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(54) **TANGENTIAL COMBUSTOR**

(76) Inventors: **David Richard Johns**, Greenville, SC (US); **Craig Steven Humanchuk**, Greenville, SC (US)

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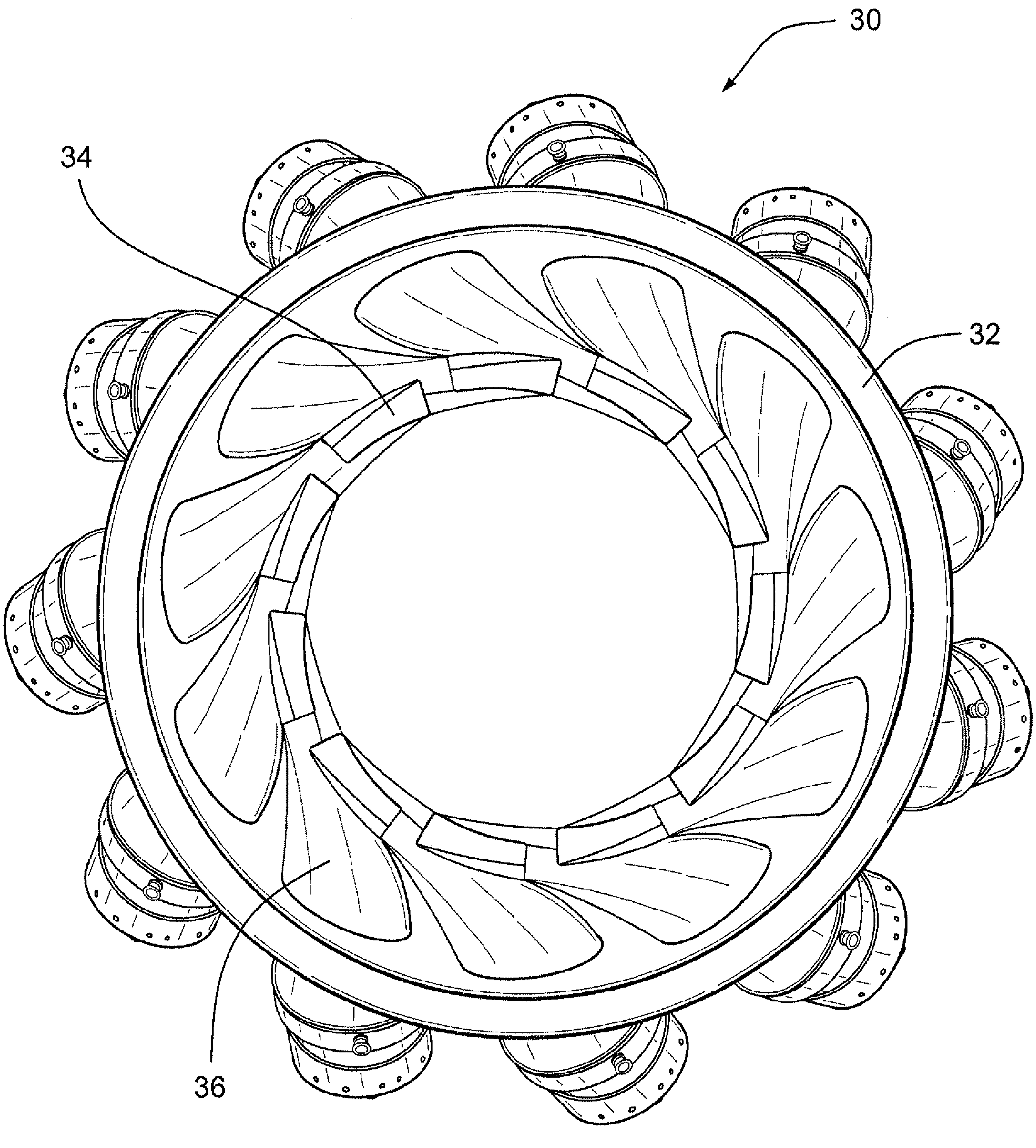
(57) **ABSTRACT**

A combustion section for a gas turbine includes a casing defining a chamber, a plurality of combustor cans disposed in the casing and oriented in an annular pattern, and a plurality of transition pieces each coupled with one of the combustor cans. The transition pieces direct products of combustion from the combustor cans into contact with rotating buckets of the gas turbine. Each of the transition pieces is angled in two planes to effect turning of the products of combustion and to shorten the gas turbine.



