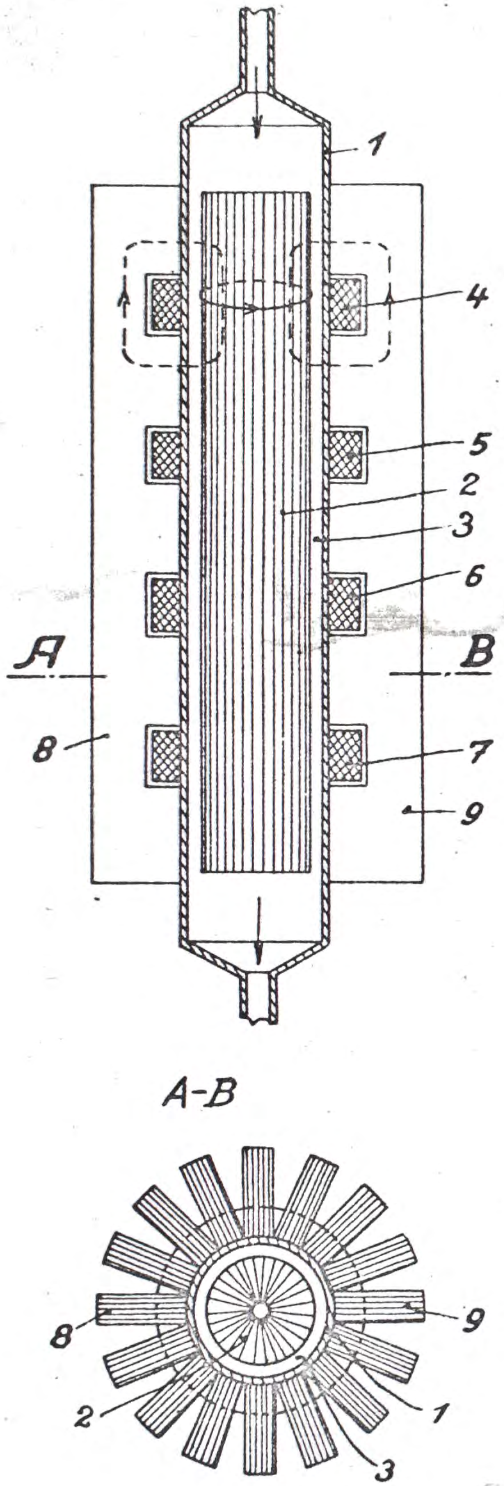
SHEET 1



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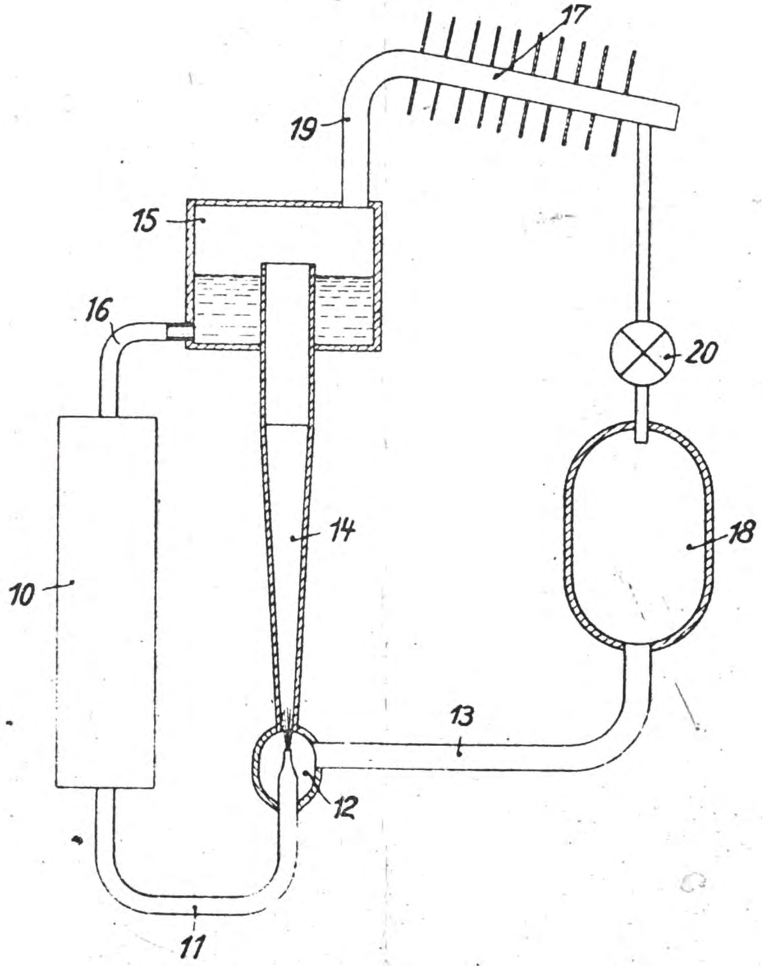
SHEET 2



