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R. BIRMANN

2,013,512

GUIDE VANE AND DIAPHRAGM CONSTRUCTION FOR TURBINES

Filed March 11, 1933

2 Sheets-Sheet 1

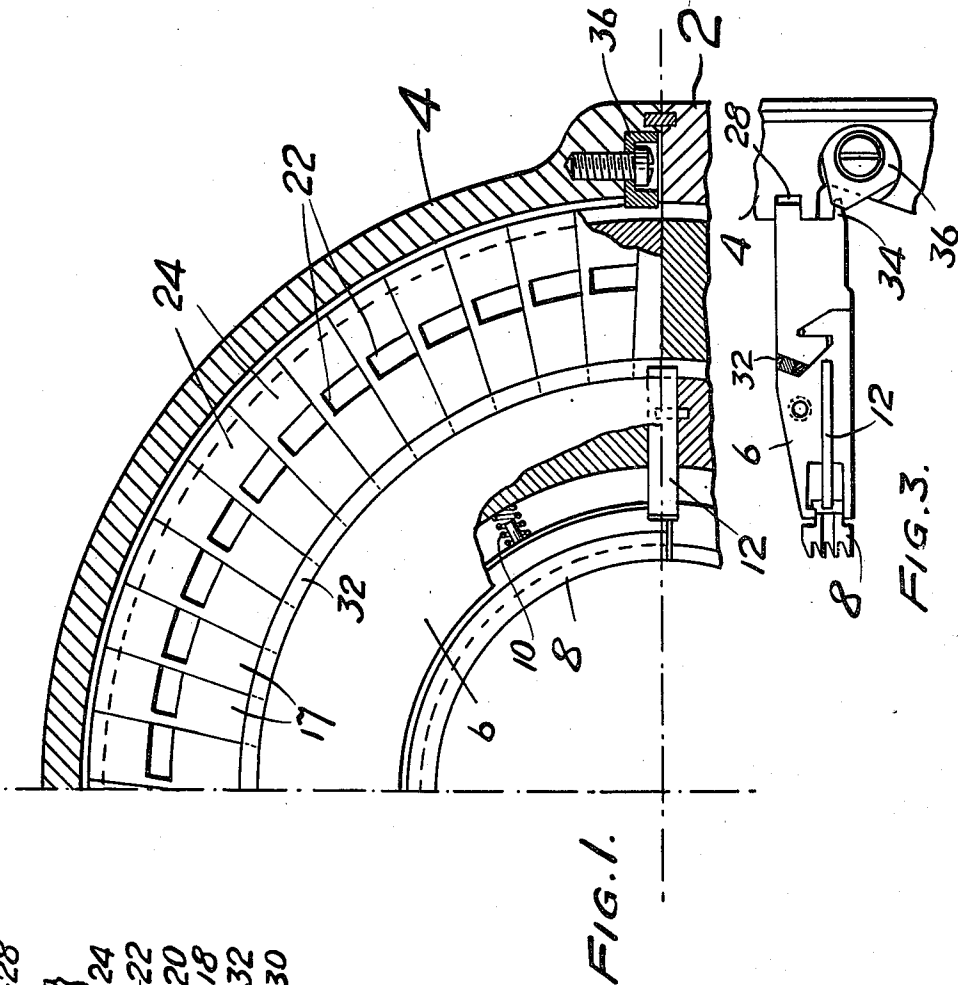


FIG. 1.

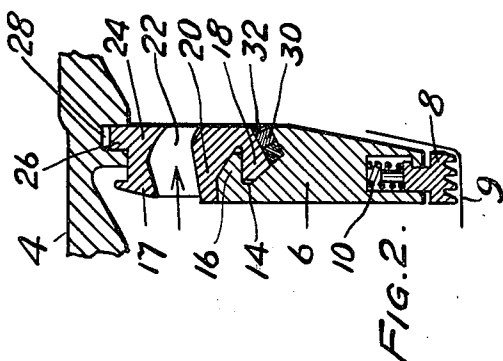


FIG. 2.

WITNESS:

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2 Sheets-Sheet 2

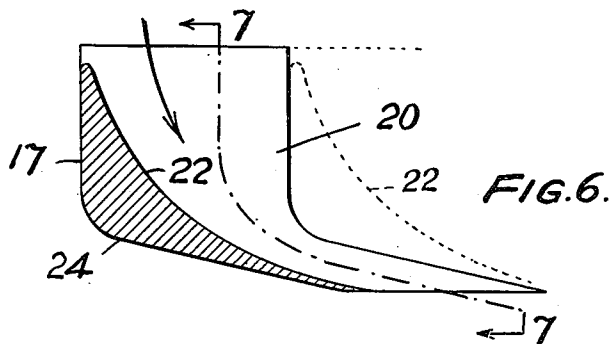


FIG. 6.