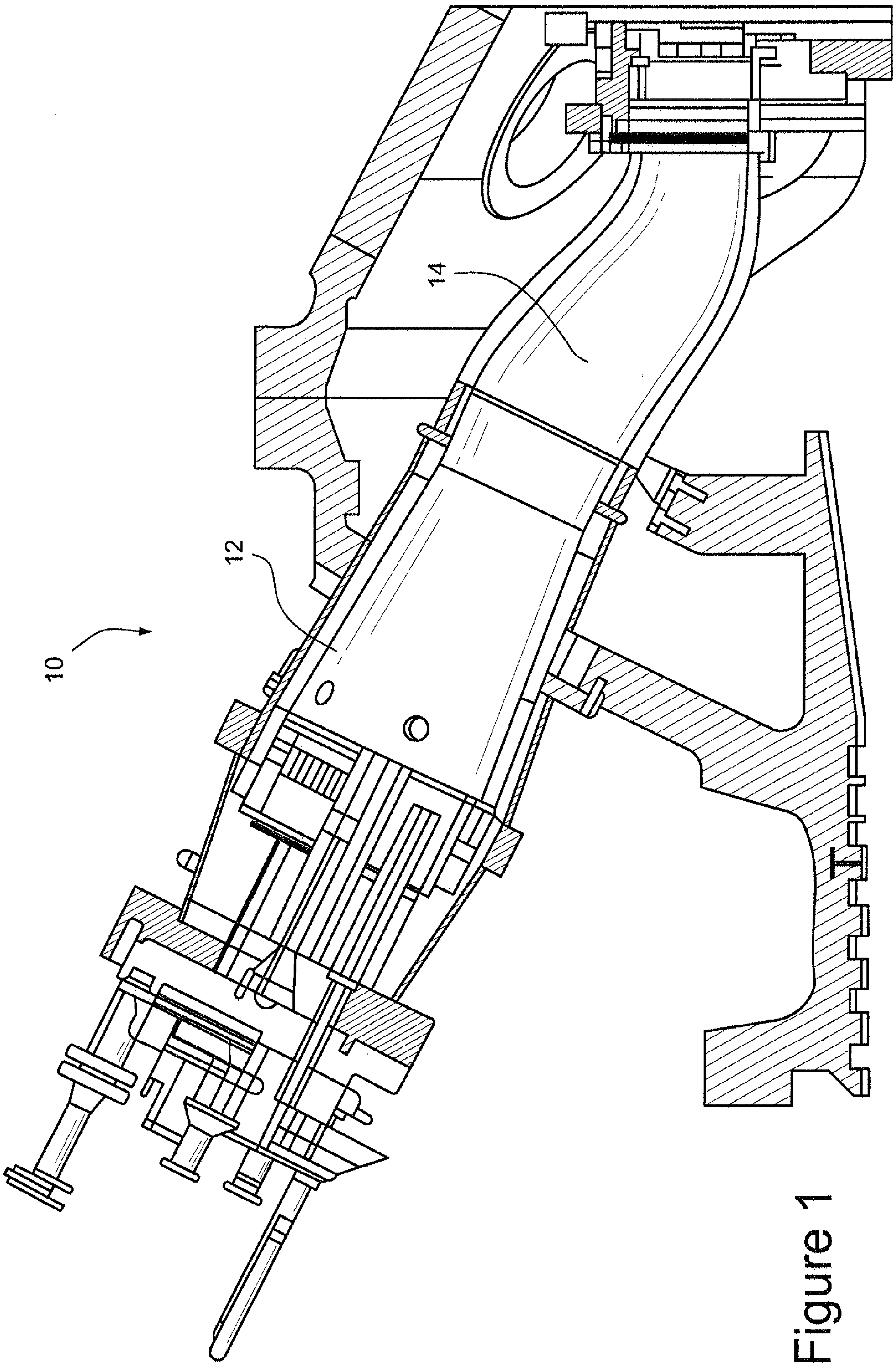


Figure 1

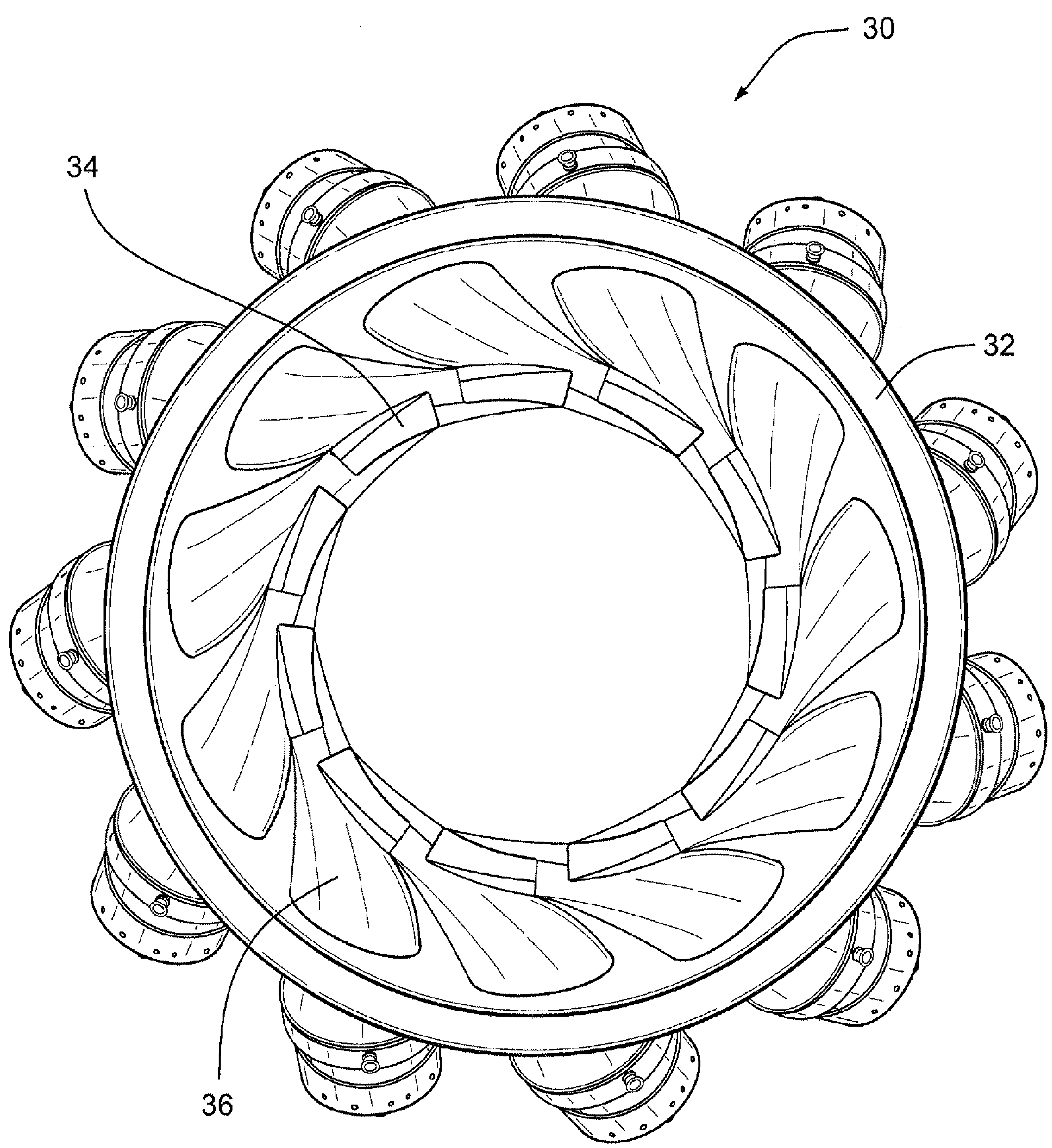


Figure 2

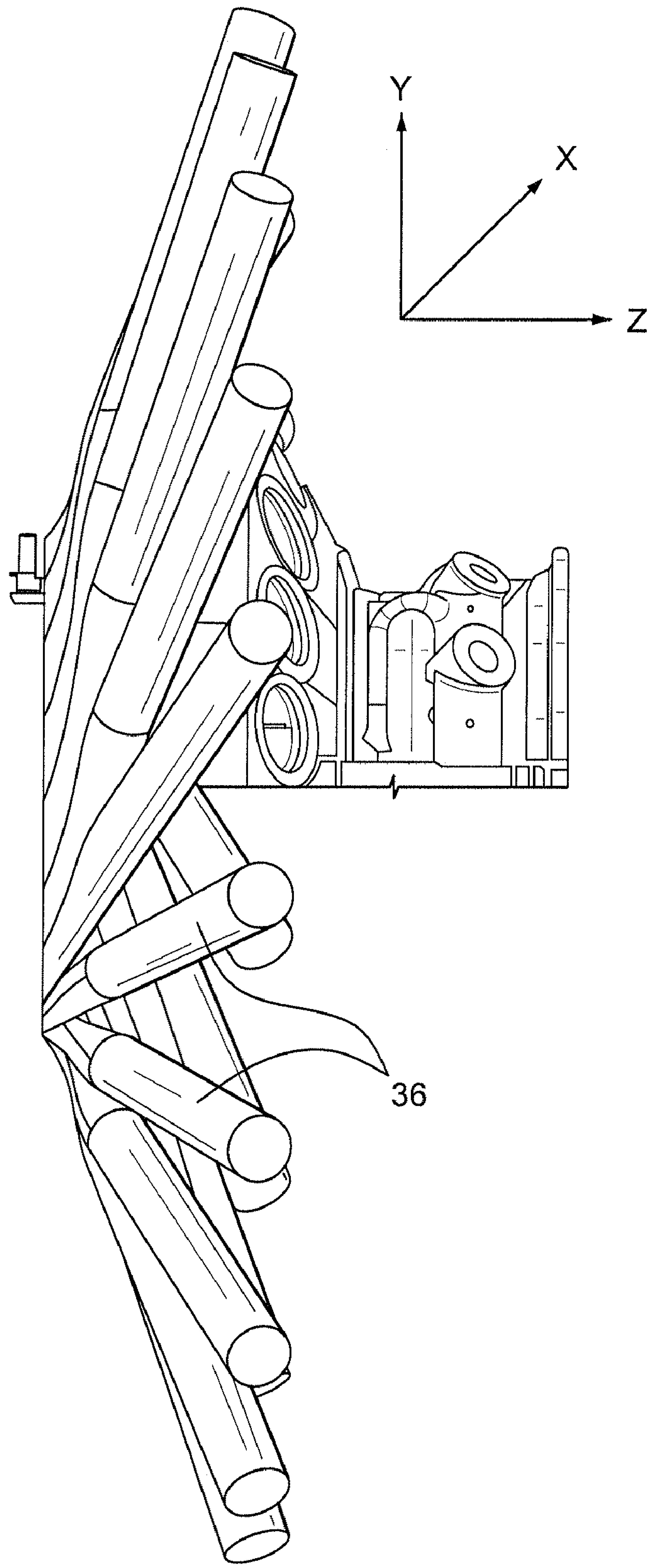


Figure 3

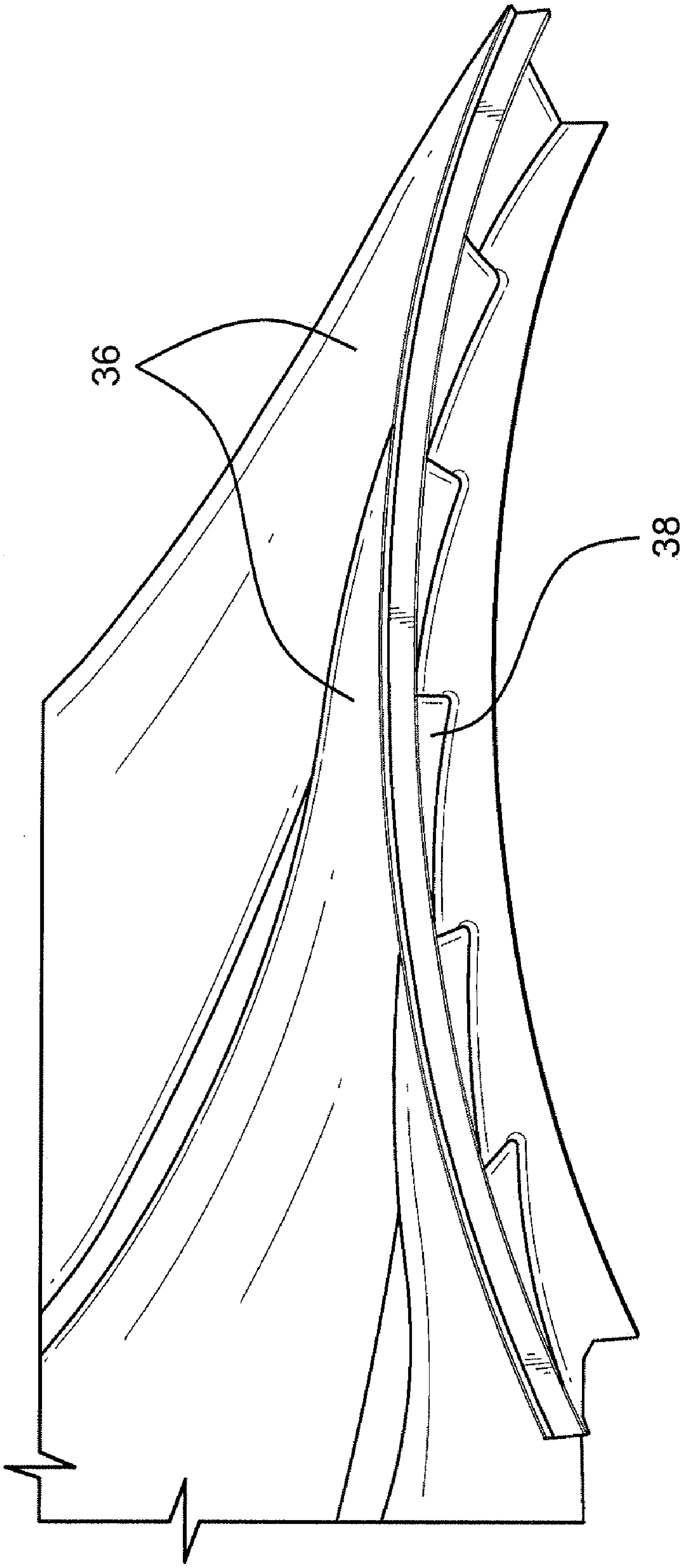


Figure 4

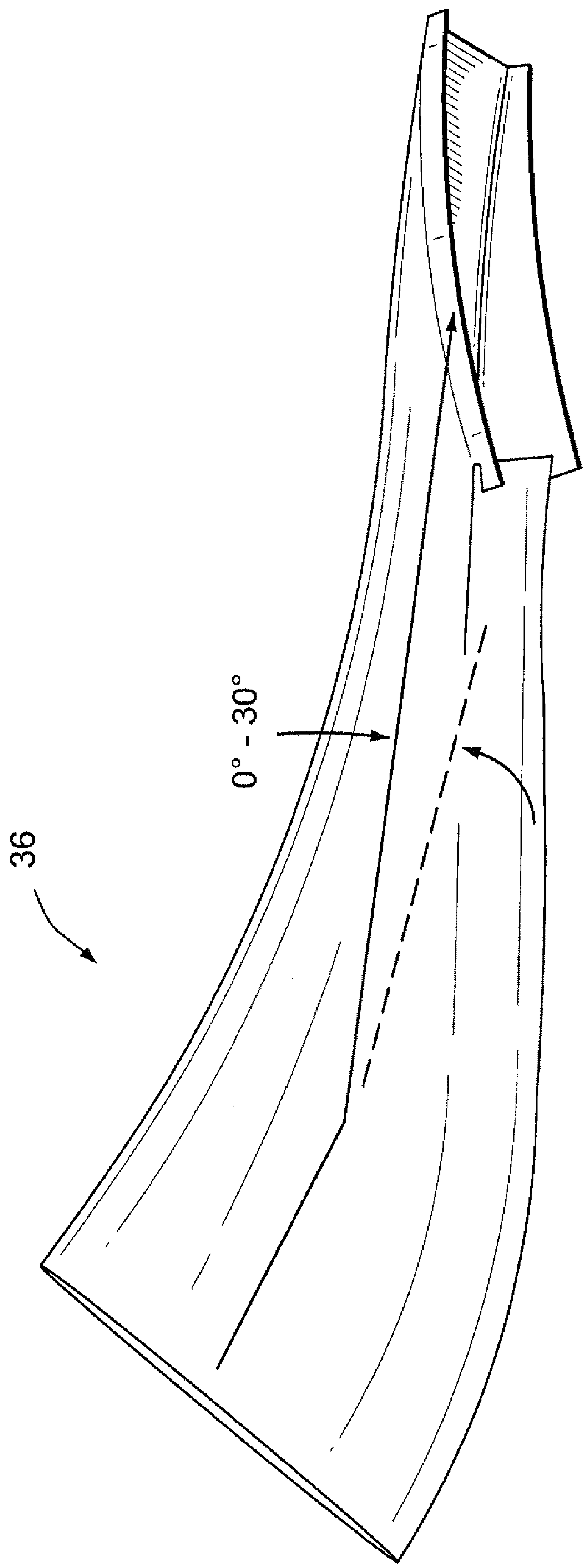


Figure 5

TANGENTIAL COMBUSTOR

BACKGROUND OF THE INVENTION

[0001] The invention relates to a gas turbine and, more particularly, to a combustion section for a gas turbine including structure for turning air flow into the turbine.