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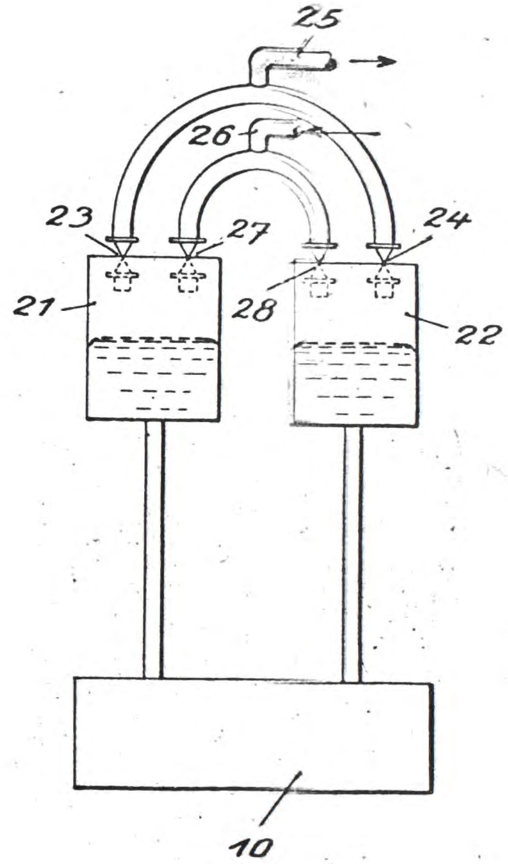
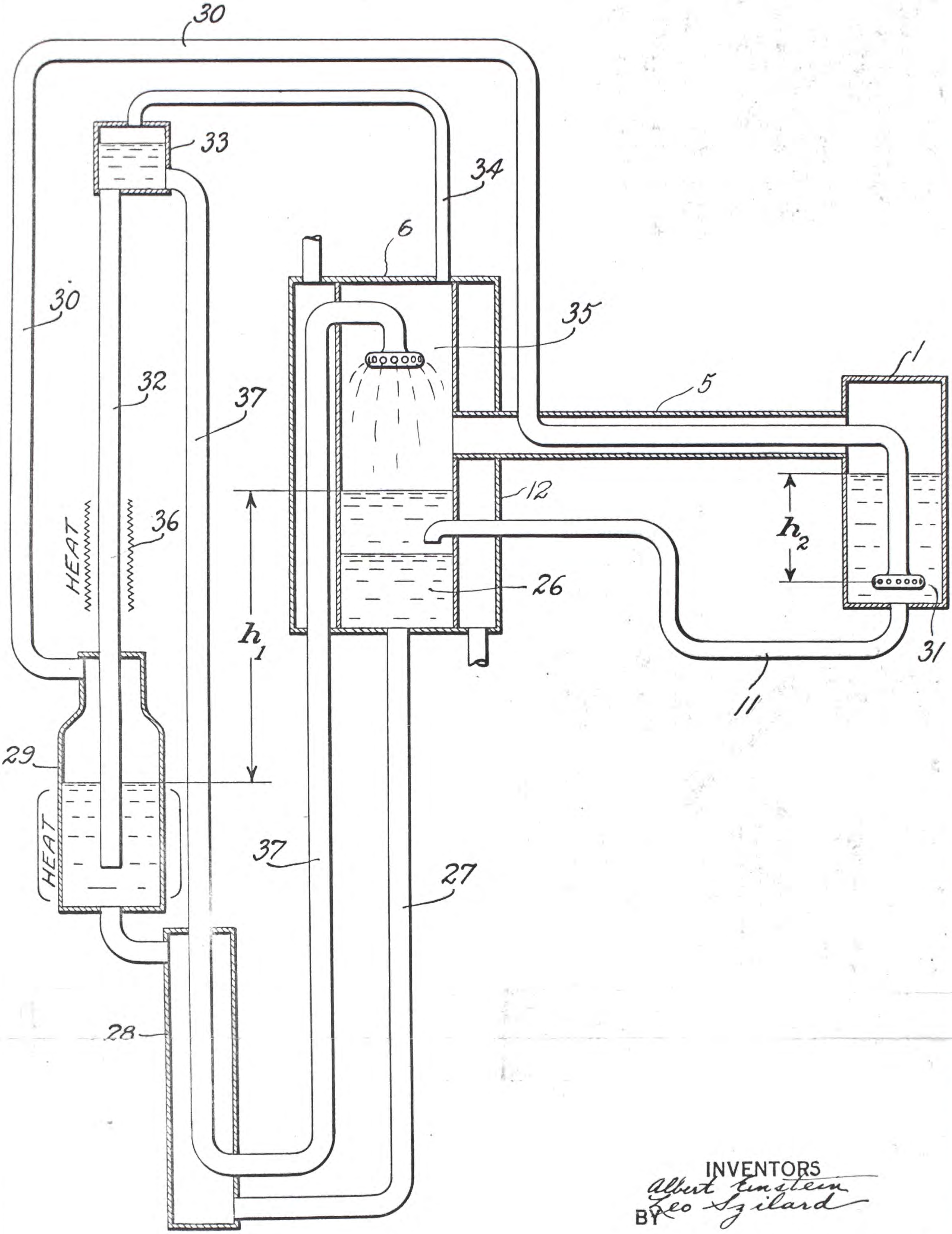


