April 17, 1956 R. C. GLAZEBROOK 2,741,992

BLADELESS IMPELLER BALANCE MEANS

Filed April 10, 1950

Fig. 1.

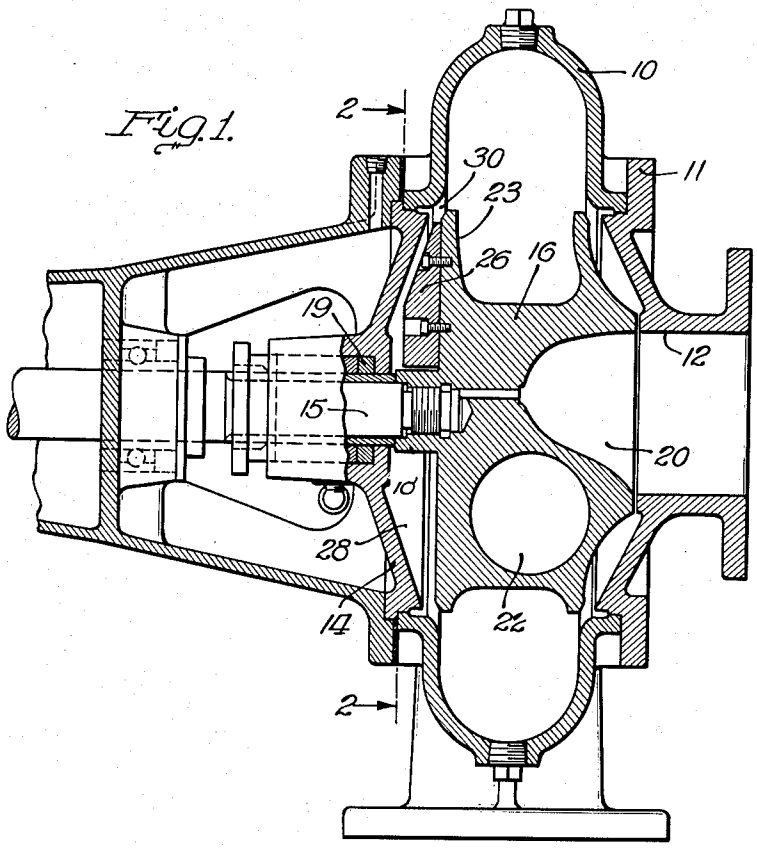


Fig. 2.

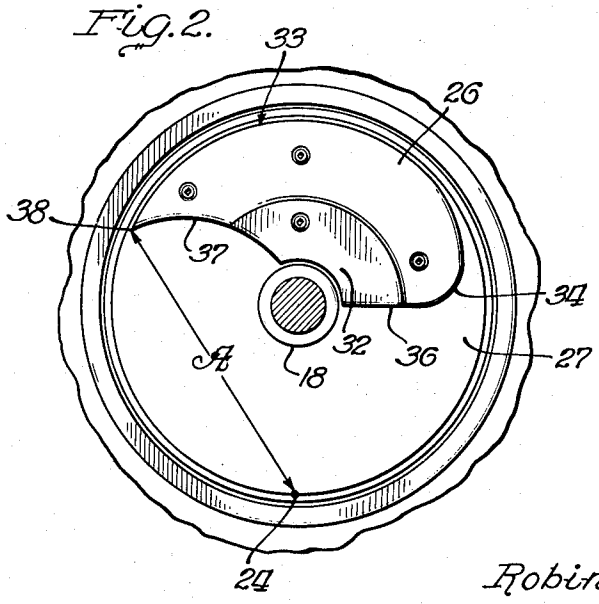
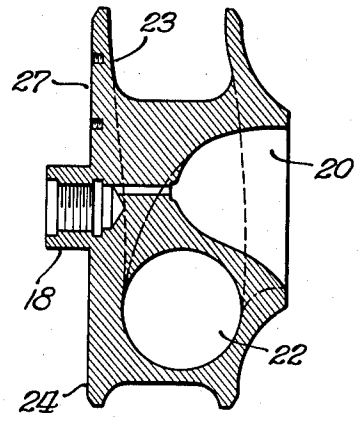


Fig. 3.



