United States Patent [19]

Lee

[11] **3,837,762**

[45] **Sept. 24, 1974**

[54] **PUMPS**

[75] Inventor: **Alan Stuart Lee,** Leicester, England

[73] Assignee: **The English Electric Company Limited,** London, England

[22] Filed: **May 30, 1973**

[21] Appl. No.: **365,163**

[30] **Foreign Application Priority Data**

May 31, 1972 Great Britain 25426/72

[52] **U.S. Cl.** **415/207,** 415/209, 415/216

[51] **Int. Cl.** .. **F04d 29/44,** F04d 29/54, F04d 15/02

[58] **Field of Search** 415/207, 210, 216, 501, 415/209, 217; 137/590; 417/424, 240, 241; 60/249, 263; 138/39, 44

[56] **References Cited**

UNITED STATES PATENTS

2,210,401	8/1940	Fulton	415/501
2,609,141	9/1952	Ave	415/210
2,694,296	11/1954	Prosek et al.	138/44
3,333,762	8/1967	Urana	915/211

FOREIGN PATENTS OR APPLICATIONS

1,373,013	8/1964	France	415/219

OTHER PUBLICATIONS

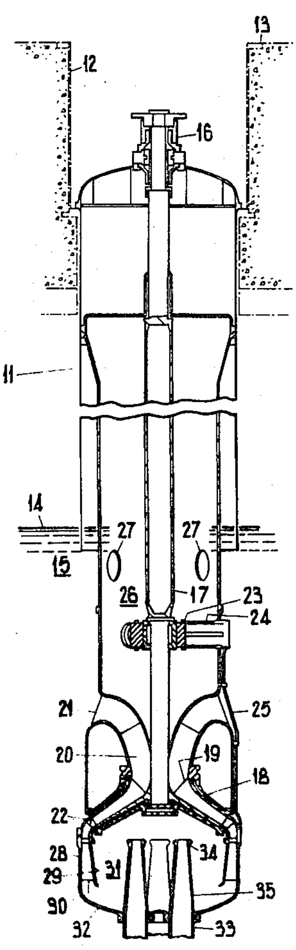
Byron Jackson Bulletin 37–5050, 1938

Primary Examiner—C. J. Husar
Assistant Examiner—Louis J. Casaregola
Attorney, Agent, or Firm—Kirschstein, Kirschstein, Ottinger & Frank

[57] **ABSTRACT**

A pump assembly having a chamber into which a pump is arranged to discharge, and a plurality of outlet pipes each having one end extending into the chamber, the wall of each outlet pipe at said one end being of streamline form, and the part of each pipe extending away from said one end being in the form of a diffuser of gradually increasing internal cross-sectional area with increasing distance from the said one end.

