

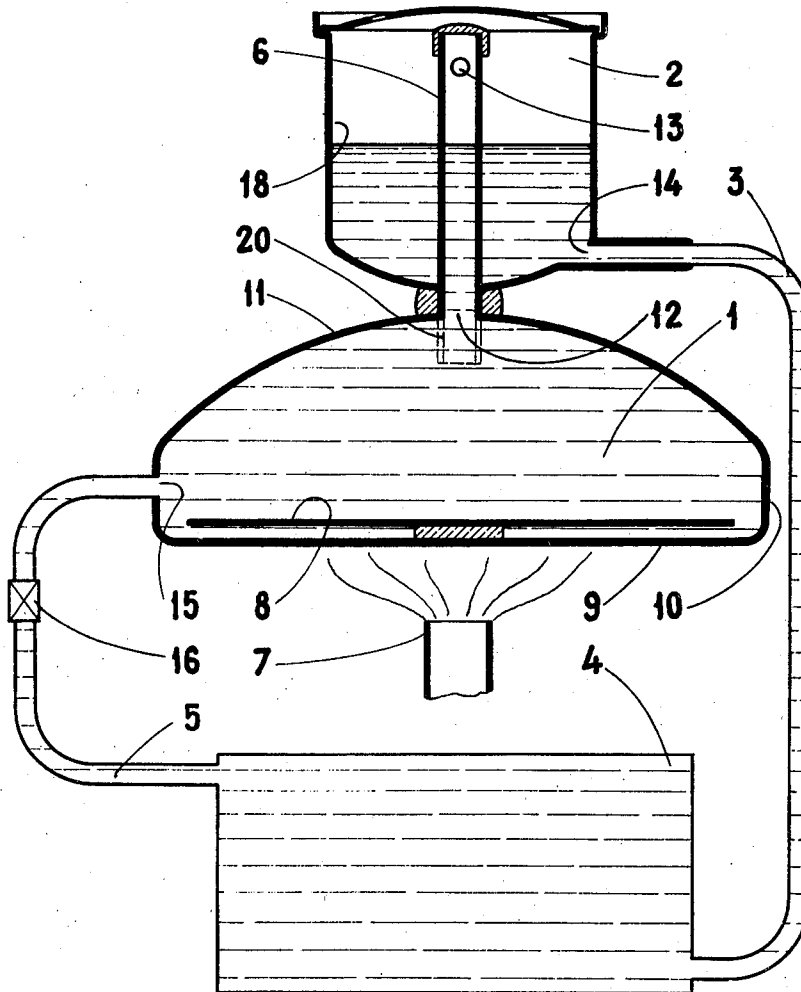
Aug. 22, 1939.

N. W. UNGE
METHOD AND APPARATUS FOR EFFECTING CIRCULATION
OF A LIQUID IN A PIPE SYSTEM
Filed June 8, 1937

2,170,225

4 Sheets-Sheet 1

Fig. 1



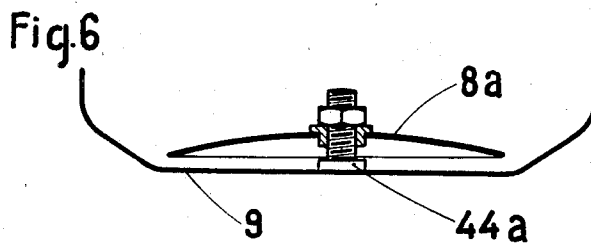
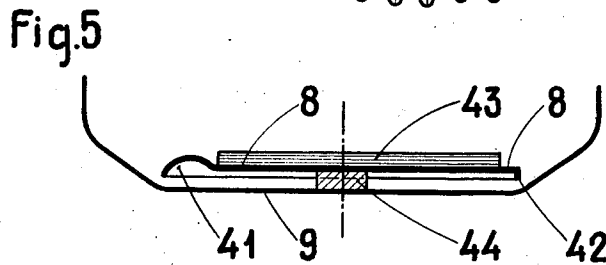
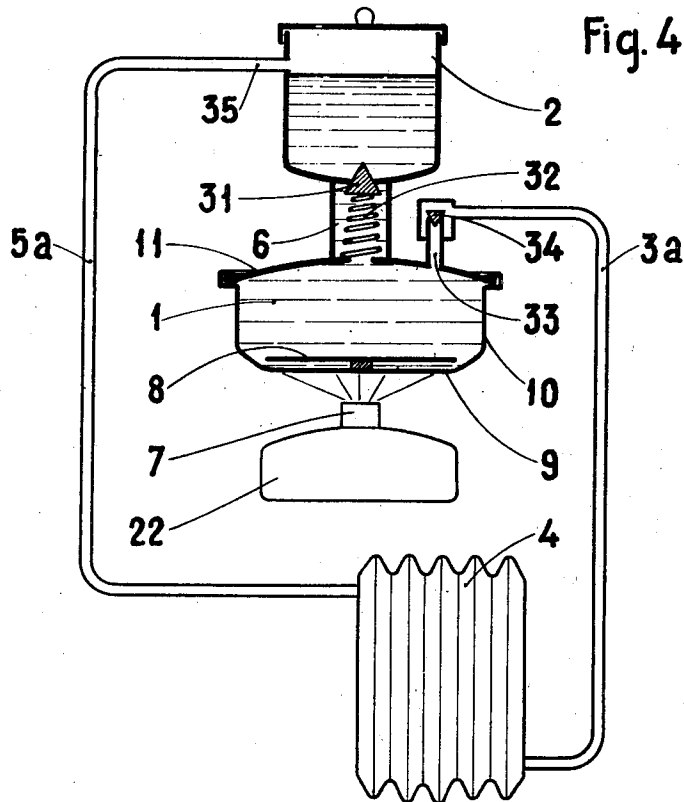
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Fig. 7

