United States Patent [19]

Davies et al.

[11] **3,720,060**

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[54] **FANS**

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[21] Appl. No.: **91,000**

[52] **U.S. Cl.**..................**60/226 R,** 60/39.31, 415/79, 415/201

[51] **Int. Cl.**..**F02k 3/00**

[58] **Field of Search** 60/226, 39.31, 262; 415/77, 415/79, 201; 416/157; 417/360

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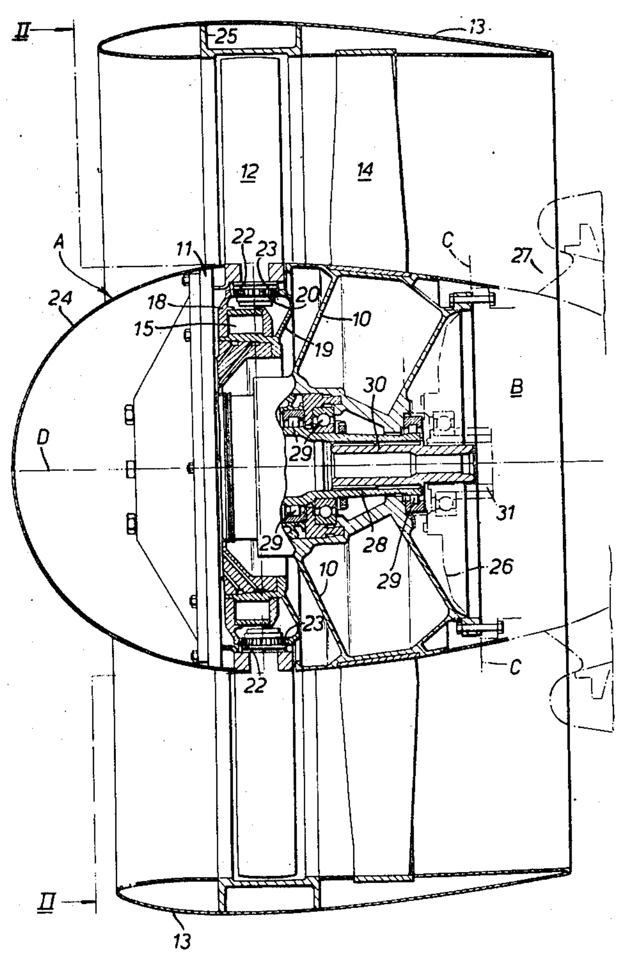
[57] **ABSTRACT**

A fan assembly for attachment to the front of a main gas turbine engine assembly to provide an engine of the ducted-fan by-pass type is constructed as a unitary assembly which can be fitted and removed as such. The assembly comprises a non-rotative portion including a main body and a by-pass duct, and a rotative sub-assembly supported in bearings by the non-rotative portion and including a hub structure and fan blading positioned and rotatably supported within the non-rotative by-pass duct.

