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(54) **CERAMIC MATRIX COMPOSITE COMPONENTS**

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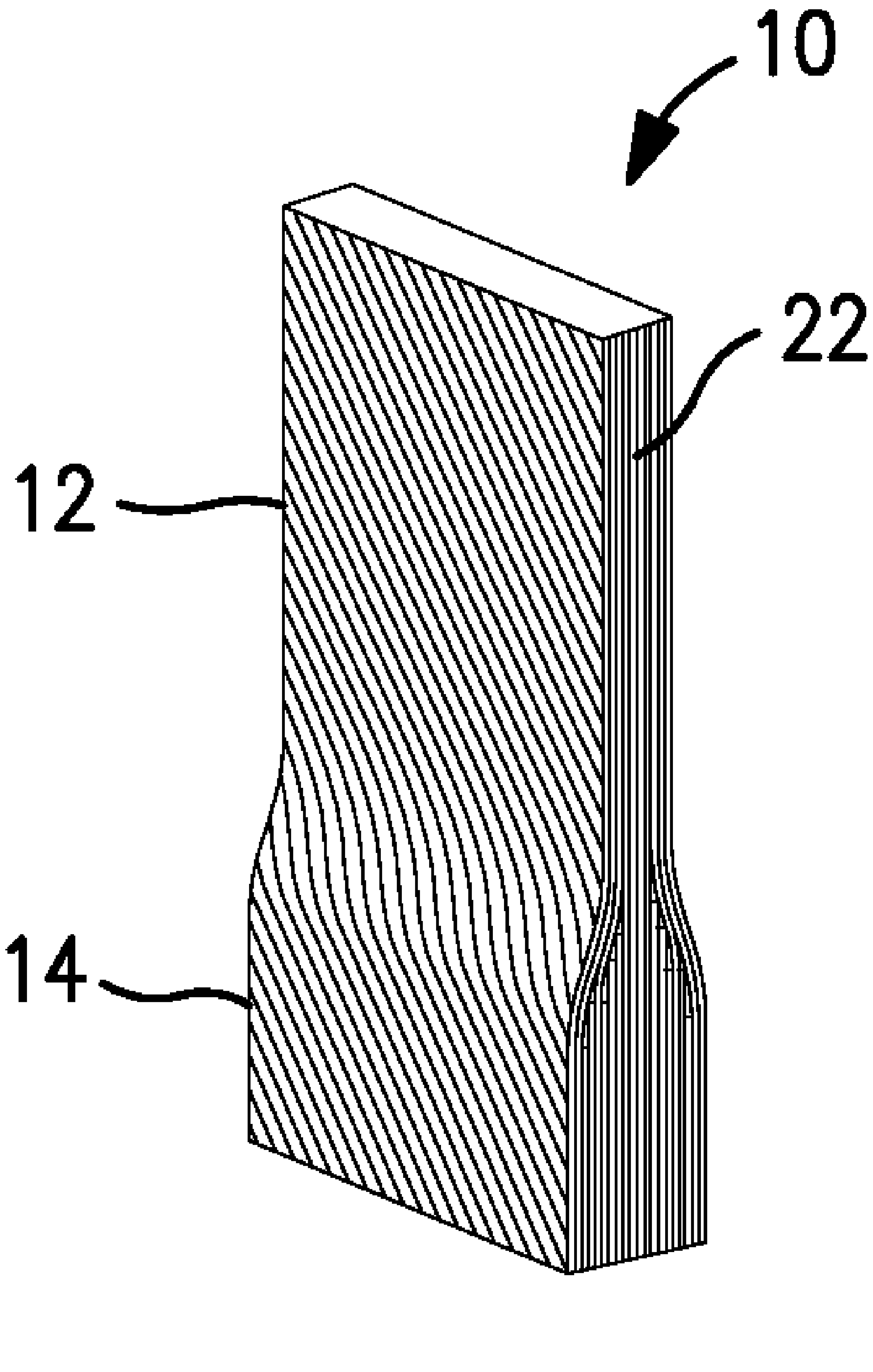
(57) **ABSTRACT**

A CMC component has an integral airfoil and root portion formed by a plurality of plies extending in a spanwise direction and an external feature formed by a plurality of bent plies.