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BLADELESS IMPELLER BALANCE MEANS

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Application April 10, 1950, Serial No. 155,015

1 Claim. (Cl. 103—103)

This invention relates in general to improvements in centrifugal pumps, and concerns in particular, the provision of means for balancing a centrifugal pump rotor of the bladeless character disclosed in co-pending application by Lindau and Glazebrook, entitled Bladeless Pump Impeller, filed September 18, 1947 and bearing Serial Number 772,610, now Patent No. 2,655,868, issued October 20, 1953. The present invention includes utilization of the balancing means to improve pump operation in a manner hereinafter to appear.

In a pump rotor or impeller of the novel bladeless character as disclosed in the aforesaid application, wherein a single fluid passage is formed in the rotor body extending from the axial suction inlet in a generally helical direction toward the opening to the impeller periphery, the distribution of mass in the rotor body is such as to result in a rotor having a heavy side, producing an unbalance of the rotor on its axis. A degree of balancing of such a rotor is possible by coring out portions of the rotor body, or otherwise reducing or removing portions of the body. However, securing the desirable high degree of balance in this way is both difficult and costly of attainment. Accordingly, it is the general purpose of the present invention to afford an effective yet relatively simple and economical provision for balancing a rotor of the character indicated, constituted by weight means applied externally on the rotor body in a position thereon to counterbalance the heavy side of the rotor and to effect a practical operating balance of the rotor member. It is a further purpose of the invention to improve the operation of a pump embodying a rotor of the form described, through utilization of the balancing weight means as an impeller element between the pump rotor and a pump casing back wall, to expel fluid and matter contained therein tending to enter that region.

The invention will be clearly understood from the following description of a presently preferred embodiment thereof, exemplified in the accompanying drawing, wherein:

Fig. 1 is longitudinal sectional elevation through a pump casing and rotor assembly, illustrating the present provisions.

Fig. 2 is a transverse sectional elevation through the pump as taken along line 2—2 in Fig. 1.

Fig. 3 is a longitudinal sectional elevation of the pump rotor.

With reference to the drawing, the centrifugal pump illustrated includes a pump casing **10** having a front wall **11** providing a central fluid inlet opening or passage **12**, and a back wall **14** thereby defining in the casing **10** a pumping chamber. Extending through back wall **14** is a pump shaft **15**, and mounted on the shaft end in the pump casing is a pump impeller or rotor **16**, the rotor having a circular hub **18** for shaft engagement. The shaft in its projection through casing back wall **14**, is sealed against fluid leakage by a suitable packing **19**.

Rotor **16** is here shown to be of the novel form and construction as fully disclosed in the application referred

to hereinabove. Briefly, then, the rotor as appears in Figs. 1 and 3, comprises a one-piece body having an axial suction inlet or eye **20**, and a single fluid passage **22** extending from the eye **20** generally helically in the body toward and opening to the rotor periphery, preferably opening into a peripheral channel **23**. As so formed, it will appear that the rotor is of truly bladeless character, completely devoid of shoulders or other projections outstanding in the rotor passage.

It will be appreciated that a rotor of this form has a heavy side as in the region of the peripheral reference point **24**, the point **24** here being located on the radius through the center of the heavy portion. The rotor, therefore, is subject to an operating unbalance consequent not only to its heavy side, but importantly also, to the reaction of the impeller or rotor upon the passage of water or water and solids entrained therein, through the single spiral or helical rotor passage **22**. The amount of unbalance, in terms of the turning moment caused thereby, can be measured by any suitable well known torque-measuring instrument. The exact method of determining the amount of unbalance is not part of this invention. It is highly desirable and necessary, therefore, to effect an operating balance of the rotor which will care for the unbalancing factors above expressed, such as to result in rotor vibration within acceptable limits in pumping operation. The desired operating balance is accomplished according to the present invention, by weight means applied externally on the rotor body in a position thereon determined in a manner presently to be described.