Nov. 11, 1930. A. EINSTEIN ET AL 1,781,541

REFRIGERATION

Filed Dec. 16, 1927



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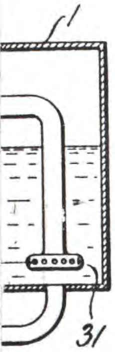
see letter from Norman Adams

Patented Nov. 11, 1930 1,781,541



UNITED STATES PATENT OFFICE

ALBERT EINSTEIN, OF BERLIN, AND LEO SZILARD, OF BERLIN-WILMERSDORF, GERMANY, ASSIGNORS TO ELECTROLUX SERVEL CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

REFRIGERATION

Application filed December 16, 1927, Serial No. 240,566, and in Germany December 16, 1926.

Our invention relates to the art of refrigeration and particularly to an apparatus and method for producing refrigeration wherein the refrigerant evaporates in the presence of an inert gas and more particularly to the type disclosed in Patent No. 1,685,764 granted September 25th, 1928, to Von Platen and Munters and our British Patent No. 282,428.

The objects and advantages of our invention will be apparent from the following description considered in connection with the accompanying drawing which shows, more or less diagrammatically, a preferred embodiment of our invention.

Referring to the drawing, reference character 1 designates an evaporator, which is ordinarily placed within a chamber to be cooled. A conduit 5 connects the upper part of evaporator 1 with the more intermediate portion of the condenser 6. A conduit 11 communicates with the bottom of evaporator 1 and extends within condenser 6 at a level below the point of communication of conduit 5 with the condenser. A cooling water jacket 12 surrounds the condenser and is adapted for the passage therethrough of water for the purpose of cooling the condenser.

A conduit 27 communicates with the bottom of condenser 6 and with the lower part of a heat exchanger jacket 28. The upper part of jacket 28 is connected to the lower part of generator 29. Generator 29 is heated in any suitable manner. A conduit 30 communicates with the upper part of generator 29 and extends within evaporator 1 to a point near the bottom thereof where it terminates in a distributor head 31. Conduit 30 extends within conduit 5 in order that the fluids passing through the respective conduits may be brought into heat exchange relationship with each other.

A conduit 32 extends upwardly from within the lower part of generator 29 and communicates with a container 33 placed at a level above that of condenser 6. A source of heat 36 is provided for heating conduit 32 at a point above generator 29. A conduit 37 extends downwardly from container 33 and passes within heat exchanger jacket 28 and thence upwardly to within the upper part of condenser 6 where it terminates in a distributor head 35. Conduit 37 passes within cooling water jacket 12 in order that fluid passing through this conduit may be cooled. A vent conduit 34 connects the upper part of container 33 with the upper part of condenser 6.

The operation of the above described apparatus is as follows:

A suitable refrigerant, for instance butane, in liquid form is contained within evaporator 1. An inert gas, for instance ammonia, is introduced into evaporator 1 through conduit 30 and distributor head 31. The refrigerant evaporates in the evaporator in the presence of the inert gas due to the fact that the partial pressure of the refrigerant is reduced thereby and the resulting gaseous mixture passes through conduit 5 to within condenser 6. Here the mixture comes in intimate contact with an absorption liquid, for example water, which is introduced into the condenser through conduit 37 and distributor head 35. Inasmuch as the ammonia gas is very soluble in water, while the butane is quite insoluble, the ammonia gas is absorbed by the water, thus freeing the butane from the gaseous mixture. Thus the butane assumes substantially the entire pressure within the condenser, which pressure is sufficient to cause its liquefaction at the temperature maintained therein by the cooling water.

