

[54] **TURBINE BLADE SEAL ARRANGEMENT**

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[58] Field of Search.....416/221, 190, 191, 220, 92,  
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[57] **ABSTRACT**

A seal arrangement for a turbine assembly including a turbine wheel, having a plurality of circumferentially arranged blades with adjacent edges of the blades being axially arranged above passages in the wheel assembly and retaining members arranged on each axial side of the wheel, a seal assembly between each adjacent pair of blades including an elongated seal member with means for maintaining the seal member in alignment with an axial recess formed by adjacent edges of the blade so that the seal member is urged radially outwardly into sealing engagement with the blades during rotation of the wheel and annular seal rings for maintaining sealing engagement between the retaining members and the plurality of blades.

17 Claims, 7 Drawing Figures

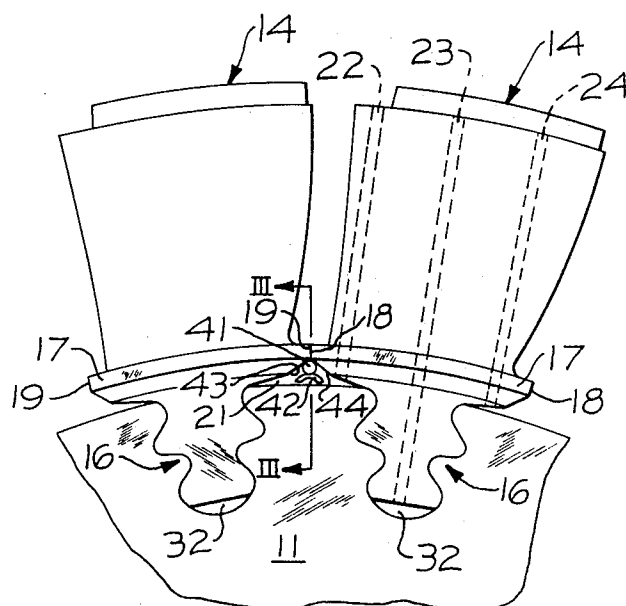


Fig. 1.

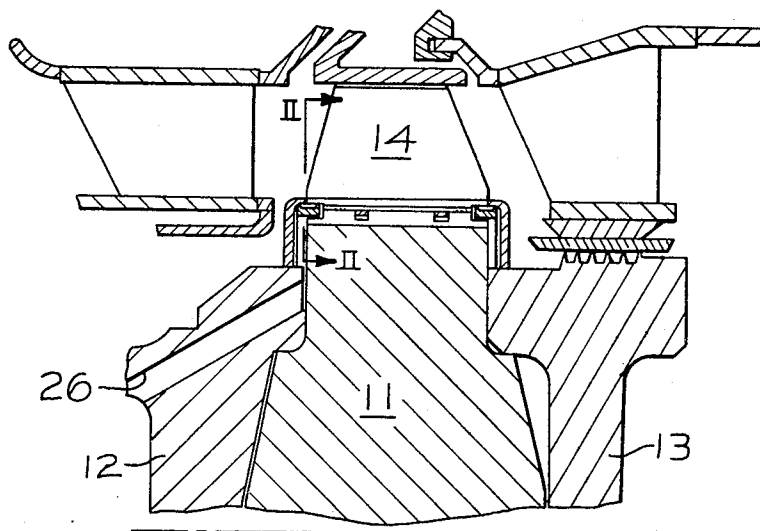
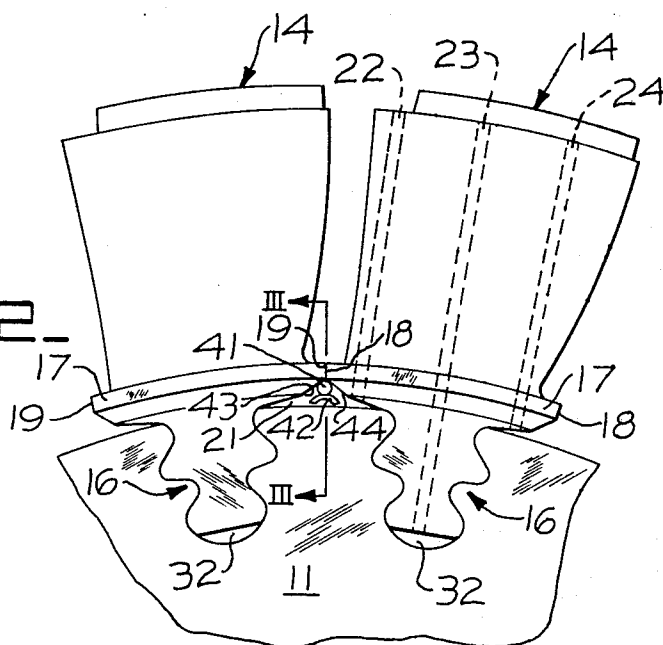