13 Claims, 4 Drawing Figures



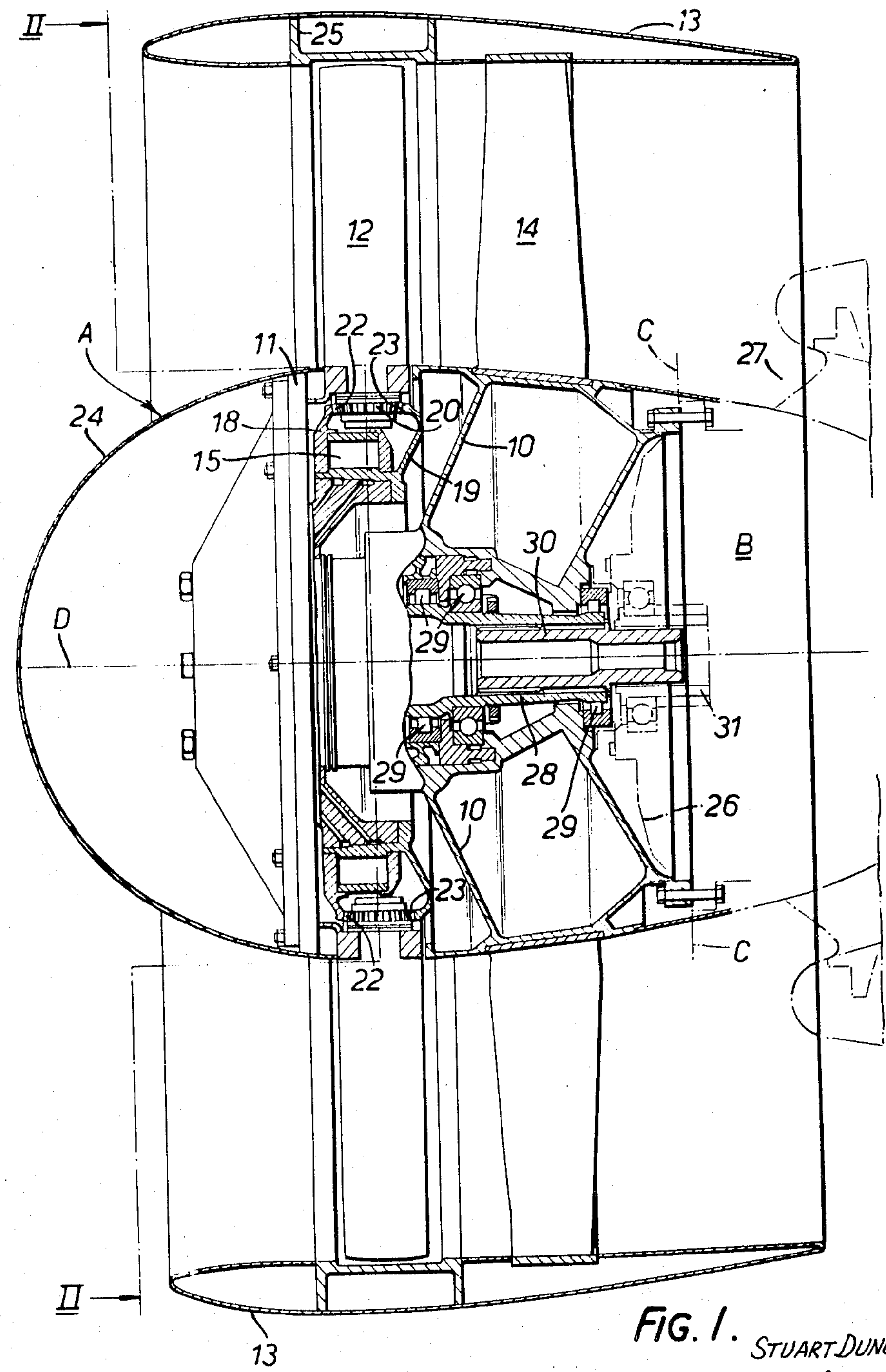


FIG. 1.

