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Allen et al.

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[54] **LIQUID METAL PUMP FOR NUCLEAR REACTORS**

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[73] Assignee: **The United States of America as represented by the United States Energy Research and Development Administration,** Washington, D.C.

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[52] **U.S. Cl.** .... **415/53 R;** 415/108; 415/211; 415/219 C; 415/111

[51] **Int. Cl.**[2] **F04D 1/00;** F04D 7/02

[58] **Field of Search** .... 415/53, 108, 211, 206, 415/219 C, 201, 111

[56] **References Cited**

UNITED STATES PATENTS

705,347	7/1902	Harris	415/211
717,096	12/1902	Harris	415/211
3,130,878	4/1964	Zimmermann	415/108
3,467,015	9/1969	Allen	415/219 C
3,476,488	11/1969	Chambert	415/219 C
3,859,008	1/1975	Wieser	415/219 C

FOREIGN PATENTS OR APPLICATIONS

124,621	9/1931	Austria	415/201
378,906	8/1923	Germany	415/201

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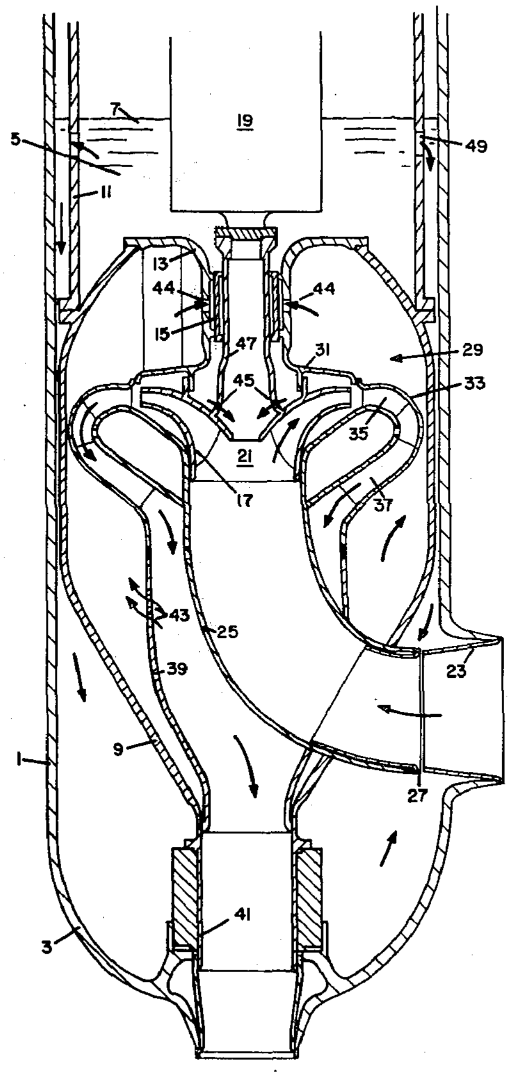
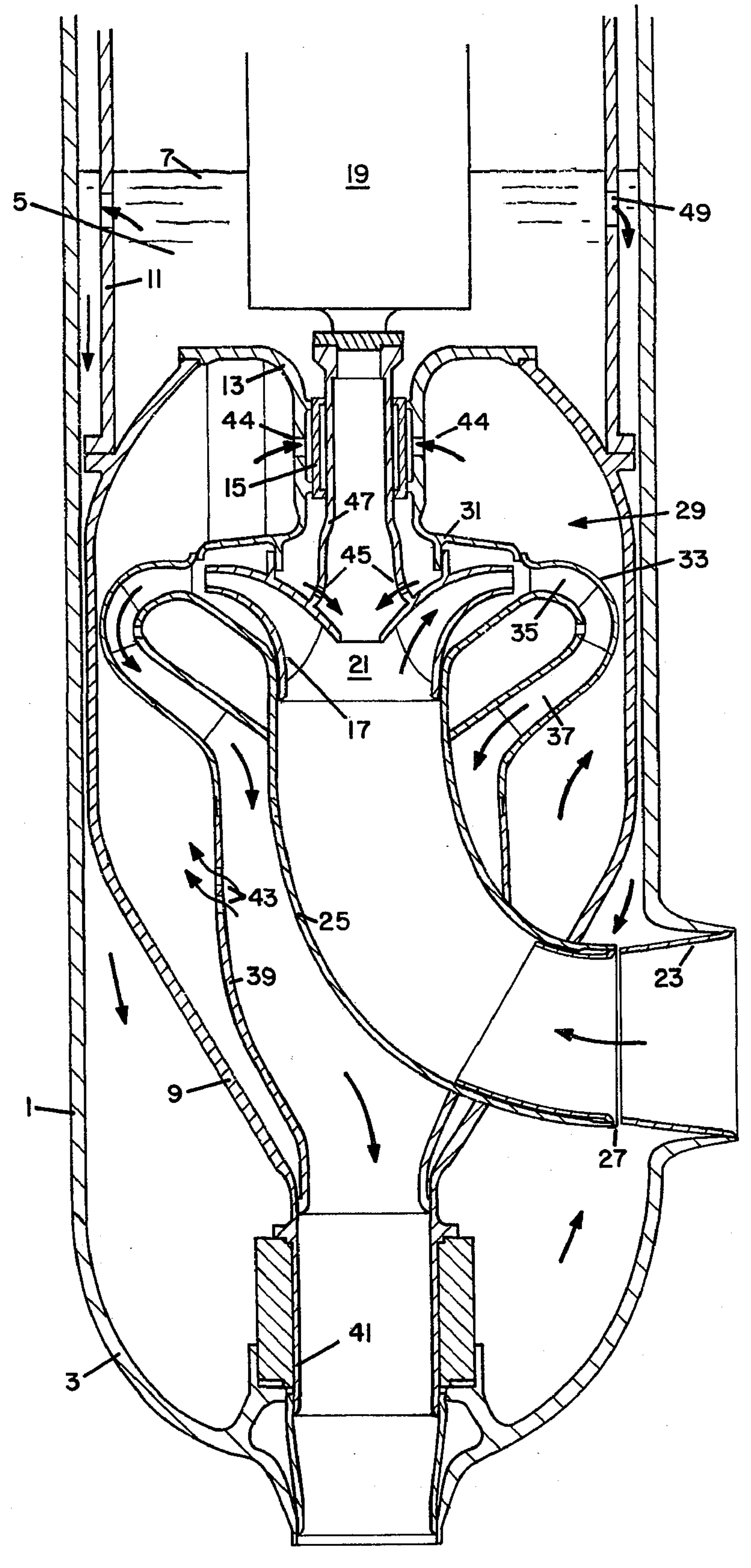
[57] **ABSTRACT**