5 Claims, 2 Drawing Figures



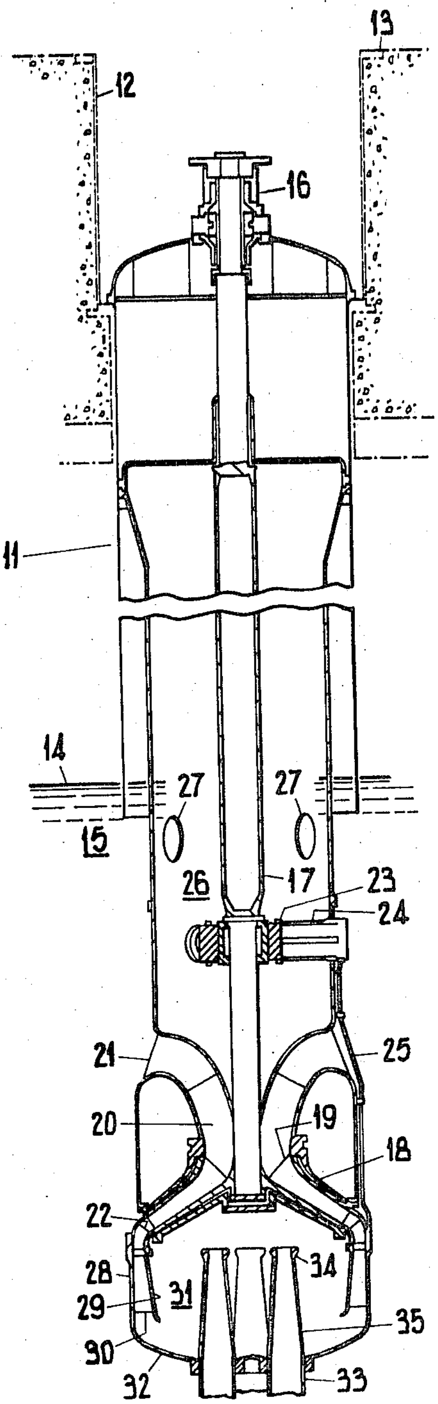

13
12
16
11
14
27
27
15
26
17
23
24
21
25
20
19
18
22
28
34
29
31
35
30
32
33

Fig.1

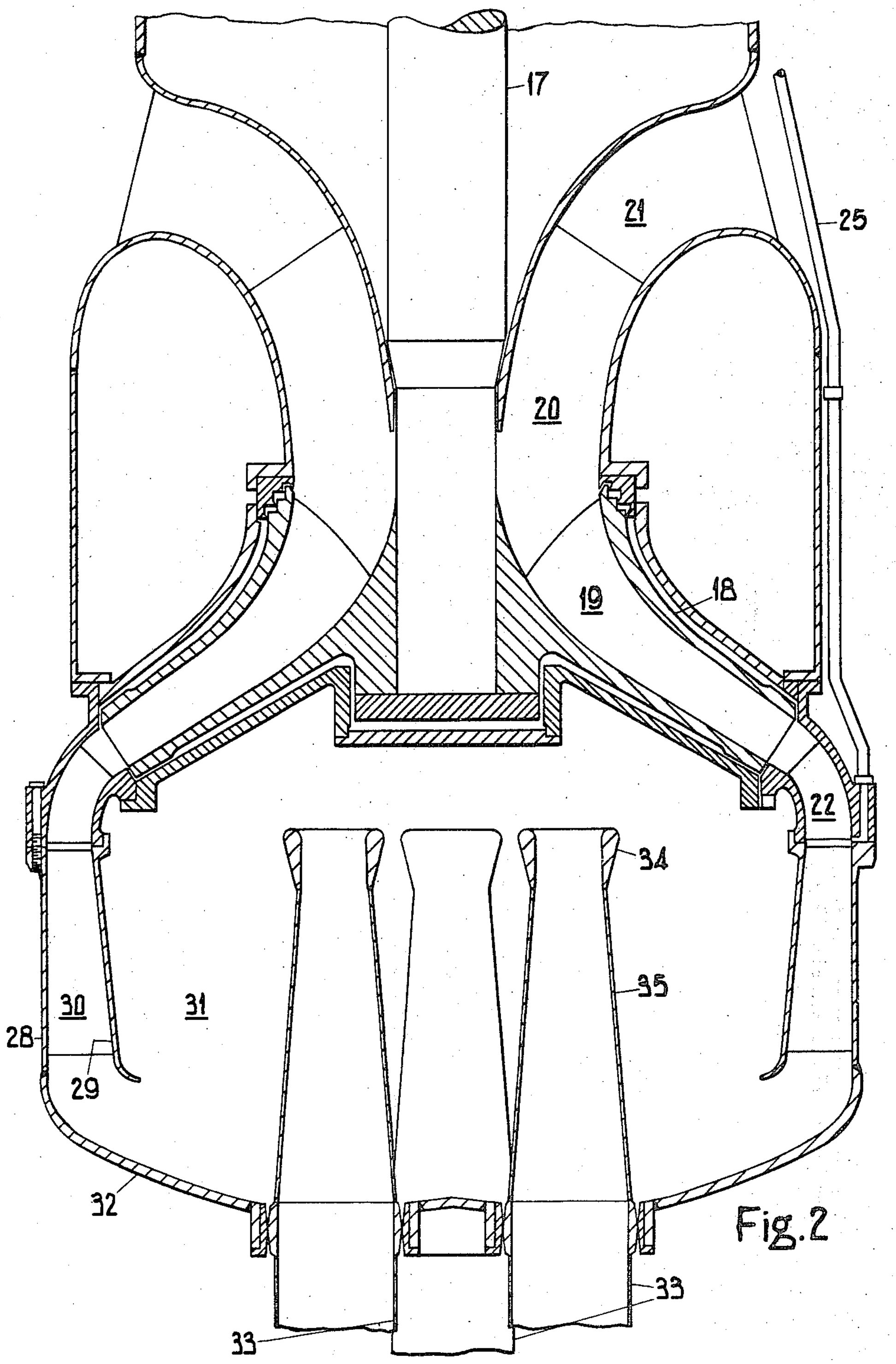


Fig. 2

PUMPS

This invention relates to pumps.

It is an object of the invention to provide a pump having an outlet arrangement which presents a smaller impedance to normal forward fluid flow from the pump than to flow in the reverse direction.

According to the present invention a pump assembly comprises a pump, a chamber into which the pump is arranged to discharge, and at least one outlet pipe in communication at one of its ends with the interior of the chamber, the wall of the/or each outlet pipe at the said one of its ends being of streamline form and a part of the/or each pipe extending away from the said one end thereof being in the form of a diffuser of gradually increasing internal cross-sectional area with increasing distance from the said one end of the pipe.

In a preferred embodiment of the invention, the pump comprises a rotary centrifugal impeller and an annular axial diffuser having a first end arranged to receive pumped fluid from the impeller and a second end, of greater annular cross-sectional area than the first end, opening into the said chamber.

Conveniently the diffuser, whose second end opens into the chamber, itself constitutes a peripheral wall section of the chamber, into which its said second end opens peripherally, and the or each outlet pipe extends into the chamber, in the axial direction of the diffuser, with its said one end directed oppositely to and away from the said second end of the diffuser, whereby fluid flowing from the pump flows in one axial direction in the diffuser and in the or each outlet pipe but in the opposite direction whilst flowing, within the chamber, from the diffuser to the outlet pipe or pipes.

An embodiment of a pump assembly having an outlet arrangement according to the invention is described below, by way of illustrating the invention, with reference to the accompanying drawings, in which:

FIG. 1 is a view, partly in axial section, of the pump assembly, and

FIG. 2 is an axial sectional view, on a larger scale; of part of the pump assembly shown in FIG. 1.