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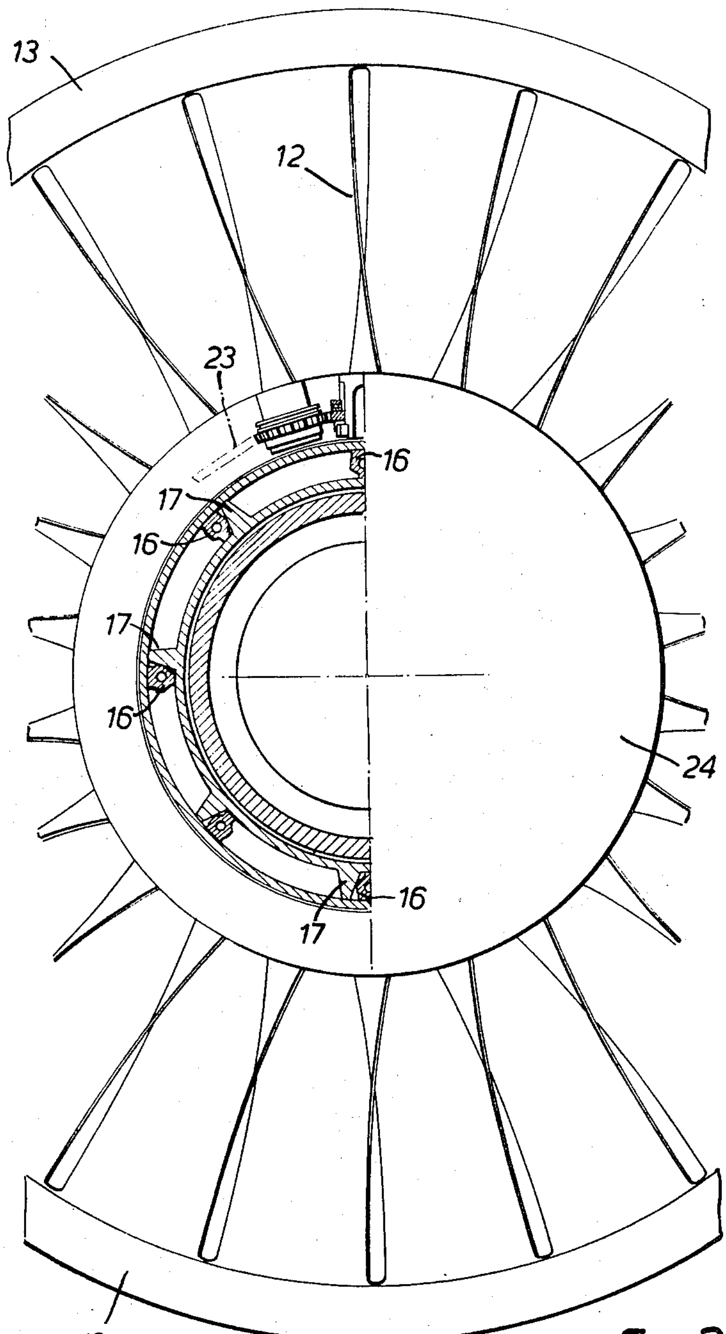

FIG. 2.

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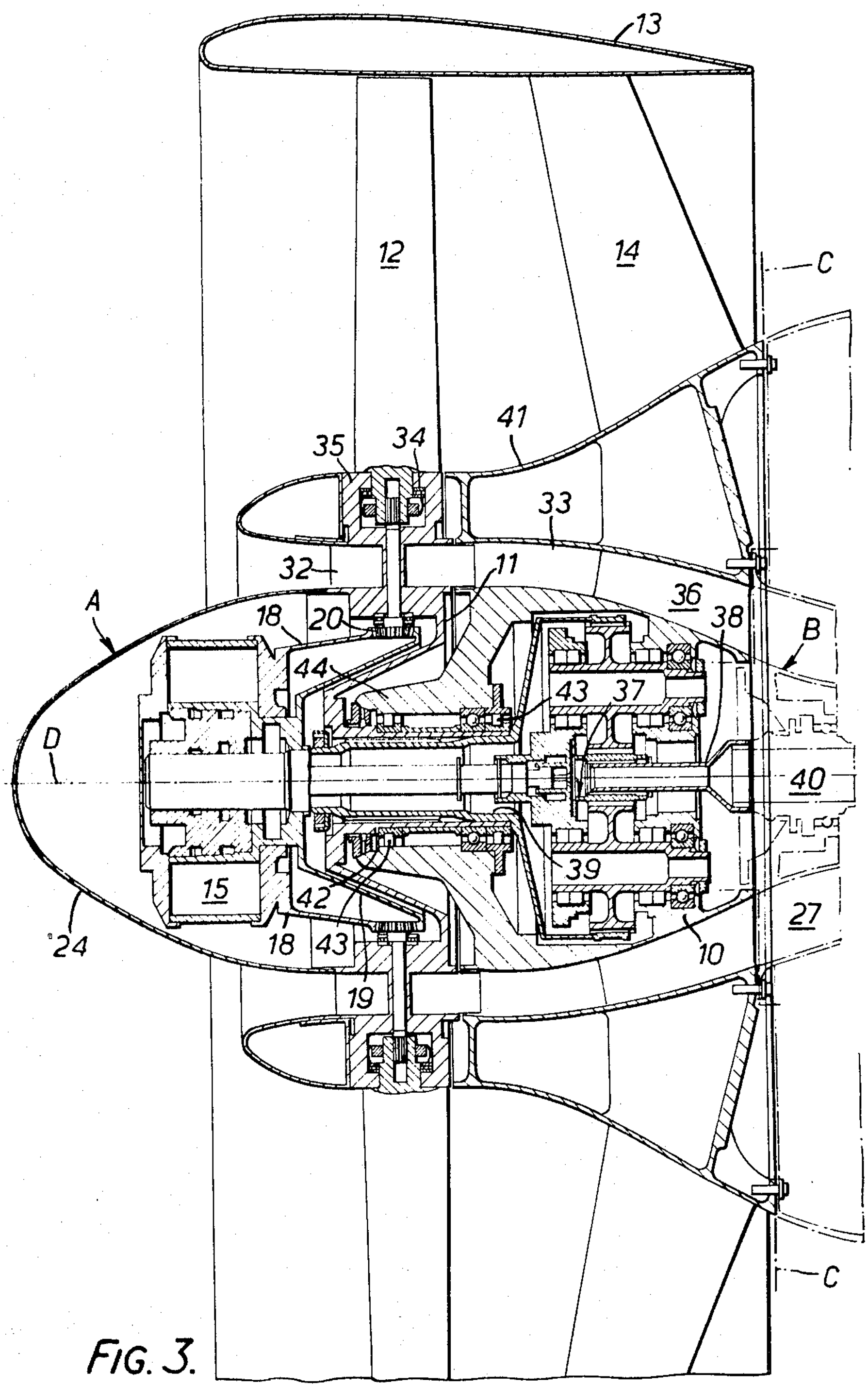
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FIG. 3.