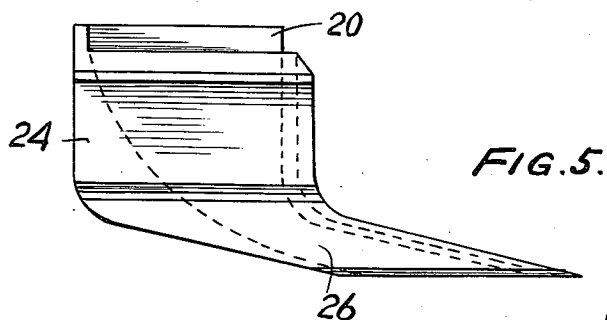


FIG. 5.

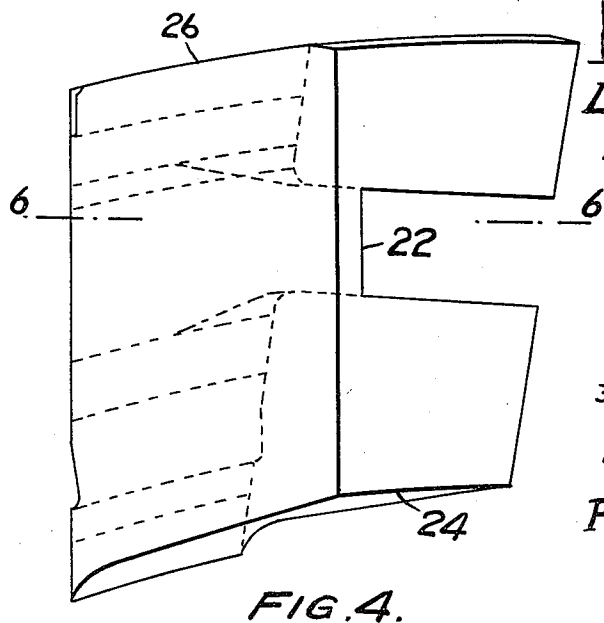


FIG. 4.

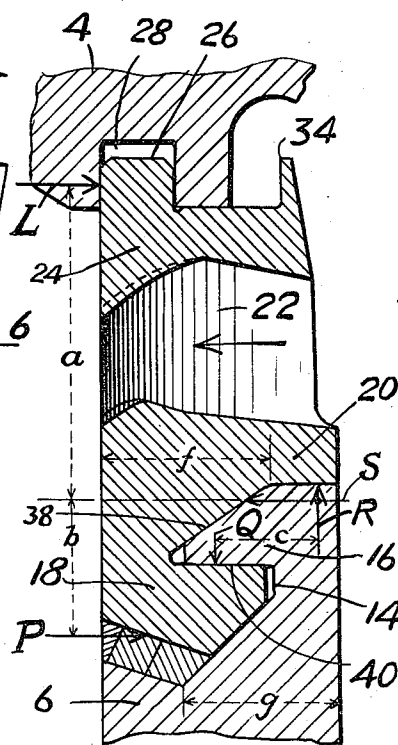


FIG. 7.

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2,013,512

GUIDE VANE AND DIAPHRAGM CONSTRUCTION FOR TURBINES

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Application March 11, 1933, Serial No. 660,351

4 Claims. (Cl. 253—78)

This invention relates to an improved construction of guide vanes and associated diaphragms for turbines, more particularly a construction designed for pressure stage turbines.

The guide vanes in an elastic fluid turbine, namely, the stationary vanes which serve to direct motive fluid to the moving buckets have different functions in velocity stage turbines and pressure stage turbines: in the former case they receive steam at high velocity and merely change its direction generally without increasing the velocity, so that there is little, if any, drop of pressure from the one side of the vanes to the other; whereas in the latter case the guide vanes receive motive fluid at low velocity and are so designed that an expansion takes place as the result of which the fluid leaves the guide vanes with high velocity, and is directed at a proper angle into moving buckets of a wheel where its kinetic energy is transformed into work.

Where a substantial pressure drop through the guide vanes occurs, there is a load of considerable amount upon the partition wall between the stages. Such partition wall by which the blades are carried, is held only at its periphery by the housing and extends inwardly to the shaft where it carries suitable packing means for preventing loss of fluid along the shaft. Since it is practically impossible to support the diaphragm adjacent the shaft, the entire load, which is equal to the exposed area of the diaphragm times the pressure drop, is transmitted to a side of the groove of the turbine case in which the diaphragm is located, the greater portion of this load, i. e. that due to pressure on the area inside the vanes, being transmitted by the vanes, which are adjacent the periphery of the diaphragm, unless special ribs are provided at the entrance side of the guide vanes to transmit the load from the diaphragm center to the shrouding. Since the last named construction requires considerably more of the valuable axial space and the ribs cause a bad disturbance of the flow to the vanes, the use of ribs, which was never very popular, is now almost entirely abandoned in favor of better constructions which do not require a greater axial width than corresponds to the width of the guide vanes.

