Aug. 6, 1957 C. E. MOSS 2,801,789

BLADING FOR GAS TURBINE ENGINES

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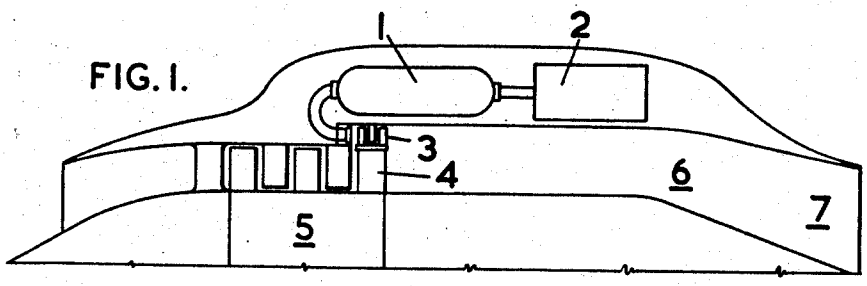


FIG. 1.

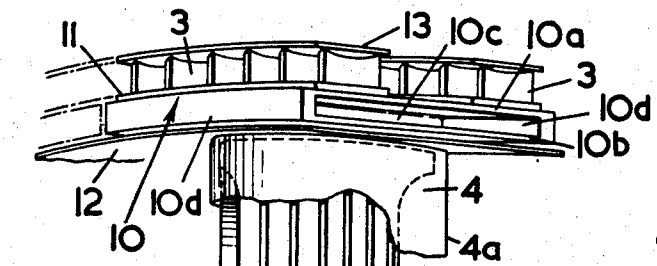


FIG. 2.

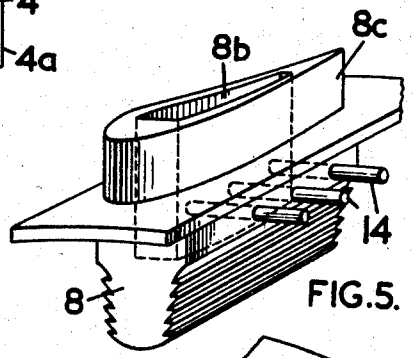
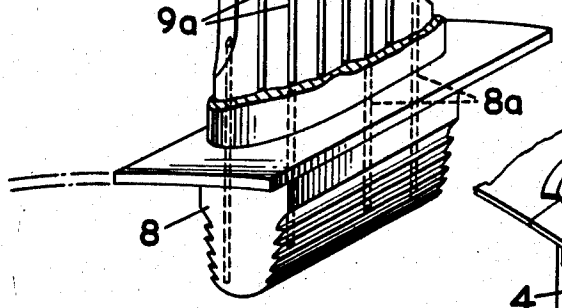


FIG. 5.



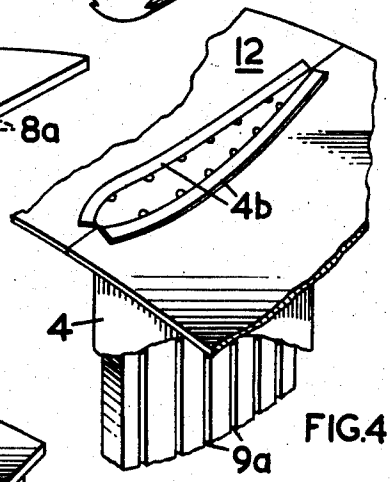


FIG. 4.

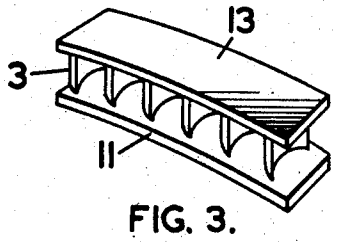


FIG. 3.

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BLADING FOR GAS TURBINE ENGINES

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14 Claims. (Cl. 230—116)

This invention relates to two tier blading in gas turbine plant of which the outer tier comprises turbine blading. Such blading is used, for example, in gas turbines of the type in which hot motive gases pass through turbine blading disposed around the blading of a compressor which it drives. An example of such a disposition of blading is set forth in co-pending United States patent application Serial No. 425,003 entitled Jet Propulsion Plant and filed April 22, 1954.

In such a gas turbine engine in which axial flow turbine blading is mounted on a shroud surrounding axial flow compressor blading, heat transfer is bound to take place between the turbine and the compressor blading and may produce serious distortion in the latter. One object of the present invention is to reduce the heat transfer in a two tier bladed element by supporting the turbine blading and its supporting shroud on the main root of the element independently of the compressor blade.