Fig. 2.



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Fig. 3.

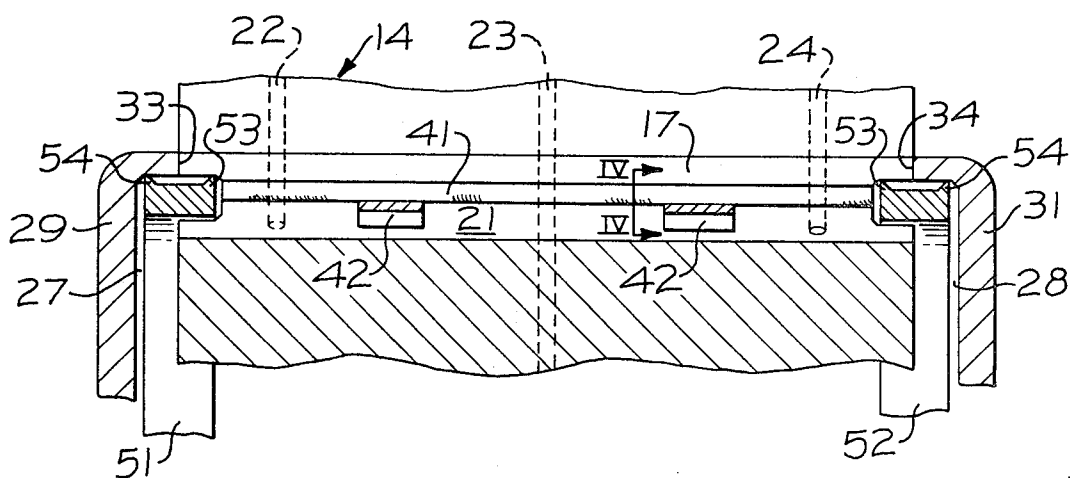
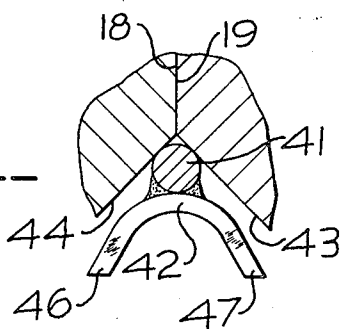