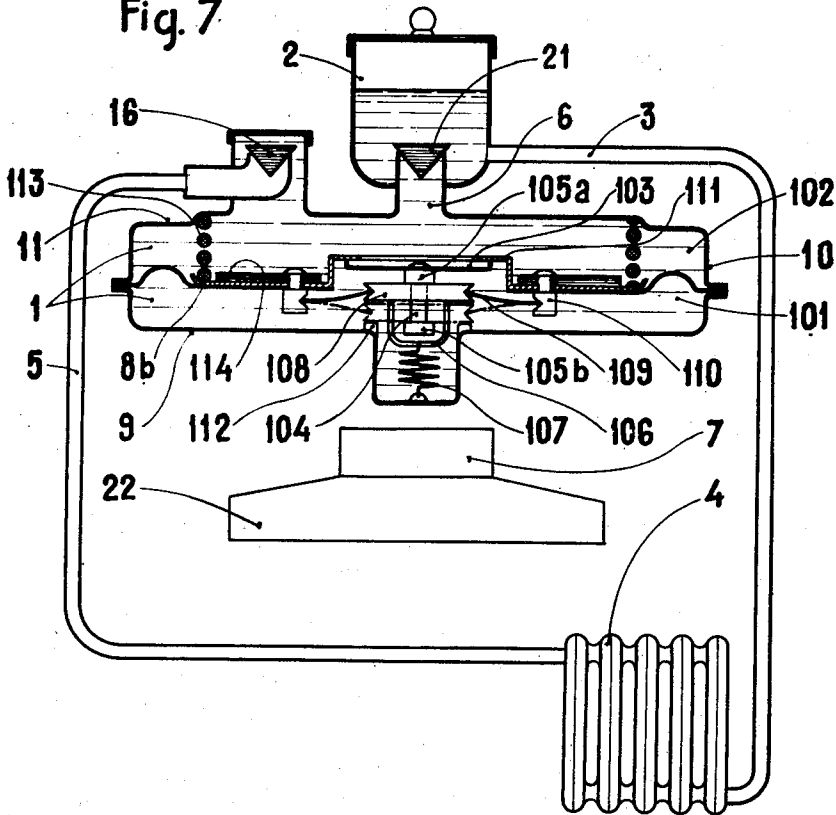
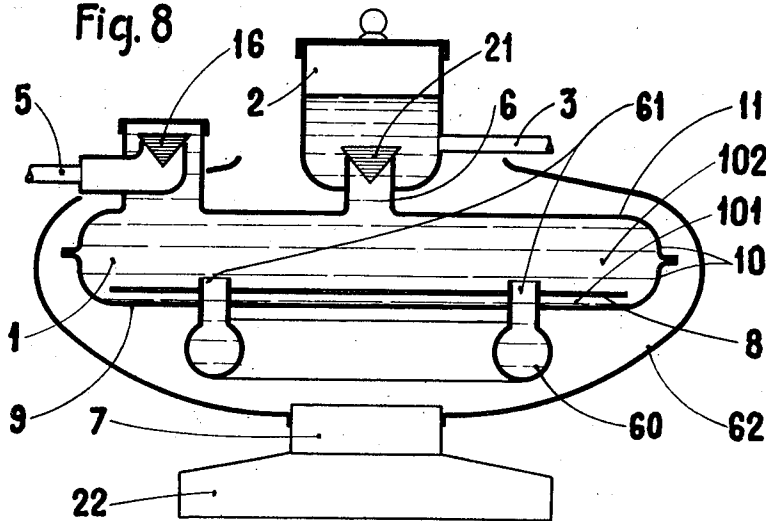


Fig. 8



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UNITED STATES PATENT OFFICE

2,170,225

METHOD AND APPARATUS FOR EFFECTING
CIRCULATION OF A LIQUID IN A PIPE
SYSTEM

Nils Wilhelm Unge, Stockholm, Sweden

Application June 8, 1937, Serial No. 147,042
In Sweden June 19, 1936

19 Claims. (Cl. 237—60)

The present invention relates to a method for effecting circulation of a liquid, for instance water, in a pipe system for heating or cooling purposes or the like and an apparatus for carrying out the method.

In central heating systems the circulation of the heat transmitting liquid is generally caused by the different specific weight of the liquid in the vertical parts of the closed pipe system in which the source of heat, the heating furnace, forms a part. In the pipes leading from said source of heat the hot liquid rises, and after having given off its heat in a radiator or other device it sinks again in the pipes leading to the furnace.

In such a system of self-circulation a certain height of rising is, thus, necessary in the pipe circuit above the heating furnace for making the circulation at all possible. The higher the ascending column of hot liquid and the descending column of cool liquid are, the more rapid will be the circulation.

