toothed annular gears and said first and second pinion gears have helical gear teeth, the helical gear teeth of said first pinion gear having an opposite angle of helix to the helical gear teeth of said second pinion gear whereby pinion thrust is balanced.

8. The gas turbine engine as claimed in claim 6 wherein said first internally-toothed annular gear and said first pinion gear meshing therewith have a gear ratio different from the gear ratio of said second internally-toothed annular gear and said second pinion gear meshing therewith, whereby said first rotor shaft rotates at a different speed from said second rotor shaft.

9. The gas turbine engine as claimed in claim 6 wherein said first rotor shaft is tubular and wherein said first internally-toothed annular gear is integrally carried by said first tubular shaft, and wherein said second rotor shaft is tubular and said second internally-toothed annular gear is integrally formed on said second tubular rotor shaft.

10. The gas turbine engine as claimed in claim 5 in which said first rotor shaft carries at least two stages of said multi-stage axial-flow fan and in which said second rotor shaft carries at least two other stages of said multi-stage axial-flow fan.

11. The gas turbine engine as claimed in claim 5 wherein said multi-stage axial-flow fan is positioned forward of the intake of said compressor means.

References Cited in the file of this patent

FOREIGN PATENTS

613,424 Canada Jan. 31, 1961