The specific gravity of liquid butane is less than that of the solution of ammonia in water and hence stratification of the two liquids occurs, the liquid butane floating upon the ammonia solution. The latter solution is indicated by reference character 26. The liquid butane passes from condenser 6 through conduit 11 and returns to evaporator 1, where it is again evaporated and the cycle repeated.

The ammonia solution flows by gravity from condenser 6 through conduit 27 and heat exchanger jacket 28 to within generator 29. Here the application of heat causes the ammonia to be expelled as a gas from the solution and this ammonia gas passes through conduit 30 and distributor head 31 to within evaporator 1, where it reduces the partial pressure of the butane, wherefore the latter evaporates as previously described.

Water, containing but little ammonia in solution, passes from generator 29 into conduit 32 where it is further heated by the source of heat 36. This heating causes the formation of vapor in conduit 32 which lifts liquid through this conduit to within container 33. The liquid thus supplied to container 33 may pass by gravity through conduit 37 to condenser 6. The hot weak liquid passing through conduit 37 is brought into heat exchange relationship with the cool strong liquid passing through heat exchanger jacket 28 and an exchange of heat between the two liquids takes place. The weak liquid is further cooled by being brought into heat exchange relation with the cooling water in jacket 12 and is hence in a condition to rapidly absorb ammonia in the condenser.

Vapor entering container 33 from conduit 32 passes therefrom through vent conduit 34 to the condenser.

During the operation of the hereinbefore described apparatus, the pressure existing in the various members is uniform with the exception of slight pressure differences, sufficient to cause flow of fluids, caused by liquid columns. The pressure existing in generator 29 must be sufficiently greater than that existing in the upper part of evaporator 1 to cause the flow of vapor to take place from distributor head 31, or, in other words, to overcome the liquid head designated by h_2. This excess pressure in the generator is balanced by the head exerted by the column of liquid equal to the differences in levels between the liquid in condenser 6 and generator 29, indicated by h_1. It is, of course, necessary that the head represented by h_2 is less than that represented by h_1 in order that flow shall take place.

While we have described a preferred embodiment for carrying out our invention, it is to be understood that modifications thereof fall within the scope of the invention, which is to be limited only by the appended claims viewed in the light of the prior art.

What we claim is:

1. Refrigerating apparatus comprising a generator, a condenser arranged at a higher level than the generator, an evaporator, a container arranged at a higher level than the condenser, said generator containing an inert gas dissolved in absorption liquid and adapted to expel the inert gas from solution, a conduit for conducting the inert gas from the generator to the evaporator, a conduit for conducting liquid refrigerant from the condenser to the evaporator, a conduit for conducting mixed vapor of refrigerant and inert gas from the evaporator to the condenser in heat exchange relation with inert gas passing into the evaporator, a conduit for conducting rich absorption liquid from the condenser to the generator by gravity, a conduit for conducting weak absorption liquid from said container to said condenser by gravity, a conduit extending upwardly from said generator to said container and means to heat the last-mentioned conduit to lift liquid from the generator to the container.

2. Refrigerating apparatus comprising a generator, a condenser arranged at a higher level than the generator, an evaporator, a container arranged at a higher level than the condenser, said generator containing an inert gas dissolved in absorption liquid and adapted to expel the inert gas from solution, a conduit for conducting the inert gas from the generator to the evaporator, a conduit for conducting liquid refrigerant from the condenser to the evaporator, a conduit for conducting mixed vapor of refrigerant and inert gas from the evaporator to the condenser in heat exchange relation with inert gas passing into the evaporator, a conduit for conducting rich absorption liquid from the condenser to the generator by gravity, a conduit for conducting weak absorption liquid from said container to said condenser by gravity, a conduit extending upwardly from said generator to said container, means to heat the last-mentioned conduit to lift liquid from the generator to the container and a vent conduit connecting the upper part of said container with said condenser.

3. Refrigerating apparatus comprising a generator, a condenser arranged at a higher level than the generator, an evaporator, a container arranged at a higher level than the condenser, said generator containing ammonia dissolved in water and adapted to expel the ammonia from solution, a conduit for conducting the ammonia gas from the generator to the evaporator, a conduit for conducting liquid butane from the condenser to the evaporator, a conduit for conducting mixed vapor of butane and ammonia from the evaporator to the condenser in heat exchange relation with ammonia gas passing into the evaporator, a conduit for conducting strong solution of ammonia in water from the condenser to the generator by gravity, a conduit for conducting weak solution of ammonia in water from said container to said condenser by gravity, a conduit extending upwardly from said generator to said container and means to heat the last-mentioned conduit to lift liquid from the generator to the container.