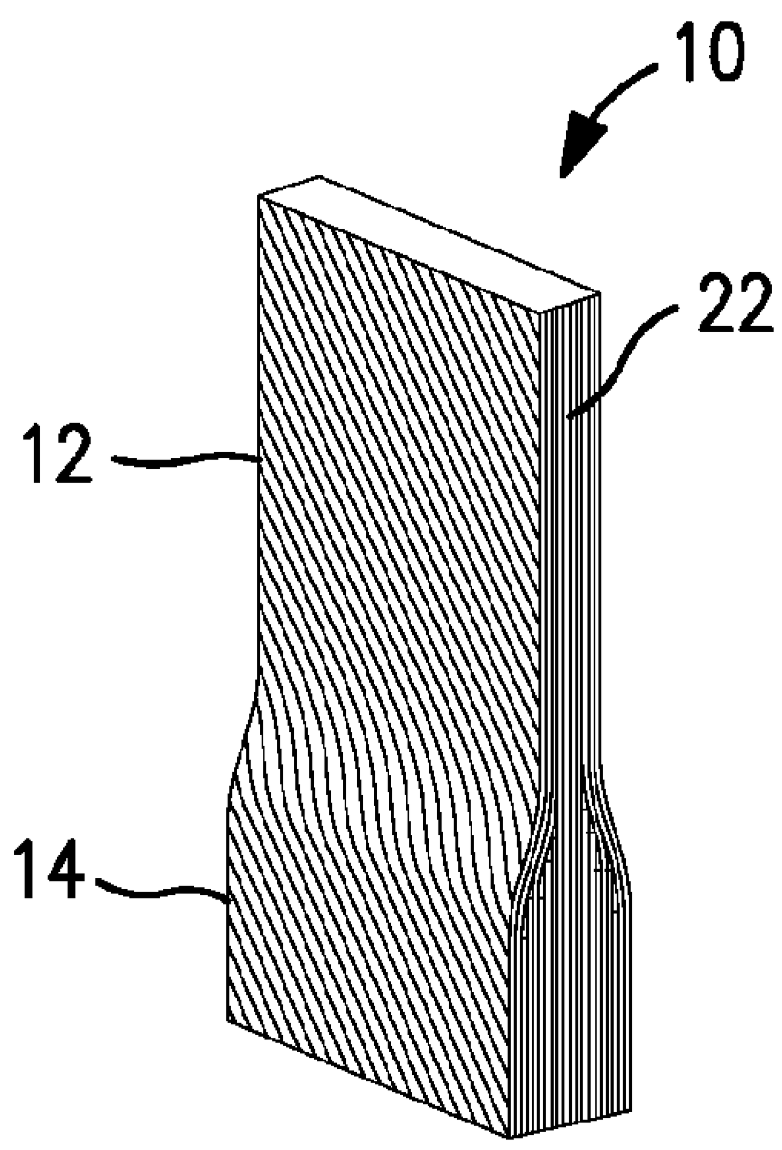


FIG. 1

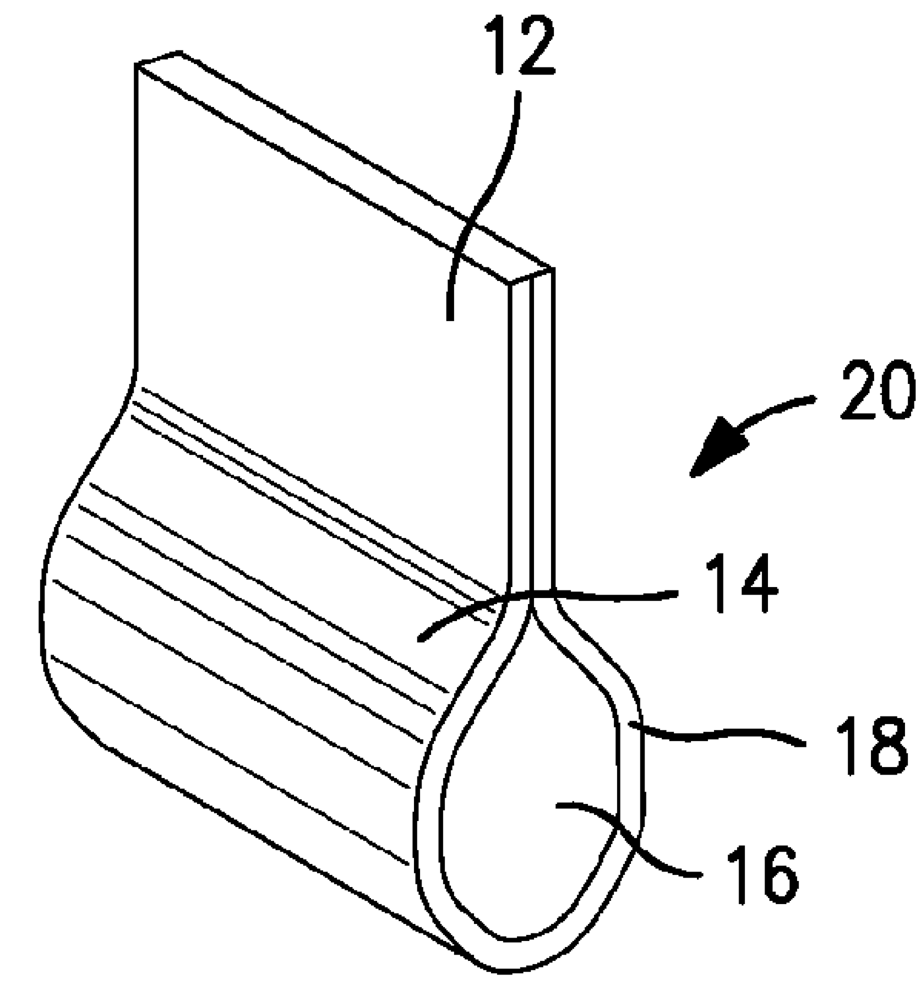


FIG. 2

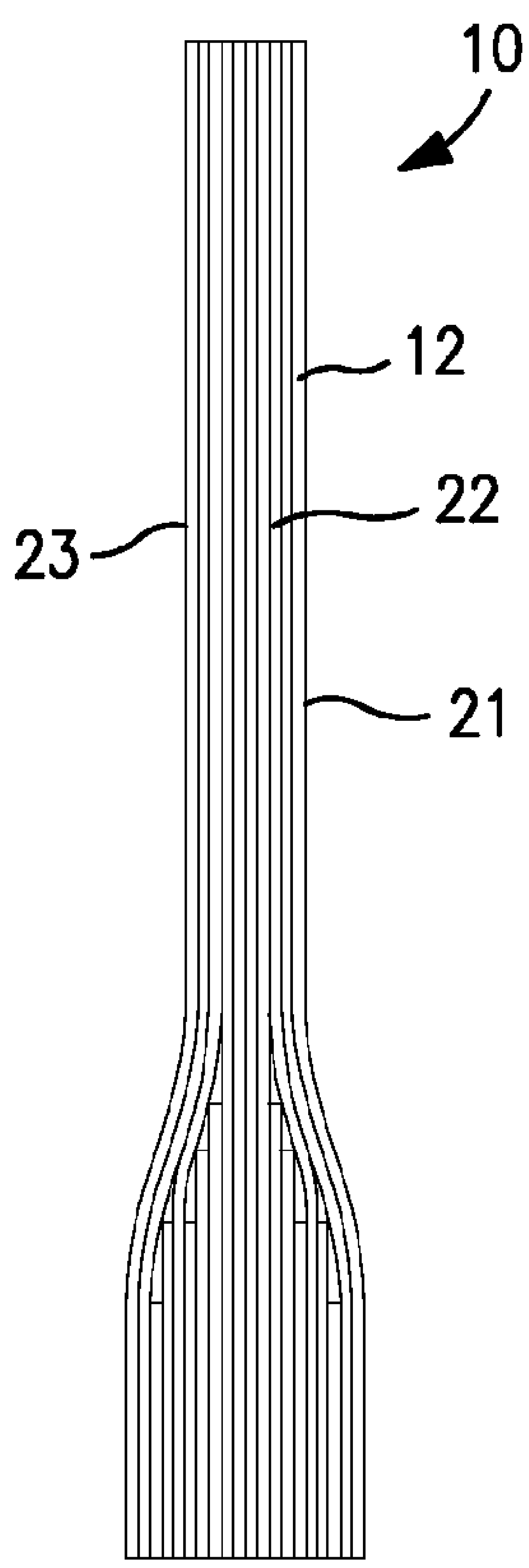


