Nov. 28, 1961 | J. L. KING | 3,010,402

OPEN-CASE PUMP

Filed March 9, 1959 | 2 Sheets-Sheet 1

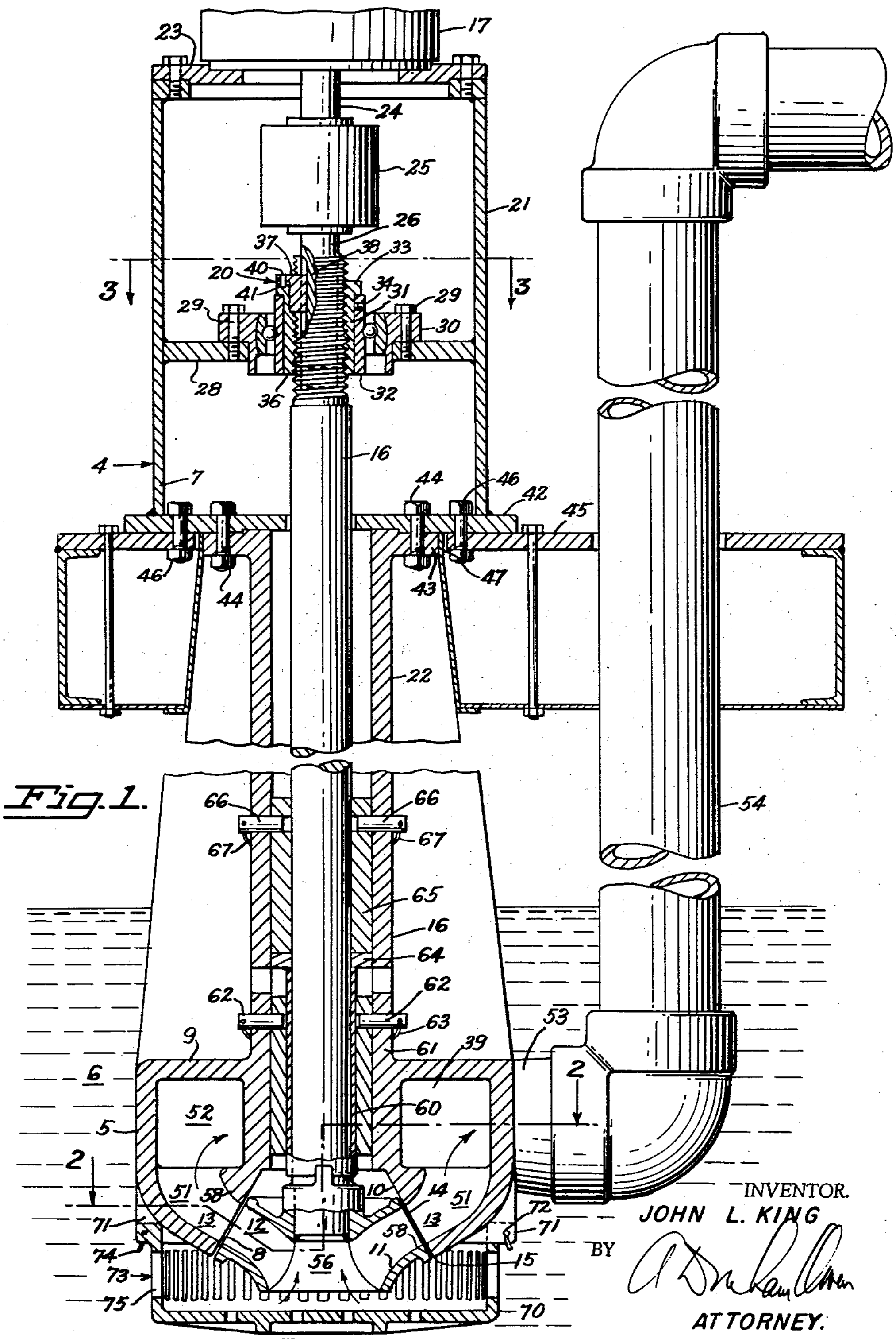

Fig. 1.

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Fig. 3.

