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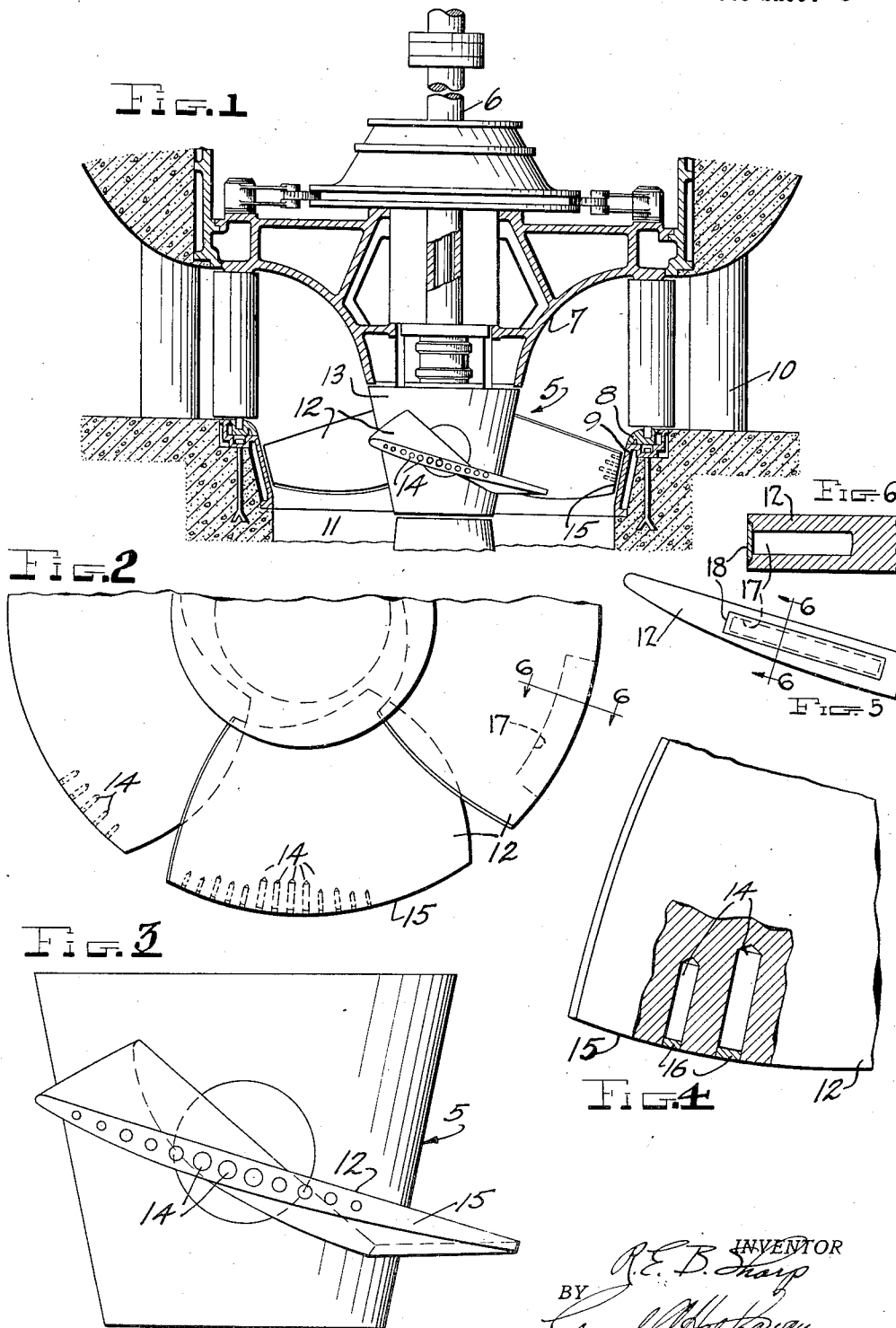
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BALANCED TURBINE OR PUMP RUNNER AND METHOD OF BALANCING

