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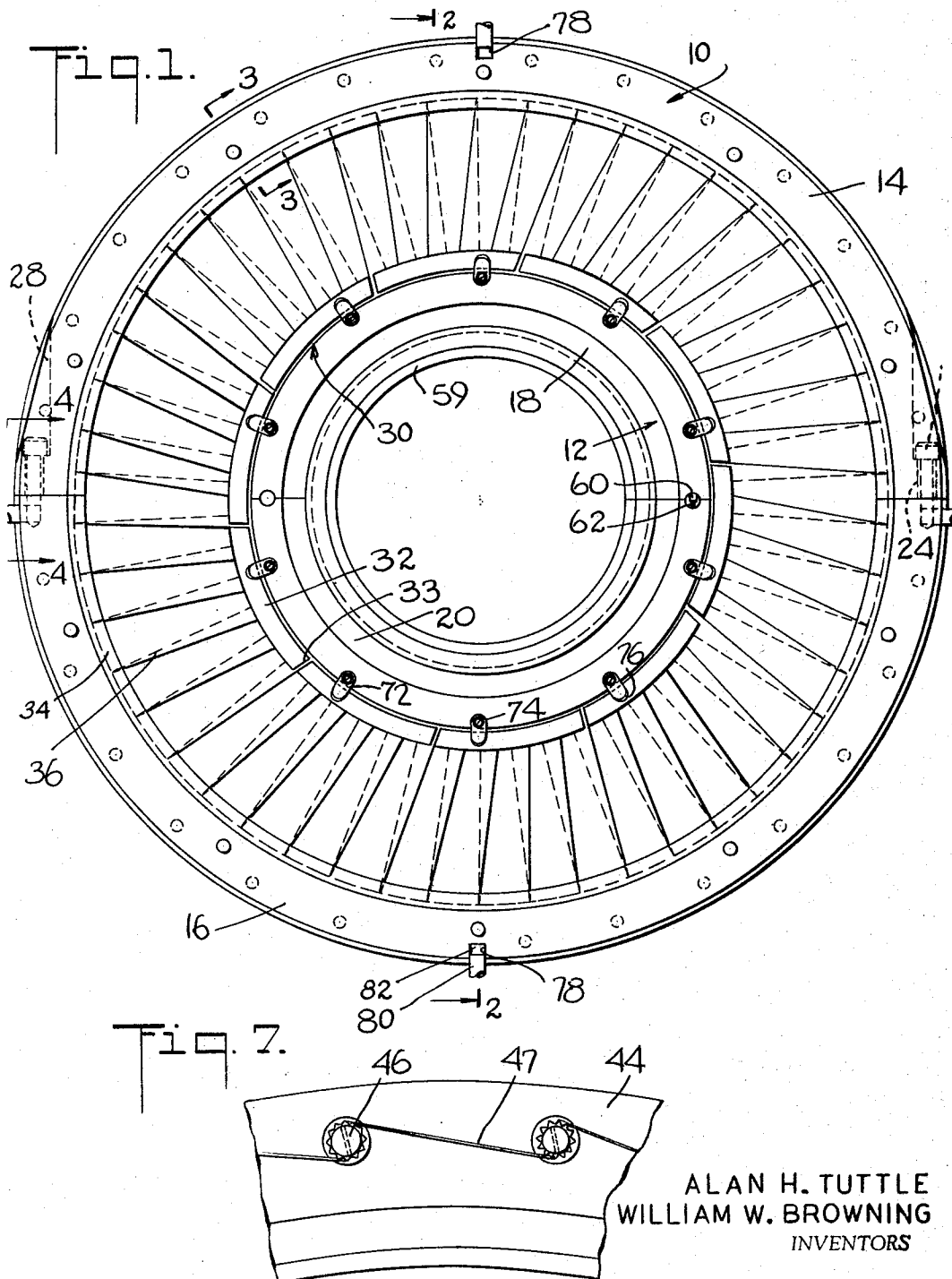
A. H. TUTTLE ET AL