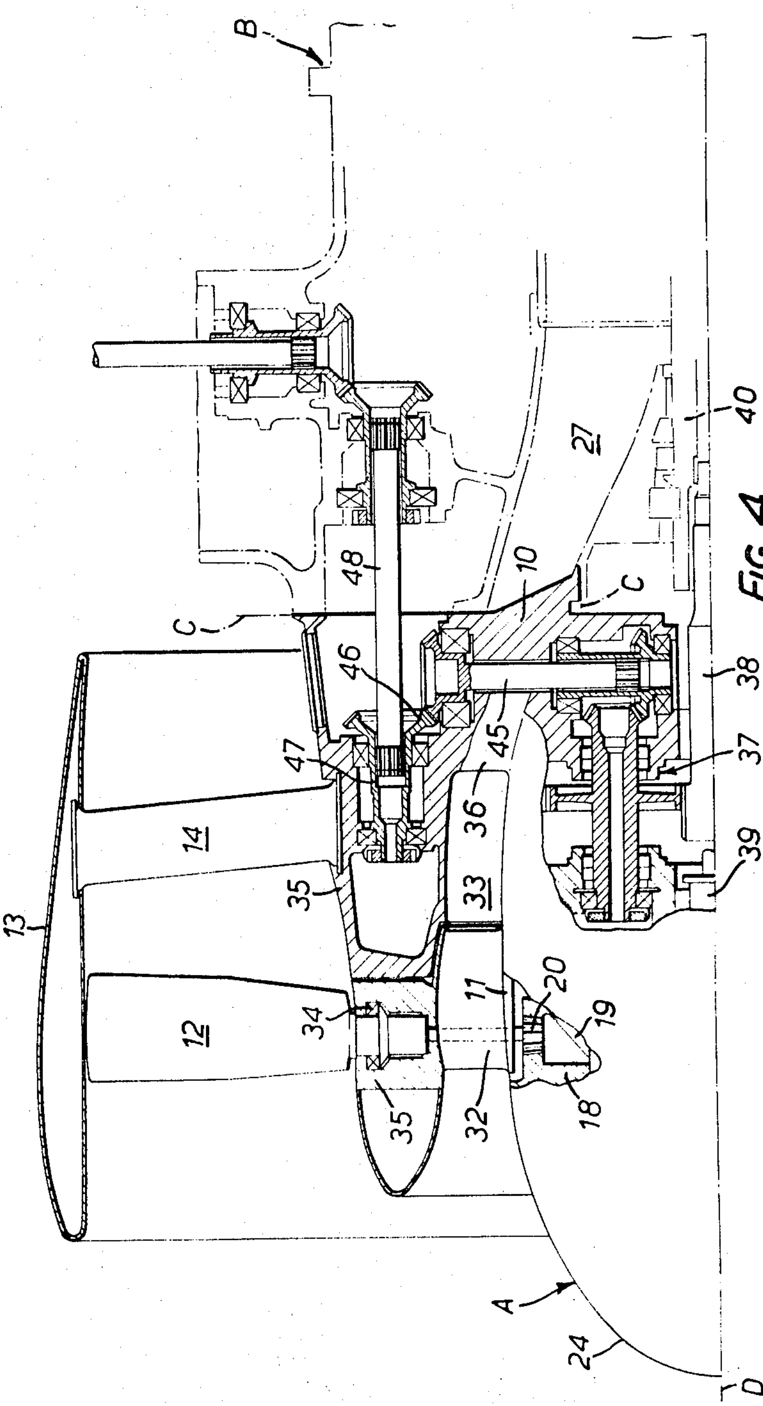
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FIG. 4.