Filed Jan. 9, 1932

2 Sheets-Sheet 1



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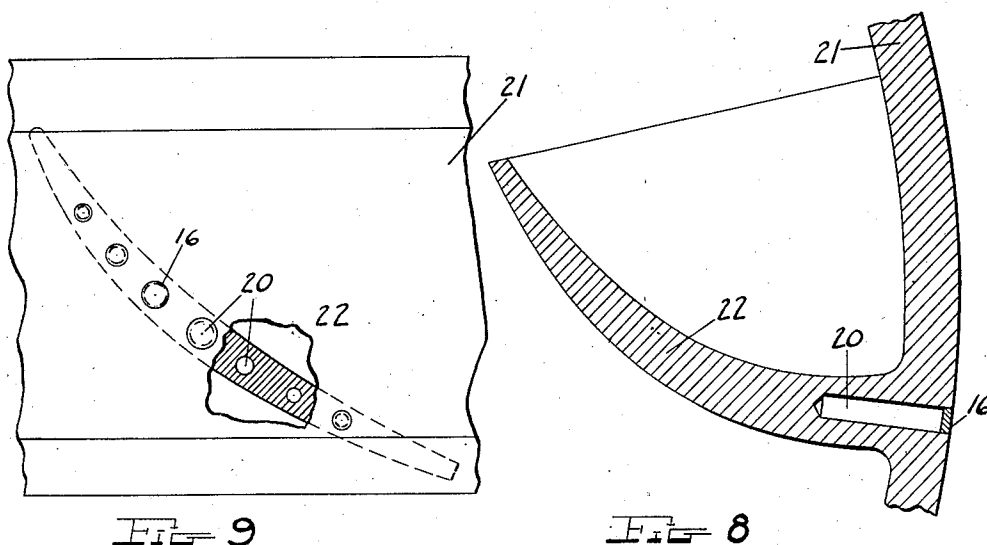
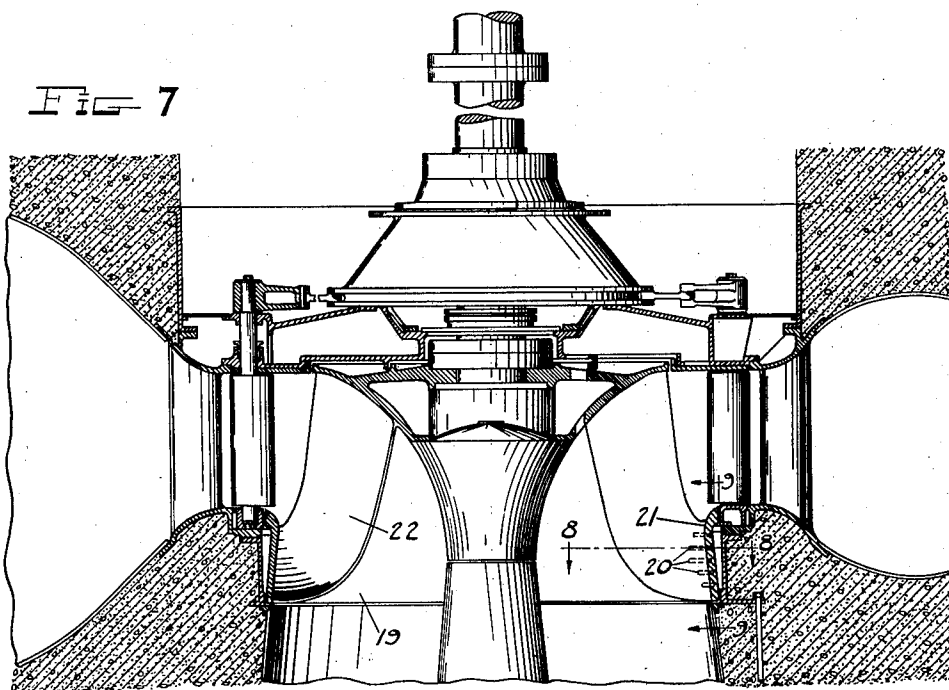
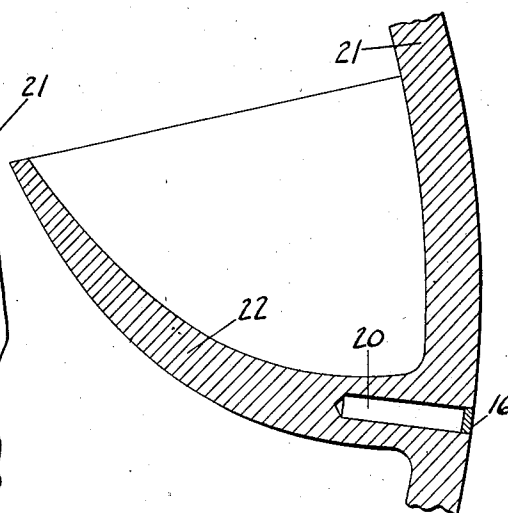


FIG 8



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BALANCED TURBINE OR PUMP RUNNER
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4 Claims. (Cl. 253—148)

This invention relates to an improved balanced turbine or pump runner and to an improved method for balancing the same.