Dependence upon the guide vanes to carry the load on the diaphragm requires that the guide vanes be so carried and constructed that failure will not occur. One of the most satisfactory types of guide vane constructions involves the use of guide vanes which are integral at their inner and outer ends with distance pieces which

serve to separate adjacent vanes by forming sectional inner and outer boundary walls for the nozzles. Such vanes are secured to the diaphragm center and the complete diaphragm, consisting of center disc and vanes, is held all around the outer portion of the guide vanes in a groove of the turbine casing. This construction is greatly favored, since the vanes can be properly machined to reduce friction losses, can be shaped to the most advantageous stream line form, and can be made of stainless steel without involving the making of the entire diaphragm of such high priced corrosion-proof material. Other advantages are attained in that the number of nozzles may be easily varied and the diaphragm can be easily split in two halves, one of which may be fastened to the wheel case cover and the other of which may be made to stay with the lower half of the turbine case.

The fastenings of the sections of the diaphragm center heretofore used have not been satisfactory, inasmuch as they did not lend themselves to the carrying of great axial loads existing on the diaphragms of modern high pressure, high temperature turbines wherein the high pressure creates a tremendous loading and the high temperature considerably reduces the strength of the material. Increase of diaphragm thickness to attain greater strength greatly increases the over-all length of the turbine and creates other difficulties in design.

The present invention has as its object the provision of an improved fastening between guide vane sections and the diaphragm center. The resulting construction has all of the advantages of the heretofore known sectional construction and in addition provides the necessary strong connection between the parts so that the connection is as strong as either the diaphragm center or the guide vane section.

Further objects of the invention relating particularly to details of construction will become apparent from the following description read in conjunction with the accompanying drawings in which:

Fig. 1 is a sectional view showing a portion of the improved diaphragm construction;

Fig. 2 is a radial section through the same;

Fig. 3 is an inverted plan view of the upper section of the casing showing means whereby the vane sections are held in position;

Fig. 4 is an axial elevation of a guide vane section;

Fig. 5 is a plan view of the same;

Fig. 6 is a horizontal section through the same; and

Fig. 7 is a section of the same by the surface indicated at 7—7 in Fig. 6 also showing associated parts of the casing and diaphragm center.

In the present disclosure the invention is shown as applied to a turbine the casing of which is made in lower and upper parts indicated at 2 and 4 respectively. This turbine is of a pressure stage type and is provided with the usual discs carrying buckets spaced by diaphragms of which only one is illustrated. This diaphragm consists of a two-part center 6 approaching the shaft and carrying a suitable packing means 8 which may be of labyrinthine type pressed inwardly by a spring 10 so as to closely approach the shaft 9 and prevent leakage axially of the shaft from the high pressure side of the diaphragm to the opposite side. A key 12 serves to line up the upper and lower sections of the diaphragm center. Near its periphery the diaphragm center is provided with a groove extending inwardly from its low pressure side as indicated at 14 and thereby providing an arcuate hook or ridge indicated at 16 at its periphery.

The guide vane sections indicated generally at 17 are illustrated in detail in Figs. 5 to 7 inclusive. Each of these consists of a lower hook portion 18 extending downwardly from the inner boundary wall 20 between which and the outer boundary wall 24 there is suitably curved vane as indicated at 22. The whole assembly is made integral and may, if desired, be made of stainless material which will not be corroded by the working fluid. Each section is provided at its outer end with a rib 26 engageable within an annular groove 28 in the casing.

The detailed construction of the various guide vane sections will be apparent from the drawings. These sections are assembled side by side so that each guide vane forms a wall of two adjacent nozzles, the guide vanes being held in spaced relationship by the engagement with each other of the outer and inner portions of the sections. There is indicated in Fig. 7 the manner in which adjacent sections are related to each other in assembly. The hooks 18 of the sections engage within the groove 14 of the diaphragm center. The groove formed in each section receives the corresponding ridge 16 of the diaphragm center. The sections are held in assembled relationship with the diaphragm center by metallic caulking strips indicated at 30 which are forced into position and held by brazing indicated at 32.