[0002] In operating a gas turbine, gas flow is exhausted from the combustor and routed by the transition duct to first stage vanes and blades (rotating buckets). As the gas flow is discharged from the outlet of the transition duct, the flow passes the first stage vanes. The function of the first stage vanes is to accelerate and turn the flow in a circumferential direction so that the predominant flow direction of the gas flow leaving the trailing edges of the vanes is angled in the circumferential or tangential direction relative to the longitudinal direction. This turned flow thus has a longitudinal component and a circumferential component. The flow angle can be substantial, in the range of 40 degrees to 85 degrees measured from the longitudinal axis. By accelerating and angling the gas flow in the circumferential direction relative to the longitudinal direction, the resulting gas flow more effectively imparts its energy to the first row blades, which in turn rotate the associated rotor assembly.

[0003] The use of first stage vanes to accelerate and turn the longitudinal gas flow in the circumferential direction presents several challenges. The vanes and the associated vane support structure must have high strength characteristics to withstand the forces generated in changing the direction of hot, high pressure gas flow over a substantial angle in a relatively short distance. The temperature of the gas flow and the heat generated by this turning process also require a vane cooling system. The forces and heat involved can crack and otherwise damage the vanes and associated support structure. To address these various requirements and operating conditions, the first stage vanes and the associated support structure and cooling systems have developed into a complex system that can be expensive to manufacture, install, and, in the event of damage, repair and replace.

