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(54) **TURBINE BLADE**

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(57) **ABSTRACT**

A turbine blade, having a plurality of auxiliary cooling channels which branch off from a main cooling channel, formed within a blade body, is provided. The plurality of auxiliary cooling channels open into outlet openings in the leading edge region of the blade body. A heat shield element is attached to the blade body in the leading edge region at a predefined spacing, wherein the heat shield element has a number of outlet channels which are arranged behind one another in the longitudinal direction and extend from the main cooling channel to the outer wall face of the heat shield element.

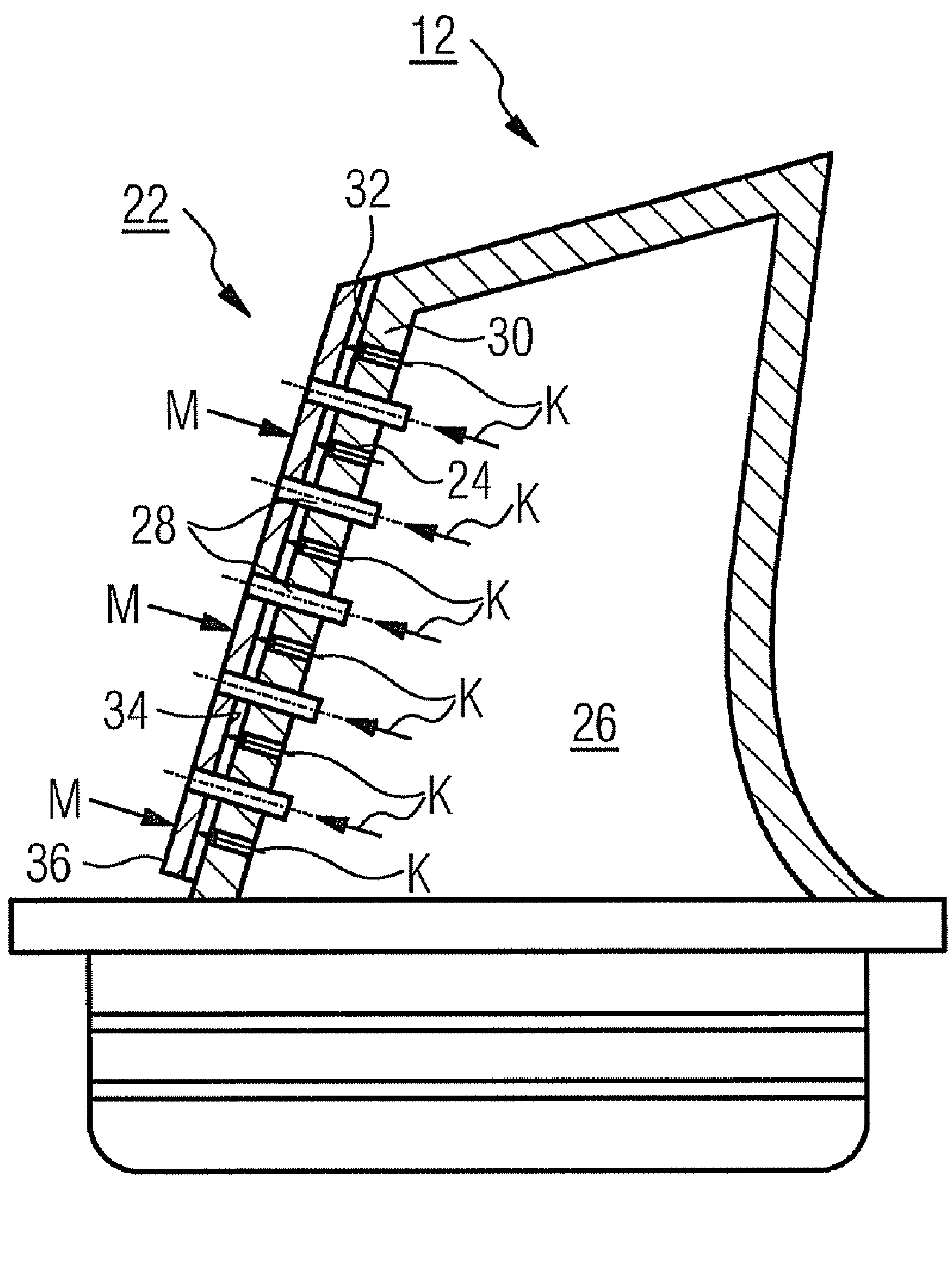


FIG 1

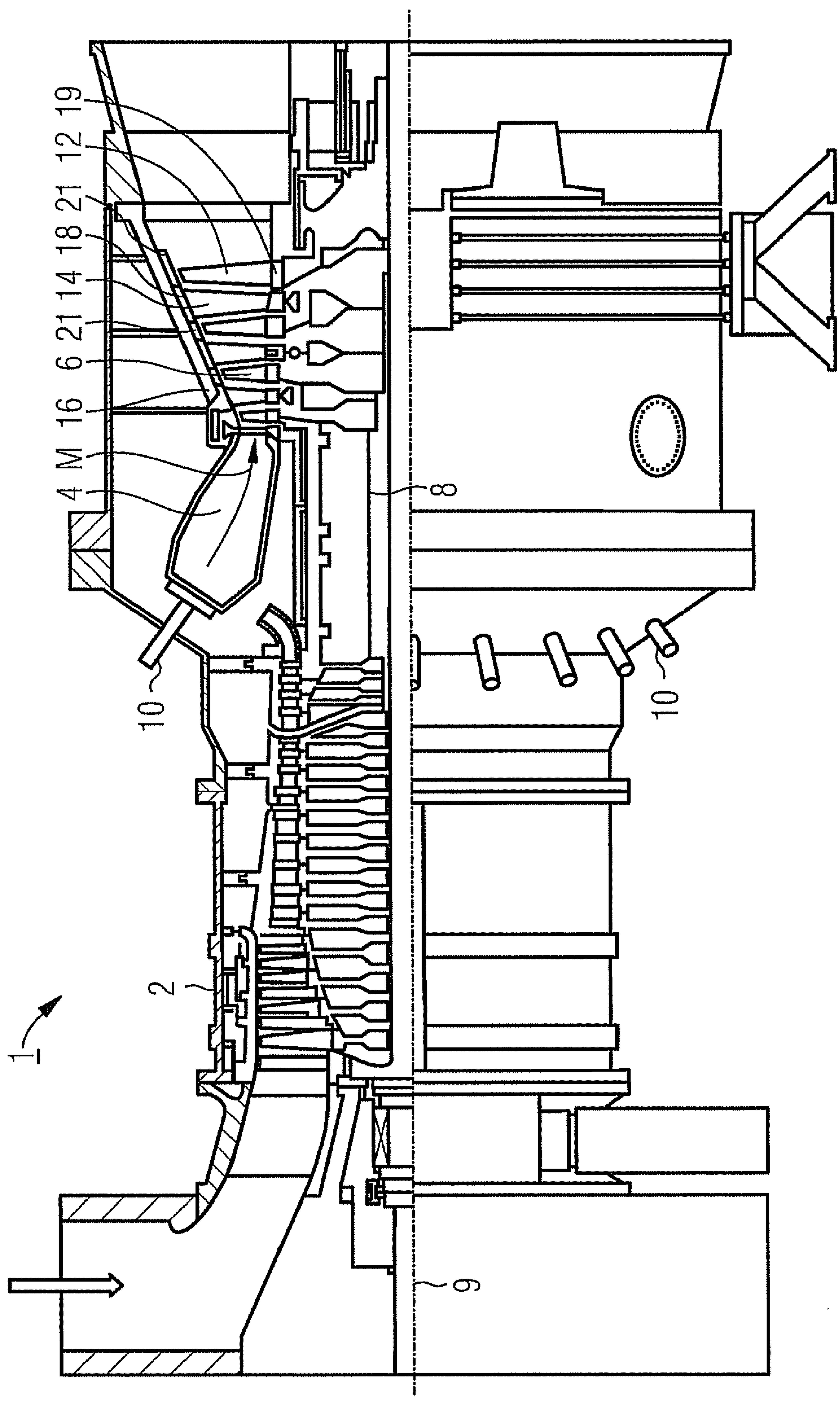


FIG 2

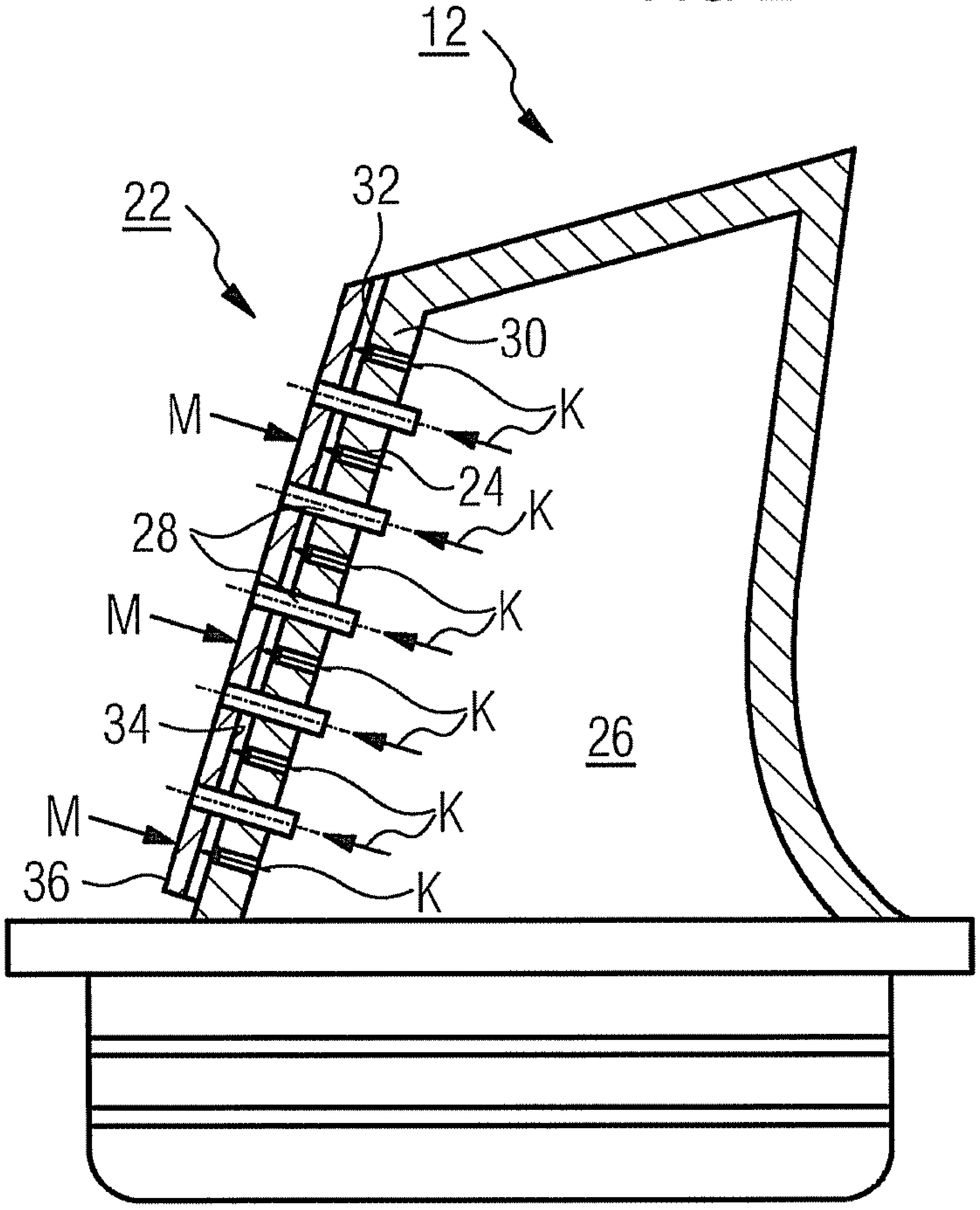


FIG 3

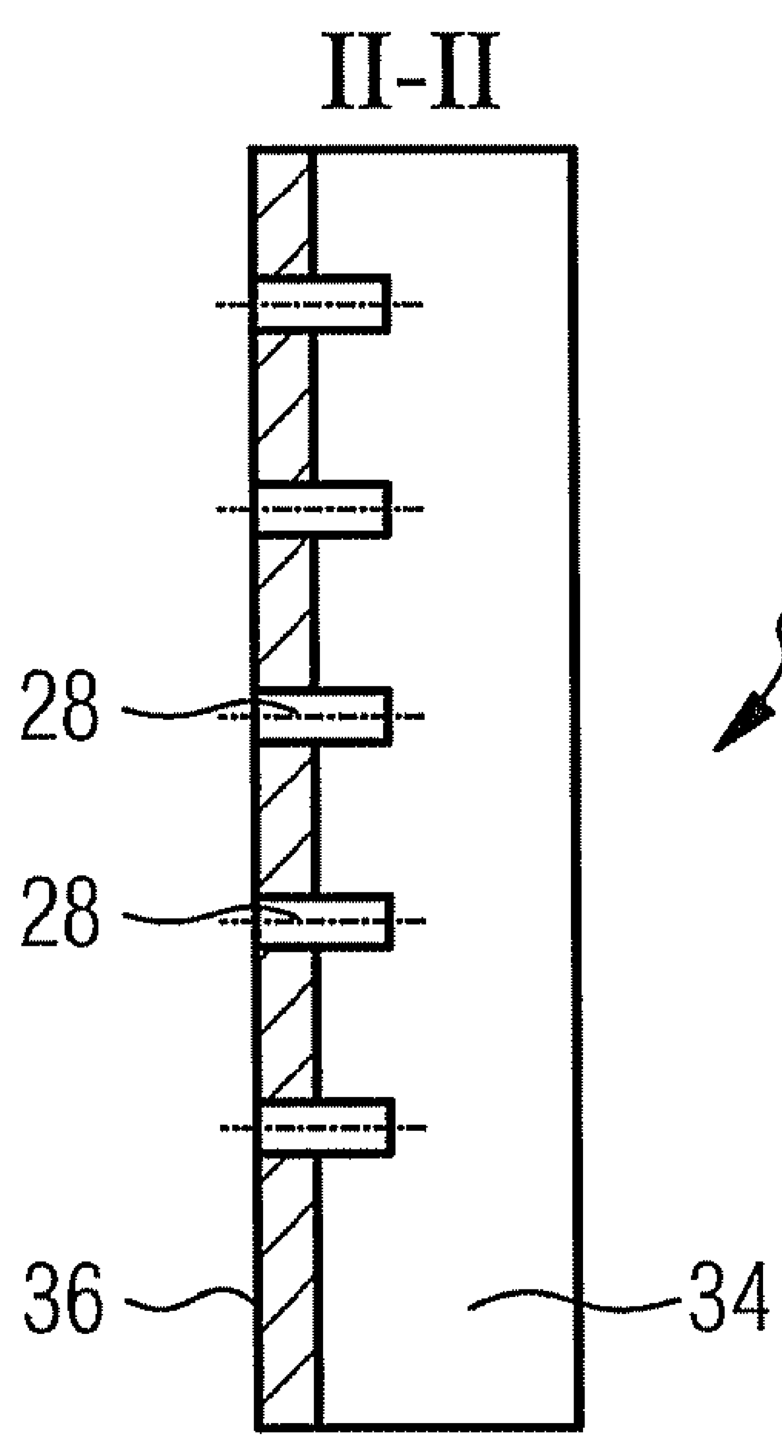


FIG 4

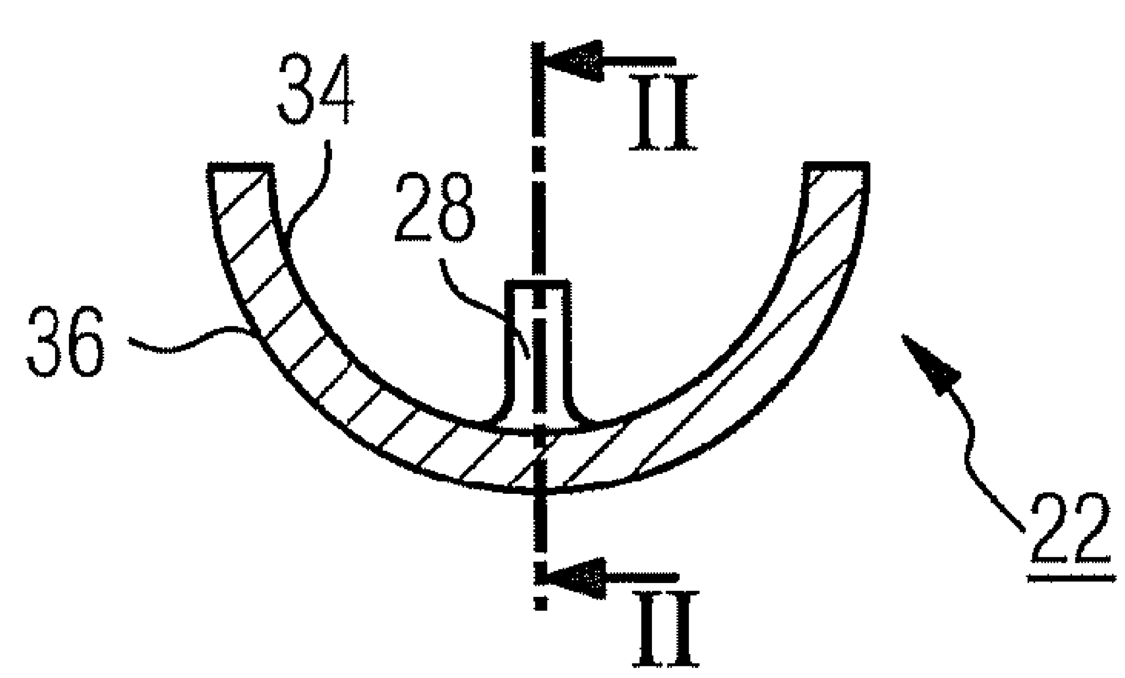


FIG 5

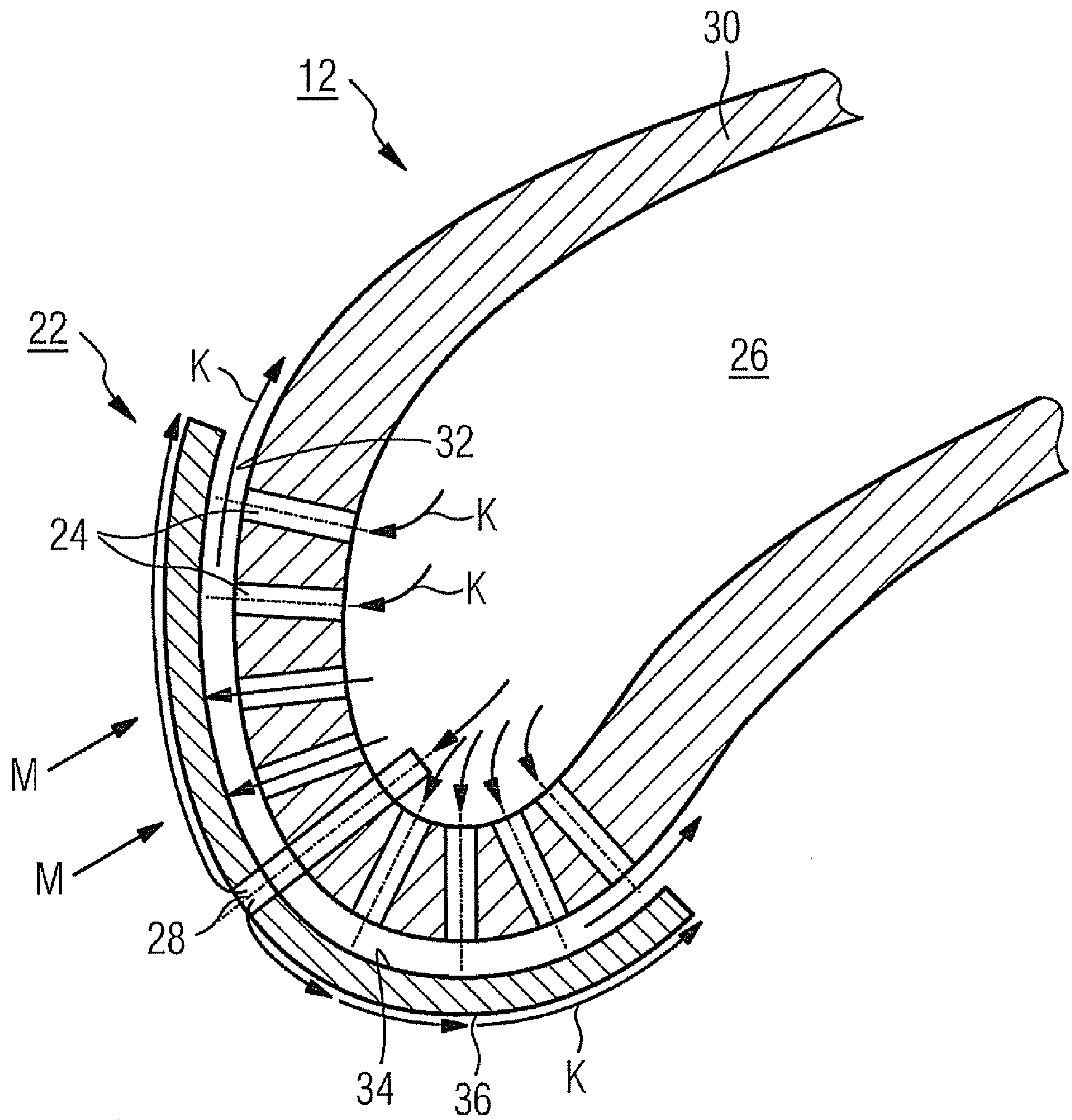
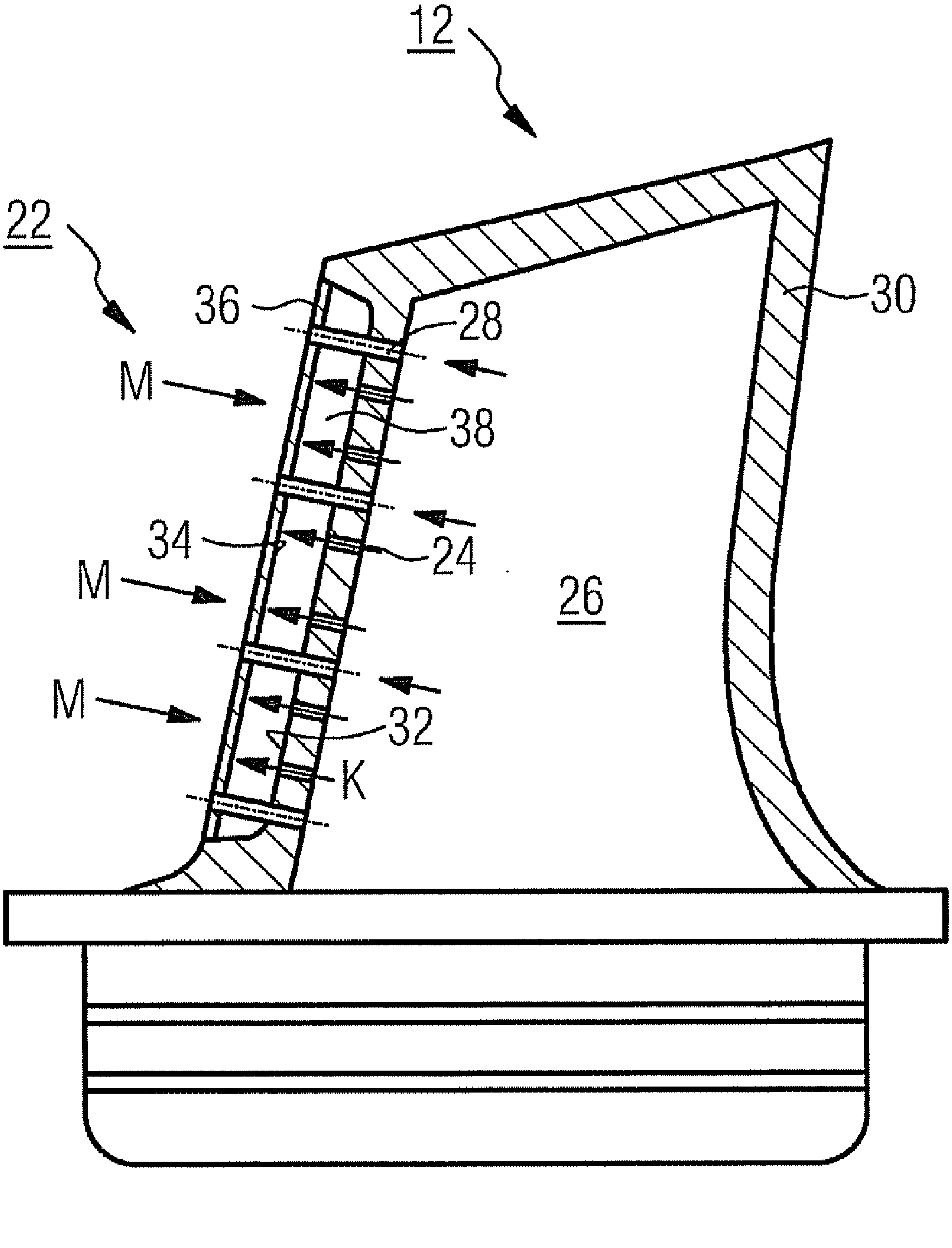


FIG 6



TURBINE BLADE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is the US National Stage of International Application No. PCT/EP2007/059989, filed Sep. 20, 2007 and claims the benefit thereof. The International Application claims the benefits of European Patent Office application No. 06022622.2 EP filed Oct. 30, 2006, both of the applications are incorporated by reference herein in their entirety.