The rotating parts of a hydraulic machine, particularly a turbine, constitute a revolving mass of appreciable magnitude which must be carefully balanced to avoid destructive or excessive vibration. The possibility of vibration due to a relatively small unbalance of weight is considerably augmented by the fact that the rotating parts are generally of very large diameter. For example, it is usual to build turbine runners with diameters ranging up to 18 ft. Some of these runners weigh as high as 100 tons, and some develop up to 84,000 horsepower per unit, at varying speeds and heads. The speed varies widely for the different units but is commonly between 100 and 200 R. P. M. It is thus seen that with factors such as these to contend with in a great many installations, the problem of avoiding unbalancing centrifugal forces is one which requires very careful work. The method disclosed herein, while particularly applicable to large runners, may also be used to advantage in balancing small size runners.

In balancing a hydraulic machine runner, it is highly desirable to maintain as nearly as possible the contour of the flow surfaces in accordance with the predetermined engineering design thereof. Such a design takes into consideration such matters as the relative velocity between the flow and the runner surfaces and the matter of cavitation of the runner blades which can be caused by an improper contour of the blade surfaces. It is also necessary to maintain the designed structural strength of the runner and turbine parts.

Heretofore various methods have been employed for balancing runners of hydraulic machines particularly hydraulic turbine runners which tend toward massiveness. One of these methods as applied to the Francis type of runner is to fill in the crown at various points thereof until the runner is in balance. Another method which is particularly applicable to the propeller type runner as well also to the Francis runner is to remove metal from the surface of the runner blades. This method has the disadvantage that it definitely alters the predetermined flow surface of the runner blade thus providing a basis for cavitation.

It is an object of my invention to provide an improved method for balancing runners particularly those of the propeller type without adding weight to the runner as is usually done in

connection with the crown of the Francis runner as above described, and without altering the predetermined design of the flow surface of the runner blades. In addition it is a further object to obtain a balanced runner without weakening the same from a structural standpoint.

In one specific aspect of the invention I have accomplished the desired degree of balance without incurring the undesirable features above mentioned, this being obtained herein by removing excess weight from the interior of the runner blades rather than from the exterior thereof as in the prior practice. Specifically this is best accomplished by gaining access to the interior of the blade through the peripheral edge thereof, for instance, as by drilling radially into the interior of the blade.

In the prior art method previously described wherein metal was removed from the surface of the blade with the consequent destruction of the perfect blade surface it is impossible for practical reasons to be able to restore the surface of the blade to its original desired contour as this would necessitate adding material to the blade at the point where metal was removed. However, in my improved method and construction, by removing a considerable amount of metal from the interior of the blade through a relatively small opening in some external part of the blade I am able to cover this opening with a relatively small amount of suitable material without negating the balancing operation. In the specific use of the invention as applied to a propeller type runner, by removing the interior metal through the peripheral edge of the blade, it is seen that I not only preserve the original blade surface but also operate through a surface (the peripheral edge) which serves no function in guiding the flow over the runner blade other than to maintain clearance with the runner casing.

A most important feature of the specific aspect of the invention is that the material is removed from a point which will give maximum balancing effect with a minimum removal of material. This is accomplished due to the material being removed from the interior of the blades adjacent the periphery thereof, it being understood that the unbalancing forces are caused by centrifugal forces of unbalanced masses. The centrifugal force varies as the square of the speed and hence it is advantageous to remove the material from near the periphery where the speed is the greatest.

It is thus possible in my improved method and balanced runner to obtain all desired advantages with minimum effort and few, if any, disadvan-

tages. Other objects and advantages will be more apparent to those skilled in the art from the following description of the accompanying drawings in which:

5 Fig. 1 is a vertical section of an adjustable blade propeller type hydraulic turbine, parts of which are shown in elevation;

Fig. 2 is an enlarged fragmentary plan view of a runner showing how my improved method of
10 balancing is applied;

Fig. 3 is an elevation of the runner hub and one blade, viewed from its peripheral edge; and

Fig. 4 is an enlarged fragmentary section of a runner blade showing in section two of the interior
15 balancing holes or chambers within the blade.