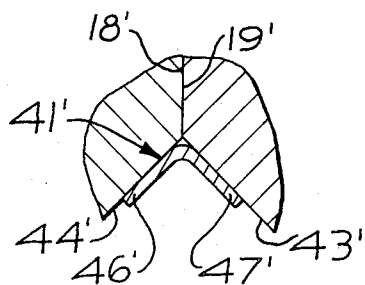
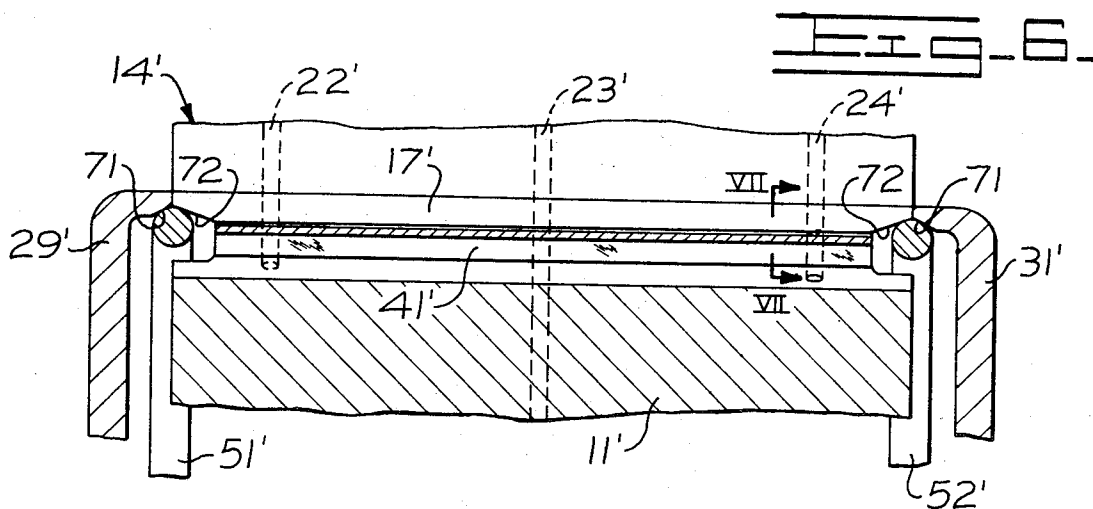
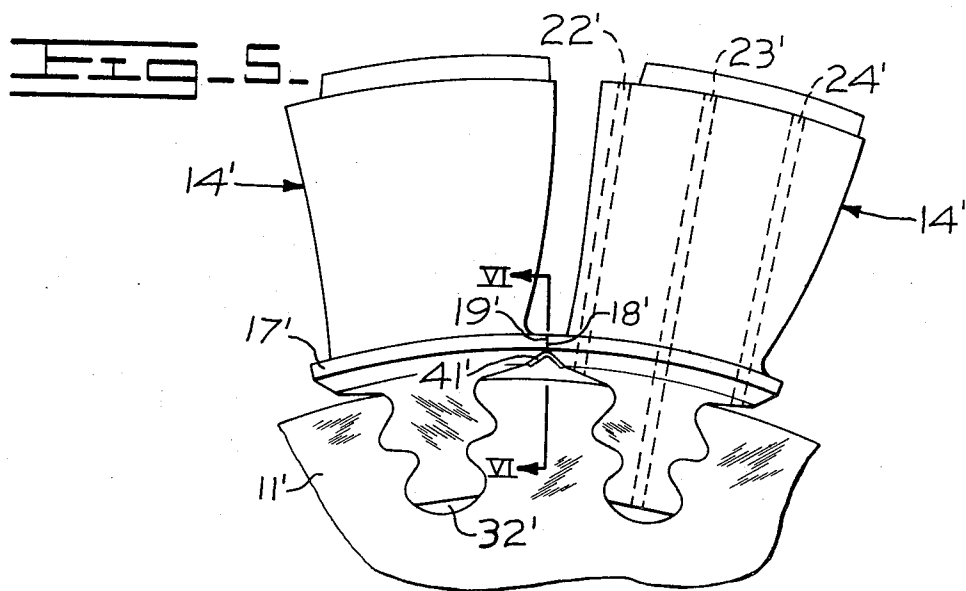
Fig. 4.



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**TURBINE BLADE SEAL ARRANGEMENT**

The present invention relates to a seal arrangement for rotor assemblies where a plurality of blades are secured to a wheel. Elongated sealing members hermetically seal axial gaps between the blades. An annular seal ring maintains sealing engagement between the blades and a retaining member arranged on one side of the wheel during operation of the assembly to isolate gas passages formed between the wheel and the blade. The combination of these two types of seals is particularly adapted for use in turbine assemblies where the blades include internal passages for communicating cooling gasses from the gas passages to tip portions of the blades.

In rotor assemblies of the type contemplated by the present invention, it has been found difficult to maintain hermetic seals between the wheel and blades which are replaceably secured about the circumference of the wheel. The importance of maintaining such seals is particularly apparent where gas passages are formed by the wheel and the blades for communicating cooling gasses through internal passages in the blades in order to cool the blades during operation. Within such an arrangement, gas leakage tends to occur through axial gaps formed between the adjacent blades as well as through radial gaps formed between the blades of the wheel and retaining members arranged on axial sides of the wheel.

During operation of such rotor assemblies, high speeds of rotation, for example, 30,000 rpm or more as well as very high operating temperatures as great as 1500° F., for example, are commonly experienced. Both of these operating characteristics tend to prevent an effective seal from being maintained both between the blades and along the axial sides of the blades as well.