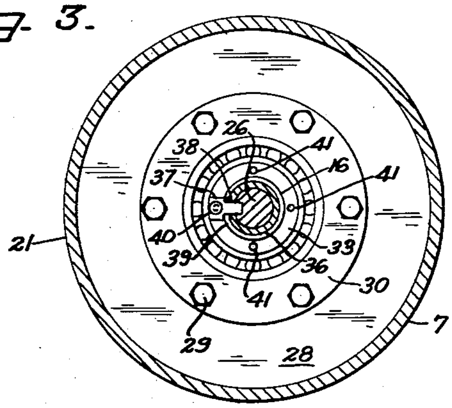
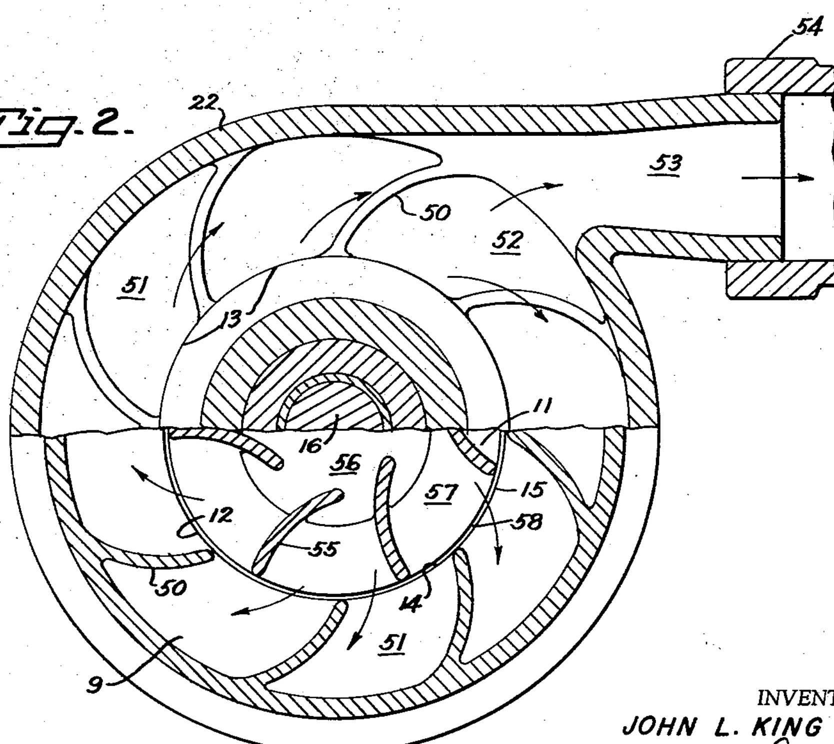


Fig. 2.



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3,010,402
OPEN-CASE PUMP

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This invention relates to an improved centrifugal pump having special utility in the transfer of liquids or molten materials at extremely high temperatures.

Many important industrial processes, such as those involving reduction, purification, and separation of certain metals and chemicals, require large amounts of heat at high temperature levels. Molten substances of high heat content can fulfill this heat requirement, but their transfer from a high-temperature reservoir or melting furnace has led to difficulties in the pumping operation.

For example, molten salt is used to melt the waste aluminum chips obtained during the machining of aluminum parts. Solid salt in a large cauldron is melted and heated to about 1500° F. by the direct application of heat to the cauldron. Then the molten salt is pumped at a suitable rate of flow to the desired location and used to melt the aluminum chips. The molten-salt method of melting aluminum chips has proved highly successful and, in fact, is the only method now known which can do the job economically.

However, the pumping of the molten salt gave rise to serious problems, and so did other operations where it became necessary to transfer liquids at extremely high temperatures. The difficulty arose from the fact that the vital elements of the pump operate in contact with the high-temperature molten material. It soon became apparent that a pump immersed in such molten material could not have the immersed pump housing constructed from more than one part. In the high-temperature environment, conventional connections such as rivets, nuts and bolts, became distorted and lost strength, and were not able to maintain the structural integrity of the pump case. Therefore, it was found necessary to use a welded or integrally cast case. But, before the present invention, this meant that when repair, replacement, or adjustment of the bearings or impeller was required, the entire pump unit had to be replaced, or the pump case had to be torn apart to gain access to the worn or damaged parts. The problem was all the more serious because the pumping of thick, molten material at extremely high temperatures tended to increase the wear of the internal operating components and more frequent repair and servicing were required.

My invention has solved the problem by providing a pump with its case open at the lower end and its impeller mounted in this open end in a way enabling its removal. An important feature of my invention is that the impeller is mounted on a shaft that extends up inside the case and is rotatably secured to the case at a point not exposed to high temperature; this feature makes it possible to adjust the impeller relative to the case during operation, when the impeller is actually in molten salt. It also provides for ready removal of the shaft and impeller from the case, when repair or replacement is needed.

