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PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Pump, especially for Refrigerating Machines.

We, Prof. Dr. ALBERT EINSTEIN, of 5, Haberlandstrasse, Berlin, Germany, of Swiss Nationality, and Dr. LEO SZILARD, of 35, Prinz Regentenstrasse, Berlin-Wilmersdorf, Germany, of Hungarian Nationality, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to a pump operating with a liquid medium and by means of which liquids, gases or vapours can be circulated or compressed, preferably in hermetically closed apparatus, especially refrigerating machines. The pumping with the aid of the operative liquid can be performed in any known manner, for example, in a jet pump.

According to the invention, such a pump is rendered highly efficient by employing as operative liquid an alkali metal in a liquid condition—for example, potassium—or a liquid alloy of an alkali metal. The transmission of energy to the operative liquid can be effected by electromagnetic means, without any solid moving machine parts, but nevertheless with a very good efficiency cycle, by allowing a magnetic field to act on the liquid metal while it is traversed by electric current. The high working efficiency is due, on the one hand, to the high electrical conductivity, and on the other hand, to the low density. A force is exerted on the liquid metal in a comparatively narrow space, where the flow is turbulent and when, in consequence, a considerable loss would occur, through friction, if mercury, for example, were employed as the operative medium.

In this sense the metals of small density are distinguished in comparison with mercury. If pumping be performed with such metals in a jet pump or similar apparatus, a far higher working efficiency—both in the absolute and with reference to the dimensions of the apparatus—is obtained than in the case of mercury, because, under the same conditions of pressure, far higher velocities are attained in the case of metals the density of which is small.

Another important point is the low vapour pressure of the alkali metals, which ensures that the operative medium will not distil over into the parts of the apparatus where it might give rise to trouble.

The alkali metals, when pure, are not liquid at room temperature, so that, when they are used in a pure state, the apparatus must be kept at a higher temperature, a condition which also restricts the condensation of vapours of the metals in the pump itself in a desirable manner. Moreover, according to the invention use may also be made of alloys of alkali metals with one another, for example, a sodium-potassium alloy.

According to the invention, use may also be made in particular of a potassium-sodium alloy which, when compounded with the two components in suitable proportions, remains liquid down to −12° C. This alloy does not solidify, even at the temperature obtaining in the evaporator of the refrigerating machine.

By subjecting the liquid metal to a magnetic field which induces electric currents in the metal itself, energy can be transmitted in a very complete manner, to the liquid metal contained in a hermetically closed apparatus (such as a refrigerating machine), by means of coils disposed outside the apparatus; and, by this means, the liquid metal can be pumped without the use of any moving machine parts.

When direct current is employed, it must, of course, be introduced into the liquid metal by means of electrodes.

In order to avoid having to employ too many ampere windings, the arrangement must be so devised that the major portion of the lines of magnetic force passes through iron, and only permeates the liquid metal over a very narrow space; that is, the liquid metal will be subjected to the ponderomotive force only in a gap of very narrow width. Since the one dimension of the space is small by comparison with its other dimensions, in the part where the ponderomotive action on the liquid metal takes place, one may simplify the matter by saying that the metal travels over a superficies, and con-

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sider the vectorial field of the ponderomotive force on that superficies (two-dimensional system).

According to the invention, the arrangement may be so devised that this vectorial field of the ponderomotive force is free from eddies; that is to say that, for each closed line lying within the superficies (within the fluid metal in the gap), the linear integral of the ponderomotive force is=0. When a plane superficies is in question, the mathematical expression therefor is:

$$\frac{\delta Y(xy)}{\delta x}-\frac{\delta X(xy)}{\delta y}=0$$

in which x and y are the Cartesian coordinates and XY the vector components within the plane.

If this vectorial field of the ponderomotive force were not free from eddies, currents would be set up in the liquid which would consume much energy and would reduce the efficiency of the arrangement to a very low figure. Whereas, in the movement of a solid body, such as the movement of the armature of an electromotor, all that need be considered is the resultant of the force acting on the armature, the construction of the field of force is by no means immaterial in the case of the movement of a liquid by electromagnetic forces.