However, it is not always possible to arrange for such a height of rising, as for instance in small boats, low houses without cellars or flats, provided that the conduits to the heat emitting device or the said device are not placed at the point of the system lying highest above the furnace, i. e. in the roof of the room to be heated, which, however, in most cases cannot be held satisfactory from a heating point of view.

The object of the present invention is to provide for circulation in a simple way without employing complicated mechanical or other means, such as motor-driven pumps or the like, even in those cases in which the height of rising in the heating system is small or negative, so that no self-circulation worth mentioning can arise, as when the heat emitting device is placed lower than the heating furnace.

The apparatus according to the invention comprises in combination, a closed vessel, the heating vessel with a suitable heating device, for example a petroleum-stove, gas-stove or other stove provided with a burner or fired with wood, coal or coke, or by electricity and with an arrangement dividing the vessel into two different zones or compartments with different temperatures of the liquid, a second vessel, preferably open and higher placed, a conduit between the two vessels connected to or forming a radiator or the like in a heat emitting device, and a connection between the two vessels for instance in the form of a pipe, allowing a liquid, filling the closed vessel completely and the first-mentioned conduit at least practically completely and the second

vessel to a certain level, to stream from the heating vessel to the second vessel, or from the second vessel to the heating vessel, but in neither case in the opposite direction. The method of effecting the circulation in said apparatus according to the invention is mainly characterized by the fact that alternate overpressures and underpressures are produced in a thermic way in the closed heating vessel, so that liquid is pressed or sucked, respectively, from one vessel to the other through the last-mentioned connection and thus liquid is sucked and pressed, or pressed, through the conduit between the vessels provided with the heat emitting device. The alternate overpressures and underpressures, i. e. the changes of pressure in the heating vessel, are in a thermic way most simply produced by generating and condensing vapor bubbles in the liquid in the vessel. On generating vapor bubbles in the closed vessel an overpressure arises in same causing an amount of liquid corresponding to the volume of the vapor bubbles to be removed from the vessel either to the second vessel, from which it is at a later moment conveyed to the heat emitting device, or directly to the conduit leading to said device, depending upon the type of apparatus used. The flow in these directions continues until the overpressure is balanced. When the vapor bubbles in the heating vessel come in contact with cooler liquid from the inlet pipe from the heat emitting device, or from the second vessel, the vapor in the bubbles is condensed, which makes the bubbles contract and by proper adaption of the apparatus and the heating disappear completely, so that underpressure arises in the vessel and a stream of liquid in the opposite direction to before arises or will arise. Hence the heating vessel acts as a pistonless pump with the energy supplied in the thermic way. Depending upon the manner of the different elements being connected to one another in the apparatus, i. e. how the latter is constructed, the circulation is then effected either by pressure or suction or both.

Instead of the direct firing of the heating vessel above mentioned, which may take place either through the bottom or through inner or outer walls in the vessel, depending upon the nature of the firing device, the heating may be carried out in an indirect way by means of a suitable medium, viz. an easily condensable vapor or gas, for example from water, alcohol or the like, produced in a generator communicating with the vessel. On supplying vapor or gas to the vessel and condensing same in the vessel the pressure changes required for the circulation of the liquid

are thereby obtained in the same way as above mentioned, at the same time as the liquid is heated.

The pumping action from the heating vessel obtained according to the invention may, besides for direct circulation in the manner described, also be used for effecting pumping in an indirect way, for instance with the aid of a membrane, bellows or the like, of other liquid, for example petroleum for the burner device, for the circulation of liquid in heat-transmission or cooling systems, or for other purposes.

In the accompanying drawings some different constructions of the apparatus according to the invention are shown, all with a radiator as heat emitting organ. Figures 1, 2, 7 and 8 show apparatus for combined action by suction and pressure and Figure 4 shows an apparatus mainly for action by pressure. Figure 1 shows an apparatus with the connection between the vessels consisting of a pipe with a liquid seal, Figure 2 an apparatus with a connection having a stop in one direction by means of a valve and with a pump driven by the pressure changes in the heating vessel for the purpose of supplying oil to the holder of the burner from a cistern. Figures 3, 5, 6 and 7 show certain constructions of a screen placed near the heating surface in the heating vessel in order to cause the generation of large vapor bubbles and thereby large pressure changes in the vessel. Figure 8 shows an additional heating arrangement below the heating vessel for supplementary heating of the liquid in the same.

In Figure 1, 1 indicates a closed heating vessel, 2 is another vessel, which in this case is open and placed higher but also may be closed to prevent any uncondensed vapor from escaping out of the system and thereby loss of liquid from same during the circulation. 3, 4 and 5 indicate a conduit between the two vessels, of which the part 4 is formed as one radiator that, however, may be replaced by a number of separate heating units. 6 is a connection pipe between the vessels 1 and 2 attached to the upper border 11 of the vessel 1 and at the top open against the vessel 2 through one or more openings 13 placed above the surface of the liquid in the vessel 2, and 7 is a burner or another source of heat for heating the vessel 1. Water or other liquid fills the upper vessel 2 to a certain level and the conduit 3, 4, 5 and the lower vessel 1 completely, and ascends in the connection pipe up to the same level as outside in the vessel 2. In consequence of the construction the pipe operates as a liquid stop between both vessels. The liquid can thus flow from the upper vessel 2 through the conduit 3, 4, 5 to the vessel 1 and from the latter to the vessel 1 through the pipe 6.