FANS

BACKGROUND OF THE INVENTION

This invention relates to fans for use in gas turbine engines of the ducted-fan by-pass type, and to gas turbine engines of that type.

SUMMARY OF THE INVENTION

According to one aspect of the invention a fan assembly for attachment to the front of a main gas turbine engine assembly to provide an engine of the ducted-fan by-pass type is constructed as a unitary assembly which can be fitted and removed as such and comprises a non-rotative portion including a by-pass duct, and a rotative sub-assembly supported in bearings by the non-rotative portion and including a hub structure and fan blading positioned and rotatably supported within the non-rotative by-pass duct.

Thus the invention provides a fan assembly, including the non-rotative duct, which is detachable and attachable as a whole thereby facilitating manufacture and maintenance of a by-pass engine. The assembly can also be designed for attachment to an existing engine of non by-pass type, thereby converting the engine to one of the by-pass type.

The fan blading is preferably arranged in a single stage and of variable pitch with the pitch adjustable under the control of a servo-system housed, at least in part, within the hub structure. In preferred constructions the by-pass duct is supported by a main body of the non-rotative portion of the assembly through a ring of stator blading positioned downstream of the fan blading, which main body is adapted for bolting to the front of the main engine assembly and also supports the rotative sub-assembly. Preferably a spinner is provided to enclose the forward part of the hub structure and forms part of the rotative sub-assembly.

The fan may if desired be of tiered form, with an inner tier of blading adapted to charge the engine compressor and an outer tier which charges the by-pass duct. The non-rotative portion of the assembly may include a splitter structure positioned downstream of the fan blading and which separates the air flow from separate tiers. This structure may, when the assembly is fitted, define an entry portion of the engine inlet leading to the engine compressor and a ring of fixed stator blading may be fixed in this entry portion.

When the blading is of variable pitch it is preferably reversible in pitch, and the pitch angle is desirably variable to provide positive pitch, zero or near zero pitch, negative pitch and a feathered position in order to provide complete control of the air flow along the duct. With tiered blading, the pitch of the outer tier may be variable in this manner with the inner tier of blading of fixed pitch. In preferred constructions a pitch-change motor of vane type is employed, having two output members in the form of bevel gears of large diameter which respectively turn in opposite directions about the rotation axis of the fan and which respectively engage opposite sides of small bevel pinions fixed on the root ends of the individual fan blades.

The fan assembly may be adapted for bolting up to the main engine assembly so as to pick up a drive for the fan either from the engine shaft or a reduction gear box embodied in the engine assembly. However, and particularly when the fan assembly is designed for conversion of an existing engine, the non-rotative main body of the fan assembly may house reduction gearing which drives the fan and picks up a drive from the engine. This reduction gearing may also provide a drive for engine auxiliaries.