[0004] First stage nozzles add approximately 1.5% total pressure drop, reducing the total pressure ratio of the machine. Performance is closely tied to pressure ratio. Another major draw on engine performance is parasitic flows. The minimum compressor mass flow in current state of the art air-cooled gas turbines represents a major reduction in overall turbine performance. This air flow could be reduced or effectively eliminated by (1) much smaller wetted surface area of the turning/throttling vanes (if turning/throttling vanes are required), (2) possible use of closed circuit cooling of the transition piece vanes, and (3) possible use of air that cools the vanes then passes through the combustor.

[0005] It would be desirable to accelerate and tangentially turn a gas flow for presentation to a first stage blade array without the complications and related costs and damage risks associated with first stage vanes.

BRIEF DESCRIPTION OF THE INVENTION

[0006] In an exemplary embodiment, a combustion section is provided for a gas turbine including rotating buckets that are driven by products of combustion from the combustion section. The combustion section includes a casing defining a chamber, a plurality of combustor cans disposed in the casing and oriented in an annular pattern, and a plurality of transition pieces one each coupled with each of the combustor cans. The transition pieces direct the products of combustion from the combustor cans into contact with the rotating buckets. Each of the transition pieces is angled in two planes to effect turning of the products of combustion and to shorten the gas turbine.

[0007] In another exemplary embodiment, the transition pieces of the combustion section are angled tangentially relative to the annular pattern and axially in a flow direction.

[0008] In yet another exemplary embodiment, a method of directing products of combustion into contact with rotating buckets of a gas turbine includes the steps of orienting a plurality of combustor cans in an annular pattern in a combustor casing, providing a plurality of transition pieces each one coupled with one of the combustor cans, and angling the transition pieces tangentially relative to the axial flow direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a cross-sectional view of a conventional combustor;

[0010] FIG. **2** is an end view of the combustion section in a gas turbine of the described embodiments;

[0011] FIG. **3** is a side view of the combustion section showing the axial orientation of the transition pieces;

[0012] FIG. **4** shows an embodiment with the transition pieces including throttling guides/vanes; and

[0013] FIG. **5** shows an embodiment with the transition pieces turned.

DETAILED DESCRIPTION OF THE INVENTION

[0014] FIG. **1** illustrates a typical combustor for a gas turbine, which includes a compressor, a plurality of combustors, and a turbine. The compressor pressurizes inlet air, which is then reverse flowed to the combustor where it is used to cool the combustor and to provide air to the combustion process. The combustor **10** includes a liner **12** that defines a combustion zone and a transition piece **14** that connects the outlet end of the combustor with an inlet end of the turbine to deliver products of combustion to the turbine. The interface between the combustion transition piece **14** and the turbine first stage nozzle requires the use of seals to reduce leakages into the gas path.

[0015] FIG. **2** is an end view of a combustion section **30** for the gas turbine. The combustion section **30** includes a casing **32** defining a chamber, and a plurality of combustor cans **34** disposed in the casing and oriented in an annular pattern as shown. A plurality of transition pieces **36**, one each coupled with each of the combustor cans **34**, serves to direct products of combustion from the combustor cans **34** into contact with rotating buckets of the turbine. Each of the transition pieces **36** is angled in two planes to effect turning of the products of combustion and to shorten the gas turbine.

[0016] As shown in FIG. **2**, the transition pieces **36** are angled tangentially relative to the annular pattern of combustor cans **34** (in an X-Y plane, with the Z axis into the page in FIG. **2**). Additionally, the transition pieces are angled axially in a flow direction (i.e., toward the turbine buckets) as shown in FIG. **3** (in the Y-Z plane, with the X axis into the page in FIG. **3**). The angles are determined to effect a proper angle of incidence to extract work from the rotating buckets. These angles vary on turbine design.

[0017] This structure offers benefits to gas turbine performance and configuration. In particular, the flange-to-flange length can be shortened, the pressure loss across the first stage nozzle can be drastically reduced, and the first stage nozzle cooling and leakage flows can be drastically reduced. Angling of the combustor in the tangential direction allows the combustor to provide all or a portion of the turning effect that is typically applied in the first stage nozzle of the turbine. As a consequence, much lower pressure drop will occur in the process of turning the air flow into the first stage bucket.