4. Refrigerating apparatus comprising a generator, a condenser arranged at a higher level than the generator, an evaporator, a container arranged at a higher level than the condenser, said generator containing ammonia dissolved in water and adapted to expel the ammonia from solution, a conduit for conducting the ammonia gas from the generator to the evaporator, a conduit for conducting liquid butane from the condenser

to the evaporator, a conduit for conducting mixed vapor of butane and ammonia from the evaporator to the condenser in heat exchange relation with ammonia gas passing into the evaporator, a conduit for conducting strong solution of ammonia in water from the condenser to the generator by gravity, a conduit for conducting weak solution of ammonia in water from said container to said condenser by gravity, a conduit extending upwardly from said generator to said container, means to heat the last-mentioned conduit to lift liquid from the generator to the container and a vent conduit connecting the upper part of said container with said condenser.

5. Method of refrigerating which comprises evaporating a liquid cooling agent in the presence of an inert gas to absorb heat and thus forming a gaseous mixture of cooling agent and inert gas, conveying the gaseous mixture into the presence of an absorption liquid at such condition that the cooling agent condenses on being deprived of inert gas in gaseous mixture therewith due to the introduction of absorption liquid into the presence of the inert gas, separating the solution of inert gas in absorption medium from the condensed cooling agent, returning the condensed cooling agent to the presence of the inert gas, separating the inert gas and absorption liquid by heat, circulating the absorption liquid by means of a separate source of heat to the presence of the gaseous mixture of cooling agent and inert gas and returning the inert gas to the presence of the liquid cooling agent.

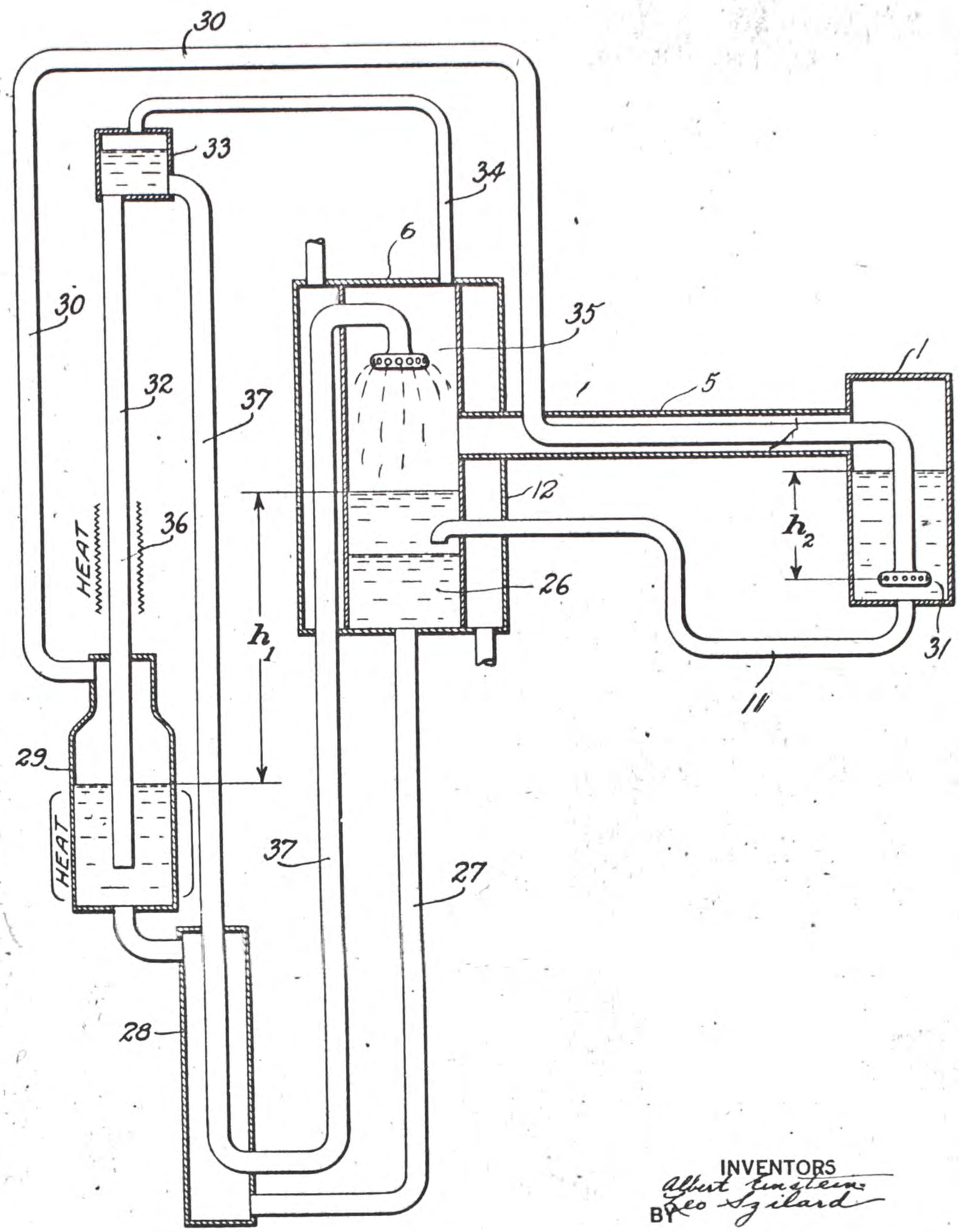
In testimony whereof we hereunto affix our signatures.