It is, therefore, an object of my invention to provide a centrifugal pump especially adaptable for transferring very high-temperature molten materials, wherein the pump impeller is mounted externally to the pump case and can be disconnected from the case without first removing a portion of the case.

Another object of the present invention is to provide an open-case centrifugal pump having an externally mounted impeller which is adjustable with relation to the case to compensate for wear of the impeller, occurring after sustained operation.

Other objects and advantages of the invention will appear from the following description of a preferred embodiment thereof.

In the drawings:

FIG. 1 is a view in elevation and in section of a pump embodying the principles of my invention. Some parts have been broken in the middle and other parts broken off, to conserve space.

FIG. 2 is an enlarged view in horizontal section taken along the line 2—2 in FIG. 1, showing the impeller and diffuser blades of the pump and the path of the molten material therethrough.

FIG. 3 is a view in horizontal section taken along the line 3—3 in FIG. 1, showing the take-up adjustment of the impeller shaft, in detail.

My invention, in broad terms, comprises an improved centrifugal pump **4** whose lower end **5** may be immersed in a pool of a liquid **6** to be pumped. The liquid **6** may be molten material at an extremely high temperature. In contrast to pumps of the prior art, where the moving pump components are enclosed in the case, my novel pump has a case or housing **7** with an open lower end **8** lying centrally of the axis of an annular diffuser section **9** and defining an upwardly extending tapered recess **10**. An impeller **11** is adapted to rotate within the recess **10** with its peripheral outlet passages **12** adjacent diffuser inlet passages **13** of the section **9**. Between the impeller **11** and an inner surface **14** of the recess **10** is a clearance gap **15**.

The impeller **11** is mounted on the lower end of a shaft **16** driven by a power source **17** that may be mounted on the upper end of the case **7**. Near the upper end of the impeller shaft **16** I have provided an adjustable take-up connection **20** to control the vertical position of the shaft **16** relative to the case **7**. By moving the shaft **16** up and down within the case **7** I can vary the width of the gap **15** between the rotating impeller **11** and the diffuser inlets **13**. Note that the impeller adjustment is made at a point on the shaft **16** far above the level of the molten material **6**, and that it may be made when the lower end **5** of the pump **4** is immersed and the pump **4** is in running position. The connection **20** is the only connection between the shaft **16** and the case **7**; so when the pump **4** is taken out of the liquid **6**, the shaft **16** may be disconnected from the power source **17** and it and the impeller **11** dropped down and out of the case **7**, for repair or replacement of worn-out parts. Thus, the utility and life of the centrifugal pump **4** is greatly increased since, with my invention, repairs, adjustments, and replacement of vital parts may be made easily and without destruction or even damage to the case **7**.

Considering the pump **4** in more detail, the case **7** has an upper housing **21** and a lower housing **22**. Mounted atop a removable plate **23** on the open upper end of housing **21** is the power source **17**, which may comprise a constant-speed electrical motor of suitable size mounted conveniently with its driving-shaft **24** substantially vertical. The shaft **24** may be connected to a flexible coupling **25** within the upper housing **21**, to eliminate alignment problems. Connected to the lower portion of the flexible coupling **25** is a short connecting-shaft **26** which is adjustably connected with the impeller-shaft **16**, in a manner explained below. The impeller-shaft **16** extends downwardly through the lower housing **22** to connect at its lower end with the impeller **11**.

On an inner flange or spider **28** of the upper housing **21** is mounted, as by bolts **29**, a self-aligning thrust-bearing **30**, through which passes the impeller-shaft **16**. The take-up adjustment 20 for the impeller-shaft 16 is provided at the thrust-bearing 30. An internally-threaded sleeve member 31 fits snugly within an inner race 32 of the thrust-bearing 30 and has a flange 33 resting on the upper rim of the inner race 32. A set-screw 34 is threaded through the inner race 32 to engage the sleeve 31 and prevent relative movement thereof. The impeller-shaft 16 has a threaded upper end 35 that engages the interior threads of the sleeve 31.

The short connecting-shaft 26 attached to the flexible coupling 25 fits within a hollow end-section 36 of the shaft 16. The section 36 is of slightly larger diameter than the shaft 25, and a driving connection between the shafts 16 and 26 is established by a key 37 which may be fixed integrally to the shaft 26 or may be fitted in a groove 38 therein. The key 37 also extends through a slot 39 (FIG. 3) in the upper threaded portion 35 of the impeller-shaft 16 and is attached to the upper flange 33 of the sleeve 31 by a screw 40 that goes into any one of a plurality of tap-holes 41 in the flange 33. Therefore, relative movement between the impeller-shaft 16 and the sleeve member 31 may be obtained by removing the screw 40, threading the shaft 16 in the sleeve 31, and putting the screw 40 back into a hole 41. This relative movement provides longitudinal adjustment of the impeller-shaft 16 and of the impeller 11 relative to the pump case 7 and the recess 10.