FIELD OF INVENTION

[0002] The invention refers to a turbine blade according to the claims.

BACKGROUND OF INVENTION

[0003] Turbomachines, especially gas turbines, are used in many areas for driving generators or driven machines. A gas turbine customarily has a rotatably mounted rotor which is enclosed by a fixed casing. The fixed sub-assemblies of a gas turbine are also collectively referred to as a stator. The energy content of a fuel in this case is used for producing a rotational movement of the rotor components. For this purpose, the fuel is combusted in a combustion chamber, wherein compressed air is supplied by an air compressor. The operating medium which is produced in the combustion chamber as a result of the combustion of the fuel, being under high pressure and at high temperature, is guided in the process through a turbine unit which is connected downstream to the combustion chamber, where it is expanded, performing work.

[0004] For producing the rotational movement of the rotor components, in this case a number of rotor blades, which are customarily assembled in blade groups or blade rows, are arranged on these rotor components and drive the rotor components by means of impulse transmission of the flow medium. For guiding the flow medium in the turbine unit, stator blade rows, which are connected to the turbine casing, are moreover customarily arranged between adjacent rotor blade rows. The turbine blades, especially the stator blades, in this case customarily have a blade airfoil, which is extended along a blade axis, for suitable guiding of the operating medium and upon which a platform, which extends transversely to the blade axis, can be formed on the end face for fastening the turbine blade on the respective carrier body.

[0005] With the design of such gas turbines, a particularly high efficiency is customarily a design aim in addition to the achievable output. An increase of the efficiency can be achieved in this case for thermodynamic reasons basically by means of an increase of the exhaust temperature at which the operating medium flows from the combustion chamber and into the turbine unit. The temperatures which are achieved during operation of such a gas turbine lie at up to 1300° C.

[0006] The components and component parts of the gas turbine which are exposed to these high temperatures of the operating medium are therefore subjected to a high thermal stress. In order to therefore ensure with high reliability a comparatively long service life of the affected components, the affected components, especially the rotor blades and/or stator blades of the turbine unit, are cooled. The turbine blades in this case are customarily provided with cooling passages, wherein an effective and reliable cooling of the leading edge of the respective turbine blade, which is thermally stressed to a particularly high degree, is especially to be ensured.

SUMMARY OF INVENTION

[0007] As cooling medium, cooling air is customarily used in this case. This cooling air can be fed to the respective turbine blade via a number of cooling medium passages which are integrated into the blade airfoil or the blade profile. From these cooling medium passages the cooling air flows into discharge passages, which branch off from these, of the respectively provided regions of the turbine blades, as a result of which a convective cooling of the blade interior and of the blade wall is achieved. On the discharge side, these passages are left open so that after flowing through the turbine blade the cooling air flows from discharge openings, which are also referred to as film cooling holes, and form a cooling film on the surface of the blade airfoil. By means of this cooling air film, the blade basic body is largely protected on the surface against a direct and intensive contact with the hot operating medium which flows past at high velocity.

[0008] In order to enable an especially uniform and effective film cooling in the leading edge region of the blade airfoil, the discharge openings in this region are customarily arranged uniformly along at least two rows which are oriented parallel to the leading edge. The discharge passages, moreover, as a rule are oriented at an angle to the longitudinal direction of the turbine blade, which assists the forming of the protective cooling air film which flows along the surface.

[0009] Since the leading edge region of the turbine blade is particularly exposed to a severe thermal stress, the leading edge of the blade can moreover be provided with a heat shielding coating. This heat shielding coating expediently consists of a material which is more resistant to temperature than that of the blade basic body. Moreover, the heat shielding coating is characterized by a low coefficient of thermal conductivity, as a result of which the temperature stress of the base material of the blade body is reduced. Therefore, the service life of the turbine blade is increased as a result of such a heat shielding coating in conjunction with cooling of the leading edge region of the blade.

[0010] This heat shield, however, has the disadvantage that after a certain time cracks occur in the heat shielding coating. These cracks reduce the protection of the blade basic body against the hot exhaust gas of the gas turbine so that as a consequence of the increased thermal stress crack development can also occur in the basic body of the turbine blade. Such cracks in the blade basic body endanger the operational safety and can lead to the breakdown of the gas turbine.

[0011] Moreover, a modular turbine blade of the type referred to in the introduction is known from GB 841 117. The turbine blade comprises a cast basic body with a blade airfoil upon which a plurality of cooling air blow-out slots are provided on the leading edge side, which are covered at a distance by a guard plate which is fastened on the blade profile on the side. The cooling air which issues from the slots cools the guarded leading edge in the manner of an impingement cooling, and subsequent to the impingement cooling is deflected by the plate in such a way that it can leave the modular turbine blade in the region of the pressure-side surface and suction-side surface.

[0012] The invention is therefore based on the object of disclosing a turbine blade of the aforementioned type which with simple means ensures an especially high operational safety of the gas turbine, even when used in high flow temperatures.

[0013] This object is achieved according to the invention by means of a turbine blade according to the features of the claims.

[0014] The invention in this case is based on the consideration that particularly with regard to the operational safety and the economical efficiency of a gas turbine the turbine blades should have a service life which is as long as possible as a result of a suitably selected heat shield. At the same time, the fact that particularly the leading edge of the turbine blade is thermally severely stressed should especially be taken into consideration. This leading edge should therefore especially be protected.

[0015] This is consequently achieved by the heat shield element being attached at a distance on the blade basic body in the leading edge region, as a result of which a direct contact of the heat shield element with the blade basic body is avoided. For cooling the blade basic body, in this case its outside surface in the leading edge region is provided with a number of secondary cooling passages, wherein these extend from the main cooling passage to the outside surface of the blade basic body. These secondary cooling passages are arranged in a uniformly distributed manner behind the heat shield element for effective cooling in the leading edge region of the blade basic body. Therefore, stresses, and cracks which result from them, can be avoided.