Now, such eddyless fields of force can be obtained in the liquid metal by allowing the current to enter the liquid metal through solid bodies (electrodes).

If alternating current be available, the employment of electrodes can be dispensed with, an eddyless vectorial field being nevertheless obtained, the electric current not being introduced into the liquid through electrodes, but induced in the liquid in such a way that the stream line of the electric current lies entirely within the liquid and closes therein.

This method avoids difficulties connected with the transitional resistance between the electrodes and the liquid metal, and an eddyless field of force is set up in the liquid metal by proceeding in the following manner:

The gap in which the ponderomotive force acts upon the liquid is formed by two substantially similar continuous surfaces concentrically disposed, such as the peripheral surfaces of concentric cylinders or cones. In the annular space thus formed the magnetic field is caused to induce currents which circulate around the cylinder or cone and the ponderomotive force then acts at right angles to the direction of the electric current, in the direction of the generating lines of the cylinder or cone.

In the accompanying drawings:—

Figure 1 represents a diagrammatic embodiment of the invention, by way of example.

Figure 2 represents, diagrammatically, a refrigerating machine according to the invention.

Figures 3*a* and 3*b* show an arrangement for moving the liquid alkali metal by electromagnetic means, in which the eddyless character of the ponderomotive field of force in the gap is attained by introducing the electric current into the fluid metal through solid electrodes. The arrangement would also be applicable for direct current.

In Figure 1 the cylindrical iron tube 1 contains an iron core 2, and the cylindrical annular space between the iron core and the tube 1 is traversed by a flow of light metal, under the action of the magnetic fields produced by the coils 4—7 in the direction of the generating lines of the cylinder, and proceeding from above downwards if suitable disposition of the poles is provided. The coils 4—7 surround the tube 1. The potential lying on adjacent coils are relatively displaced by about 90°. 8 and 9 are iron plates belonging to the bundles shown in the section A—B. The magnetic field permeating the liquid metal in the cylindrical gap travels from above downwards or from down upwards, the rate of displacement of the field being found by multiplying the periodicity by the spacing of the coils. An electric current flowing round the iron core 2 is induced in the liquid metal, a representative stream line being marked on the figure. The force acting on the liquid light metal is parallel to the axis of the cylinder throughout, and the field of force is practically eddyless.

The 90° phase displacement between the currents of the adjacently disposed coils is produced in the same known manner as suggested for the establishment of the artificial phase for asynchronous motors.

The liquid alkali metals, such as the aforesaid potassium-sodium alloy, corrode some metals, but can be used, without giving rise to any troubles, in iron vessels from which air is excluded. Besides hydrocarbons such as propane, butane, pentane, etc., other refrigerating agents such as ethyl ether and other ethers, for example, methyl ethyl ether may be employed.

In Figure 2, which shows a refrigerating machine, 10 is a device in accordance with the invention, in which a sodium-potassium alloy is set in motion by electrodynamic means. The sodium-potassium alloy is forced into the tube 11 and conducted to the jet pump 12, where the vapour of a refrigerating medium (for example, a hydrocarbon of any kind) is aspirated through the pipe 13 and compressed in a vertical upcast pipe and forced into the gas-separating chamber 15. From this latter, the sodium-potassium alloy flows through the down pipe 16, back into the device 10, whilst the vapour of the refrigerator medium flows through the pipe 19 into the air-cooled condenser 17 and is there liquefied, flowing thence, through a throttle 20, into the evaporator 18.

Figure 3*a* shows, in section, electrodes 34 and 35, with an intermediate gap 36, measuring 1×20 mm. in cross-sectional area and about 6 cm. in length. At both the open ends the gap opens into the pipes 37 and 38 and is bounded, on the narrow side, by the said electrodes, and on the wider side by the insulating plates 39 and 40 shown in the section A—B in Figure 3*b*. By means of the electromagnet shown in Figure 3*b*, a magnetic field is maintained in the gap, which is filled with liquid alkali metal, and an electric current is passed through the alkali metal by means of the electrodes. A force is then exerted on the liquid alkali metal, at right angles to the magnetic lines of force and also at right angles to the flow of the electric current and, given suitable disposition of the poles, forces the liquid out of the pipe 37 into the pipe 38. When alternating current is employed, care must be taken to see that the magnetic field and the electric current are in phase in the alkali metal. In the present instance, this is attained by connecting the coil 24 of the electro-magnet in series with the primary winding of the transformer 25, whilst the secondary circuit of the transformer is connected to the electrodes. The coil 24 may, of course, be connected directly to the electrodes, without the interposition of a transformer.