When the liquid in the connection pipe 6 is on a level with the liquid in the upper vessel 2 no flow of liquid takes place in one or other direction in the conduit 3, 4, 5. If the vessel 1 is heated, so that vapor is generated therein, or if vapor is introduced from an outer source, a quantity of liquid corresponding to the volume of the vapor bubbles will, until the overpressure ceases, flow up into the vessel 2, where, thus, the level of liquid rises. When the heating of the vessel is properly adapted the vapor bubbles will condense wholly or in part on coming into contact with liquid of lower temperature than that prevailing at the heating surface, and hence underpressure is created in the vessel 1. The volume formerly taken up in the vessel 1 by the vapor bubbles is now

replaced by liquid, which is most readily done from the pipe 6 where a rapid sinking of the level, perhaps down to the vessel 1, sets in. At this moment the pressure in the opening 15 of the inlet to the vessel 1 from the column of liquid in the pipe 6 and the vessel 1 becomes less than the pressure of the column of liquid from the upper surface in the vessel 2 to the opening 15 acting through the conduit 3, 4, 5, and so liquid flows through the outlet 14 of the vessel 2 and the conduit 3, 4, 5 into the vessel 1, which in its turn involves the cessation of the underpressure in the vessel 1 by the refilling of the same and the pipe 6 and thus the stream in that direction will end. The raised level of liquid in the vessel 2 and the suction in the inlet 15 contribute also to increase the circulation of liquid through the apparatus. Through the continued heating of the vessel 1 the procedure is then repeated with alternate overpressures and underpressures. Generally the number of complete cycles amounts to 15 to 60 per minute, but it may be raised to 120 per minute or even more. The time for every change of pressure will thus be rather short. Especially the reduction of the pressure through the condensation takes place very rapidly.

The best effect is obtained when the generation of vapor or the introduction of vapor to the vessel 1 takes place in a zone or part of the vessel with a comparatively high temperature, from which the vapor bubbles wholly or in part stream into another cooler zone or part of the vessel, whereat the vapor bubbles condense more or less completely and vapor bubbles in the hotter zone in generation, introduction or growing are cooled by relatively cold liquid streaming in from the other zone for filling the space after the escaped or contracted vapor bubbles. In accordance with the invention that is effected by arranging a screening off in the vessel 1 at a certain, if desired adjustable, distance from the heating surface of the vessel. When the vessel is heated through the bottom or vapor is introduced from another source the screen should be arranged at a certain distance from the bottom, preferably in the form of a plane or slightly bent plate, a conical or calotte-formed sheet or the like, though it may be placed in any other position. It may also be provided with openings, for instance round apertures, radial or circular slits or the like, through which the vapor bubbles may pass away from the space between the heating surface and the screen into the other cooler space and liquid may flow from this latter space to the screened off space. Preferably these openings are placed symmetrically in relation to the centre of the screen. When a screen without openings is used it has proved preferable to have it provided with one or more protuberances, for example in the form of torus rings or with a rim or the like at their outer border acting as or forming gathering spaces for the vapor arising or supplied under the screen in heating the liquid, which in this way is congregated to large bubbles that pass away and/or are contracted by the relatively cool liquid coming in from that space. The screen which should be arranged in such a way that there is a space of sufficient size between it and the wall of the vessel, results in the supplied heat being retained and concentrated in the part of the vessel between the heating surface and the screen, which part, consequently, will become hotter than the other part. In that way the vaporization in the screened

off space will be greater, and larger bubbles are formed than is the case when a heating vessel without screen is used. The larger the vapor bubbles are that are formed or supplied and condensed in the several moments of each cycle, the larger will be the pressure changes in the heating vessel and, thus, the more powerful will become the circulation of liquid in the apparatus.

The proportion between the volume of the screened off space and that of the other space in the heating vessel has a great influence on the course of the vaporization and, thus, on the magnitude of the circulation, so that when using a certain proportion a maximum circulation is attained for a certain supply of heat. This proportion is, however, dependent upon the shape and volume of the vessel and can, therefore, not be stated generally. On using vessels with heating through the bottom it has proved that if the distance between the screen 8 and the bottom 9 is kept appropriate, for instance $\frac{1}{50}$ to $\frac{1}{4}$ inch in small vessels, i. e. vessels with diameters up to 10 inches, generally, however, only $\frac{1}{50}$ to $\frac{1}{8}$ inch, there are formed under the screen a small number of very large bubbles instead of innumerable small bubbles as in vessel without a screen. To attain a complete condensation of the vapor bubbles from the vessel 1 the connection 6 may be provided with a cooling arrangement.

If a heating surface other than the bottom is used, for instance a cylinder surface inside which coal or coke is burnt, the screen should be placed at a certain distance from that surface and be fitted with a suitable play to the walls of the heating vessel at the outer edge and, if desired, with apertures or slits to facilitate the admission of liquid for the cooling in the screened off space. In such a case it has been found suitable to apply a spiral pipe or the like between the heating surface and the screen to make the formation of large vapor bubbles easier, along which the small vapor bubbles formed slide upwards and congregate to large bubbles in the upper part of the screened off space.