According to another aspect of the invention a gas turbine engine of the ducted-fan by-pass type has a front-mounted fan assembly which is detachable as a complete assembly and comprises a rotative sub-assembly, which includes blading and a hub of the fan, and a non-rotative portion by which the assembly as a whole is mounted and which includes a stationary duct portion which surrounds the fan blading.

BRIEF DESCRIPTION OF THE DRAWINGS

Three fan assemblies in accordance with the invention are illustrated in the accompanying drawings and will now be described, by way of example, with reference thereto. The assemblies are shown attached to the forward ends of main gas turbine engine assemblies, whereby in each case to provide a gas turbine engine of the ducted-fan by-pass type also in accordance with the invention. In the drawings:

FIG. 1 is an axial sectional view of one of the assemblies, only the immediately adjacent portion of the engine assembly to which it is attached being shown,

FIG. 2 is a front view of the assembly of FIG. 1, the left-hand half of this figure being shown partly in section on the line II — II in FIG. 1,

FIG. 3 is a view similar to that of FIG. 1 but illustrating another of the fan assemblies, and

FIG. 4 is a half view, mainly in axial section, of the third fan assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In each of the illustrated embodiments the fan assembly A is attachable to and detachable from the main engine assembly B as a unit. For this purpose of differentiation the fan assemblies are shown in full lines in the drawings and the adjacent portions of the main engine assemblies in broken lines. The fan assembly of each arrangement comprises a non-rotative portion having a main body **10** which defines an interface, identified by the line C in the drawings, at which the assembly A is bolted up to the front end of the main engine assembly B. A rotative sub-assembly including a hub structure **11** and blading **12** of the fan is supported in spaced anti-friction bearings in the non-rotative main body **10**. The blading **12** is of variable pitch which is reversible to produce a reverse air flow along a non-rotative by-pass duct **13** within which the fan is rotatably supported. The by-pass duct **13**, which forms part of the non-rotative portion of the fan assembly A, is supported by the main body **20** through a ring of stator blades **14** disposed downstream of the fan blading **12**.

The pitch of the fan blading **12** is adjustable under the control of a servo-system including a double-acting multi-vaned vane motor **15** disposed within the hub structure **11**. Co-acting vanes **16** and **17** (see FIG. **2**) of the motor **15** are respectively attached to bevel gear output members **18** and **19** which turn in opposite directions about the rotation axis D of the fan. Each of the large multiplicity of adjustable-pitch fan blades **12** has a relatively small bevel pinion **20** fixed to its root end, the bevel teeth **22** and **23** of the members **18** and **19** respectively meshing with each pinion **20** on diametrically opposite front and rear sides of the latter. Thus all the blades **12** are adjustable in unison, with a balanced torque applied to the blade roots from the vane motor **15**.

A follow-up servo valve (not shown) controlling the blade pitch is disposed coaxially with and within the pitch change motor **15**. This valve is not illustrated as it may be of known type, for example connected to a rearwardly extending pitch control member which passes out of the fan assembly A centrally and which is arranged for external remote control of pitch. Alternatively the valve may be controlled by hydraulic pressure ducted through a control duct disposed centrally of the assembly, a feedback connection from the servo valve extended back rearwardly to the control means providing the hydraulic control pressure. As a further alternative, the blading may be under governor control, in which case the governor hydraulic control pressure is supplied to the control valve within the hub **11**.

A spinner **24** which forms part of the rotative sub-assembly encloses the forward end of the hub structure **11**, and a guard ring **25** built into the duct **13**, shown in FIG. **1**, surrounds the tips of the fan blades **12**. This protects the duct structure in the event of blade breakage.