3,300,180

SEGMENTED DIAPHRAGM ASSEMBLY

Filed Nov. 17, 1964

2 Sheets-Sheet 1



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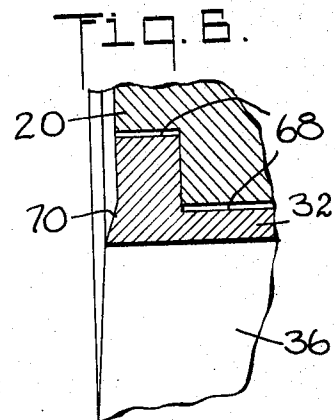
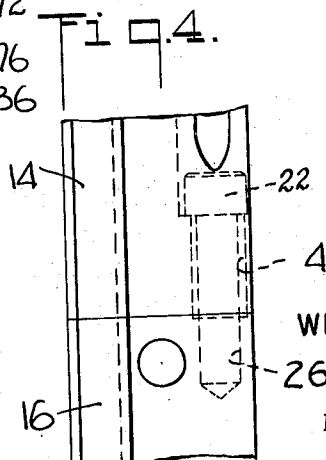
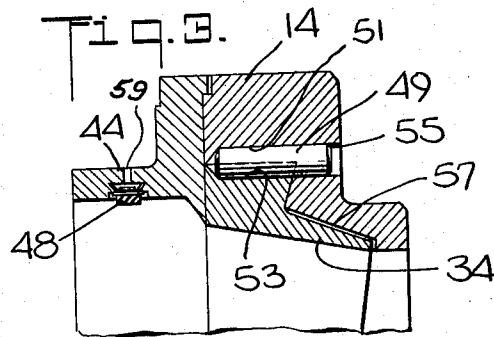
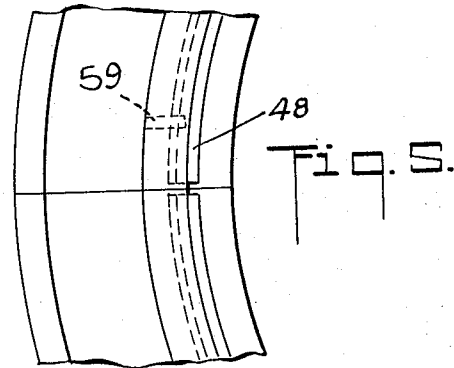
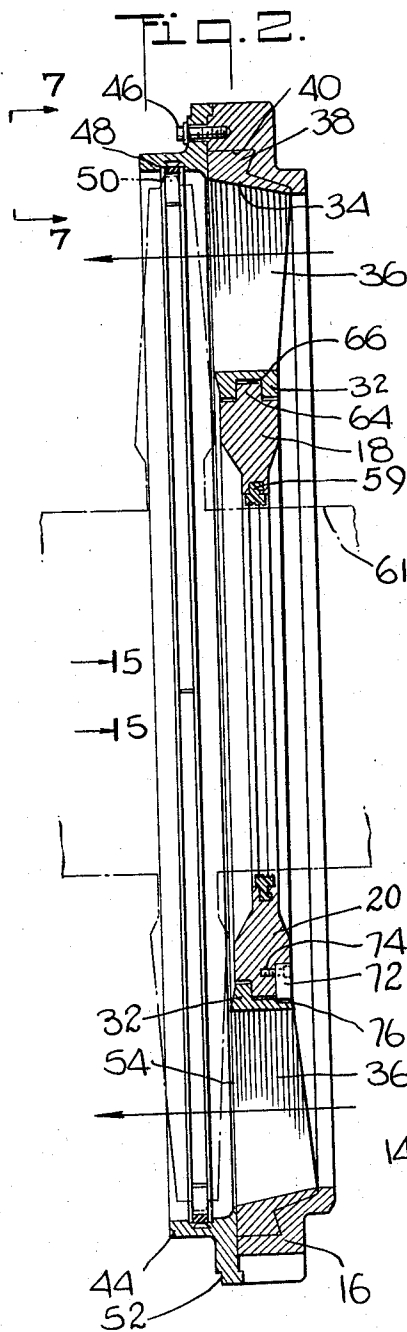
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SEGMENTED DIAPHRAGM ASSEMBLY

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12 Claims. (Cl. 253—78)

This invention relates to diaphragm assemblies for use in turbines.