FIG. 3

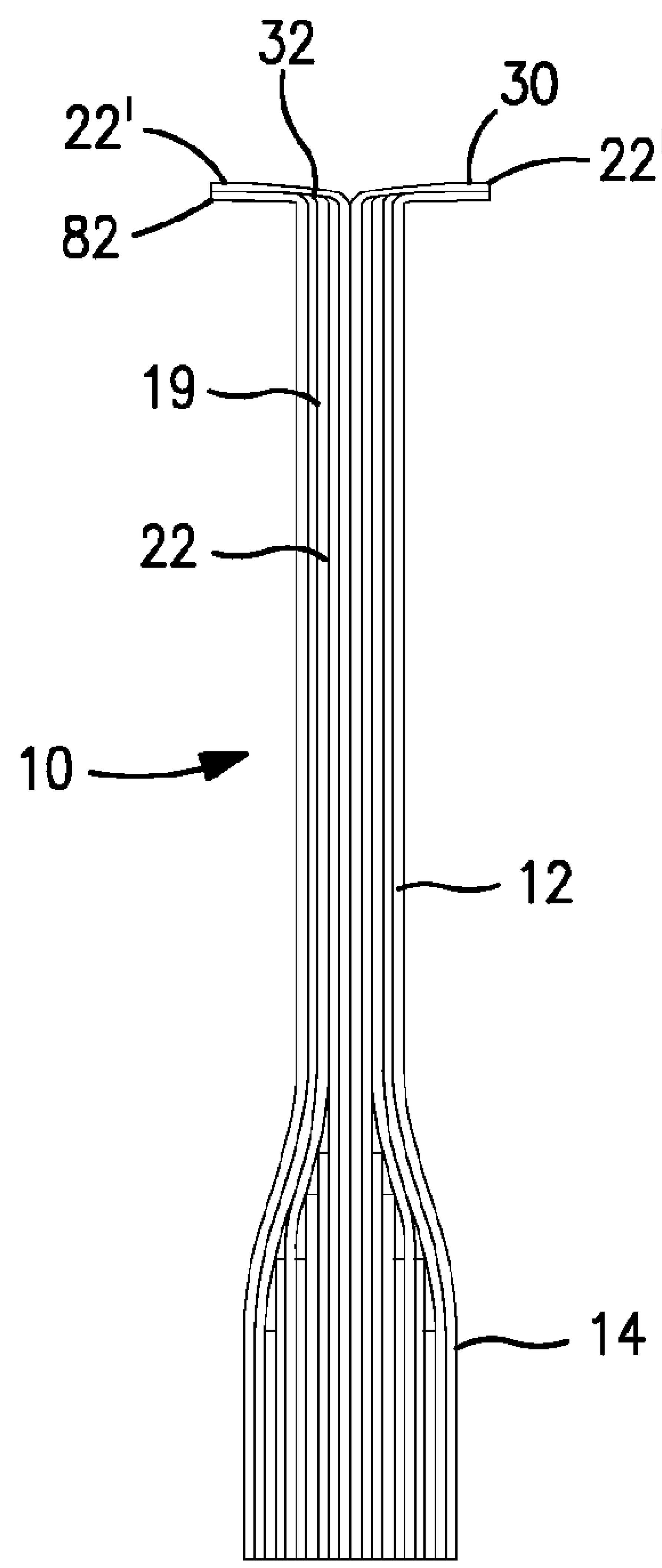


FIG. 4

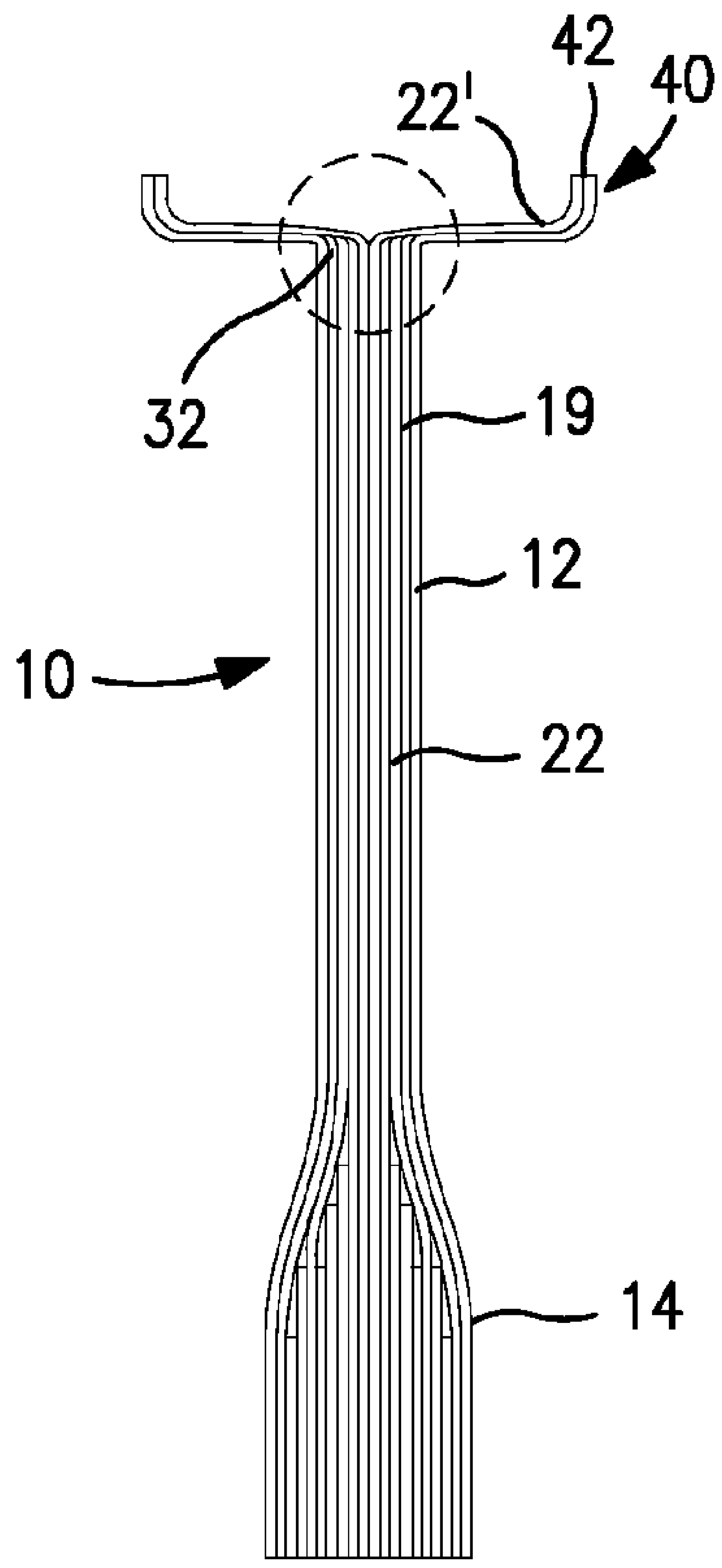


FIG. 5

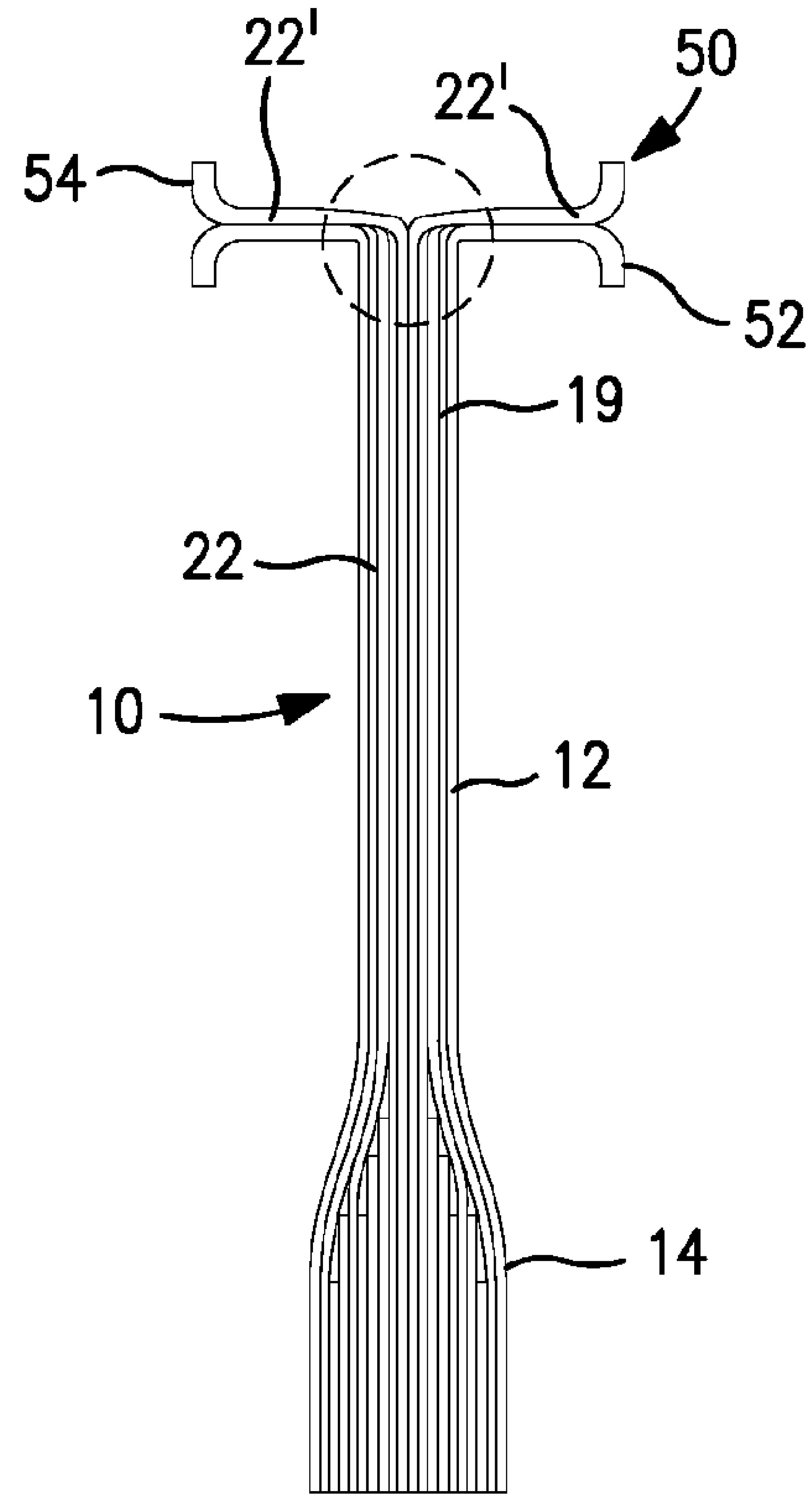