Fig. 5 is an enlarged fragmentary edge view of a blade showing a peripheral balancing slot and cover plate therefor;

Fig. 6 is a section on lines 6—6 of Figs. 2 and 5;

20 Fig. 7 is a vertical section of a Francis runner balanced in accordance with my improved method;

Fig. 8 is a horizontal section taken on line 8—8 of Fig. 7; and

25 Fig. 9 is a fragmentary side elevation of the runner blade and shroud band taken on line 9—9 of Fig. 7.

While the hydraulic turbine used for purposes of illustration is of the adjustable blade propeller type, it will of course be understood that the invention may be applied to other types of turbines whether of the adjustable or fixed blade. The turbine shown may be considered as a conventional type for purposes of this description, and hence it need only be briefly described as comprising a runner generally indicated at 5 mounted on a shaft 6 which is supported in suitable bearings carried by a head cover 7. This head cover together with a lower distributor
40 ring 8, throat ring 9 and a speed ring including the guide vanes 10, guide the flow to the runner from which it is discharged into a suitable draft tube herein shown as of the spreading type 11. The runner blades 12 are suitably adjusted or rigidly supported as desired by the runner hub 13. These runner blades may be of any construction usually employed, the general characteristics of which are, that there are relatively few blades usually six or less, the blades are relatively flat in the direction of flow thereover, are inclined more
50 nearly to the horizontal than the vertical and are relatively thin, consistent however with the necessary strength to support the column of water flowing through the runner and to impart the necessary torque to the runner shaft.

To balance the runner the direction of unbalance will first be determined in accordance with usual procedure whereupon holes 14 will be drilled into the interior of the blades from the
60 periphery 15. The number of holes, their diameter and the extent of drilling will be determined in accordance with the degree of unbalance while the circumferential distribution of the holes will be determined not only by the degree of unbalance but also by the direction or directions of unbalance and the amount of material that may be safely removed from any one blade or from adjacent blades. The bending stresses of the blades are at a minimum near the periphery of the runner, and hence they may be drilled adjacent thereto with maximum safety. Various depths and sizes of holes have been shown although it will of course be understood that these sizes and depths are used only to diagrammatically illustrate the invention.
75

If desired, plugs 16 may be suitably rigidly fastened in the outer ends of the holes to close the same and thus present a smooth continuous periphery, it being understood that even though irregularities may appear in the peripheral surface still this will not affect the flow surfaces of the runner. 80

Instead of removing metal by drilling, if preferred the metal may be removed by chipping deep slots 17, which are covered by relatively thin rectangular plates 18, fastened in place by welding or other suitable means. Such a slot and plate are shown as applied to one of the blades in Figs. 5 and 6 in which case the slot 17 may be relatively long as shown in one of the blades
90 in Fig. 2.

The invention is also applicable to a Francis runner 19, shown in Fig. 7, as by drilling holes 20 through the usual shroud ring 21 into blades 22 along the neutral axis thereof. The previously outlined advantages of my improved method as applied to the propeller runners are equally applicable to the Francis runner. Hence there is no need for further discussion. 95

It will of course be understood by those skilled in the art that various changes may be made in the construction and arrangement of the interior blade holes, while the application of the holes may be variously applied to the different types of runners whether of the fixed or adjustable blade type. The method herein disclosed may also be varied in accordance with particular conditions without departing from the spirit of the invention as set forth in the appended claims. 100

I claim:

1. The method of balancing a runner of a hydraulic machine wherein the runner has a hub supporting a plurality of blades projecting outwardly therefrom, consisting in first determining the direction of unbalance of the runner and then removing material from the interior of a blade through the peripheral edge thereof whereby the blade surface over which the hydraulic fluid normally flows remains intact. 105 110 115

2. The method of balancing a runner of a hydraulic machine wherein the runner has a hub supporting a plurality of blades projecting outwardly therefrom, consisting in first determining the direction of unbalance of the runner and then drilling a hole or series of holes of the same or different diameters into the interior of said blade from the peripheral edge thereof whereby the blade surface over which the hydraulic fluid normally flows remains intact. 120 125 130

3. The method of balancing a runner of a hydraulic machine wherein the runner has a hub supporting a plurality of blades projecting outwardly therefrom, consisting in first determining the direction of unbalance of the runner, then drilling a hole or series of holes of the same or different diameters into the interior of said blade from the peripheral edge thereof, and finally closing the outer end or ends of the drilled hole or holes whereby the blade surface over which the hydraulic fluid normally flows remains intact. 135 140 145

4. A balanced propeller type hydraulic runner having a plurality of relatively thin blades provided with balancing holes within the interior thereof, said holes projecting inwardly from the peripheral edge of the blades whereby the blade surface over which the hydraulic fluid normally flows remains intact. 150

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