[0016] For cooling the heat shield element, this has a number of discharge passages which extend from its outside surface in the direction of the blade basic body. This passage, which is formed for guiding a cooling flow, additionally also serves as a connecting element between the heat shield element and the blade basic body. The discharge passage in this case projects with one end into a main cooling passage which is formed inside the blade, wherein the medium which flows in the main cooling passage can flow for cooling the heat shield element on its outside surface.

[0017] By means of a heat shield system which is formed in such a way the especially critical region, that is to say the leading edge region of the turbine blade, is especially effectively protected against the high temperatures of the operating medium of the turbine. As a result of cooling the heat shield element and the blade basic body it is possible to increase the temperature of the operating medium of the turbine, which flows around the turbine blade, above the temperature which is possible for the material of the turbine blade. The cooling is carried out in such a way by a cooling flow from the main cooling passage being directed in part through the discharge passages of the heat shield element onto its outside surface, and in part by a cooling flow from the main cooling passage flowing via the secondary cooling passages of the blade basic body through the gap which is formed by the heat shield element and the blade basic body. By means of cooling medium which is guided in such a way, a protective film is formed on the outside surface of the heat shield element. This cooling film prevents a direct contact of the hot operating medium of the turbine with the heat shield element, as a result of which the temperature stress of the outside surface which is exposed to inflow is reduced. The increase of the temperature of the heat shield element which therefore occurs does not directly have an effect on the temperature of the blade basic body in the leading edge region, however, since the heat shield element is arranged at a distance from the blade basic body. The heat transfer between the heat shield element and the blade basic body is significantly reduced, moreover, by means of the cooling medium which flows between the inside surface of the heat shield element and the outside surface of the blade basic body by the heat in the leading edge region being carried away by means of the internal cooling flow.

[0018] The heat shield element especially preferably has a shape which is adapted to the profile of the blade basic body in the leading edge region. Consequently, the effect is achieved of the turbine blade also having a flow-optimized shape in the leading edge region after attaching the heat shield element. Moreover, the shape of the heat shield element which corresponds to the blade basic body leads to a uniform extent of the gap in the leading edge region. Consequently, the cooling medium flows with predominantly constant velocity along the outside surface of the blade basic body and along the inside surface of the heat shield element, as a result of which the cooling in the leading edge region of the turbine blade is carried out especially uniformly. Therefore, no excessively high stresses, which could lead to crack developments, occur, particularly in the blade basic body.

[0019] In a further expedient development, the heat shield element is produced from a material which is more resistant to temperature in comparison to the blade basic body. Since the heat shield element is directly exposed to inflow of hot operating medium during operation of the turbine, this component is particularly exposed to a high temperature stress. Therefore, the heat shield element should be produced from an especially temperature-resistant material in order to particularly ensure the operational safety and to minimize the downtimes of the turbine.

[0020] In addition to the use of temperature-resistant materials, for increasing the resistance of the heat shield element this should be cooled. If in this case the heat shield element is designed for impingement cooling for an especially effective cooling, this is achieved by the distance of the heat shield element from the blade basic body being sufficiently minimized.

[0021] For this purpose, the heat shield element is preferably arranged at a distance of 1 mm to 3 mm from the blade basic body.

[0022] A heat shield element which is attached up to this distance in the leading edge region of the turbine blade particularly ensures a sufficiently high impingement velocity of the cooling medium upon the inside surface of the heat shield element, as a result of which an especially effective cooling by means of impingement cooling is achieved. Since the static pressure in the main cooling passage of the blade basic body is predetermined, the impingement velocity of the cooling flow, in addition, for example, to the diameter of the secondary cooling passages, is determined in particular by the distance of the heat shield element from the blade basic body. A sufficiently high velocity of the cooling medium directly before impinging on the inside surface of the heat shield element is necessary since an intimate contact between the cooling medium and the inside surface of the heat shield element takes place in this way. By means of such impingement cooling a significantly more effective carrying away of heat is possible than is possible, for example, in the case of a film cooling.

[0023] In an especially advantageous development, the secondary cooling passages are arranged in a manner in which they are oriented essentially perpendicularly to the inside surface of the heat shield element. Therefore, the cooling flow from the main cooling passage impinges perpendicularly upon the inside surface of the heat shield element, as a result of which a large part of the kinetic energy of the cooling medium is used for an especially intimate contact between the particles in the cooling flow and the inside surface of the heat shield element. As a result, the heat of the heat shield element in an especially effective manner is transmitted to the internal cooling flow and carried away.

[0024] In a further variant, the heat shield element is connected to the blade basic body in the edge regions of the turbine blade. For foaming the especially effective impingement cooling, the blade basic body, preferably in its leading edge region, is provided with a recess. The advantage of this alternative embodiment lies inter alia in the fact that the original flow-optimized shape of the turbine blade is maintained.

[0025] The described heat shield element can advantageously be used at the places of the turbomachine where component parts and sub-assemblies of the thermal turbomachine are impinged upon with the hot operating medium. However, the use of the heat shield element is especially preferable for the protection of the leading edge region of the turbine blade since the temperature stress of the blade basic body is especially high in this region. Inter alia, the downtimes of the gas turbine are minimized by means of such a heat shield element since the service life is increased because of the heat shield element.

[0026] As a result of the extremely high thermal stress of the heat shield element, cracks can occur in the heat shield element, even when using an especially temperature-resistant material, especially after a specified operating period of the turbine. In this case, for example within the scope of the maintenance operations of the gas turbine, the heat shield elements can be removed in a relatively simple manner and replaced by new ones. Therefore, the affected turbine blades do not have to be completely exchanged as previously in the case of crack development in the leading edge region of the turbine blade.