Thus a two tier bladed element according to the present invention has a structural portion comprising a main root, a pillar upstanding from said root and a main shroud carried at the upper end of said pillar in combination with a turbine blade carried on said shroud and a hollow compressor blade enveloping said pillar and secured to said structural portion by the end of the compressor blade adjacent the main root, the pillar being free to expand radially with respect to the compressor blade.

In the accompanying drawings,

Fig. 1 is a sectional view of a gas turbine plant which includes two tier bladed elements.

Fig. 2 is a perspective view of one specific form of two tier bladed element.

Fig. 3 is a perspective view of a turbine blade assembly forming part of the element of Fig. 2.

Fig. 4 is a perspective view of part of the element of Fig. 2 looking from above, with the upper part of the element removed.

Fig. 5 is a perspective view of an alternative root assembly for the element of Fig. 2.

Figure 1 shows a gas turbine plant in which a rocket combusion chamber **1** supplied with fuel from a fuel tank **2** discharges a gaseous stream to drive turbine blades **3** mounted peripherally around a row of compressor blades **4**. The compressor blades **4** are carried on a compressor rotor **5** which is thus driven directly by the turbine to draw in atmospheric air and discharge a stream of compressed air to mix with the turbine-driving gases in a downstream chamber **6** and to produce a propulsive jet which issues to atmosphere through a propulsion nozzle **7**. Each of the compressor blades **4** forms part of a two-tier bladed element of which the outer tier comprises the turbine blades **3**.

One form of two-tier bladed element as shown in detail in Fig. 2 has a structural part comprising a main root **8**, a pillar **9** upstanding from the root **8** and carrying at its upper end a main shroud **10**. The compressor blade **4** is formed from a sheet of blade material profiled to blade form and enveloping the pillar **9**, and the turbine blades **3** are formed in rows, each row on a root **11** secured to the shroud **10**.

In this embodiment, the structural part of the two tier bladed element is formed from an I section by forging or machining. The base of the I section subsequently forms the root **8**, the upright forms the pillar **9** and the head forms the shroud **10**. Preferably, the pillar is first formed with a rectangular or trapezoidal cross-section and subsequently machined to approximate to the profile of the compressor blade. To make the structure as light as possible consistent with safe stressing, the pillar may be reduced in cross-section between the root and shroud ends, and may be provided with grooves **9***a* as shown in Fig. 4. At the root end, the pillar is profiled to the final shape of the interior of the compressor blade. The sheet subsequently forming the compressor blade **4** is then bent to hollow aero-foil shape of the correct profile, the edges of the sheet meeting along the trailing edge **4***a*. The edges of the sheet forming the trailing edge of the compressor blade are forced apart, the blade is fitted over the pillar, and the edges brought together again; the profiled sheet fitting closely around the profiled base of the pillar, and contacting the pillar at the upper end to provide an upper sliding support for the blade. Over the remainder of its length, the pillar is spaced from the enveloping compressor blade.

The edges of the sheet are then united by furnace brazing. The sheet at the same time is brazed to the base of the pillar. Since the compressor blade is secured to the pillar only at the base or root end, it will be seen that the pillar can expand radially under centrifugal force or thermally independently of the compressor blade.

When the plant is in operation, expansion of the pillar will produce a clearance between the end of the compressor blade and the adjacent shroud. To prevent disturbance of the flow path around this clearance and to prevent enlargement of the compressor flow path, the compressor blade may be provided with a lip **4***b* to which is secured a thin lamina forming an inner shroud **12** extending parallel to the main shroud **10**. This lamina preferably extends from the lip on one side of the compressor blade to the adjacent lip of the next compressor blade.

The head of the I section or main shroud **10** is subjected to a large centrifugal force which tends to bend its ends radially outwards. Accordingly the shroud is designed for combined lightness and strength. In the preferred embodiment as shown in Fig. 2 the shroud is formed in the shape of a double box, open at each end, by milling the head of the I section inwardly from opposite ends to leave the upper surface **10***a* and the lower surface **10***b* of the shroud connected only by a central web **10***c* and by those sides **10***d* of the shroud which lie in a plane transverse to the flow path. The top surface of the shroud, which is preferably thicker than the bottom surface, carries the turbine blading in two rows, separated by a space for stator blading. The turbine blades of each row are mounted on or formed integrally with a root element **11** as shown in Fig. 3 which is secured, for example by brazing to the top surface of the shroud. The tips of the turbine blades may also be connected by a tip shroud **13**.