[0018] In yet another alternative arrangement, with reference to FIG. **4**, the transition piece includes throttling vanes **38**. The throttling vanes may be formed by contouring the sides of the transition piece. The throttling vanes would further accelerate and straighten the flow to bring the air to ideal conditions to extract work in the first stage bucket.

[0019] More recent aerodynamic analysis has shown that the throttling vanes may not be required. In an alternative construction, with reference to FIG. **5**, ends of the transition pieces **36** may be turned, possibly up to 30° or more, to give the required overall turning.

[0020] Another big reduction in heat load occurs because there is higher heat transfer where turning is taking place. With limited or no circumferential turning being done on the hot side (now done before the combustion chamber), the result is lower heat transfer on the hot side. Turning the air while it is still cold is a significant advantage of this configuration.

[0021] Additionally, the turning/throttling vanes (if required) will have much smaller wetted surface area than current first stage nozzles. As a result, less heat transfer will be required to keep them within acceptable material temperatures. Moreover, by integrating the combustor transition piece and the first stage turning vanes, the opportunity to use air that eventually passes through the combustor to cool the nozzle is facilitated. Since the combustor transition piece will take the place of the first stage nozzle, there will be no interference leakages between these two pieces as in conventional designs.

[0022] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. A combustion section for a gas turbine including rotating buckets that are driven by products of combustion from the combustion section, the combustion section comprising:

a casing defining a chamber;

a plurality of combustor cans disposed in the casing and oriented in an annular pattern; and

a plurality of transition pieces each one coupled with one of the combustor cans and directing the products of combustion from the combustor cans into contact with the rotating buckets, wherein the transition pieces are angled tangentially relative to an axial flow direction.

2. A combustion section according to claim **1**, wherein all of the combustor cans and the transition pieces are correspondingly angled tangentially relative to the axial flow direction.

3. A combustion section according to claim **1**, wherein the combustor cans and the transition pieces are angled to effect a proper angle of incidence to extract work with the rotating buckets.

4. A combustion section according to claim **1**, wherein ends of the plurality of transition pieces are turned.

5. A combustion section according to claim **4**, wherein the ends of the plurality of transition pieces are turned up to 30°.

6. A combustion section according to claim **1**, wherein the plurality of transition pieces comprise throttling vanes.

7. A combustion section according to claim **6**, wherein the throttling vanes are formed by contouring sides of the transition pieces.

8. A combustion section for a gas turbine including rotating buckets that are driven by products of combustion from the combustion section, the combustion section comprising:

a casing defining a chamber;

a plurality of combustor cans disposed in the casing and oriented in an annular pattern; and

a plurality of transition pieces each coupled with one of the combustor cans and directing the products of combustion form the combustor cans into contact with the rotating buckets, wherein each of the transition pieces is angled in two planes to effect turning of the products of combustion and to shorten the gas turbine.

9. A combustion section according to claim **8**, wherein the two planes comprise a circumferential plane and a tangential plane.

10. A method of directing products of combustion into contact with rotating buckets of a gas turbine, the method comprising:

orienting a plurality of combustor cans in an annular pattern in a combustor casing;

providing a plurality of transition pieces one each coupled with each of the combustor cans; and

angling the transition pieces tangentially relative an axial flow direction.

11. A method according to claim **10**, wherein all of the combustor cans and the transition pieces are correspondingly angled tangentially relative to the axial flow direction.

12. A method according to claim **10**, wherein the angling step is practiced by angling the transition pieces to effect a proper angle of incidence to extract work with the rotating buckets.

13. A method according to claim **10**, further comprising flowing products of combustion from the combustor cans through the transition pieces into contact with the rotating buckets.

14. A method according to claim **13**, wherein the flowing step comprises turning the products of combustion in a tangential direction relative to the annular pattern and turning the products of combustion in an axial direction toward the rotating buckets.

15. A method according to claim **14**, wherein the angling step comprises integrating the transition pieces with respective turning vanes of the rotating buckets.

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