FIG. 6

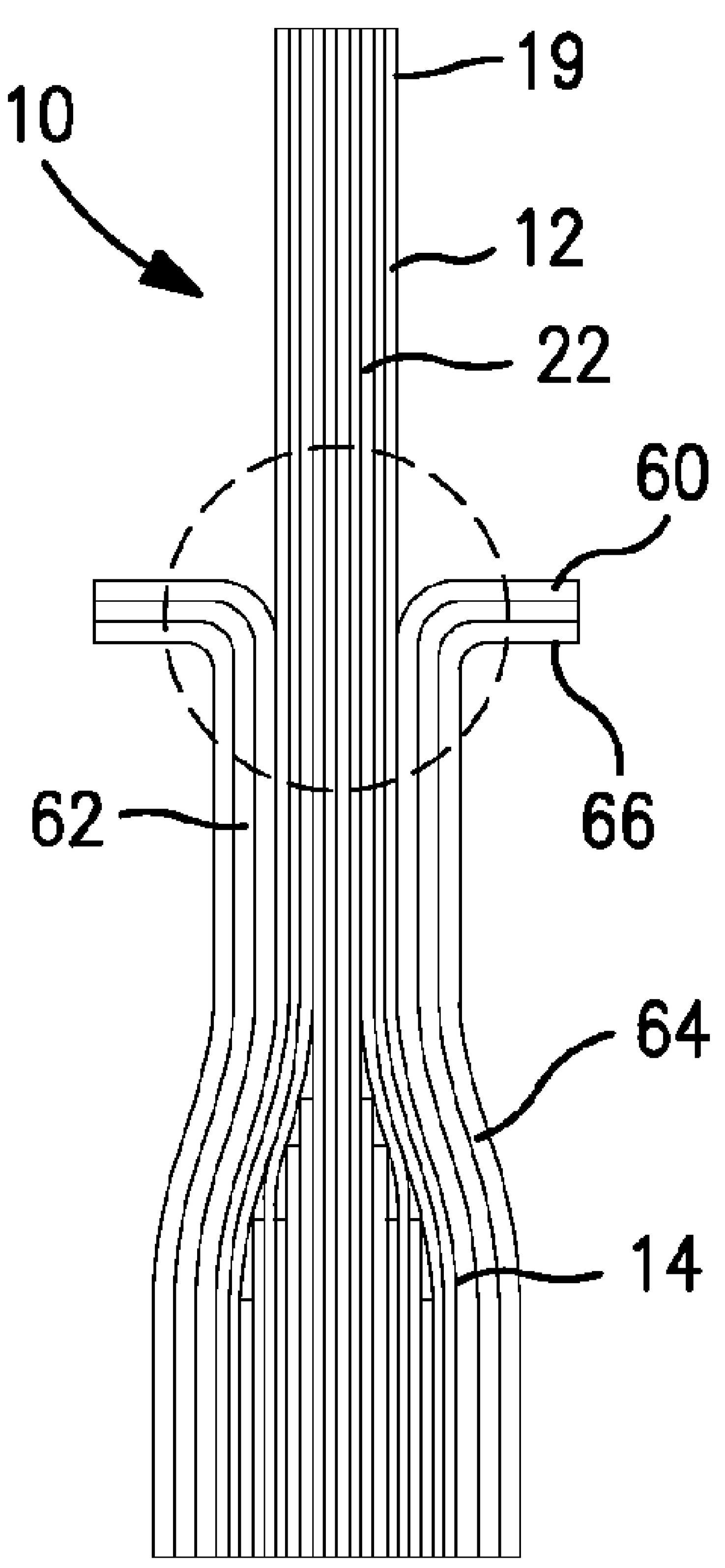


FIG. 7

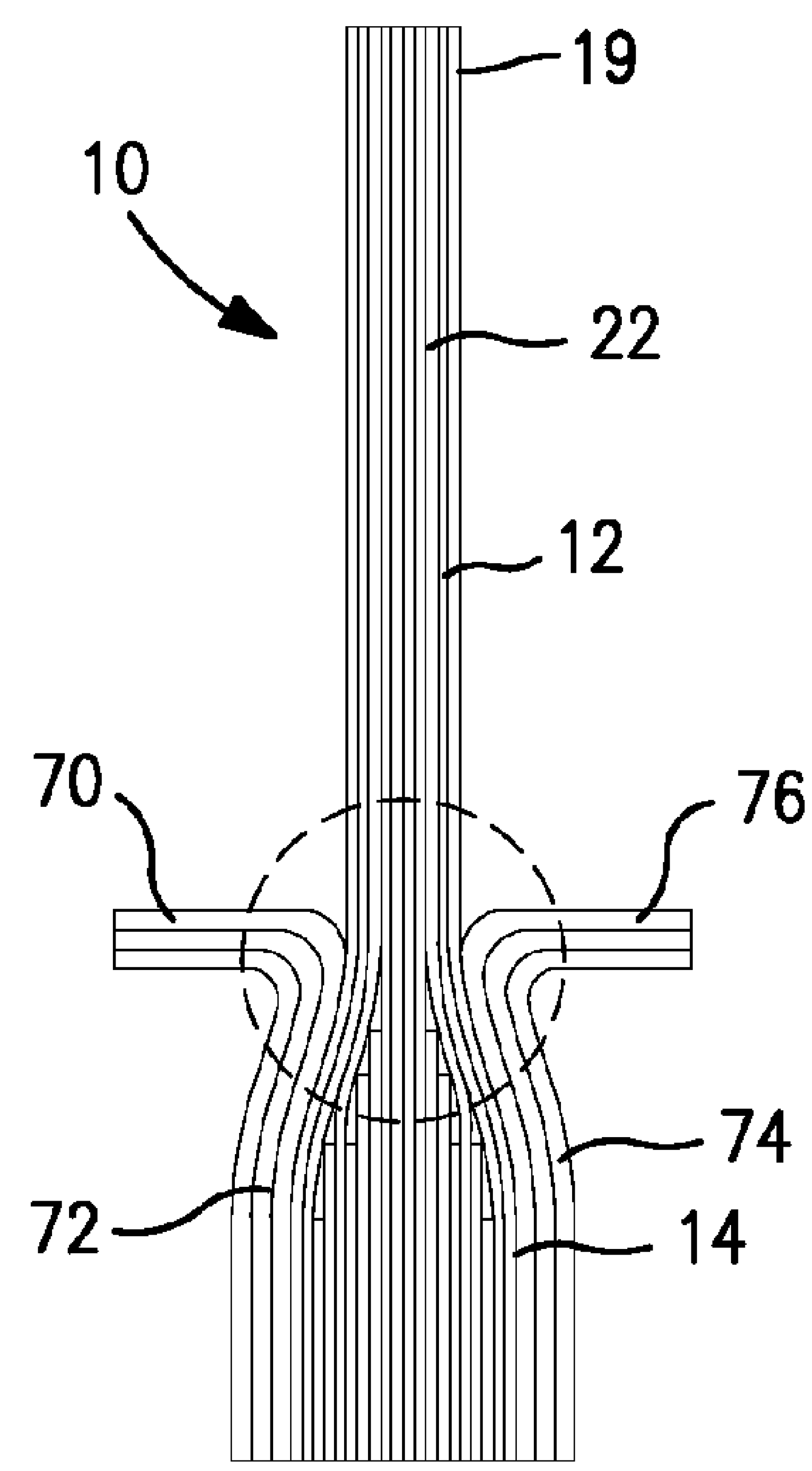


FIG. 8

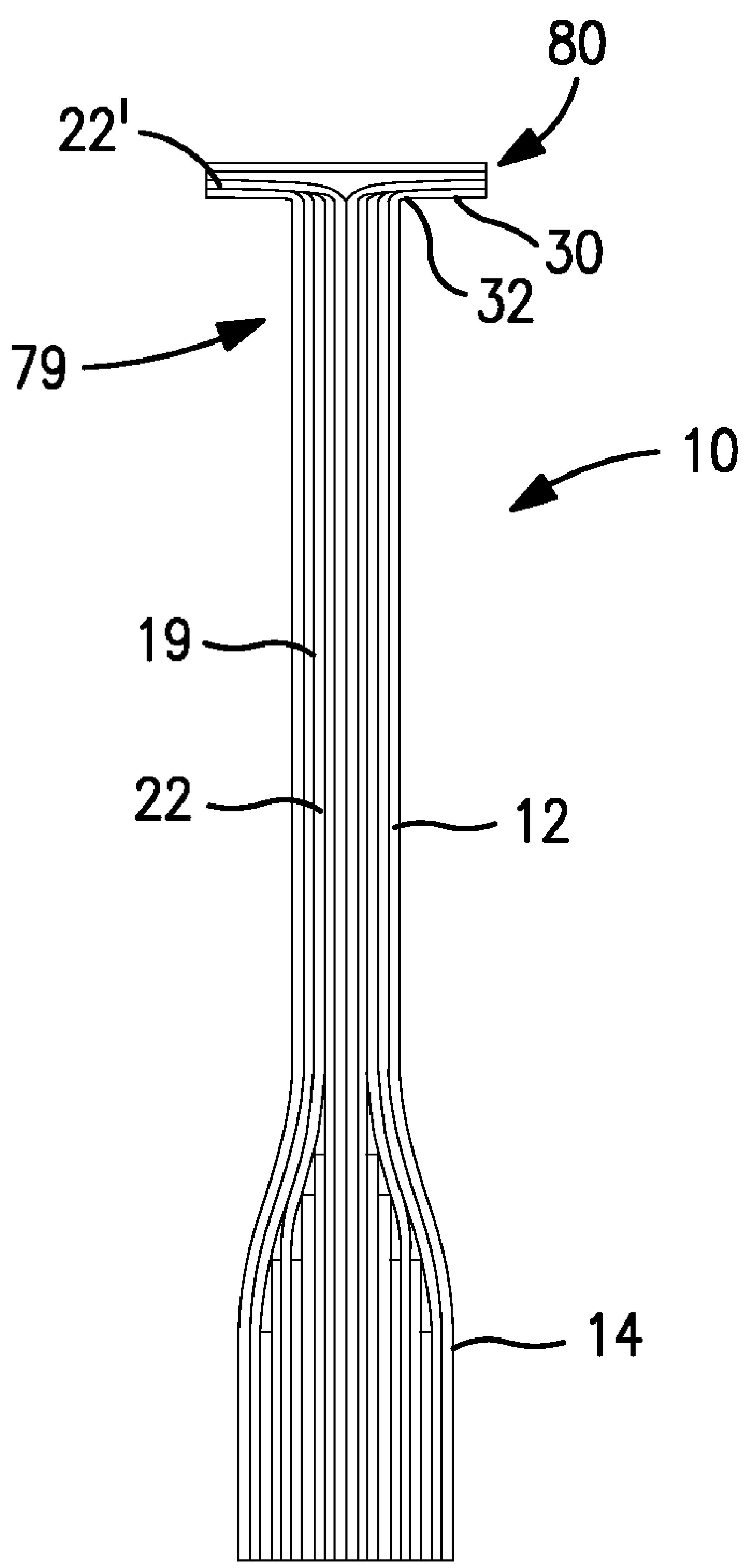