An object of the invention is the provision of diaphragm assemblies of segmented construction which are capable of withstanding extremely rapid heat build-up to high operational temperatures without the development of damaging thermal stresses therein.

Another object of the invention is the provision of diaphragm assemblies which are too large to be precision cast as a unit, through the desirable use of precision cast nozzle blade segments of high temperature resistant materials, and forged inner and outer retaining means for the said nozzle blade segments.

Another object of the invention is the provision of diaphragm assemblies of segmented nozzle blade and segmented inner and outer retaining means construction which enable the convenient replacement of one or more of the said nozzle blade segments while requiring minimum disassembly of the diaphragm assemblies and the turbine in which the said assemblies are utilized.

A further object of the invention is the provision of diaphragm assemblies of particularly durable design and construction, whereby long periods of satisfactory, maintenance free operation of the said assemblies under demanding operation conditions, are assured.

A still further object of the invention is the provision of diaphragm assemblies which are particularly, though not exclusively, adapted for use in peaking power generation, double flow power recovery gas turbines of the nature disclosed in the copending application for U.S. Patent of Albert F. Hanschke et al. S.N. 444,665, filed April 1, 1965 and assigned to the assignee hereof.

The above and other objects and significant advantages of the invention are believed made clear by the following description thereof taken in conjunction with the accompanying detailed drawings wherein:

FIGURE 1 is a front elevation view of the diaphragm assembly of the invention;

FIGURE 2 is a vertical cross sectional view taken along line 2—2 of FIGURE 1, and includes the phantom depiction of turbine rotor structure in operative relationship with the diaphragm assembly of the invention;

FIGURE 3 is a sectional view taken along line 3—3 of FIGURE 1;

FIGURE 4 is a view taken in the direction indicated by line 4—4 in FIGURE 1;

FIGURE 5 is a view of the adjacent extremities of the retaining plate segments of the diaphragm assembly taken in the direction indicated by line 5—5 of FIGURE 2;

FIGURE 6 is a detailed view of the radially inner extremity of one of the nozzle blade segments of the diaphragm assembly; and

FIGURE 7 is a view of a portion of the retaining plate of the diaphragm assembly taken in the direction indicated by line 7—7 in FIGURE 2.

Referring now to the said drawings, the herein-disclosed preferred embodiment of the diaphragm assembly of the invention comprises an outer retaining ring generally indicated at 10, and a concentric, inner retaining disc generally indicated at 12. The said retaining ring and disc are each split along the same horizontal plane, as made clear in FIGURE 1, with the said ring comprising ring segments 14 and 16, and the said disc comprising

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segments 18 and 20, respectively. The retaining ring 10 and retaining disc 12 are preferably forged from any suitably high temperature resistant material, as for example Type 347 stainless steel. Locking socket, head cap screws 22 extend as shown through oversize bores 24 (FIGURE 4) in retaining ring segment 14, into threaded bores 26 (FIGURE 4) in retaining ring segment 16, to thus secure the said retaining ring segments in the depicted positions thereof. Grooves 28 are formed as shown in the retaining ring segment 14 to enable the convenient insertion of the said cap screws 22 into the said bores 24.

Nozzle blade segments are generally indicated at 30 and extend as shown between the radially inner surface of the retaining ring 10, and the periphery of the retaining disc 12. Each of the nozzle blade segments 30 is preferably of unitary construction, and is preferably precision cast from any suitably high temperature resistant material, as for example Type 347 stainless steel. The said nozzle blade segments each comprise an arcuate inner shroud segment 32, and arcuate outer shroud segment 34 and a plurality of nozzle blades 36 of suitable design extending therebetween. Slight clearance is provided between the adjacent circumferential extremities of the inner shroud segments 32, in the manner indicated at 33 in FIGURE 1, to enable circumferential expansion thereof without development of damaging thermal stresses therein. In the herein-disclosed preferred embodiment of the invention, ten nozzle blade segments are utilized, each of which comprises five nozzle blades. It is, however, to be clearly understood that variation in the number of nozzle blade segments, and/or the number of nozzle blades per segment, are considered well within the scope of the invention.