Particularly in turbine assemblies, leakage of the cooling gases has been found to be a factor in determining the specific fuel consumption or pounds of fuel consumed per horsepower hour of operation for the turbine. The specific fuel consumption can be increased if adequate seals are provided to assure that none of the cooling gas enters into the rotor chamber about the wheel except through the internal passages in the blades. Although the advantages of the present sealing arrangement have been described above with particular reference to a turbine assembly employing internally contained cooling gasses, it will be apparent that the seal arrangement of the present invention is equally adaptable for use in other rotor assemblies as well.

Accordingly, it is an object of the present invention to provide an effective seal between axially arranged, adjacent edges of blade members secured to a rotor wheel.

It is a further object of the invention to provide such a seal wherein an elongated seal member is maintained in proper alignment so that it tends to be urged into sealing engagement during operation of the rotor wheel. With the elongated seal member being arranged radially inwardly of adjacent surfaces between which it is to provide a seal, the seal may be formed either by centrifugal forces arising during rotation of the wheel or by internal gas pressure, for example.

It is also an object of the present invention to provide an annular seal means for maintaining an effective seal between the axial side of the blade members and a retaining member arranged on one side of the wheel.

Other objects and advantages of the present invention are made apparent in the following description having reference to the accompanying drawings.

In the drawings:

FIG. 1 is a fragmentary view of a first stage turbine assembly taken along the axis of the turbine wheel;

FIG. 2 is a view taken along section line II—II of FIG. 1;

FIG. 3 is an enlarged fragmentary view taken along section line III—III of FIG. 2 to more clearly illustrate the components of the present seal arrangement;

FIG. 4 is a view taken along section line IV—IV of FIG. 3 to more clearly illustrate the cross sectional configuration of an elongated seal member of the type contemplated by the present invention; and

FIGS. 5, 6 and 7 are similar respectively to FIGS. 2, 3 and 4 while illustrating an alternate embodiment of the present seal arrangement.

Referring now to the drawings, a first stage turbine providing an exemplary environment for the present invention is illustrated in FIG. 1 as including a rotor or turbine wheel 11 with retaining members 12 and 13 arranged on axial sides of the wheel 11. The member 12 is a radially extending portion of the shaft upon which the wheel 11 is mounted while the member 13 is a spacer which assists in supporting and aligning the wheel.

Referring also to FIG. 2, a plurality of turbine blades 14 are circumferentially arranged about the wheel 11 and secured in place by means of an axially arranged interlocking configuration indicated at 16 in FIG. 2. The interlocking arrangement 16 firmly secures the base portions 17 of the blades to the wheel 11. With the blades so arranged upon the wheel, surfaces 18 and 19 on the base portion of adjacent blades are arranged above axial gas passages such as that indicated at 21 between the outer circumference of the wheel 11 and the adjacent surfaces 18 and 19.

As noted above, the turbine assembly illustrated in the drawings is of a type wherein the blades include a plurality of internal passages, such as those indicated in the one blade of FIG. 2 at 22, 23, and 24, through which cooling gases are directed to reduce the operating temperature of the blades. Cooling gases for the passages 22 - 24 are introduced through a passage 26 in the retaining member 12 and annular recesses 27 and 28 formed respectively on opposite sides of the wheel by annular extensions 29 and 31 of the retaining members 12 and 13. The annular recesses are in communication with the axial passages 21 so that compressed cooling gas or air is communicated from the inlet passage 26 through the recess 27 to the internal passages 22 and 24 by means of the axial passages 21. Referring particularly to FIG. 2, an axial gas passage 32 is also formed between the wheel and the root portion of each blade base 17 for communicating the annular recesses with certain of the internal passages such as that indicated at 23.

As may be best seen in FIG. 3, each of the retaining member extensions 29 and 31 forms an annular surface, indicated respectively at 33 and 34, which tends to be maintained in sealing engagement with the axial sides of the base portion 17 of each blade. Because of the severe operating conditions for the turbine, including wide temperature variations and high speeds of operation, the extensions 29 and 31 are often forced

away from the wheel and blades so that cooling gases may escape across the seal surfaces 33 and 34. For similar reasons, gas leakage also tends to occur between the adjacent seal surfaces 18 and 19 of the blades.