The pump assembly shown in the drawings and indicated generally by the reference **11** is intended for use in circulating molten sodium as the reactor primary coolant in, for example, a civil fast reactor, and as shown in FIG. 1 is mounted vertically with its upper end secured in sealing engagement in an aperture **12** in a reactor containment vessel **13**, with its lower end immersed below the surface level **14** of a reservoir of molten sodium **15** contained within the vessel **13**. At its upper end the pump assembly **11** comprises an electric motor **16** for rotating a shaft **17** on the lower end of which is secured an impeller **18** provided with vanes **19**. Rotation of the shaft **17** and impeller **18** impels molten sodium, in an annular duct **20** defined by fixed parts of the pump assembly and provided with fixed vanes **21** and **22**, centrifugally outwards past the vanes **22**. The duct **20** is below the surface level **14** of the sodium **15**, and is thus kept filled with sodium which enters it past the vanes **21**. The shaft **17** is supported near its lower end by a bearing **23** mounted by means of struts **24**. The bearing **23** may, as shown, be a hydrostatic bearing and in that case it may, as shown, be supplied with molten sodium under pressure via a pipe **25** which bleeds off a small proportion of the sodium in the duct **20** in the vicinity of the vanes **22** and supplies it

via one of the struts **24** to the bearing **23**. This sodium then flows from the bearing into the space **26** surrounding the bearing and the shaft **17**, this space being in any case filled with sodium up to the surface level **14** because it is open to the sodium **15** through apertures **27**. The sodium impelled past the vanes **22** (apart from any bled to the bearing **23** as just described) then passes through an annular axial diffuser having coaxial outer end inner walls **28** and **29** and fixed vanes **30**, the sodium entering this diffuser at a first, upper end thereof and being discharged therefrom at a second, lower, end thereof which is of greater annular cross-sectional area.