The outer shroud segments 34 comprise arcuate, generally dovetail shaped projections 38 (FIGURE 2) which extend therefrom into complementary shaped, arcuate mounting grooves 40 which are formed as shown in the radially inner surfaces of the retaining ring segments 14 and 16, to thus in part fix the location of the said nozzle blade segments relative to the outer retaining ring 10.

A generally cylindrical, segmented retaining plate 44 is bolted by a plurality of bolts 46 to the said outer retaining ring, in the manner best seen in FIGURE 2, and bears against the adjacent surfaces of outer shroud segments 36 to thus prevent longitudinal movement of the nozzle blade segments 30 relative to the outer retaining ring 10. The said bolts 46 are preferably safety wired by a safety wire 47 (FIGURE 7) on assembly to positively prevent loosening thereof due to operational vibration of the turbine. Dowels 49 project as seen in FIGURE 3 through bores 51 in the outer retaining ring segments 14 and 16, respectively, into grooves 53 formed in the outer shroud segments 34. This prevents circumferential movement of the nozzle blade segments 30 in the mounting grooves 40 of the said outer retaining ring segments under the influence of the forces exerted on the said nozzle blade segments by the hot, pressurized gases flowing between the nozzle blades 36, during turbine operation, in the general direction indicated by the arrows in FIGURE 2. The dowels 49 are retained in position in the bores 51 by tack welding as indicated at 55. Slight clearance is provided between the adjacent upstream surfaces of the outer shroud segments 34 and retaining ring segments 14 and 16, respectively, in the manner indicated at 57 in FIGURE 3, to enable some expansion of the said shroud segments relative to the said ring segment at this location.

The retaining plate 44 carries generally cylindrical tip seals 48, of conventional honeycomb construction, which are spun thereon as shown. A plurality of stop pins 59

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project through bores in the retaining plate 44 in the manner best seen in FIGURE 5, into contact with the tip seals 48 to retain the latter in the depicted positions thereof. The said seals in turn cooperate with the tips of the turbine rotor blades, as indicated in phantom at 50 in FIGURE 2, for obvious purpose. A locating surface 52 (FIGURE 2) is formed as shown adjacent the lower extremity of the retaining plate 44. The said locating surface is machined in exact, predetermined relationship to the exit edges 54 of the nozzle blades 36 after assembly of the diaphragm, and may thus be utilized, in cooperation with non-illustrated turbine casing structure, to insure exact location of the diaphragm assembly within the turbine casing.

The respective segments 18 and 20 of the retaining disc 12 are positioned insubstantial, end face contact in the manner best seen in FIGURE 1, and longitudinally extending, generally cylindrical locating pins 60 are positioned in opposed, complementary shaped grooves formed in the respective end faces of the said retaining disc segments. The said locating pins are retained in position in the grooves in retaining disc segment 20 by attachment pins 62 extending therebetween as seen in FIGURE 1. A labyrinth packing ring 59 (FIGURE 2) is carried as shown from the radially inner surfaces of the retaining disc segments 18 and 20, and cooperates with the turbine rotor structure as indicated in phantom at 61 for obvious purpose. Thus may be understood whereby the said retaining disc segments are free to expand in the radially outward direction to a slight degree while being maintained in proper alignment by the said locating pins 60 to prevent undesirable contact between the said labyrinth packing ring 59 and the rotor structure as indicated in phantom at 61.

Each of the retaining disc segments 18 and 20 includes an arcuate projection 64 extending therefrom in the radially outward direction in the manner best seen in FIGURE 2, and a generally complementary shaped, arcuate groove 66 is formed in the respective radially inner surfaces of each of the inner shroud segments 32, with the said projections 64 extending into the said grooves 66, with slight clearance for relative, generally radial movement between the respective inner shroud and retaining ring segments in the manner best seen at 68 in FIGURE 6. The said inner shroud segments are machined as shown at 70 in FIGURE 6 to assume the same thickness at the radially inner extremities thereof as the respective inner retaining ring segments 18 and 20.