In order to hold the assembled sections and upper diaphragm center within the upper half of the housing there are provided duplicate means of the type indicated in Figs. 1 and 3 each comprising a locking piece 36 held to the cover by a screw and engaging the flange 34 of the corresponding end guide vane section. From the above brief description of the assembly without reference to the matters of increased strength it will be seen that all of the advantages are obtained which follow from the use of a sectional guide vane construction. Inasmuch as the sections are small, complete machining is possible to give the guide vanes their proper shape and direction. It will also be obvious that the nozzles which are formed by the assembly may be interchanged for others of greater or less number by merely substituting other sections. If nozzles are undesired through certain portions of the circle the guide vane sections may be replaced at such localities by solid members.

The mechanical advantages of the arrangement from the standpoint of strength will be best appreciated from Fig. 7. Without going into details of the theoretical considerations involved, but considering an approximate analysis sufficient for descriptive purposes, the action may be understood by considering the moments acting upon a guide vane section. The reaction of the casing holding the diaphragm against axial moment is represented at L. In the present construction in which the hook 16 of the diaphragm is wedged into the grooves of the guide vane sections, the moment produced by the force L is opposed by forces (assumed, for simplicity, concentrated rather than distributed as is actually the case) forming the couples P and S, and Q and R, the forces S and Q acting on the contacting surfaces 38 and 40, respectively. For convenience, considering the couples acting about the intersection of S and R, there follows:

$$L.a = P.b + Q.c$$

By comparison with the conventional constructions referred to above, it will be found that the lever arms b and c of the forces corresponding to P and Q are less than in the present construction, so that the forces must be larger for the same L, a being fixed by the nozzle height. In the present construction, the dimensions f and g may be made of the order of twice the root widths of the former constructions. As a result there are not only decreased forces but these are distributed over increased areas in the new construction. The axial dimensions are not, however, increased by the new construction.

The design conforms to the principle of eliminating any superfluous material and to let every bit of material contribute an equal share to the strengthening and stiffening of the fastening which rule is grossly violated by the old fastening methods, thereby accounting for their inefficiency. Maximum use is not only made of the material of the guide vane sections but also of the material of the diaphragm center. As a result, several times the strength of the previously used constructions is obtained thereby permitting the same load to be carried with much smaller axial space requirement than any previously known construction.

In multistage turbines which often have twelve or more stages, the sum total of the axial spaces so saved is very considerable and has an important bearing on increased efficiency and reduced manufacturing cost. The manufacturing cost is further reduced by the fact that the vanes can readily be assembled from the side and do not have to be inserted at a certain point in a dovetail groove and slid into position or inserted in a parallel sided groove and held therein by cross pins.

While one specific embodiment of the invention is disclosed it will be obvious that numerous variations will be made without departing from the scope of the invention in applying the same to diaphragms or turbines of different types. The mechanical advantages of assembly make the construction not only useful for pressure stage turbines where strength is required but also for velocity stage turbines where great strength is not required but ease of assembly and accurate guidance of the working fluid is desirable.

What I claim and desire to protect by Letters Patent is:

1. A diaphragm construction for a turbine including a diaphragm center having a groove in its

low pressure face providing an axially extending wedge-shaped ridge at its edge; and a plurality of guide vane sections each of which is arranged to engage the casing at its outer end and has its inner end provided with a hook portion extending within said groove and a groove for the reception of said axially extending ridge, said ridge having a wedging fit in the groove of each guide vane section.

10 2. A diaphragm construction for a turbine including a diaphragm center having a groove in its low pressure face providing an axially extending ridge at its edge; a plurality of guide vane sections each of which is arranged to engage the casing at its outer end and has its inner end provided with a hook portion extending within said groove and a groove for the reception of said axially extending ridge; and caulking holding said hook portion within the groove in the diaphragm center.

20 3. A diaphragm construction for a turbine including a diaphragm center having a groove in its low pressure face providing an axially extending ridge at its edge; and a plurality of guide vane sections each of which is arranged to engage the casing at its outer end and has its inner end

provided with a hook portion extending within said groove and a groove for the reception of said axially extending ridge, said last named groove having its inwardly facing surface in extended stress transmitting engagement with an outwardly facing surface of the diaphragm center, such engagement extending to a substantial distance axially beyond the extremity of said hook portion in the direction of the high pressure face of the diaphragm center.

10 4. A diaphragm construction for a turbine including a diaphragm center having a groove in its low pressure face providing an axially extending ridge at its edge; and a plurality of guide vane sections each of which is arranged to engage the casing at its outer end and has its inner end provided with a hook portion extending within said groove and a groove for the reception of said axially extending ridge, said last named groove having its inwardly facing surface in extended stress transmitting engagement with an outwardly facing surface of the diaphragm center, said engagement extending substantially to the high pressure face of the diaphragm center.

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