It has also proved advantageous to have the screen made of heat insulating material, for example asbestos or the like, or covered on one side or both sides with such a material. By that the heat transmission from the screened off space to the other space in the heating vessel is reduced, and so the vaporization and the formation of large vapor bubbles in the first-mentioned space are furthered.

The circulation is also furthered if in the inlet pipe 5 to the heating vessel 1 near the opening 15 is placed a valve 16 that prevents a return flow from the vessel 1 into said pipe. Practically the whole free space formed in the vessel on the condensation of the large vapor bubbles is then filled by liquid from the pipe 6, by which the difference in pressure between the liquid outside and inside the pipe 6 and thus the flow from the vessel 2 into the conduit 3 are increased. The smaller the diameter of the pipe 6, the greater may its length be kept, and the stronger will, thus, be the circulation.

The liquid streaming into the vessel 2 has, especially when a screen is used, a considerably lower temperature than the vaporization temperature of the liquid, but is, however, relatively hot. The evaporation from the open jets of liquid through the openings 13 and from the surface of the liquid in the vessel 2 may, therefore, become rather great in certain cases. Naturally, the temperature of the liquid streaming into the

vessel 1 from the conduit 5 depends upon how great the cooling is in the conduits 3 and 5 and the radiator 4.

The greater the temperature difference is between the different spaces in the heating vessel, the more rapid will be the pressure changes and by that the circulation of the liquid. At the same time the temperature of the liquid flowing out into the pipe system 3, 4, 5 will, however, be decreased and, consequently, also the quantity of heat that may be emitted from the system. Great temperature difference is attained if the vessel, as shown in Figure 1, is made with non-insulated walls 10, for instance of sheet metal, in the cooler zone and/or highly heat emitting upper border, for instance of sheet metal also, if desired cooled by a cooling medium such as water or the like. By these means the temperature of the liquid in the upper part of the vessel—the cooler zone—will be rather considerably decreased. If on the contrary the side walls 10 and/or the upper border 11 are insulated with a suitable non-conducting material or if the liquid is supplementarily heated in the upper zone or in any other way, the temperature difference will be less and the circulation not quite as powerful, but the liquid streaming out into the pipe system will be hotter and can, thus, in spite of the reduced circulation, emit more heat from the pipe system.

The apparatus according to the invention is suitably carried out as the drawings show with the second vessel 2 of smaller diameter than the heating vessel 1 and directly connected to and placed above the latter with the connection pipe 6 attached to the upper border 11 of the lower vessel. In certain cases the pipe 6 may at the lower end finish below the upper border 11 of the lower vessel, for instance by an elongation 20 as indicated in dotted lines in the drawings. However, the pipe may also start from another part of the vessel other than the upper border. Preferably the screen 8, in this case shown as a plane plate, should be placed in fixed relationship to the lower vessel 1 in order not to be lifted by the vapor pressure. The fixing may, for instance, be made by a screwing means, allowing an adjustment of the height of the plate above the bottom according to the conditions and the circulation desired in different cases. Preferably the connection between the vessels 1 and 2 should be made in such a way that the vessels may be turned axially in relation to each other and, thus, their inlets and outlets made to point in desired directions.

The apparatus according to Figure 2 fundamentally corresponds to that shown in Figure 1. However, the stop in the pipe 6 against the drawing in of liquid from the vessel 2 when underpressure is prevailing in the heating vessel 1 consists of a pressure valve 21 instead of a liquid seal, which valve lets through liquid from the latter vessel to the vessel 2 when overpressure prevails in the vessel 1. Moreover there is placed in the inlet pipe 5 to the vessel 1 a valve 16, allowing liquid to stream into the vessel from the pipe when underpressure is existing in the vessel 1 and preventing liquid from streaming in the opposite direction when overpressure is existing in the vessel.

When overpressure arises in the vessel 1 the valve 21 will be lifted and liquid streams from the space above the screen 8 up into the vessel 2. According to the magnitude of the circulation and the cooling in the circulation conduits

3, 4, 5 this liquid has generally a temperature of between 40 and 90° C. When the overpressure ceases the valve 21 will be shut, and at the following rapid condensation of the vapor bubbles both above and below the screen 8 the valve 16 will be opened by the underpressure arising, and a volume of liquid corresponding to the reduction of volume in the vessel 1 will be rapidly drawn in from the pipe system 3, 4, 5 and thus from the vessel 2. The raised level of liquid in the vessel 2 contributes then to increase the flow of relatively hot liquid from the vessel 2 to the vessel 1 through the pipe system 3, 4, 5. Next moment the underpressure ceases, the valve 16 will be shut, and a new pressure increase sets in by the generation of vapor bubbles in the screened off space between the screen 8 and the bottom 9, when again hot liquid is pressed up into the vessel 2 and so on. In this case an air chamber or bell 50 is arranged in connection with the conduit 5 for equalizing the fluctuations of pressure in the conduit.

The advantages of this apparatus over the apparatus with liquid seal according to Figure 1 are that the consumption of energy through oscillations of the column of liquid in the pipe 6 is avoided and that, consequently, the underpressure is better utilized for the conveyance of the circulation liquid, and further that the risk of boiling in the vessel 1 is reduced since the temperature in same will be lower.