The present invention provides an axially arranged, elongated seal 41 which is maintained during operation in sealing engagement between each pair of surfaces 18 and 19. Aligning members 42 are associated with the seal member 41 to maintain it in proper alignment with the adjacent surfaces 18 and 19. Referring particularly to FIGS. 3 and 4, the seal member 41 is a wire and the aligning members 42 are V-shaped or winged tabs which are secured to the wire, for example by welding. During rotary operation of the wheel, such a seal assembly may be urged into sealing engagement across the adjacent surfaces 18 and 19 with a sealing force of approximately 4 pounds for example, when the turbine wheel is operating at its designed speed.

Referring particularly to FIGS. 2 and 4, the surfaces 18 and 19 are beveled as best indicated at 43 and 44 to provide an annular recess for properly seating the sealing wire 41 across the adjacent surfaces 18 and 19.

As best seen in FIG. 4, the aligning members 42 include portions 46 and 47 which extend angularly apart and downwardly from the seal member 41. The sealing member or wire 41 is preferably coated with silver (for example, 0.002 to 0.003 inches thick) so that the surface of the wire is deformable and adapted for conforming to any irregularities in the surfaces 43 and 44.

The aligning members 42 tend to maintain the seal members 41 in proper alignment when the wheel is not rotating. For this purpose, the overall radial dimension of the seal member 41 together with the retaining members 42 is preferably somewhat greater than the dimension between the blade portion 17 and the periphery of the wheel adjacent the beveled surfaces 43 and 44. As the wheel 11 is turned in rotation, the seal members or wires 41 are urged radially outwardly so that they engage the beveled surfaces 43 and 44, thus providing an effective seal across the adjacent surfaces 18 and 19.

Referring again particularly to FIG. 3, an annular seal ring is also provided for maintaining an effective seal between each of the retaining member extensions 29 and 31 with the blades 14. As illustrated in FIG. 3, these annular seals are provided by rigid annular rings 51 and 52. Radially extending projections or V-shaped edges 52 and 53 on each ring serve to provide a narrow annular seal surface for respective engagement with one of the retaining members 29 and 31 and the base portion 17 of each blade preferably, the rings 51 and 52 are constructed of a material having a relatively higher coefficient of expansion. For example, the rings may be designed so that at ambient temperatures, there is a diametrical clearance of approximately 0.001 to 0.002 inches between the V-shaped projections 52, 53 and the adjacent portions of the retaining members 29, 31 and the base portions 17 of the blades. Thus, as the turbine is brought up to its optimum operating temperature, for example, approximately 1500° F, the rings expand somewhat faster than other portions of the assembly and enter into intimate engagement with the retaining members 29, 31 and the base portion of the blade to achieve a tight seal during operation of the turbine. This feature allows rotating freedom for the tur-

bine wheel and blade to be initially balanced and also allows the blades to properly position themselves upon the turbine wheel as the turbine is accelerated toward its optimum designed speed, for example, 30,000 rpm or greater.

Another embodiment of the seal arrangement is illustrated in FIGS. 5-7. Components in those figures correspond with various components described above with reference to FIGS. 2-4. Accordingly, similar primed numerals are employed to indicate the corresponding components of FIGS. 5-7. Referring to those three figures and particularly to FIGS. 6 and 7, the elongated seal assembly is provided by a similar elongated member 41' which incorporates both the sealing means and the means for maintaining the member in alignment with the adjacent surfaces 18' and 19' (see FIG. 5). As best seen in FIG. 7, the elongated member 41' when viewed in cross section, includes winged extensions 46' and 47' for maintaining the member 41' in proper alignment with the annular recess formed by the beveled surfaces 43' and 44'.

Referring particularly to FIG. 6, the annular seals are comprised of flexible seal rings 51' and 52' arranged in annular grooves formed by beveled surfaces 71 and 72 formed respectively by the retaining members 29', 31' and adjacent portions of the blade bases 17'.