There is no need for the transmission of energy to be effected direct from the liquid alkali metal to the substance which is to be pumped. On the contrary, the liquid alkali metal may describe a reciprocating movement and thus move to and fro in front of it a heavy liquid hydrocarbon forming a liquid piston in a cylinder. The hydrocarbon piston can effect the compression of any kind of vapour in the same way as a piston pump. If operating in this way the direction of flow of the liquid metal must be periodically reversed.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A pump, especially for refrigerating machines, for circulating liquids or compressing vapours in a closed system, in which energy is transmitted by the aid of an operative medium to the substance which is to be pumped, characterised in that the operative medium is an alkali metal, for example, potassium or an alloy comprising at least one alkali metal.

2. A pump according to claim 1, characterised in that the operative medium is a potassium-sodium alloy.

3. A pump according to claim 1 or 2, characterised in that a magnetic field acts on the metal traversed by an electric current, thereby imparting to the liquid metal the movement necessary for pumping.

4. A pump according to claim 3, characterised in that the vectorial field of the ponderomotive force in the liquid metal is eddyless.

5. A pump according to claim 3 or 4, characterised in that the electric current enters the liquid metal through solid conductors (electrodes).

6. A pump for alternating current working, according to claim 3 or 4, characterised in that the liquid metal is moved in an annular gap formed between concentric surfaces, such as, for example, the peripheral surfaces of two cylinders, by the action of a travelling field produced by two or more phase actions in such manner that the ponderomotive forces act on the liquid metal to cause it to move from one end of the annular gap to the other end.

7. A pump according to claim 3, 4, 5 or 6, characterised in that a rotary field, or a similarly moved magnetic field, acts on the liquid metal.

8. A pump according to claims 3, 4, 5 or 6, characterised in that the direction of flow of the metal is periodically reversed.

Dated this 2nd day of December, 1929.
EDWARD EVANS & Co.,
27, Chancery Lane, London, W.C. 2,
Agents for the Applicants.

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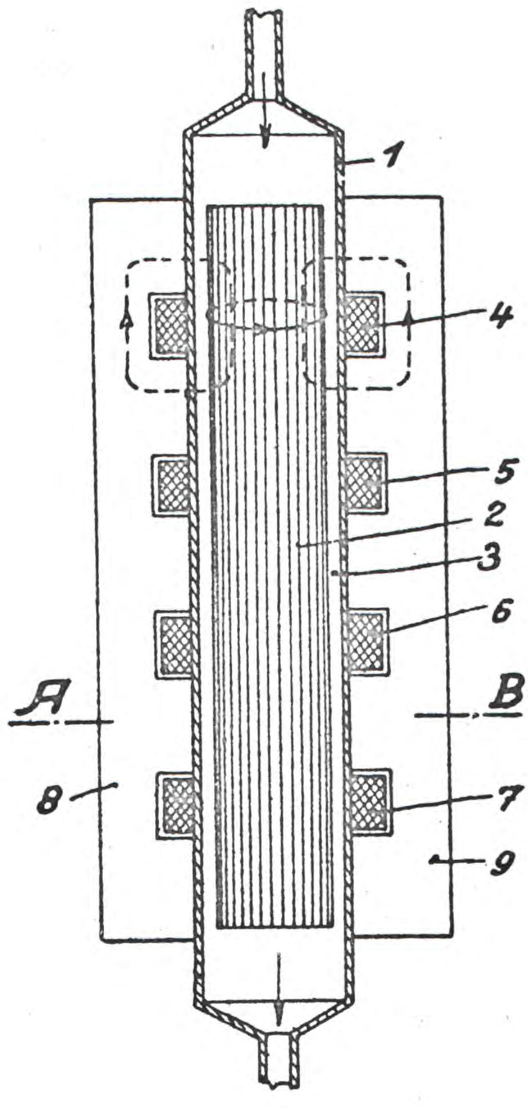
Fig.1.