ALBERT EINSTEIN.
LEO SZILARD.

Nov. 11, 1930. A. EINSTEIN ET AL 1,781,541

REFRIGERATION

Filed Dec. 16, 1927



INVENTORS
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1200 wds
3 p. drawings

PATENT SPECIFICATION

Convention Date (Germany): Dec. 27, 1927.

303,065

Application Date (in United Kingdom): Dec. 24, 1928. No. 38,091 / 28.

Complete Accepted: May 26, 1930.

COMPLETE SPECIFICATION.

Electrodynamic Movement of Fluid Metals particularly for Refrigerating Machines.

We, Prof. ALBERT EINSTEIN, of Swiss Nationality, of 5, Haberlanderstrasse, Berlin, Germany, and Dr. LEO SZILARD, of Hungarian Nationality, of 95, Prinzregentenstrasse, Berlin-Wilmersdorf, Germany, 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:—

This invention relates to apparatus in which fluid metal moves forward under the influence of a magnetic field on the liquid through which electric current is passing, more particularly in which fluid metal is pumped from a chamber that is under low pressure into a chamber under higher pressure. Such apparatus can be employed for pouring molten metal into a mould or it may be used in refrigerating machines for feeding mercury or other liquid metals to the device. If the electric current is not passed into the liquid through electrodes but is induced in it in such manner that the stream lines of the electric current are wholly in the liquid and form closed lines therein, difficulties are avoided that are inherent in the transmission resistance between electrode and liquid, but generally a field of ponderomotive force is created in the liquid which is not free from eddies. If this field of force in the fluid metal is not free from eddies, there is a great loss of energy owing to useless agitation of the liquid.

The invention relates to apparatus in which the field of ponderomotive force is free from eddies within the liquid; according to the invention the field of ponderomotive force, which acts upon the liquid, results from a magnetic field of which the lines of force cut or cross an annular chamber through which the liquid stream is caused to flow, the magnetic field being produced by at least two or more coils energized by electric current.

Figure 1 of the accompanying drawings illustrates diagrammatically a form of apparatus according to the invention, by way of example.

An iron core 2 is inserted into an iron cylinder 1. Mercury flows in the cylindrical annular chamber between the iron core and the tube 1, under the influence of the magnetic fields produced by the windings 4, 5, 6 and 7, in the direction of the longitudinal axis of the cylinder, and, if the polarity be suitably chosen, from top to bottom. The windings 4 to 7 surround the tube 1. The currents which flow in the adjacent windings are about 90° out of phase relatively to each other, while on the other hand the windings 4 and 6—likewise the windings 5 and 7—may be connected up in series. 8 and 9 are sheet iron plates shown in laminated form on the section line A—B. When the polarity is correctly chosen, the magnetic field in the mercury in the cylindrical annular chamber is moved from top to bottom; the rate of change of the magnetic field is obtained by multiplying the frequency by the identity distance apart of the windings. In the mercury an electric current is induced which circulates around the iron core 2. Such a line of force is shown in this figure of the drawings. The ponderomotive force that influences the mercury is at all points parallel to the axis of the cylinder, and the ponderomotive field is practically free from eddies.

A 90° displacement of phase between the currents in adjacent windings is produced in known manner as has been proposed for the production of the artificial phase for asynchronous motors.

Figure 2 illustrates diagrammatically a refrigerating machine according to the invention in which 10 is a device for causing mercury to move by electro-dynamic means. The mercury is forced into the tube 11 and fed to the mercury jet pump 12. The vapour of a cooling agent (for example, methyl alcohol or a suitable hydrocarbon) is drawn off through the pipe 13, compressed in a vertically extending pipe, and forced into the vapour separating chamber 15. The mercury passes out of this chamber, through the downwardly directed pipe 16, and back into the device 10, while the vapour of the cooling agent flows through the pipe 19 into the air-cooled condenser 17, where it is liquefied; the cooling medium then flows through a throttle 20 into the vaporiser 18.