In Figure 2 there is also shown means for pumping petroleum or other fuel oil from a cistern 30 to a fuel holder 22 belonging to the burner 7 by which the circulation apparatus may be left without supervision for a long time, as the fuel supply into the holder 22 may automatically be kept constant. Through the pipe 23 the pressure changes in the heating vessel 1 are transferred to bellows 24 or other similar pumping device that expands and contracts with the increases and the decreases of the pressure in the vessel. The bellows are placed in a tank 25 with an inlet valve 26 from the supply cistern 30 for fuel oil. From the pressure valve 27 the oil is conveyed through a conduit 28 to the holder 22 of the burner 7. The oil level in the holder 22 is kept constant or limited by means of an overflow 29.

The pumping arrangement above described may, besides for pumping fuel oil, also be used for other purposes, for instance for pumping liquid for other heating or cooling arrangements or the like or for delivering other mechanical work.

The apparatus according to Figure 4 differs from the preceding ones in that the circulation is mainly effected by pressure. In this the heating vessel 1 is combined with the vessel 2 through a connection or pipe 6 provided with a suction valve 31, which is kept in its position by a spring 32. From the vessel 1 there runs out a conduit 33 provided with the pressure valve 34 and through the conduit 3a, the radiator 4 and the conduit 5a communicating with the vessel 2, suitably through a pipe 35 finishing above the surface of the liquid in the vessel 2.

When overpressure arises in the vessel 1 through the vaporization the valve 34 will be lifted and liquid stream from the vessel through the conduit 3a, 4, 5a, 35 or 36 until the vapor bubbles are condensed in the cooler zone of the vessel 1 and then overpressure ceases and the valve 34 shuts. Due to the continued condensation underpressure is then rapidly created in the ves-

sel 1 which causes the valve 31 to open and liquid to flow from the vessel 2 into the vessel 1 and fill up the vacant space after the condensed vapor bubbles. If an air chamber is used for equalizing the changes in pressure, it should preferably join the conduit 3a, 4, 5a between the valve 34 and the vessel 2.

The apparatus according to Figure 4 has an advantage over those shown in Figures 1 and 2 in that the liquid in the vessel 2 obtains a lower temperature. Hence the evaporation in the vessel 2 from the surface of the liquid and, perhaps, from the open jets in same will be less, and therefore it is more seldom wanted to fill liquid into the apparatus.

In Figures 3, 5 and 6 some special embodiments of the screen 8 are shown for use in vessels with heating or introduction of vapor through the bottom. In Figure 3 there is shown a screen 8 provided with an aperture or hole 51, covered with a plate 52 of metal, asbestos, rubber or other suitable material, that is kept in its position by a managing device, spring or the like 53. The plate 52 operates as a valve that is lifted when overpressure arises under the screen and gives the vapor bubbles accumulated there free and rapid passage through the hole 51 to the upper space in the heating vessel 1. The vacant space after the bubbles is then rapidly filled with liquid streaming in at some place of the outer border of the screen and, perhaps, through the hole 51, too, resulting in a mighty circulation of liquid in the system. To the left in Figure 5 a screen is shown provided at its circumference with a vapor gathering space in the form of a torus shaped protuberance 41, and to the right a similar space formed by the screen plate being provided with a rim 42 at the border. 43 is a plate of heat insulating material, for instance asbestos, placed on the screening off plate 8 which is kept at a certain distance from the bottom 9 by a projection or an inserted layer 44 with an adapted height. In Figure 6 there is shown a calotte-formed screen 8a, by which the collecting of the vapor takes place up in the cupola. In this case the distance of the screen from the bottom 9 may be regulated by the screw 44a.

In Figure 7 an apparatus with a special form of the screen is shown that is made as a membrane 8b furnished with a valve 103 and dividing the heating vessel into two separate spaces, a lower hot space 101 heated through the bottom and an upper cooler space 102. The last-mentioned space communicates with the vessel 2 both by the direct connection 6 and the pipe system 3, 4, 5. The membrane may be replaced by another movable organ, for example bellows, a piston or the like, and made from or covered with a heat-insulating material. Through the valve 103 communication can take place between the two spaces in the vessel. The valve 103 is provided with a rod 104 on which a ring 108 can move with the movements limited by the shoulders 105a and 105b on the rod. Normally the valve is being kept pressed against its seat 111 in the membrane by means of two flat springs or the like 109, set between said ring 108 and two supports 110 fastened in the membrane. Between the ring 108 and the bottom 9 of the vessel a coil spring or the like 107 with a chape 106 is applied. 112 are fixed supports in the vessel limiting the movement of the ring 108 downwards. 113 is a spring or the like which normally keeps the membrane in the position shown in the drawings and which in the membrane moving up-

wards is compressed by the overpressure that arises by the heating of the liquid in the space under the membrane and exerts an increasing counter-force on the membrane. 114 is a heat insulating covering on the membrane. The rod 104 with the shoulders 105a and 105b, the ring 108 and the springs 109 and 107 form a lifting- and restoring-arrangement for the valve 103 which in certain positions of the membrane rapidly changes the direction of the resultant of the forces acting upon the valve, whereby a rapid opening and shutting of the valve is caused.