FIG. 9

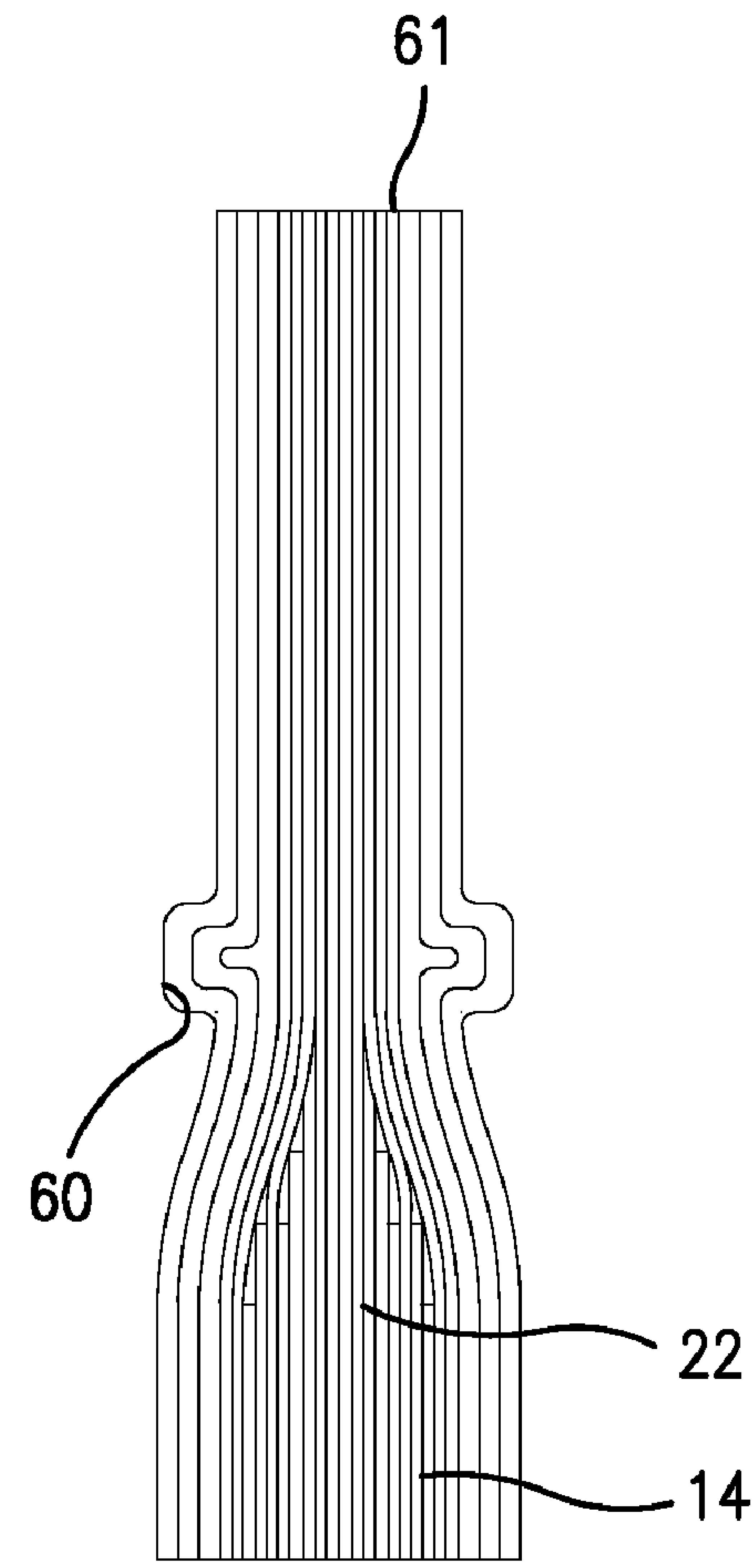


FIG. 10

CERAMIC MATRIX COMPOSITE COMPONENTS

BACKGROUND

[0001] The present disclosure is directed to a ceramic matrix composite (CMC) components, such as a blade or vane, for use in a gas turbine engine which is provided with a platform.