The pump assembly as described in the preceding paragraph is of known kind, but in accordance with the present invention it is provided, as described below, with a chamber into which it discharges and with one or (as shown in the drawings) more outlet pipes in communication with the interior of the chamber.

The said chamber, indicated by the reference **31**, is defined in part by the diffuser, which itself constitutes a peripheral wall section thereof, and is closed at its upper end by fixed parts of the pump assembly in the vicinity of the impeller **18** thereof. At its lower end the chamber **31** is closed by a dished or bowl-shaped plate **32** which is secured in sealed manner, for example by welding, to the lower end of the outer wall **28** of the diffuser. The plate **32** is apertured to receive, in sealed engagement therewith, four outlet pipes **33** which extend in the axial direction and project upwardly into the chamber **31** with an end **34** of each pipe in communication with the interior of the chamber. The wall of each outlet pipe, at its end **34**, is of streamline form so that as sodium flows into the pipes **33** from the chamber **31** there is little or no separation of the fluid flow from the pipe walls. A part **35** of each pipe **33**, extending away from the end **34** thereof, is in the form of a diffuser, being of gradually increasing internal cross-sectional area with increasing distance from the end **34**, whereby little or no turbulence is introduced into the sodium as it flows from the end **34** of a pipe **33** to the greater-diameter part thereof below the part **33**.

As already described, the illustrated pump assembly is shown mounted in a nuclear reactor; and the outlet pipes **33** would convey the pumped liquid sodium from the pump assembly to a core of the reactor, where it would be distributed to nuclear fuel elements within the core. Four pipes **33** are associated with the pump assembly as a safety factor, so that in the event of a failure of one of the pipes a reduced but still sufficient, proportion of the output of the pump assembly will continue to reach the fuel elements. It will be understood that in other applications in which such safety considerations do not apply a pump assembly in accordance with the invention might be provided with less outlet pipes and perhaps with only one.

A further consideration when (as would be the case in a nuclear reactor) a plurality of pumps are operating in parallel in a fluid-flow system is that it will usually be desirable or essential that even a complete failure of one of the pumps should not result in the system as a whole being subjected to a leakage so serious as to prevent the remaining pumps from maintaining a reduced but still satisfactory supply to the intended destination of the pumped fluid; and the pump outlet means according to the invention enables this desirable object to be achieved, as will not be explained. In normal operation of the illustrated pump assembly, the sodium impelled by the impeller **18** enters the diffuser at relatively high speed and, as it passes from the upper end of the diffuser to the lower end thereof which is of greater annular cross-sectional area, its speed is reduced and part of its kinetic energy is converted, almost without loss, into pressure energy. Sodium in the chamber **31**, under the relatively high pressure which thus obtains there, flows into the ends **34** of the outlet pipes **33** and, because of the relatively small total internal cross-sectional area of the pipes **33** at their ends **34**, as compared with that of the chamber **31** in which the sodium flows to those ends, the flow rate of the sodium in the ends **34** of the pipes is relatively high. The streamline form of the pipe walls at their ends **34** ensures, however, that the flow is substantially non-turbulent and that the conversion of pressure energy to kinetic energy is effected with little loss of energy. The provision of the pipe sections **35** in the form of diffusers then provides a smooth transition, again with negligible energy loss, from the ends **34** to the main runs of the pipes **33** which are of wider bore and in which, accordingly the kinetic energy of the flowing sodium is less again. In the event of failure of one of several pumps **11** acting in parallel, however (or, equally, in the event that the chamber **31** associated with one of several such pumps becomes fractured so that the output from the pump is lost by leakage), the flow of sodium in the pipes **33** associated with that pump and that chamber **31** will be reversed due to the pressure from the outputs of the other pumps; and it is important for safety reasons that this reverse flow should be minimised so as not to constitute a serious leakage of the outputs from the other pumps. Satisfactory minimisation of such reverse flow is, in fact, achieved by the arrangement described above, because the diffuser sections **35** and ends **34** of the pipes **33**, opening into the chamber **31**, present a much greater impedance to flow in the reverse direction than to flow in the forward direction. This is because, for flow in the reverse direction, the ends **34** of the pipes **33** open abruptly into the much greater cross-sectional area of the chamber **31** and the reverse flow becomes turbulent with large dissipation of energy. Thus high flow rates in the reverse direction are prevented, and the possible diversion, due to leakage, of the outputs from the other pumps, is limited. The described configuration acts, in fact, as a fluid diode.