If a three phase current is available, the apparatus shown in Figure 1 is connected to the source of current in such manner that a uniformly moving magnetic field is produced—that is to say, the windings 4, 5 etc. are connected in similar manner to the windings of a three phase current motor and there is produced a magnetic field moving in a straight line instead of a rotating field.

The transmission of energy from the mercury to the vapour that is to be compressed may be variously effected in the refrigerating machine. For example, water may be drawn in by means of a mercury jet pump and the vapour compressed by the water. Alternatively, by intermittently reversing the direction of motion of the magnetic field, the mercury can be caused to flow intermittently into a vessel which communicates by valves with two chambers that are under different pressures, so that the mercury compresses the vapour, and forces it into the chamber under the higher pressure, while the vapour is drawn off by the mercury from the chamber which is under the lower pressure.

In order that this action may be better understood one form of such an apparatus is hereinafter more fully described by way of example and illustrated diagrammatically in Figure 3 of the accompanying drawings.

10 is the electro-magnetic device in which the direction of movement of the fluid metal is reversed by changing the polarity of one part of the winding. In this way the fluid metal is drawn out of the cylinders 21 and 22, or is forced into them, alternately. The valves 23 and 24 permit the compressed vapour to pass into the pressure pipe 25, while the vapour is drawn by suction out of the suction pipe 26 through the valves 27 and 28 into the cylinders 21 and 22.

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. Apparatus for moving fluid metals, intended more particularly for use with refrigerating machines, in which a magnetic field influences metal traversed by electric current, characterised in that a stream of the liquid metal is caused to flow through an annular chamber which is cut or crossed by the lines of force of a magnetic field produced by at least two or more coils energised by electric current, the magnetic field inducing electric currents in the annular chamber, which currents circulate around the axis of the chamber.

2. Apparatus according to claim 1, characterised in that the currents in two adjacent coils have a phase difference, thus producing a magnetic field which moves in a straight line parallel to the axis of the annular chamber in the manner that the field in a poly-phase motor moves in a circular path.

3. Apparatus according to claim 1 or claim 2, comprising a tube having an iron core disposed therein, an annular space being formed around the core and iron sheets disposed outside the annular space.

4. Apparatus according to claim 1, claim 2, or claim 3, characterised in that in a refrigerating machine mercury is moved by the apparatus.

5. Apparatus according to claim 1, claim 2 or claim 3, characterised in that fluid metal is poured into a mould by the apparatus.

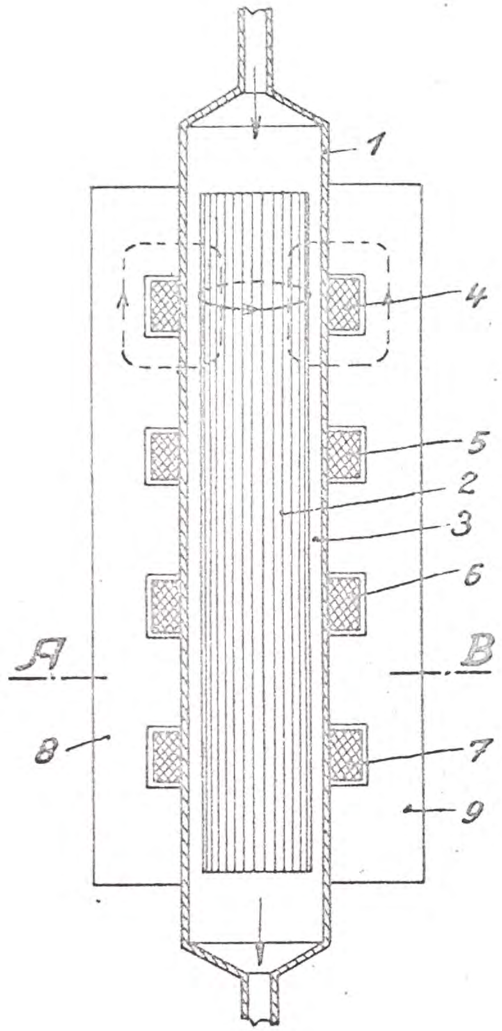
Dated this 24th day of December, 1928.

EDWARD EVANS & Co.,
27, Chancery Lane, London, W.C. 2,
Agents for the Applicants.