In the present example, the balancing weight **26** is constituted by a mass or block of suitable material which in final assembly, is bolted, welded or otherwise secured to or provided on the rotor on its rear face **27**. As appears in Fig. 1, the weight is shaped to conform with adequate clearance, to the annular chamber **28** formed by the rear face of the rotor in cooperation with the casing back wall **14**. Chamber **28** opens to the interior of casing **10** peripherally of the rotor, as through the annular port **30**, from which it will appear that fluid and solid or other matter contained therein, delivered into the casing on the discharge side of the rotor, will tend to enter the chamber **28** through said port **30**. Since the present bladeless rotor pump is intended particularly although not exclusively, for sawage and trash pumping, it is important to prevent accumulation of solids, stringy or fibrous and other matter in the chamber **28**. Accordingly, the rotor balancing weight element is here adapted to function as an impeller, serving to eject or expel the matter tending to enter the chamber. To this end the weight element is formed to provide an impeller having a portion **32** adapted for relatively close overlying relation to the rotor hub **18**, and presenting an arcuate periphery **33** terminating in a rounded nose **34** merging with the leading impeller edge **36**, and an arcuate trailing edge **37**. In effectively expelling solids, stringy and other foreign matter from chamber **28**, the impeller element prevents or precludes wrapping of stringy and fibrous trash around the impeller hub **18** and the adjacent portion of the shaft exposed in chamber **28**. Consequently, the present arrangement avoids impeller drag and consequent lowered efficiency which otherwise would result were the indicated condition of hub and shaft clogging permitted.

It is to be noted here also, that in forming the weight element to have the dual function of pump impeller balancing and prevention of trash accumulation in the pump back chamber **28**, it is given an effective streamlined shape as indicated in the drawing. Thus the weight element is conditioned to have no more than a negligible adverse effect on the over-all operating efficiency of the impeller structure.

Turning now to the manner of establishing the coun-

terweight value and location of the weight element on the rotor to attain the desired operating balance of the latter, the weight element shaped as shown to provide the auxiliary impeller function hereinabove described, is located on the side of the rotor opposite the heavy side and in a position thereon such that the rotor will be out of static balance and out of dynamic balance when running dry, that is, when the rotor is revolved up to normal running speed but without passing water through it. The exact position of the weight is determined and thence the balanced condition of rotor and weight assembly is adjusted as by removal of metal from the weight and/or the rotor body as through surface grinding or the like, such that the rotor assembly in normal pumping operation, will have a practical range of unbalance vibration. The weight and positional factors of the weight element are related to the constructional character of the rotor including the relative location of its heavy side, the outside diameter of the rotor and the diameter or cross-sectional capacity of the rotor passage. Thus for a given rotor, the weight element is located such that the distance A (Fig. 2) between the heavy side reference point 24 and the trailing tip or terminal end 38 of the weight, is a fixed value obtaining uniformly in all rotors of the same construction, outside diameter and size of passage.