In the embodiment of FIGS. **1** and **2** the fan hub structure **11** supports only a single tier of blading **12** which charges both the engine compressor (not shown) and the by-pass duct **13**. The non-rotative main body **10** of the assembly A bolts up to the front of the engine casing **26** immediately ahead of the engine compressor inlet **27**. A central hollow portion **28** of the hub structure, which extends rearwardly of the fan blading **12** into the main body **10**, is supported in said spaced bearings **29** and is driven by a splined quill coupling member **30** which is in splined engagement on the one hand with the hub portion **28** and, on the other hand, with a forward female end **31** of the main engine shaft. The hub portion **28** supports the remainder of the rotative sub-assembly and is directly supported in the bearings **29** within the main body **10**.

In the other two embodiments, shown respectively in FIGS. **3** and **4**, two tiers of blading are provided. The outer tier is formed by the variable pitch blading **12** and charges the by-pass duct **13** and the inner tier blading **32** charges the engine compressor through the engine inlet **27**, a duct **33** formed within the main body **10** leading from the inner tier blading **32** to the engine compressor inlet **27**. Only the outer tier blading **12** is of variable pitch, to this end the blading roots of this tier being supported in bearings **34** in a shroud ring **35** which encircles and is attached to the tips of the inner tier blades **32**. Thus the shroud ring **35** forms part of the rotative sub-assembly, and the inner tier blades **32** are hollow to allow the roots of the outer blades **12** to project through into the hub structure **11** within which the pinions **20** are disposed for the purpose of pitch adjustment, by the vane motor **15**, as already described.

A flared splitter structure **41** which forms part of the stationary main body **10** separates the two air flows, to the compressor inlet **27** and along the by-pass duct **13** respectively, and is in effect an extension of the shroud ring **35** in the aerodynamic sense. The structure **41** provides the outer wall of said duct **33** and not only supports the by-pass stator blading **14**, which in turn supports the by-pass duct portion **13** of the fan assembly A, but it also in effect extends the engine compressor inlet **27** forwardly to the fixed tier blading **32**. Thus the splitter structure **41** defines an entry portion of the compressor inlet, and within this entry portion a further ring of stator blading **36** is fixed within the duct **33**.

In the fan assembly A of FIGS. **3** and **4** the non-rotative main body **10** houses reduction gear **37** with coaxial input and output members **38** and **39**. The input member **38** picks up a quill drive from the main engine shaft **40** and the output member **39** is directly coupled to the hollow central portion **42** (FIG. **3**) of the fan hub structure. The stationary main body **10** projects forwardly into the fan hub structure **11** in order to provide adequate bearing support for the latter, by way of said spaced bearings **43** (as shown in FIG. **3**), forwardly of the reduction gear **37**. This necessitates that the vaned motor **15** is mounted forwardly of the fan blading **12** and **32** within the front spinner **24** (as also shown in FIG. **3**), the output bevel gears having appropriately cranked webs so that they project rearwardly around the forwardly projecting bearing portion **44** (see FIG. **3**) for engagement with the pinions **20** of the outer tier of blading **12**.

The embodiments of FIGS. **3** and **4** are generally similar, although in the construction of FIG. **4** the reduction gear **37** also provides an auxiliary drive by way of a vertical drive shaft **45** which projects upwardly through one of the stator blades **36** into the splitter structure **41** where it drives, through right-angle bevel gearing **46**, an internally splined hollow drive member **47**. When the fan assembly A is fitted to the main engine assembly B the auxiliary drive from the member **47** is provided by a splined auxiliary drive shaft **48** which extends into the front of the main engine casing and is offset from the main engine shaft **40** above the engine compressor inlet **27**.

In the drawings the duct portion **13** of the fan assembly A is shown as providing the complete by-pass duct of the ducted-fan engine. However, if a larger overall duct length is required the main engine assembly B may also include a stationary duct portion aligned with and providing a rearward extension of the duct portion **13** of the fan assembly A while leaving the latter still attachable to, and detachable from, the engine assembly B as a complete unit.

We claim:

1. A fan assembly for attachment to the front of a main gas turbine engine assembly to provide an engine of the ducted-fan by-pass type, constructed as a unitary assembly which can be fitted and removed as such and comprising a non-rotative portion including a by-pass duct, and a rotative subassembly supported in bearings by the nonrotative portion and including a hub structure and fan blading positioned and rotatably supported within the nonrotative by-pass duct, the rotative subassembly also including a spinner which encloses the forward part of the hub structure.