[0002] Ceramic matrix composites (CMCs) have been proposed for application in the high temperature sections of gas turbine engines because of their high strength in hot, corrosive, and oxidating atmospheres. For high efficiency gas turbine engines, the gas temperatures at the turbine section of the engine may be so high that nickel based superalloy blades would need substantial cooling to withstand the high gas temperatures.

[0003] Cooling turbine blades incurs engine efficiency penalties as the cooling air bypasses the high pressure turbine. As a result of this, less energy is extracted from the gas flow by the turbines. Therefore, there is a desire to use high temperature materials such as ceramic matrix composites (CMCs) for turbine blades and eliminate the cooling requirements for metallic blades.

[0004] Turbine blades tend to have high aspect ratio, or long in radial direction of the engine but narrow in the blade chord direction. They also tend to be thin for best aerodynamic performance. Such long, narrow and thin blades have low bending and torsional stiffness and therefore have the propensity to vibrate under unsteady aerodynamic pressure. The vibration could potentially cause blade high cycle fatigue (HCF).

[0005] To prevent HCF induced fatigue of turbine blades, shrouds are commonly added to the tip of the blades and sometimes to the mid-span of the blades. The shrouds serve at least two purposes: (1) stiffening the blades through centrifugal loading and contact between the shrouds; and (2) adding damping through frictional rubbing between the shrouds. The shrouds of metal turbine blades are typically integrally cast with the blade airfoils, platforms and roots.

SUMMARY

[0006] The present disclosure teaches a CMC turbine component having a platform which has been strengthened for HCF resistance.

[0007] In accordance with the present disclosure, there is provided a CMC component which broadly comprises an integral airfoil and root portion having a core formed by a plurality of plies extending in a spanwise direction and an external feature formed by a plurality of bent plies. The external feature may be a platform located at different places on the blade.

[0008] Other details of the (CMC) blade are set forth in the following detailed description and the accompanying drawings wherein like reference numerals depict like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a perspective view of a CMC blade without a blade root insert;

[0010] FIG. **2** is a perspective view of a CMC blade with a blade root insert;

[0011] FIG. **3** is a side view of a blade without a platform at blade tip;

[0012] FIG. **4** is a side view of a blade with platform at blade tip;

[0013] FIG. **5** is a side view of a blade with end platforms;

[0014] FIG. **6** is a side view of a blade with split end platforms;

[0015] FIG. **7** is a side view of a blade with a mid-span platform;

[0016] FIG. **8** is a side view of a blade with a root end platform;

[0017] FIG. **9** is a side view of a blade with added plies at the blade tip; and

[0018] FIG. **10** is a sectional view of a blade with plies extending from the root to the tip.

DETAILED DESCRIPTION

[0019] As used herein, the term "platform" means a platform which can be at the blade tip, mid-span and root and a shroud such as a blade tip platform.

[0020] Referring now to the drawings, FIG. **1** shows a CMC turbine blade **10** having a tapered wedge geometry. As can be seen in the Figure, the blade **10** has an airfoil portion **12** and a root portion **14** formed by plies **22** of a CMC material extending in a spanwise direction. The CMC material forming the airfoil portion **12** and the root portion **14** may be layers or plies **22** of two-dimensional ply drop offs or a three dimensional weave. The turbine blade **10** differs from other composite turbine blades in that it does not have a core formed from a material such as rigid foam.

[0021] FIG. **2** illustrates a turbine blade **20** having a root portion **14** with a ceramic core insert **16** and a surrounding CMC material **18** forming the blade root portion **14** and the airfoil portion **12**.

[0022] FIG. **3** is a side view of an unshrouded blade **10**, i.e., without a platform at its blade tip. The blade **10** may formed by a plurality of plies **22** extending in a spanwise direction. The airfoil portion **12** of the blade **10** typically has a curved pressure side **21** and a curved suction side **23**.

[0023] FIG. **4** is a side view of a CMC blade **10** having an integral airfoil **12** and root portion **14** and where the core **19** of the blade is formed by a plurality of plies **22** of a CMC material extending in a spanwise direction. As can be seen from the figure, a tip shroud **30** is added. The tip shroud **30** may be formed by having a plurality of the plies **22'** extend beyond the tip portion **32** of the blade **10**. The extended plies or extensions **22'** are bent with respect to the spanwise direction of the blade **10**. For example, the extended plies **22'** may be bent by approximately ninety degrees so that the extended plies are almost horizontal. As can be seen in FIG. **4**, a first portion of the extended plies or extensions **22'** may be bent in a first direction and a second portion of the extended plies or extensions **22'** may be bent in a second direction opposed to the first direction.

[0024] Referring now to FIG. **5**, there is shown a CMC blade **10** having an integral airfoil **12** and root portion **14** and where the core **19** of the blade is formed by a plurality of plies **22** of a CMC material. The blade **10** in this figure is provided with end platforms **40** formed by a plurality of plies or extensions **22'** which extend beyond the tip portion **32** of the airfoil portion **12**. Each of the end platforms **40** may be formed by bending a portion of the extended plies or extensions **22'** with respect to the spanwise direction of the blade **10**. The extended plies or extensions **22'** may first be bent at an angle of approximately ninety degrees with respect to the spanwise direction in either the first or second direction. The tips **42** of the bent plies are then bent with respect to the first and/or second direction so as to extend vertically upwards, substantially in a spanwise direction. For example, the tips **42** of the extended plies or extensions **22'** may be bent by an angle of approximately ninety degrees with respect to the first or second direction. In another embodiment, the tips **42** of the bent plies are bent with respect to the first and/or second direction so as to extend vertically downwards, substantially in a spanwise direction.

[0025] Referring now to FIG. **6**, there is shown a blade **10** with split end platforms **50** formed by the extended plies or extensions **22'**. As before, the blade **10** is formed by a CMC material and has an integral airfoil **12** and root portion **14**. The blade **10** also has a core **19** which is formed by a plurality of plies **22** of a CMC material. The split end platforms **50** may be formed as in the embodiment of FIG. **5** with the exception that the tips **52** of some of the bent plies or extensions **22'** and the tips **54** of other of the bent plies or extensions **22'** are bent in a third direction approximately 90 degrees upwardly or in a fourth direction approximately 90 degrees downwardly.

[0026] The end platform configurations shown in FIGS. **5** and **6** create contact area between blades and thereby increase the stiffness and damping effect.