A pump for use in pumping high temperature liquids at high pressures, particularly liquid metals used to cool nuclear reactors. It is of the type in which the rotor is submerged in a sump but is fed by an inlet duct which bypasses the sump. A chamber, kept full of fluid, surrounds the pump casing into which fluid is bled from the pump discharge and from which fluid is fed to the rotor bearings and thence to the sump. This equalizes pressures inside and outside the pump casing and reduces or eliminates the thermal shock to the bearings and sump tank.

3 Claims, 1 Drawing Figure

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LIQUID METAL PUMP FOR NUCLEAR REACTORS

BACKGROUND OF THE INVENTION

This invention was made in the course of, or under a contract with the United States Atomic Energy Commission.

The invention relates generally to pumps for high temperature, high pressure liquids, particularly liquid metals.

Certain types of nuclear reactors are cooled by liquid metal, e.g., sodium. The coolant is normally supplied by a centrifugal pump. One type involves a rotor mounted within a sump, but fed by a system that bypasses the sump so as to reduce head losses due to energy losses, induced vortices and turbulence which can easily occur within the sump fluid. Such a pump is shown in U.S. Pat. No. 3,467,035, granted Sept. 16, 1969 to Harvey G. Allen.

In an operating reactor system, such pumps are subject to high mechanical stresses and thermal shock. They should be suitable for handling liquid metal at temperatures up to 1200°F and for thermal shocks up to 250°F/20 seconds.

Thermal shocks of this magnitude present several problems. They may limit the thickness of the metal to a value that is not acceptable under pressurization and other mechanical loading. This is particularly the case when thermal shock is applied to one surface only. It poses a serious threat to pump enclosure safety and problems with component functional reliability.

A hydrostatic radial bearing is an integral part of the pump. Bearing exposure to thermal shock will cause relative thermal growth between the close running clearances. Therefore, thermal shock protection of the bearing becomes a major problem.

It is therefore an object of this invention to provide a structure which will minimize mechanical stress in parts which are necessarily subject to thermal shocks, eliminate thermal shock in parts necessarily subject to stress and eliminate thermal shock to the bearing.

SUMMARY OF THE INVENTION

This invention is directed to a pump of the type described above and illustrated by U.S. Pat. No. 3,467,015. Novel features enable it to remain structurally sound under very high temperature levels (1200°F) and severe thermal transients (250°F/20 seconds). This is accomplished by providing a chamber surrounding the pump casing and proving for bypass flow of limited quantities of liquid so as to provide a system in which pressure differences are minimized across walls which are subject to thermal shock on one surface. By this arrangement thermal shock is minimized on other walls, which are subject to high pressure differentials, and thermal shock to the bearing is minimized.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing shows diagrammatically a vertical section through a pump embodying the invention.

DETAILED DESCRIPTION

The pump is located in a tank 1 having a bottom portion 3 which is closed except for the inlet and outlet connectors and which forms a sump which during operation contains a body of liquid 5 having an upper surface 7. All parts of the pump except the drive shaft are

located below the level of surface 7. Within the tank is a chamber 9 above which is a support cylinder 11.