Determination of the distance A in a pump rotor of given construction, outside diameter and diameter or sectional capacity of its single helical passage, may be and in practice is, accomplished through subjection of the given rotor to vibration tests and adjustments of the balancing weight thereon. Such tests and weight adjustments are conducted under conditions of actual pumping operation of the rotor, until the vibration tests show a practical operating balance of the rotor. For rotors of the character herein concerned, the maximum degree of rotor vibration occurring in normal pump operation, should not exceed a three thousandths double amplitude reading of a standard or well-known vibration indicator or vibrameter. Accordingly, in present balance adjustment of the rotor, the mass or weight element is adjusted by shifting it angularly relative to the rotor hub, until the vibrameter reading indicates a minimum unbalance below the three thousandths double amplitude limit. Or, stating the test in another way, the range of vibrations between the minimum double amplitude vibration obtainable by test and the maximum permissible three thousandths double amplitude will indicate the range of pump unbalance that is permissible for satisfactory pump operation. The indicated angular shift of the weight element may be accommodated in respect to the test weight in such balance adjustment determination, by mounting the weight on the impeller in any suitable manner permitting angular shift thereof. Although not shown herein, such mounting may include arcuate slots in the weight element through which the weight attachment screws extend, or an arcuate series of tapped holes in the impeller for selective reception of the weight attachment screws. Once proper weight location is determined, measurement of the distance between the weight end 38 and the rotor heavy side reference point 24, provides the distance A. That distance then determines the location of the balance mass on all rotors of like characteristics. More specifically with respect to the foregoing determination, the steps involved in the determination process which is essentially empirical are (*a*) mounting an impeller of a given size including the outside diameter thereof and the diameter of the impeller passage, for free turning on a horizontal axis; (*b*) allowing the impeller to turn and come to rest with its heavy side lowermost; (*c*) marking the heavy side point 24 on the impeller near its periphery, such that this point is on a vertical line through the impeller axis; (*d*) selecting a weight of the shape shown and applying it to the impeller opposite the heavy side of the latter; (*e*) should this weight cause a turning of the impeller to a position in which the weight is below the turning axis, then repeat step (*d*) by applying a weight element of lesser weight value, or reduce the weight of the first applied weight element as by grinding off metal, until after one or more repetitions of this step, the impeller remains in position with the heavy side mark 24 substantially lowermost; (*f*) mounting the impeller with the weight element thereon, in a pump casing and operating the assembly under actual fluid pumping conditions utilizing fluid containing solids and stringy or other matter; (*g*) making vibration test of the operating pump to determine the extent of unbalance vibration; (*h*) if vibration be greater than the maximum permissible three thousandths double amplitude reading, then remove the impeller and either grind off metal from the weight or angularly shift the position of the weight element in one direction or the other, or both; (*i*) repeating steps (*f*) and (*g*) and then (*h*) if necessary, until vibration is less than or not in excess of the permissible maximum. Once the selection and location of the weight element is thus determined, the distance A becomes a definite fixed distance for the given size impeller, and the weight value of the weight element is thereby fixed for the given impeller. Thereafter in impeller production, all impellers of the given size will have balancing weights of equal value as thus determined, positioned at the distance A from the heavy side reference mark 24 of each impeller (the mark 24 being determined as to each impeller, in accordance with steps (*a*), (*b*) and (*c*) above). The distance A for rotors of larger or smaller diameter and differing in constructional characteristics including the sectional capacity of the rotor passages thereof, may be determined in the same manner. As an example of the result of the foregoing adjustment and test, it is found in the instance of rotors of a given construction in which the diameter of the rotor passage is 2 inches, and the outside diameter of the rotor is 7 inches, that the distance A is 5⅝ inches, while for an 8 inch outside diameter rotor, the distance A is 6$\frac{3}{16}$, and for a 9 inch rotor the distance A is 7 inches. Once the distances A have been determined for rotors of differing characteristics in the respects above pointed out, it then becomes relatively simple to properly locate and fix the weight elements, so that upon adjustment of the counterweight values thereof as through removal of metal from selected zones of the weight, the rotors will be conditioned for balanced operation wherein the degree of rotor vibration is well within predetermined practical limits.

Having now described and illustrated a presently preferred embodiment of the invention, what I desire to claim and secure by Letters Patent is:

In a centrifugal pump assembly for pumping solids-containing fluids, a casing having a pumping chamber therein and an axial suction passage communicating with said chamber, and a back wall, a pump rotor operative in the casing, the rotor comprising a unitary body having front and back faces and providing an axial suction opening in the front face, the body further having a single passage extending from the suction opening through the body in a generally helical trend therein toward and opening to the body periphery, said rotor being located in the casing with its said suction opening in axial alignment with the casing suction passage and its said back face spaced from and cooperating with said casing back wall to form a second chamber therebetween communicating with the pumping chamber, and a balance weight member in said chamber and secured to the back face of the rotor body, said member having a predetermined mass and being located in a predetermined position of securement on the back face of the rotor body such as to establish, within predetermined limits, a practical minimum of rotor unbalance in pumping operation of the rotor to pass solids-containing fluid through said single passage thereof, said member further having a portion thereof extending toward and terminating adjacent the periphery of the rotor body, said portion having an arcuate mar-

ginal surface providing an impeller vane, and said impeller vane operating in said second chamber to expel fluid and any solids contained therein, tending to enter the chamber.

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