Finally Figure 8 shows a construction of the apparatus according to the invention in which a separate additional heating device for the liquid in the heating vessel is arranged to obtain a comparatively high temperature on the liquid flowing out into the pipe system. Here the additional heating device consists of a ring-formed pipe 60 applied in such position in relation to the heating vessel as to come in contact with the flame from the burner 7 and its combustion gases. Through a number of tubes 61 the liquid heated in the pipe 60 streams up into the relatively cool space 102 above the screen and is replaced by comparatively cool liquid from that space. Naturally the heating device may also have other forms than that shown, for example as a pipe coil, pipe spiral, flat-pipe or the like. 62 is a screen, mantle or the like of sheet metal, asbestos or other suitable material which compels the combustion gases against the outer wall 10 and the upper border 11 of the vessel 1. In one or both of these ways the liquid in the space 102 is supplied with additional heat besides the heat brought to it through the bottom. It has been proved that by the application of such an additional heating device the efficiency of the whole circulation apparatus has been raised by 20% or more. However, the heating of the liquid in the space 102 may not be driven so far that boiling occurs in this space, for then the pressure changes would be rendered more difficult and by that also the circulation in the system.

In the Figures 1, 2, 4, 7 and 8 the vessel 2 has been shown placed above the vessel 1, but the vessels may have any positions in relation to each other. However, it is advantageous to have both the vessels positioned on a higher level than the heating radiator 4.

Above the invention has been described mainly in connection with a heat transmission system. However, it may be used to advantage for effecting transport of liquids for other purposes also, for instance for cooling, in which case, for example, the circulating liquid after the outlet from the vessel 2 first is highly cooled and thereafter in another device again takes up heat, i. e. effects cooling in said device. In such a case a liquid of low boiling point, for instance alcohol, may be suitably used.

The invention is not limited to the methods and apparatus above described or to the apparatus and details shown in the drawings which have been cited and shown by way of example only, but comprises any methods and apparatus in which the circulation between two vessels, of which at least one is closed and provided with a heating device and an arrangement dividing the vessel into two zones or compartments of different temperatures, said vessels communicating with each other by two separate conduits, is performed by the aid of alternate overpressures and underpressures in the closed vessel, effected in a thermic way.

What I claim as new and desire to secure by Letters Patent of the United States of America is:

1. Method of effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, consisting in producing in a thermic way alternate overpressures and underpressures in a closed vessel provided with a heating device the said vessel being divided into a high liquid temperature zone and a low temperature zone, the said overpressure resulting from the evacuation of the liquid in the high temperature zone into the liquid of the low temperature zone, the said underpressure resulting from the refilling of the evacuated high temperature zone by the liquid from the low temperature zone, the volumetric proportions of both high and low temperature zones being such as to effectively condense any vapor which is introduced from the high temperature zone into the low temperature zone, said vessel being connected to the pipe system both directly and through a second vessel, suitably higher placed than the first vessel, so that a quantity of the liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level is upon the production of overpressure in the closed vessel caused to move in desired direction first, from one vessel to the other through the connection between them which is arranged so as to allow the liquid to flow from one vessel to the other but not in the opposite direction, and thereafter through the pipe system.

2. Method of effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, consisting in producing alternate overpressures and underpressures in a closed vessel provided with a heating device and connected to the pipe system both directly and through a second vessel, suitably higher placed than the first vessel, by generating and condensing vapor bubbles in the liquid in said closed vessel, so that a quantity of the liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level is caused to move in desired direction first, from one vessel to the other through the connection between them which is arranged so as to allow the liquid to flow from one vessel to the other but not in the opposite direction, and thereafter through the pipe system, said vaporization in the heating vessel taking place in a zone of the vessel with comparatively high temperature from which the vapor bubbles stream into another cooler zone in the vessel at least in part, whereby the vapor bubbles are more or less completely condensed and the vapor bubbles in the process of generation or growth are cooled and more or less completely condensed in the hotter zone by relatively cool liquid streaming in from the cooler zone.

3. Method of effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, consisting in producing alternate overpressures and underpressures in a closed vessel provided with a heating device and connected to the pipe system both directly and through a second vessel, by generating and condensing vapor bubbles in the liquid in said closed vessel, so that a quantity of the liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level is caused to move in desired direction first, from one vessel to the other through the connection between them which is arranged so as to allow the liquid to flow from one vessel to the other but not in

the opposite direction, and thereafter through the pipe system, said vaporization in the heating vessel taking place in a zone of the vessel with comparatively high temperature from which at least part of the vapor bubbles stream into another cooler zone in the vessel, whereby the vapor bubbles are more or less completely condensed and the vapor bubbles in the process of generation growth are cooled and more or less completely condensed in the hotter zone by relatively cool liquid streaming in from the cooler zone, the liquid in the cooling zone being additionally heated by the flame and/or the combustion gases from said heating device in an additional heating means in direct communication with said cooler zone.