2. A fan assembly for attachment to the front of a main gas turbine engine assembly to provide an engine of the ducted-fan by-pass type, constructed as a unitary assembly which can be fitted and removed as such and comprising a non-rotative portion including a by-pass duct, and a rotative subassembly supported in bearings by the nonrotative portion and including a hub structure and fan blading positioned and rotatably supported within the nonrotative by-pass duct, the fan blading being of variable pitch with the pitch adjustable under the control of a servo-system housed, at least in part, within the hub structure.

3. A fan assembly for attachment to the front of a main gas turbine engine assembly to provide an engine of the ducted-fan by-pass type, with a fan of tiered form having an inner tier of blading adapted to charge the engine compressor and an outer tier of blading to charge a by-pass duct, constructed as a unitary assembly which can be fitted and removed as such and comprising a nonrotative portion including the by-pass duct, and a rotative subassembly supported in bearings by the nonrotative portion and including a hub structure and fan blading positioned and rotatably supported within the nonrotative by-pass duct, the inner tier of blading being of fixed pitch and the outer tier of fan blading being of variable pitch with the pitch adjustable under the control of a servo-system housed, at least in part, within the hub structure.

4. A fan assembly for attachment to the front of a main gas turbine engine assembly to provide an engine of the ducted-fan by-pass type, constructed as a unitary assembly which can be fitted and removed as such and comprising a nonrotative portion including a by-pass duct, and a rotative subassembly supported in bearings by the nonrotative portion and including a hub structure and fan blading positioned and rotatably supported within the nonrotative by-pass duct, the fan blading being variable in pitch angle to provide positive pitch, zero or near zero pitch, negative pitch and a feathered position in order to provide complete control of the air flow along the duct with the pitch adjustable under the control of a servo-system housed, at least in part, within the hub structure.

5. A fan assembly for attachment to the front of a main gas turbine engine assembly to provide an engine of the ducted-fan by-pass type, constructed as a unitary assembly which can be fitted and removed as such and comprises a non-rotative portion including a by-pass duct, and a rotative subassembly supported in bearings by the nonrotative portion and including a hub structure and fan blading positioned and rotatably supported within the nonrotative by-pass duct, the fan assembly being adapted for bolting up to the main engine assembly so as to pick up a drive for the rotative subassembly from the main engine shaft.

6. A fan assembly according to claim 5, wherein the fan blading is arranged in a single stage.

7. A fan assembly according to claim 5, wherein the by-pass duct is supported by a main body of said nonrotative portion through a ring of stator blading positioned downstream of the fan blading, which main body is adapted for bolting to the front of the main engine assembly and also supports the rotative sub-assembly.

8. A fan assembly according to claim 5, and gearing to drive the rotative subassembly, said gearing being housed within the fan assembly.

9. A fan assembly according to claim 8, wherein said gearing is reduction gearing.

10. A fan assembly according to claim 8, wherein said gearing is housed within the nonrotative portion of the fan assembly.

11. A gas turbine engine embodying a fan assembly according to claim 10, wherein the duct portion of the fan assembly provides the complete by-pass duct of the engine.

12. A fan assembly for attachment to the front of a main gas turbine engine assembly to provide an engine of the ducted-fan by-pass type, constructed as a unitary assembly which can be fitted and removed as such and comprising a nonrotative portion including a by-pass duct, and a rotative subassembly supported in bearings by the nonrotative portion and including a hub structure and fan blading positioned and rotatably supported within the nonrotative by-pass duct, the fan assembly being adapted for bolting up to the main engine assembly so as to pick up a drive for the rotative subassembly from a reduction gear box embodied in the engine assembly.

13. A fan assembly according to claim 5, wherein the fan is of tiered form with an inner tier of blading adapted to charge the engine compressor and an outer tier of blading which charges the by-pass duct.

* * * * *