The provision of the chamber **31** between the pump and the pipes **33** also confers another benefit, of a different kind. It is well known that acoustic waves are transmitted with little attenuation along a fluid in a pipe of constant or only slightly varying cross section, and this could lead, in a reactor coolant system, to noise (including high frequency noise) generated in a pump of the system producting, in other parts of the reactor, vibrations which could be dangerous or could interfere with instrumentation of the reactor. For example, one method of detecting failed fuel elements in a reactor is by means of hydrophones, in the fuel channels, which detect the noise from boiling of the sodium coolant in the vicinity of a ruptured fuel element container. Such boiling is known to produce noise most effectively at high frequencies of the order of 100 KHz, and noise of similar frequencies may also be produced by cavitation of a pump. It is therefore important that such high frequency noise, generated in the pump unit **11**, should be attenuated before it reaches the fuel channels to which it would otherwise be transmitted by the pipes **33**. In the illustrated configuration the chamber **31**, with its greater cross-section than that of the diffuser constituted by the walls **28** and **29**, and then that of the pipe ends **34**, and the fact that the pipe ends **34** are directed away from the end of the diffuser opening into the chamber **31**, mean that accoustic waves in the sodium can only be transmitted to the pipes **33** after multiple reflection at which attenuation occurs. Also the restricted cross-sections of the pipe ends **33** severely limit the entry of sodium-transmitted acoustic waves into the sodium in the pipes **33**. Thus an attenuation of sodium-transmitted noise, including high frequency noise, takes place between the pump and the pipes **33**.

I claim:

1. A pump assembly comprising:

a. a pump;

b. a chamber into which the pump is arranged to discharge;

c. at least one outlet pipe in communication at one of its ends with the interior of the chamber;

d. a wall defining each outlet pipe at said one of its ends being of streamline form;

e. a part of each outlet pipe extending away from the said one end thereof being in the form of a diffuser of gradually increasing internal cross-sectional area with increasing distance from the said one end of the outlet pipe;

f. the total internal cross-sectional area of the said one end of the outlet pipes being small compared with the internal cross-sectional area of the chamber; and

g. the said one end of each outlet pipe opening abruptly into the much greater cross-sectional area of the chamber so that the arrangement of outlet pipes and chamber acts as a fluid diode.

2. A pump assembly as claimed in claim **1**, wherein the pump comprises a rotary centrifugal impeller, and there is provided a further annular axial diffuser having a first end arranged to receive pumped fluid from the impeller and a second end, of greater annular cross-sectional area than the first end, opening into the said chamber.

3. A pump assembly as claimed in claim **2** wherein the second end of said annular axial diffuser constitutes a peripheral wall section of said chamber into which its second end opens peripherally, and each outlet pipe extends into the chamber in the axial direction of the said annular axial diffuser with its said one end directed oppositely to and away from the second end of the annular axial diffuser, whereby fluid flowing from the impeller flows in one axial direction through the annular axial diffuser and through each diffuser formed by a part of an outlet pipe, but flows in the opposite axial direction while flowing, within said chamber, from said annular axial diffuser to each diffuser formed by a part of an outlet pipe.

4. A pump assembly as claimed in claim **3** wherein the pump is located above the chamber and each outlet pipe extends downwards from the chamber with the said one end extending upwards into the chamber.

5. A pump assembly as claimed in claim **4** having four outlet pipes in communication with the interior of the chamber.

* * * * *