[0027] The same techniques can be used to add platforms at different blade span locations. FIG. **7** illustrates an unshrouded blade **10** having an integral airfoil **12** and root portion **14**. The integral airfoil **12** and root portion **14** have a core **19** formed by a plurality of plies **22** of CMC material extending in a spanwise direction. The blade **10** further has platforms **60** located essentially at the mid span of the airfoil portion **12** of the blade **10**. The platforms **60** are formed by a plurality of plies **62** of CMC material having a first portion **64** extending in a spanwise direction and a second portion **66** bent with respect to the spanwise direction of the blade **10**. The second portion **66** is bent outwardly at an angle of approximately ninety degrees with respect to the spanwise direction. FIG. **10** illustrates yet another blade **10** having a mid-span platform **60**. As can be seen, the plies **22** of CMC material extend from the root portion **14** to the tip portion **61**.

[0028] FIG. **8** illustrates an blade **10** having an integral airfoil **12** and root portion **14**. The integral airfoil **12** and root portion **14** have a core **19** formed by a plurality of plies **22** of CMC material extending in a spanwise direction. The blade **10** further has root end platforms **70** formed by a plurality of plies **72** of a CMC material having a first portion **74** extending along the root portion **14** and a second portion **76** bent with respect to the spanwise direction. The second portion **76** may be bent outwardly at an angle of approximately ninety degrees with respect to the spanwise direction.

[0029] The plies **62** and **72** may be formed from the same CMC material which is used to form the plies **22** of the core **19** of the blade **10**. They may be attached or joined to the plies **22** forming exterior portions of the core **19** of the blade **10** using any suitable technique for joining plies of ceramic matrix composite materials together.

[0030] Due to centrifugal loading, the shrouds or platforms shown in FIGS. **4-8** induce compressive stress at ply transition regions (circled by dashed lines in these figures). The compressive stresses impede delamination between the plies. However, the manufacturing process may introduce defects in these transition regions and lower the interlaminar tensile strength. To counter such a potential reduction in interlaminar tensile strength, through thickness stitching **79** can be added to these regions as shown in FIG. **9**. For embodiments where the shrouds **30** are located at the blade tip **32**, as in the embodiment of FIG. **4**, extra plies **80** of CMC material can be added and bonded to the bent portions of the extended plies. The extra plies **80** also help to stiffen the blade.

[0031] For the shroud arrangement shown in FIG. **4**, the edges **82** of the shroud **30** could be shaped to maximize the effect of shroud interlocking, which enhances stiffening and damping effect.

[0032] The fiber architecture and material selection for the CMC blade designs described herein may be tailored to achieve the required material properties for blade performance. Material properties of importance include: in-plane tensile strength, interlaminar tensile strength, interlaminar shear strength, elastic modulus, thermal conductivity, and thermal expansion.

[0033] The blade to shroud/platform transition can be achieved by forming the plies **22** of the core **19** from two dimensional ply layups or an integrally woven three-dimensional fiber weave. Weaving can be used to create a three dimensional architecture that divides into two separate three dimensional architectures to create the shroud/platform segments. The three-dimensional weaves can be created on either a Doppie or Jacquard loom. The Jacquard loom has the capability to create more complicated architectures since it controls the placement of each fiber tow individually.

[0034] With regard to the added plies **80** shown in FIG. **9**, the additional plies **80** can be attached to two dimensional ply layups by such methods as stitching and Z-pinning.

[0035] Referring now to FIG. **10**, there is shown a blade having a root portion **14** and a tip portion **61**. As can be seen from the figure, the plies **22** run from the root portion **14** to the tip **61** and from a mid-spin platform **60**.

[0036] The CMC blade-shroud/platform designs described herein can be fabricated in a variety of CMC systems including: silicon carbide/silicon carbide (SiC/SiC), melt infiltrated SiC/SiC, SiC/silicon-nitrogen-carbon (SiC/SiNC), and oxide/oxide. A useful fiber for the designs described herein is a high modulus SiC fiber due to temperature and loading considerations. A variety of SiC fibers can be used for reinforcement, including Sylramic, iBN Sylramic, Hi-Nicalon, Hi-Nicalon Tupe S, CG Nicalon, and Tyranno SA.

[0037] The blade-shroud/platform designs described herein provide low vibration and additional high cycle fatigue strength.

[0038] While the present invention has been described into context of a turbine blade, the same technology could be used to form other turbine engine components such as a vane.

[0039] There is provided herein a shrouded CMC blade. While the shrouded CMC blade has been described in the context of specific embodiments and combination thereof, other unforeseen alternatives, modifications, and variations may become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications, and variations as fall within the broad scope of the appended claims.

What is claimed is:

1. A CMC component comprises an integral airfoil and root portion having a core formed by a plurality of plies extending in a spanwise direction and an external feature formed by a plurality of plies bent with respect to said spanwise direction.

2. The CMC component according to claim **1**, wherein said bent plies are attached to an exterior portion of said component and form a platform.

3. The CMC component according to claim **2**, wherein said bent plies each have a first portion which extends from the root portion to a mid span portion of said airfoil and a bent portion at an angle to said first portion.

4. The CMC component according to claim **2**, wherein said bent plies each have a first portion which extends along the root portion and a bent portion at an angle to said first portion which form a platform adjacent said root portion.

5. The CMC component according to claim **1**, wherein said bent plies comprises extensions of at least some of said plies forming said integral airfoil and root portion, said extensions extending beyond a tip portion of said airfoil portion, and wherein said external feature comprises a tip shroud formed by said extensions.

6. The CMC component according to claim **5**, wherein said tip shroud is formed by a bent portion of said extensions and said bent portion is bent at an angle to said spanwise direction.

7. The CMC component according to claim **6**, wherein a first number of said extensions are bent in a first direction and a second number of said extensions are bent in a second direction opposed to said first direction.

8. The CMC component according to claim **7**, wherein said first number of said extensions have a first tip portion which are at an angle with respect to said first direction and said second number of said extensions have a second tip portion which are at an angle with respect to said second direction.

9. The CMC component according to claim **6**, wherein said first number of said extensions includes a plurality of extensions having a bent tip portion extending in a third direction and a plurality of extensions having a bent tip portion extending in a fourth direction opposed to the third direction forming a split end shroud.

10. The CMC component according to claim **9**, wherein said second number of said extensions includes a plurality of extensions having a bent tip portion extending in said third direction and a plurality of extensions having a bent tip portion extending in said fourth direction opposed to the third direction forming said split end shroud.

11. The CMC component according to claim **5**, further comprising a plurality of plies positioned on said extensions.

12. The CMC component of claim **11**, wherein said plurality of plies are attached to said extensions by one of stitching and Z-pinning.

13. The CMC component of claim **1**, wherein said component is a turbine blade.

14. The CMC component of claim **1**, wherein said component is a vane.

* * * * *