It is apparent, of course, that many types of take-up adjustment structures, which are common to interconnecting shaft members, can be used. Thus, while I have shown one mechanism for adjusting the vertical position of the impeller-shaft 16, I wish it to be understood that my invention is not limited to this specific mechanism of shaft adjustment.

In the installation shown in FIG. 1, the upper housing 21 is welded to a base mounting-plate 42, which is connected to an integral flange 43 of the lower housing 22 by a suitable attaching means 44, such as bolts or rivets. The mounting-plate 42 may then be removably connected to a floor-plate 45 by bolts 46. The lower housing 20 extends down through an opening 47 in the floor-plate 45 into the molten material 6, which may be in a heated cauldron (not shown).

At the bottom portion of the lower housing 22 and integral with it is the diffuser section 9. The diffuser 9 may be of a standard type used in centrifugal pumps, with directional vanes 50 spaced circumferentially (see FIG. 2) to direct the flow of the liquid 6 received from the impeller 11. The vanes 50 define passages 51 and operate in the conventional manner to transform the velocity imparted to the liquid 6 by the impeller 11 into a pressure-head. Leaving the passages 51, the liquid 6 enters a circular collecting chamber 52 at an increased pressure and leaves the chamber 52 by an exit 53 which leads into a pump outlet-conduit 54.

The diffuser inlets 13 are located along the periphery 14 of the conical recess 10 in which the impeller 11 rotates. The impeller 11 may be of conventional design, having circumferentially spaced impeller blades 55, as shown in FIG. 2, spaced evenly around an axial inlet-eye 56 at its center of rotation. Impeller passages 57 between the blades 55 direct the molten material 6 outwardly to the periphery of the impeller 11 at an angle to the axis of rotation of the impeller 11.

The impeller 11, as seen in cross-section, has tapered sides 58 which include the impeller-outlets 12 from the passages 57. An important feature of my invention is that the angle of taper of the impeller sides 58 is substantially the same as the taper of the wall 14 of the conical recess 10 in the diffuser section 9. The impeller-shaft 16 is mounted along the axis of the case 7, which is also the axis of the conically tapered recess 10. In mounting the impeller 11, I prefer to weld it to the shaft 16 to make a secure connection. The impeller 11 is thus positioned so that the impeller outlet passages 12 are aligned with the inlets 13 to the diffuser 9, leaving only a small clearance gap 15 between the impeller 11 and the diffuser inlet 13.

Within the lower housing 22, a stainless steel sleeve member 60, providing bearing protection, is press-fitted to the impeller-shaft 16 directly above the impeller 11. Between the sleeve member 60 and the lower housing 22 is mounted a first shaft-bearing 61 made of carbon, preferably in the form of solid graphite. The bearing 61 may be held in place by pins 62 extending through the sidewall of the lower housing 22 into the carbon-bearing 61 and retained by lock-wires 63 attached therethrough. A washer 64, resting on the sleeve member 60, retains a second carbon-bearing 65 similarly held in place by pins 66 with lock-wires 67.

A strainer 70 may be attached to the lower end of the lower housing 22. For this purpose, integral brackets 71 may extend from the housing 22 with holes 72 which align with similar holes 73 on the strainer 70. Locking-wires 74 may be passed through the holes 72 and 73 to secure the strainer 70 in place. The strainer 70 is perforated with apertures 75 of any desired shape, which permit flow of the molten material 6 while preventing the influx of lumps or foreign material into the impeller 11.

In operation, the lower end 5 of the pump 4 is immersed in the molten material 6, such as molten salt at 1500° F. Power is supplied to the electrical motor 17 which turns the impeller-shaft 16 and the impeller 11 at the desired speed. The rotating impeller 11 draws the molten material 6 up through the strainer 70 into its inlet-eye 56 and into the impeller passages 57. The impeller 11 is positioned within the recess 10 so that its outlet passages 12 pass adjacent the diffuser-inlets 13 in the conical recess 10. The molten material 6 thus passes from the impeller 11 across the clearance-gap 15 into the diffuser section 9 where pressure is built up before the liquid 6 enters the collecting-chamber 52 and leaves the housing 20 through the chamber's exit 53.