Guide and support keys 72 are positioned as shown in complementary shaped, opposed grooves formed in the adjacent surfaces of the retaining disc segments 18 and 20, and the inner shroud segments 32, respectively. In the hereindisclosed preferred embodiment of our invention, one such guide and support key 72 is provided for each inner shroud segment 32, it being understood that a greater number of the said guide and support keys may of course be utilized per shroud segment. The said guide and support keys 72 are retained in position in the respective retaining disc segments 18 and 20 by socket head, cap screws 74, and extend into the complementary shaped grooves in the inner shroud segments 32 with slight clearance as indicated at 76 in FIGURE 2, between the extremities of the said guide and support keys and the bottoms of the said grooves. Thus may be understood whereby the respective retaining disc segments 18 and 20 are supported, through the medium of the guide and support keys 72, from the inner shroud segments 32, and guided, relative radial expansion of the said retaining disc and inner shroud segments is made possible. In the manufacture of the diaphragm assembly of the invention, the respective inner shroud and retaining disc segments are preferably milled as a unit to insure a proper fit of the said guide and support keys.

Generally radially extending guide notches 78 are

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formed as best seen in FIGURE 1, at approximately 90° intervals in the respective peripheries of the retaining disc segments 14 and 16, and generally radially extending pins 80 are provided as shown to extend as shown from the turbine casing structure into the said holes 78 to properly position the diaphragm assembly within the turbine casing. As should be noted, clearance is provided between the extremities of the said pins 80 and the bottom of the said holes 78, in the manner indicated at 82 in FIGURE 1, to provide for guided radial expansion of the diaphragm relative to the turbine casing structure.

As mentioned hereinabove, the diaphragm assembly of the invention in particularly, though not exclusively, adapted for use in peaking power generation gas turbines of the nature disclosed in the copending application for U.S. patent, S.N. 444,665. Such turbines may, for example, be required to come up to maximum inlet nozzle blade operating temperatures in the neighborhood of 1200° F. in only six minutes from the commencement of operation thereof, whereby becomes clear that the thermal stresses which might be developed by rapid heat-up of this nature as a result of the thermally induced expansion of the structural components of the diaphragm assembly, could prove very damaging to the said assembly, were provision not made to prevent the development of the said thermal stresses. Such provision is made in the diaphragm assembly of the invention and takes the form of the segmented construction thereof and the clearances provided between the various structural components of the said construction. More specifically, it may be noted that the segmented construction of the retaining disc 12 enables the free thermal growth of the respective disc segments 18 and 20 without the development of damaging thermal stresses therein, it being understood that locating pins 60 would not substantially impede this thermal growth. Similarly, the provision of clearances between the periphery of the segmented retaining disc 12 and the inner shroud segments 32 (including the clearances 76 and the radially outer extremities of guide and support pins 72, and the clearances 66 at the radially outer extremities of disc projections 63), and the clearances 33 between adjacent inner shroud segments 32, enable the relatively unrestricted thermal growth of the nozzle blade segments 30 relative to the retaining disc 12 without the development of damaging thermal stresses in either of these structural elements of the diaphragm assembly. In addition, the provision of clearances 57 between the upstream portions of outer shroud segments 34 and the retaining ring segments 14 and 16, respectively, provide for limited thermal growth of the nozzle blade segments 30 relative to the said ring segments. Further, the provision of clearances 82 between the extremities of turbine casing guide pins 80, and the bottoms of guide notches 78 in the outer retaining ring 10 of the diaphragm assembly, enable the thermal growth of the diaphragm assembly as a whole relative to the turbine casing without the development of damaging thermal stresses.

Should the replacement of one or more of the nozzle blade segments 30 be required, all that is necessary is sufficient disassembly of the turbine casing to expose one or both of the segments of the retaining plate 44 and the retaining ring 10 (depending upon the number and location of the nozzle blade segments to be replaced), the removal of one or more of the retaining plate and outer retaining ring segments through the removal of locking wire 47 bolts 46 and cap screws 22, respectively, the removal and replacement of the particular nozzle blade segment or segments to be replaced, and the reassembly of the respective outer retaining ring and retaining plate segments.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown but that they may be widely modified within the invention defined by the claims.