4. Method of effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, consisting in producing alternate overpressures and underpressures in a closed vessel provided with a heating device and connected to the pipe system both directly and through a second vessel, by generating and condensing vapor bubbles in the liquid in said closed vessel, so that a quantity of the liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level is caused to move in desired direction first from one vessel to the other through the connection between them which is arranged so as to allow the liquid to flow from one vessel to the other but not in the opposite direction, and thereafter through the pipe system, said vaporization in the heating vessel taking place between its heating surface and a screen placed at a suitable distance from said heating surface, in order to produce large vapor bubbles and thereby high overpressures and underpressures in the vessel on the generation of the vapor bubbles and their condensation in the vessel.

5. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels consisting of the pipe system in circuit with a heating element in the form of a heat emitting device in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction, said closed vessel including an arrangement dividing the vessel into a high liquid temperature zone and a low liquid temperature zone, the volumetric proportions of both high and low temperature zones being such as to effectively condense any vapor which is introduced from the high temperature zone into the low temperature zone.

6. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device in the form of a generator for easily condensable vapor or gas; a second vessel, suitably open and higher placed; a conduit between the two vessels consisting of the pipe system in circuit with a heating element in the form of a heat emitting device in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction said closed vessel

including an arrangement dividing the vessel into a high liquid temperature zone and a low liquid temperature zone, the volumetric proportions of both high and low temperature zones being such as to effectively condense any vapor which is introduced from the high temperature zone into the low temperature zone.

7. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied and dividing the vessel into two communicating zones with different temperatures of the liquid, thereby causing the formation of large vapor bubbles in the liquid on heating same in the vessel.

8. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; and an additional heating means; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied and dividing the vessel into two communicating zones with different temperatures of the liquid, thereby causing the formation of large vapor bubbles in the liquid on heating same in the vessel; the cooler zone of said closed vessel communicating with said additional heating means so that the liquid of said zone may be additionally heated in said means.

9. Apparatus for effecting circulation of liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied, dividing the vessel into two communicating zones with different temperatures of the liquid and thereby causing the formation of large vapor bubbles in the liquid on heating same in the vessel; said screen being shaped as a plate, preferably plane, and of such a size in relation to the heating vessel that the vacant space after the vapor bubbles leaving the screened off hotter zone may be rapidly filled by liquid streaming in from the other cooler zone.

10. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission,

cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied, dividing the vessel into two communicating zones with different temperatures of the liquid; said screen being shaped as a plate, preferably plane, and provided with a rim for accumulating the vapor bubbles formed in the liquid between said surface and the screen to large bubbles.

11. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied, dividing the vessel into two zones with different temperatures of the liquid; said screen being provided with an aperture and dimensioned in such a way in relation to the heating vessel that the vacant space after the vapor bubbles leaving the screened off hotter zone may be rapidly filled by liquid from the other cooler zone through said aperture and the interspace between the screen and the vessel.

12. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied, dividing the vessel into two communicating spaces with different temperatures of the liquid; said screen being provided with a hole covered by a plate acting as a valve between the screened off hotter space between said surface and the screen and the other cooler space in the vessel.

13. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is

supplied, dividing the vessel into two communicating spaces with different temperatures of the liquid; said screen being made at least in part of heat-insulating material so as to decrease the heat losses from the screened off hotter space to the cooler space in the vessel.

14. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen in the form of a movable member, placed at a suitable distance from the surface of the vessel where heat is supplied and dividing the vessel into two separate spaces with different temperatures of the liquid; said member being provided with a valve allowing communication between the hotter space and the other cooler space in said vessel; said latter space being connected with said second vessel through both the last-mentioned connection and the pipe system.

15. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied, dividing the vessel into two communicating spaces with different temperatures of the liquid; said conduit being provided with a valve, suitably placed near the inlet to the heating vessel, allowing the liquid to flow into said vessel when underpressure is prevailing in same, but not to flow in the opposite direction when overpressure is prevailing in same.

16. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied, dividing the vessel into two communicating spaces with different temperatures of the liquid; said latter connection being carried out as a pipe with one or more openings placed higher than the normal upper level of liquid in said second vessel.

17. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second

vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied, dividing the vessel into two communicating spaces with different temperatures of the liquid; said latter connection comprising a pipe with a valve which on pressure being changed in the heating vessel allows the liquid to flow from one vessel to the other but not in the opposite direction.

18. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; and another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied, dividing the vessel into two communicating spaces with different tempera-

tures of the liquid; said conduit being provided with a valve, preferably placed near the outlet from the heating vessel, allowing the liquid to flow from said vessel out into the conduit to said heat emitting device when overpressure is prevailing in said vessel, but not to flow in the opposite direction when underpressure is prevailing in same.

19. Apparatus for effecting circulation of a liquid in a pipe system for heat transmission, cooling and the like, comprising in combination, a closed vessel with a heating device; a second vessel; a conduit between the two vessels including the pipe system and connected to a heating element in a heat emitting device; another connection between the two vessels allowing a liquid filling the pipe system and the closed vessel completely and the second vessel to a certain level to flow from one vessel to the other but not in the opposite direction; said closed vessel including a screen placed at a suitable distance from the surface of the vessel where heat is supplied, dividing the vessel into two communicating spaces with different temperatures of the liquid; and a pumping arrangement comprising a movable organ, for instance bellows, preferably connected to said heating vessel, by means of which the pressure changes in the circulation apparatus resulting from the heating of said vessel may be used for delivering mechanical work.

NILS WILHELM UNGE.