When the two tier elements are mounted on a rotor, the small gap between adjacent main shrouds **10** will be covered by the inner shroud **12** attached to the compressor blading to effect a seal.

To reduce the conduction of heat down the pillar or compressor blade wall, especially where the compressor air temperature is high due for example to ram effect,

means are provided for introducing cooling air or other coolant fluid into the space between the pillar and the compressor blade wall through passages **8***a* formed in the main root and base of the pillar. The coolant supplied to the compressor blading may be fuel or oxidant which is discharged at the tips or along the trailing edges of such blading.

In an alternative embodiment the element is formed from a T-shaped section of which the head provides the main shroud and the upright provides the pillar to which a main root is subsequently attached. In such a case as shown in Fig. 5, the base of the pillar is fitted into a slot **8***b* in the main root **8** and retained by transverse pins **14**. The root **8** is preferably formed with a small upstanding spigot **8***c* profiled to aero-foil section on to which the compressor blade is subsequently secured, but slotted to permit entry of the pillar. The main root in such case may be made of material different from that of the pillar, for example the root may be of high tensile strength steel, while the pillar is of a high creep strength alloy such as that known by the name Nimonic.

Again in the case of an element formed from a T section, as distinct from one formed integrally from an I section, the lamina forming the inner shroud **12** attached to the lipped compressor blading may be a light integral shroud ring having apertures through which each compressor blade is fitted and attached similarly by the lip thereof before the main root of each element is secured in position.

I claim:

1. A two tier bladed element, for a gas turbine plant, having a structural portion comprising a main root, a pillar upstanding from said root and a main shroud carried at the end of said pillar remote from the root in combination with a turbine blade carried on said shroud and a hollow compressor blade enveloping said pillar and secured, only at the end of the compressor blade adjacent said root, to said structural portion.

2. An element according to claim 1 wherein said shroud is formed as a box-like structure and comprises an upper and lower surface and at least two parallel sides connecting said surfaces.

3. An element according to claim 1 comprising an upper surface on said shroud, and a turbine blade root secured to the upper surface of said shroud and supporting said turbine blade.

4. An element according to claim 1 including a plurality of turbine blades, a common turbine blade root on which said turbine blades are mounted, said turbine blade root being secured to said shroud.

5. An element according to claim 1 including a plurality of turbine blades arranged in two rows, and including two turbine blade roots secured to said shroud each supporting one row of said blades.

6. An element according to claim 1 wherein said shroud, said pillar and said main root are formed integrally.

7. An element according to claim 1 wherein said shroud and said pillar are formed intgerally and said main root is secured to the end of the pillar remote from said shroud.

8. An element according to claim 1 wherein the end of the pillar remote from the shroud engages a slot in said main root and including pins extending transversely through said main root and said pillar and securing said pillar in said slot.

9. An element according to claim 8 including a spigot upstanding from said main root around which the end of the compressor blade adjacent said main root fits and is secured, said spigot having a slot through which the pillar extends.

10. An element according to claim 1 including a lip on each side of the compressor blade at the end thereof adjacent said main shroud and an inner shroud separate from said main shroud engaging said lip.

11. An element according to claim 1 having a passage for coolant fluid extending through said main root and between said pillar and said compressor blade.

12. A gas turbine plant, a compressor rotor therein, a row of two-tier bladed elements mounted on said rotor, each said element having a structural portion comprising a main root, a pillar upstanding from said root and a main shroud carried at the end of said pillar remote from the root in combination with a turbine blade carried on said shroud and a hollow compressor blade enveloping said pillar and secured, only at the end of the compressor blade adjacent said root, to said structural portion; an inner shroud ring extending close to each said main shroud and having apertures through each of which a compressor blade extends, and means on each said compressor blade, at the end thereof adjacent said main shroud, engaging said ring.

13. A gas turbine plant according to claim 12 wherein, in each said element, said main shroud and said pillar are formed integrally.

14. A two tier bladed element, for a gas turbine plant, having a structural portion comprising a main root, a pillar upstanding from said root and a main shroud carried at the end of said pillar remote from the root, in combination with a turbine blade carried on said shroud and a hollow compressor blade enveloping said pillar and secured, only at the end of the compressor blade adjacent said root, to said pillar, wherein said compressor blade is slidably supported by the pillar at the end of the compressor blade adjacent said shroud.

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