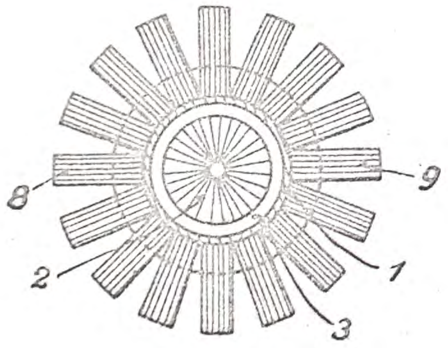
Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1930.

SHEET 1

Fig. 1.

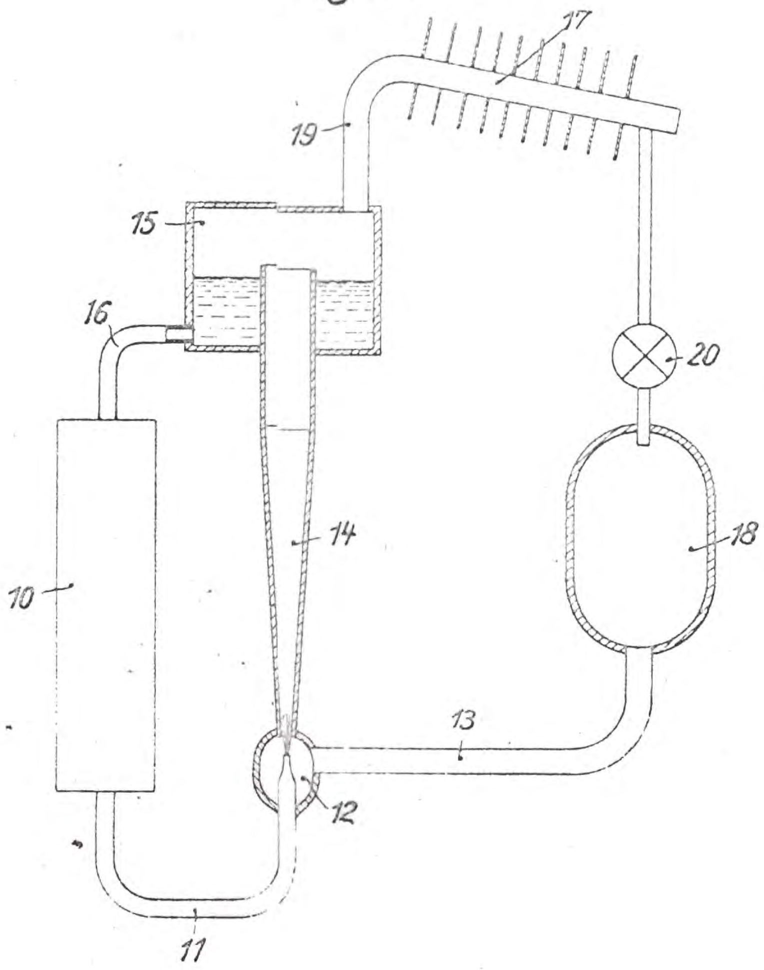


A-B



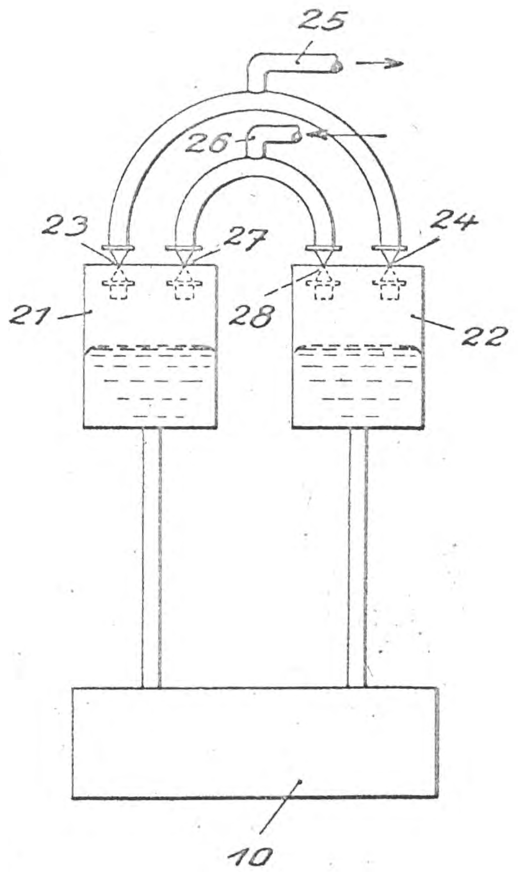
SHEET 2

Fig. 2.



SHEET 3

Fig. 3.



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