The upper portion of chamber 9 is formed by a radial bearing housing 13 within which is a sodium lubricated bearing 15.

The pump impeller 17 is journaled in bearing 15 and is driven by hollow drive shaft 19, which is driven from overhead, as shown in U.S. Pat. No. 3,467,015. The impeller 17 is of the overhung type, i.e., it is free from shaft obstruction in the impeller eye 21.

Fluid enters through frustoconical reducer 23 which is mounted in the wall of tank 1. It then is conducted by feed conduit 25 to eye 21 of impeller 17. Conduit 25 is slightly spaced from reducer 23 to leave a gap 27. The internal diameter of conduit 25 is slightly reduced adjacent its inlet end, so there is a slight venturi effect at gap 27.

Impeller 17 operates in a pump casing 29, the upper portion 31 of which is integral with bearing housing 13. The outer portion 33 of the pump casing includes diffuser passages 35 and straightening vanes 37 which remove the tangential component of the fluid flow and increase the fluid static pressure. The liquid then flows out through discharge adapter 39 and discharge conduit 41, which forms a continuation of chamber 9.

The arrangements for minimizing thermal shock and mechanical stress will now be described. Openings 43 bleed a small proportion of the pump outlet flow into chamber 9, which is filled with liquid, thus equalizing the pressure inside and outside pump casing 29 and discharge adapter 39. Openings 44 deliver this liquid to the sodium lubricated bearings 15. Here the flow divides. A part flows downwardly through openings 45 in hollow shaft 47 and into impeller 17. The remainder flows upwardly into the main body of fluid 5. It overflows through openings 49 in cylinder 11. This bearing discharge and internal leakage enters gap 27, mixes with the feed, and re-enters the impeller.

The relationship of the invention to the thermal shock and mechanical stress will now be described.

The thermal shock arises from sudden changes in temperature of the fluid entering inlet nozzle 23, due to reactor startup and changes in operating conditions. The high temperatures (up to 1200°F) make it necessary to maintain the mechanical stresses comparatively low. This imposes conflicting requirements, since thin sections are desirable to resist thermal shock and thick sections are desirable to resist mechanical stress. The fluid holes 43 tend to equalize the pressures inside and outside the pump casing 29. The latter, which is subject to high thermal shock, may therefore be made comparatively thin. The dilution resulting from the comparatively small flow (say 1% of the pump discharge) into the large volume of fluid in chamber 9 and tank 1 greatly reduces or completely eliminates thermal shock to these parts, which may be made of thick material.

As mentioned above, it is highly desirable to minimize thermal shock to the sodium-lubricated bearing 15. The molten sodium is supplied through holes 44 from the interior of chamber 9. As has been mentioned earlier, the relatively small flow through openings 43 is diluted by the large volume of fluid in chamber 9, smoothing out changes in temperatures and preventing thermal shock to the bearings.

The parts which are subject to full thermal shock on one side only, e.g., the pump casing 29, are made three-eighths inch or less in thickness. This is practical be-cause the bleeding of fluid equalizes pressure on both sides. The tank **1** and the chamber **9**, on the other hand are protected from thermal shock. This permits them to be made as thick as desired to contain the full discharge pressure of the pump, typically about 250 lb./sq/in., and other forces. The tank **1**, in particular, is a major structural part of the pump system and is typically 2 inches or more in thickness. Other parts are of intermediate thickness.

It will be apparent from the above description that this invention equalizes the pressures on opposite sides of walls subject to thermal shock, permitting them to be made relatively thin, substantially eliminates thermal shock to thick walls, and substantially eliminates thermal shock to the bearings.

We claim:

1. A pump for use in pumping high temperature liquid under high pressures comprising a tank closed at its bottom to form a sump, a substantially closed chamber within said tank and spaced therefrom, a substantially closed casing within said chamber and spaced from it over most of its area, but merging with the upper portion of said chamber to form a bearing housing and merging with the lower portion of said chamber to form an outlet duct, a centrifugal pump rotor suspended within and discharging into said casing and having a bearing within said bearing housing, an inlet duct passing through the walls of said tank, said chamber, and said casing and communicating with said pump rotor, passageways through the wall of said casing and through said bearing housing, said bearing communicating with said sump, whereby a portion of the liquid discharged from said pump will flow into the space between said casing and said chamber, then into said bearing, and finally into said sump, thereby equalizing pressures inside and outside said casing and reducing thermal shock to said chamber, bearing and tank on changes in temperatures in said inlet duct.

2. A pump as defined in claim **1** and further comprising an opening providing restricted communication between said inlet duct and the interior of said tank outside said chamber.

3. A pump as defined in claim **2** wherein said inlet duct comprises a frustoconical reducer passing through the wall of said tank and a feed conduit slightly spaced from the smaller end of said reducer and leading to said pump rotor.

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