During operation of the pump, slight leakage occurs through the clearance gap 15, but the adjustable feature of my pump permits this clearance 15 to be kept at the optimum amount, thereby reducing leakage to a minimum. The adjustment is made at the take-up connection 20 on the thrust-bearing 30 by merely loosening the screw 40 and rotating the impeller-shaft 16 relative to the threaded sleeve 31 by the desired amount and tightening the screw 40. This rotation causes the shaft 16 to move up or down in the case 7 to vary the clearance-gap 15 between the beveled impeller 11 and the conical recess 10.

For complete removal of the impeller-shaft 16, the strainer 70 is removed and the shaft 16 is then disengaged from the sleeve 31 by rotating it until it drops free from the case 7. It is thus a simple matter to render any necessary repairs to the internal pump parts, such as the diffuser 9 or the bearings 61 and 65. The impeller 11 itself can be repaired by adding metal to its peripheral surfaces so that its life can be extended substantially.

The present invention thus provides a pump for molten material which can be easily serviced and adjusted in running position to provide efficient operation and long life under extreme conditions. My pump thereby enables the use of molten materials wherever they may be needed for heat and power transmission.

While I have described my novel pump structure in conjunction with high temperature molten materials, citing the aforementioned example of molten salt, it is obvious that the principles of my invention are applicable wherever materials with severe temperature properties are encountered and where high performance, and ease of maintenance of the pump output, become more important considerations than absolute maximum efficiency. For example, the open-case pump of the present invention may also be used to good advantage in pumping materials at extremely low temperatures such as liquid oxygen where again the material being pumped imposes severe limitations on the endurance and accesibility of the pump structure. It is obvious of course that my invention will also find applications in the pumping of molten metals such as sodium or lead in various heat transfer cycles or smelting processes.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

I claim:

1. In a centrifugal pump for transferring molten material of extremely high temperature, such as molten salt, comprising a housing; a shaft extending through and mounted in said housing, having a beveled mixed-flow impeller mounted on its lower end; a source of power mounted on the upper portion of said housing, having a drive-shaft extending therefrom; a flexible coupling attached to said drive-shaft; a connecting-shaft attached to the other side of said coupling; a self-aligning thrust-bearing mounted in the upper portion of said housing, said impeller-shaft having a hollow sleeve portion at its upper end adapted to fit within said thrust-bearing and around a lower portion of said connecting-shaft; locking means on said thrust-bearing to adjustably attach said impeller-shaft to said connecting-shaft; an integral diffuser section on the lower portion of said housing and a discharge pipe leading therefrom; an inwardly tapered conical recess in the outer surface of the lower portion of said housing adjacent said diffuser section; inlets to said diffuser section located within said recess; said impeller-shaft being mounted through the center of said recess, on an axis coincident with the axis of said recess, said beveled impeller being attached to said shaft and having a central inlet and a plurality of peripheral outlets; said impeller being positioned on said impeller-shaft so that its outlets are substantially adjacent and aligned with said diffuser inlets.

2. A centrifugal pump for transferring molten material, comprising a case having a diffuser section integral therewith; an inlet to said diffuser section, said inlet being formed in a wall of a frusto-conical recess in said case; a detachable impeller-shaft mounted in said case on an axis substantially through the center of said recess; means to adjust the length of said impeller-shaft to vary the clearance between said impeller and the diffuser inlet including means to completely disconnect said impeller-shaft for removal from said pump case; an impeller mounted on the end of said shaft, having a centrally located inlet and outlets along a beveled periphery; and means to rotate said shaft within said recess so that the impeller outlets pass directly adjacent to a diffuser inlet; and material-outlet means mounted on said case.

References Cited in the file of this patent

UNITED STATES PATENTS

1,370,451	Johnston	Mar. 1, 1921
2,273,420	Schott	Feb. 17, 1942
2,434,018	Stepanoff	Jan. 6, 1948
2,706,622	Steaaf	Apr. 19, 1955
2,854,926	Haight et al.	Oct. 7, 1958
2,865,299	Hornschuch et al.	Dec. 23, 1958
2,874,642	Forrest	Feb. 24, 1959

FOREIGN PATENTS

12,886	Great Britain	of 1885
257,111	Great Britain	Aug. 26, 1926
774,692	Great Britain	May 15, 1957
808,796	Germany	July 19, 1951
904,849	France	Mar. 19, 1945
954,669	Germany	Dec. 20, 1956
1,175,345	France	Nov. 10, 1958