What is claimed is:

1. A seal arrangement for a turbine assembly including a rotatable turbine wheel, turbine blades having base portions secured about the periphery of the wheel, the base portions having axially arranged adjacent edges, axial gas passages being formed between the adjacent edges of the base portions and the wheel, the blades having internal passages for communicating cooling gas from the axial passages to tip portions of the blades, a retaining member arranged on one side of the wheel and having an annular surface tending to engage the base portions of the blades, an annular recess being formed between the retaining member and wheel radially inwardly of the annular surface, the annular recess being in communication with the axial passages, means for introducing cooling gas into the annular recess, the seal arrangement comprising an elongated seal assembly arranged in the axial gas passage between each adjacent pair of blades including an elongated seal member movably disposed in the axial passage and means for maintaining the seal member in alignment with an axial recess formed by adjacent edges of the base portions so that the seal member is urged radially outwardly into sealing engagement with the adjacent edges of the base portions during rotation of the turbine wheel, and annular seal means arranged in the annular recess for sealing engagement with the retaining member and the base portions of the blades.

2. The seal arrangement of claim 1 wherein at least a portion of the seal member is deformable for intimately conforming in sealing relation with the base portions of the blades.

3. The seal arrangement of claim 2 wherein at least a portion of the seal member is coated with silver.

4. The seal arrangement of claim 1 wherein the seal member is a wire and the aligning means are members secured to the wire and having angularly extending wing portions.

5. The seal arrangement of claim 1 wherein the elongated seal assembly comprises an elongated seal member which in cross-section includes winged extensions forming the aligning means.

6. A seal arrangement for a rotor assembly having a rotor wheel, rotor blades being secured by base portions in circumferential arrangement to the perimeter of the wheel, adjacent edges of the base portions of the blades being axially arranged with respect to the wheel and forming axial gas passages between the adjacent edges of the base portions and the wheel, a retaining member being arranged on each axial side of the wheel, the retaining members having annular surfaces tending to engage the base portions and annular recesses located radially inwardly of the annular surfaces, comprising an elongated seal member movably arranged in each axial gas passage adjacent an axially arranged recess formed by the adjacent edges of the base portions, means for maintaining the seal member in alignment with the axial recess so that the seal member is urged radially outwardly into sealing engagement with the adjacent edges of the base portions during rotation of the rotor wheel, and

annular seal means arranged in each annular recess for respective sealing engagement with the retaining members and the base portions of the blades.

7. The seal arrangement of claim 6 wherein the seal aligning means comprise members arranged radially inwardly of the seal member in oppositely angled relation with respect to a radial plane passing through the seal member.

8. The seal arrangement of claim 7 wherein the axial passages are formed between peripheral portions of the wheel and surfaces of the base portions of the blades, adjacent the axial recess the seal aligning members being secured to the seal member and extending radially inwardly therefrom.

9. The seal arrangement of claim 8 wherein the overall radial dimension of the seal member and seal aligning members at least slightly exceeds the spacing between a peripheral portion of the wheel and surfaces

of the base portions adjacent the axial recess.

10. The seal arrangement of claim 8 wherein the seal member is deformable at least on a portion of its surface for conforming in sealing relation with the base portions of the blades.

11. The seal arrangement of claim 10 wherein at least a portion of the seal member is coated with silver.

12. The seal arrangement of claim 8 wherein the seal member is a wire and the seal aligning members are formed by winged tabs secured to the wire.

13. The seal arrangement of claim 8 wherein the seal member and seal aligning members are integrally formed as an elongated member which in cross-section includes winged extensions comprising the seal aligning members, the outer surface of the elongated member providing for sealing engagement with the base portions of the blades.

14. The seal arrangement of claim 6 wherein the annular seal means comprises resilient seal rings arranged for sealing engagement with annular grooves formed by the retaining members and the base portions of the blades.

15. The seal arrangement of claim 6 wherein the annular seal means comprises rigid annular rings having radially extending projections forming seal surfaces of limited axial width for sealing interaction respectively with one of the retaining members and the base portions of the blades.

16. The seal arrangement of claim 15 wherein the seal surfaces of the annular seal rings normally have smaller diameters than the surfaces of the retaining member and base portions with which they interact, the annular seal ring having relatively greater coefficients of expansion so that the seal surfaces are in contact with the retaining member and base portions under optimum operating temperatures for the rotor assembly.

17. The seal arrangement of claim 6 wherein the rotor assembly is a stage portion of a turbine, the blades having internal passages for communicating cooling gas from the recesses to the blade tips.

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