We claim:

1. In a diaphragm assembly for use in turbines, outer retaining means, inner disc means spaced from said outer retaining means, a plurality of nozzle blade segments each of which comprises at least one nozzle blade, said nozzle blade segments extending between said spaced outer retaining means and said inner disc means, respectively, means for attaching said nozzle blade segments to said outer retaining means, said inner disc means comprising a plurality of arcuate segments, and guide and support means for supporting said arcuate segments from said nozzle blade segments with freedom for relative movement therebetween and for guiding said nozzle blade segments and said inner disc segments during such movement.

2. In a diaphragm assembly as in claim 1 wherein, said nozzle blade segments each comprise an inner shroud segment and an outer shroud segment spaced therefrom with at least one nozzle blade extending between said segments, said inner shroud segments being spaced in the circumferential direction to enable the expansion thereof in the said direction, and said guide and support means extending between said inner disc segments and said inner shroud segments, respectively.

3. In a diaphragm assembly as in claim 2 wherein, said outer retaining means comprises a generally cylindrical outer member which is divided into a plurality of arcuate segments, and said inner disc means further comprise locating means cooperatively associated with the respective arcuate segments thereof for enabling guided, relative movement therebetween.

4. In a diaphragm assembly as in claim 1 wherein said nozzle blade segments each consist of an integral precision cast unit which further comprises an arcuate inner shroud segment and an arcuate outer shroud segment spaced therefrom with said nozzle blades extending between said segments.

5. In a diaphragm assembly as in claim 1 wherein, said nozzle blade segments each comprise an arcuate inner shroud segment and an arcuate outer shroud segment spaced therefrom with said nozzle blades extending therebetween, and said means to attach said nozzle blade segments to said outer retaining means comprise arcuate projections formed on said outer shroud segments and arcuate grooves of complementary configuration formed in the segments of said outer member, said projections extending radially outward into said grooves, and retaining plate means attached to said segments of said outer member for retaining said projection in said grooves.

6. In a diaphragm assembly as in claim 1 wherein, said nozzle blade segments each comprise an arcuate inner shroud segment and an arcuate outer shroud segment spaced therefrom with said nozzle blades extending therebetween, and said guide and support means comprise generally radially aligned grooves formed in opposed, spaced surfaces of said inner disc means segments and said inner

shroud segments, respectively, and guide keys extending from said grooves in said inner disc means segments into said grooves in said inner shroud segments with radial clearance therebetween.

7. In a diaphragm assembly as in claim 6 wherein, said guide and support means further comprise arcuate projections formed on said inner disc means segments and arcuate grooves formed in said inner shroud segments, said projections extending radially outward from said inner disc means segments into said arcuate grooves in said inner shroud segments with radial clearance therebetween.

8. In a diaphragm assembly as in claim 7 wherein said inner shroud segments are spaced in the circumferential direction to enable expansion thereof in the said direction.

9. In a diaphragm assembly as in claim 5 wherein, said retaining plate means comprise a generally cylindrical member having a surface thereof which bears against said outer shroud segment projections to retain the latter in the said arcuate grooves, and generally cylindrical, turbine rotor tips seal elements carried by said generally cylindrical member.

10. In a diaphragm assembly as in claim 5 wherein said retaining plate means comprise a generally cylindrical member having an exposed locating surface formed thereon in predetermined relationship to the orientation of said nozzle blades within the diaphragm assembly whereby, the said locating surface may be utilized to insure proper orientation of the diaphragm assembly within a turbine casing.

11. In a diaphragm assembly as in claim 7 further comprising, guide and support members cooperatively associated with said generally cylindrical outer member and said turbine casing for supporting the former within the latter with freedom for relative movement therebetween, and for guiding said member during such movement.

12. In a diaphragm assembly as in claim 11 wherein, said outer retaining means comprise an exposed locating surface formed thereon in predetermined relationship to the orientation of said nozzle blades within the diaphragm assembly whereby, the said locating surface may be utilized to insure proper orientation of said nozzle blades within said turbine casing.

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