A-B

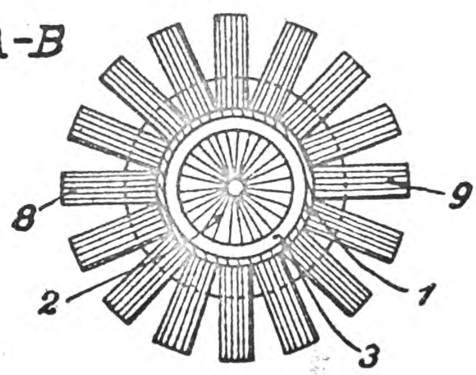


Fig. 2.

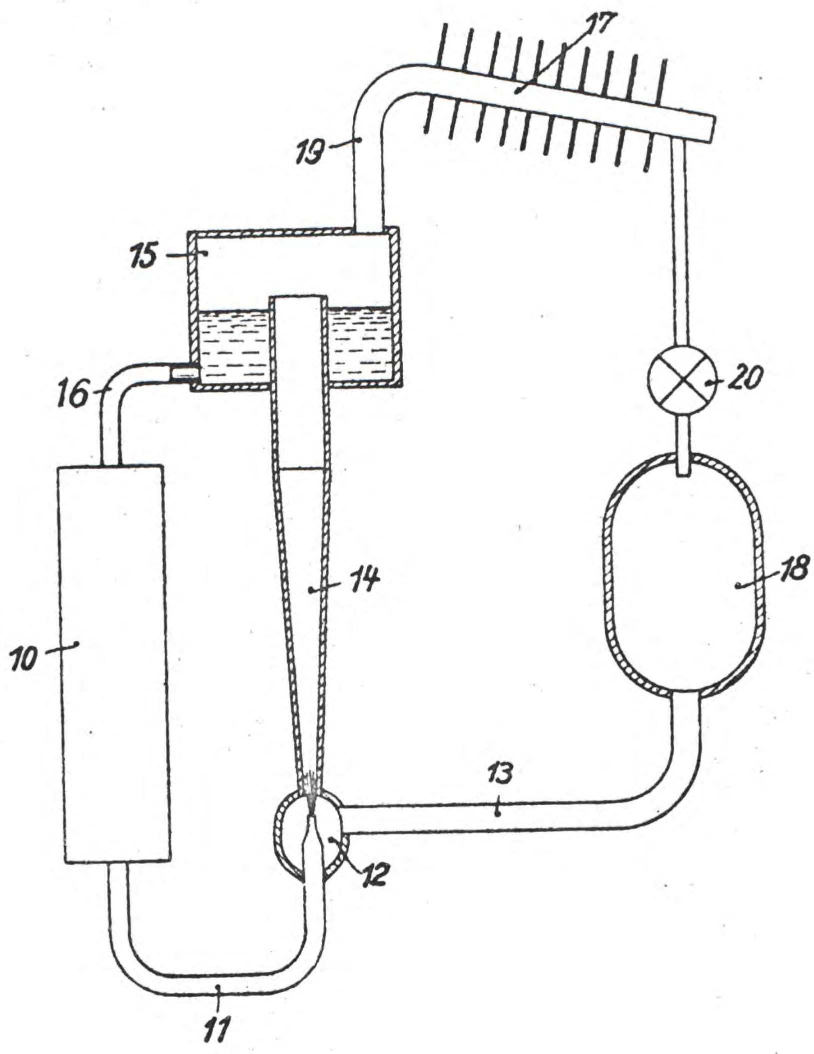


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Fig. 3b.