[0027] The advantages which are achieved with the invention are especially that by means of the heat shield element which is connected upstream to the blade basic body of the turbine blade an efficient protection of the leading edge region of the turbine blade against the high temperatures of the operating medium of the turbines is provided. In particular, such a heat shield system enables the use of impingement cooling, as a result of which the heat shield element can be cooled in an especially effective manner. Furthermore, by means of the heat shield element the possible occurrence of cracks, which extend from the outside surface of the heat shield element and spread into the blade basic body, is prevented. Moreover, the heat shield elements according to the invention can subsequently be attached on the turbine blades in a simple manner and with relatively little cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] An exemplary embodiment of the invention is explained in more detail with reference to a drawing. In the drawing:

[0029] FIG. **1** shows a half-section through a gas turbine,

[0030] FIG. **2** shows a turbine blade, which is provided with a heat shield, in longitudinal section,

[0031] FIG. **3** shows a heat shield element which is sectioned in the longitudinal direction,

[0032] FIG. **4** shows a heat shield element in cross section,

[0033] FIG. **5** shows a cross section through a turbine blade which is provided with a heat shield element,

[0034] FIG. **6** shows in alternative embodiment a turbine blade with a heat shield element which is integrated into the leading edge region of the blade basic body.

[0035] Like parts are provided with the same designations in all the figures.

DETAILED DESCRIPTION OF INVENTION

[0036] The gas turbine **1** according to FIG. **1** has a compressor **2** for combustion air, a combustion chamber **4**, and also a turbine unit **6** for driving the compressor **2** and for driving a generator, which is not shown, or a driven machine. For this purpose, the turbine unit **6** and the compressor **2** are arranged on a common turbine shaft **8**, which is also referred to as a turbine rotor, to which the generator or the driven machine is also connected, and which is rotatably mounted around its center axis **9**. The combustion chamber **4**, which is designed in the style of an annular combustion chamber, is equipped with a number of burners **10** for combustion of a liquid or gaseous fuel.

[0037] The turbine unit **6** has a number of rotatable rotor blades **12** which are connected to the turbine shaft **8**. The rotor blades **12** are arranged on the turbine shaft **8** in the manner of a ring and so form a number of rotor blade rows. Furthermore, the turbine unit **6** comprises a number of fixed stator blades **14** which are fastened also in the manner of a ring on an inner casing **16** of the turbine unit **6**, forming stator blade rows. The rotor blades **12** in this case serve for driving the turbine shaft **8** by means of impulse transmission by the operating medium M which flows through the turbine unit **6**. The stator blades **14**, on the other hand, serve for flow-guiding of the operating medium M between two rotor blade rows or rotor blade rings which follow each other in each case as seen in the flow direction of the operating medium M. A pair consisting of a ring of stator blades **14** or a stator blade row, and a ring of rotor blades **12** or a rotor blade row, which follow each other, in this case is also referred to as a turbine stage.

[0038] Each stator blade **14** has a platform **18** which is arranged as a wall element for fixing the respective stator blade on the inner casing **16** of the turbine unit **6**. The platform **18**, as also the turbine blade **12**, **14**, in this case is a comparatively thermally severely stressed component part. Each rotor blade **12** is fastened in a similar manner on the turbine shaft **8** via a platform **19** which is also referred to as a blade root.

[0039] Between the platforms **18**, which are arranged at a distance from each other, of the stator blades **14** of two adjacent stator blade rows, a guide ring **21** is arranged in each case on the inner casing **16** of the turbine unit **6**. The outer surface of each guide ring **21** in this case is also exposed to the hot operating medium M which flows through the turbine unit **6**, and in the radial direction is at a distance from the outer end of the rotor blades **12**, which lie opposite it, by means of a gap. The guide rings **21** which are arranged between adjacent stator blade rows in this case serve especially as shroud elements which protect the inner casing **16**, or other installed parts on the casing, against overstressing as a result of the operating medium M which flows through the turbine **6**.

[0040] The combustion chamber **4** in the exemplary embodiment is designed as a so-called annular combustion chamber, in which a multiplicity of burners **10**, which are arranged around the turbine shaft **8** in the circumferential direction, open into a common combustion space. For this purpose, the combustion chamber **4** is designed in its entirety as an annular structure which is positioned around the turbine shaft **8**.

[0041] For achieving a comparatively high efficiency, the combustion chamber **4** is designed for a comparatively high temperature of the operating medium M of about 1000° C. to 1600° C. In order to also enable a comparatively long service life in the case of these operating parameters which are unfavorable for the materials, the rotor blades **12**, as shown in FIG. **2**, have a heat shield element **22** which is attached in the leading edge region. Each of the heat shield elements **22** which are attached to the rotor blades **12** is equipped on the operating medium side with an especially heat-resistant protective coating, such as ceramic, or is produced from a high temperature-resistant material.

[0042] As shown in FIG. **2**, the turbine blade **12**, **14** is provided with a number of secondary cooling passages **24** in the leading edge region. The discharge passages **28**, which are also attached in the leading edge region of the turbine blade **12**, **14** and which project into a main cooling passage **26**, serve as fastening elements for the heat shield element **22** in addition to the guiding of the cooling medium K. On account of the higher pressure which prevails in the main cooling passage **26** of the blade basic body **30** compared with the ambient pressure in the turbine unit **6**, the cooling air K, which is preferably used as cooling medium K, flows via the secondary cooling passages **24** into the gap which is formed between the outside surface **32** of the blade basic body **30** and the inside surface **34** of the heat shield element **22**, and also through the discharge passages **28** of the heat shield element **22**, wherein the cooling air K which flows from the discharge passages **28** forms a protective film between the operating medium M and the outside surface **36** of the heat shield element **22**. On the other hand, the cooling air K which escapes from the secondary cooling passages **24** of the blade basic body **30** flows against the inside surface **34** of the heat shield element **22** and cools this by means of the impingement cooling effect which occurs as a result.

[0043] FIGS. **3** and **4** show the heat shield element **22** in two different sectional views in each case, wherein it becomes apparent from the longitudinal section of the heat shield element **22** which is shown in FIG. **3** that the discharge passages **28**, as seen in the longitudinal direction of the heat shield element **22**, are arranged one behind the other, and wherein each discharge passage **28** extends from the outside surface **36** of the heat shield element **22** towards its inside surface **34**. The discharge passages **28** in this case, as shown in FIG. **4**, can be concentrically arranged perpendicularly to the longitudinal direction of the heat shield element **22**.