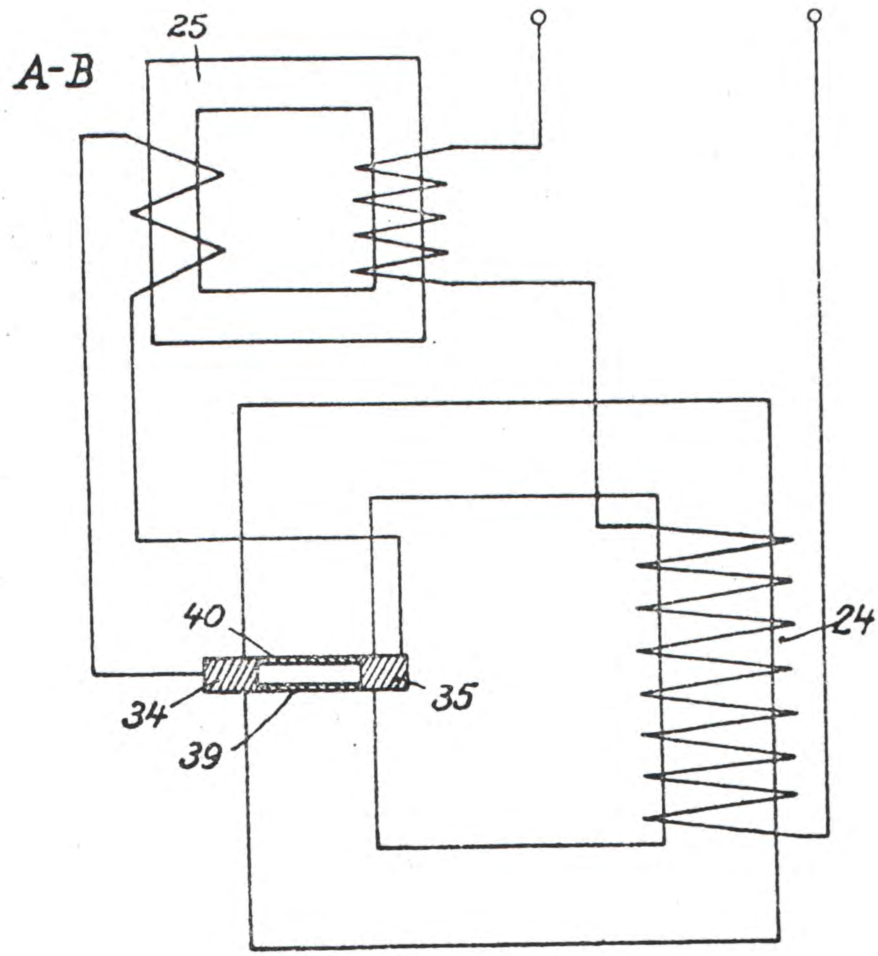
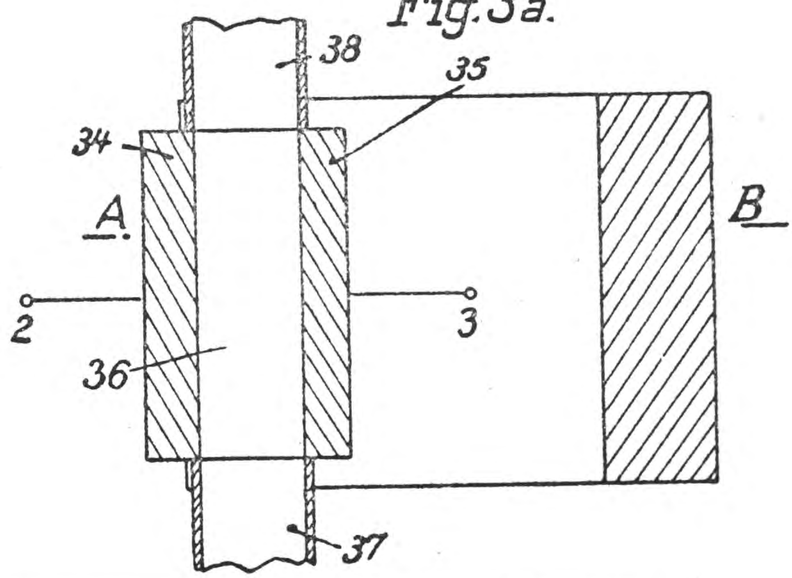


Fig. 3a.



2100 wds
3 p. drawings