[0044] As can especially be gathered from the view in FIG. **5**, the heat shield element **22** has a shape which is adapted to the profile of the blade basic body **30** in the leading edge region. Consequently, the effect is achieved inter alia of the turbine blade **12**, **14** also having a flow-optimized shape after attaching the heat shield element **22** on the blade basic body **30**. Moreover, a heat shield element **22** which is curved in such a way results in a constant distance between the inside surface **34** of the heat shield element **22** and the outside surface **32** of the blade basic body **30**, as a result of which an especially effective cooling in this region is made possible. The cooling air K which is required for the cooling in this case flows from the main cooling passage **26** of the turbine blade **12**, **14**, through the secondary cooling passages **24**, and through the discharge passages **28**, as a result of which a cooling film is formed on the outside surface **36** of the heat shield element **22** on account of the cooling air K which flows from the discharge passage **28** and on account of the operating medium M which flows in the turbine unit **6**. The cooling of the inside surface **34** of the heat shield element **22** and of the outside surface **32** of the blade basic body **30** in the leading edge region of the turbine blade **12**, **14** is carried out by the discharging of the cooling air K from the secondary cooling passages **24**, wherein the inside surface **34** of the heat shield element **22** is cooled in an especially effective manner as a result of the impingement cooling effect which occurs in the process.

[0045] In order to achieve as far as possible an impingement cooling on the inside surface **34** of the heat shield element **22** in each of the regions which are exposed to inflow of the cooling air K, the secondary cooling passages **24** are preferably arranged in such a way that the cooling air K which flows from the secondary cooling passages **24** impinges perpendicularly to the inside surface **34** of the heat shield element **22**. The distance of the heat shield element **22** from the blade basic body **30** in this case is preferably to be selected so that as a result of a sufficiently high flow velocity of the cooling medium K when impinging upon the inside surface **34** of the heat shield element **22** an intimate contact between the cooling air K and the impingement surface is brought about, and in this way the impingement effect is established.

[0046] An especially expedient design of the turbine blade **12**, **14** with the heat shield element **22** according to the invention is shown in FIG. **6**. In this case, the heat shield element **22** was integrated into the leading edge region of the blade basic body **30**, as a result of which the original external shape of the turbine blade **12**, **14** is advantageously maintained. The aerodynamic design of the turbomachine is therefore not altered, as a result of which reduction of the efficiency of the gas turbine, for example on account of vortex formations on the outer edges when a heat shield element **22** is attached externally on the blade basic body **30**, is prevented.

[0047] The gap between the heat shield element **22** and the blade basic body **30** which is required for creating impingement cooling is consequently achieved in the case of this special embodiment of the turbine blade **12**, **14** by the heat shield element **22** being seated in a recess **38** which is provided in the blade basic body **30**. In this way, the outside surface of the turbine blade **12**, **14** which reaches into the flow passage of the gas turbine is partially formed by the outside surface of the heat shield element **22**.

[0048] The free ends of the heat shield element **22** according to FIG. **5** are formed flush on the blade walls which are formed by the basic body **30** in the case of the design according to FIG. **6** in order to achieve an offset-free surface of the turbine blade **12**, **14**. For this, the part of the blade basic body **30** which lies opposite the heat shield element **22** is set back towards the inside of the blade so that the edge regions of the heat shield element **22** are connected to the blade body.

1.-**7**. (canceled)

8. A turbine blade, comprising:

a blade body, provided with a first outside surface which is an outside surface of the blade body, in a leading edge region of the blade body;

a heat shield element, which is arranged on the first outside surface at a distance from the blade body; and

a plurality of secondary cooling passages, which branch off from a main cooling passage formed inside the blade body, wherein the plurality of secondary cooling passages open into a plurality of discharge openings in the leading edge region, and

wherein the heat shield element has a plurality of discharge passages which extend from the main cooling passage to a second outside surface, the second outside surface is an outside surface of the heat shield element.

9. The turbine blade as claimed in claim **8**, wherein the turbine blade is used in a gas turbine.

10. The turbine blade as claimed in claim **8**, wherein the heat shield element has a shape that is adapted to a profile of the turbine blade in the leading edge region.

11. The turbine blade as claimed in claim **10**, wherein the heat shield element is produced from a first material which is more resistant to temperature than a second material of the blade body.

12. The turbine blade as claimed in claim **8**, wherein the heat shield element is arranged at the distance of no more than 3 mm from the blade body.

13. The turbine blade as claimed in claim **8** wherein the heat shield element is curved whereby a constant distance between an inside surface of the heat shield element and the first outside surface is maintained.

14. The turbine blade as claimed in claim **8**, wherein the plurality of secondary cooling passages are arranged essentially perpendicularly to an inside wall surface of the heat shield element.

15. The turbine blade as claimed in claim **14**, wherein the plurality of secondary cooling passages, are uniformly distributed behind the heat shield element.

16. The turbine blade as claimed in claim **8**, wherein a plurality of edge regions of the heat shield element are connected to the blade body.

17. The turbine blade as claimed in claim **8**, wherein the plurality of discharge passages are arranged one behind the other.

18. A thermal turbomachine, comprising:

a plurality of turbine blades, each turbine blade comprising:

a blade body, provided with a first outside surface which is an outside surface of the blade body, in a leading edge region of the blade body,

a heat shield element, which is arranged in the first outside surface at a distance from the blade body, and

a plurality of secondary cooling passages, which branch off from a main cooling passage formed inside the blade body;

wherein the plurality of secondary cooling passages open into a plurality of discharge openings in the leading edge region, and

wherein the heat shield element has a plurality of discharge passages which extend from the main cooling passage to a second outside surface, an outside surface of the heat shield element.

19. A thermal turbomachine as claimed in claim **18**, wherein the turbomachine is a gas turbine.

20. The thermal turbomachine as claimed in claim **18**, wherein the heat shield element has a shape that is adapted to a profile of the turbine blade in the leading edge region.

21. The thermal turbomachine as claimed in claim **20**, wherein the heat shield element is produced from a first material which is more resistant to temperature than a second material of the blade body.

22. The thermal turbomachine as claimed in claim **18**, wherein the heat shield element is arranged at the distance of no more than 3 mm from the blade body.

23. The turbine blade as claimed in claim **18** wherein the heat shield element is curved whereby a constant distance between an inside surface of the heat shield element and the first outside surface is maintained.

24. The thermal turbomachine as claimed in claim **18**, wherein the plurality of secondary cooling passages are arranged essentially perpendicularly to an inside wall surface of the heat shield element.

25. The thermal turbomachine as claimed in claim **24**, wherein the plurality of secondary cooling passages, are uniformly distributed behind the heat shield element.

26. The thermal turbomachine as claimed in claim **18**, wherein a plurality of edge regions of the heat shield element are connected to the blade body.

27. The thermal turbomachine as claimed in claim **18**, wherein the plurality of discharge passages are arranged one behind the other.

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