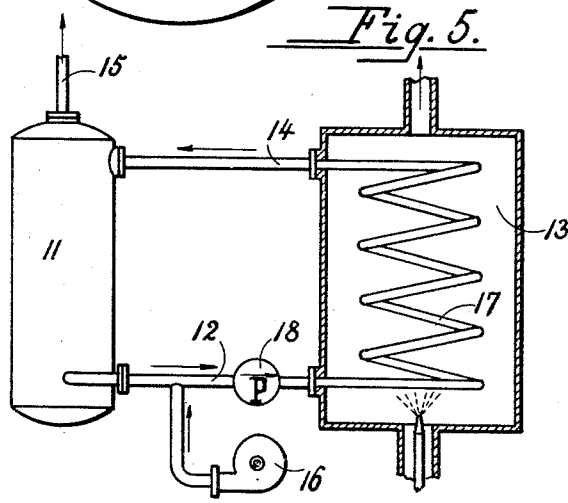
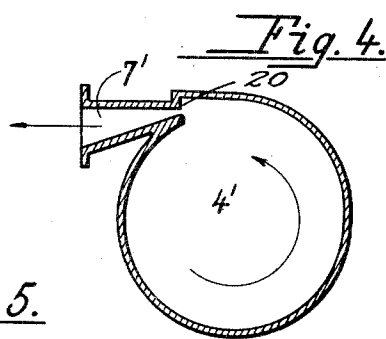
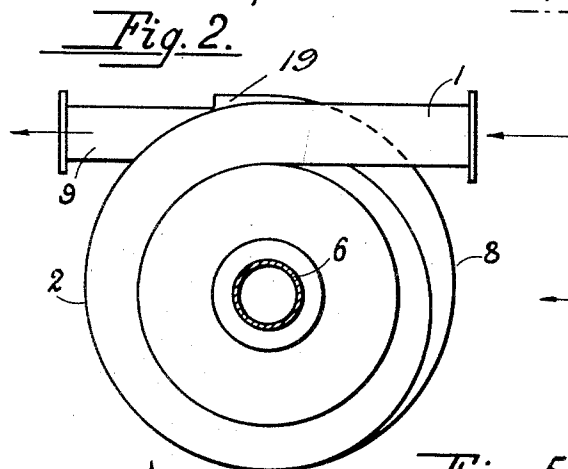
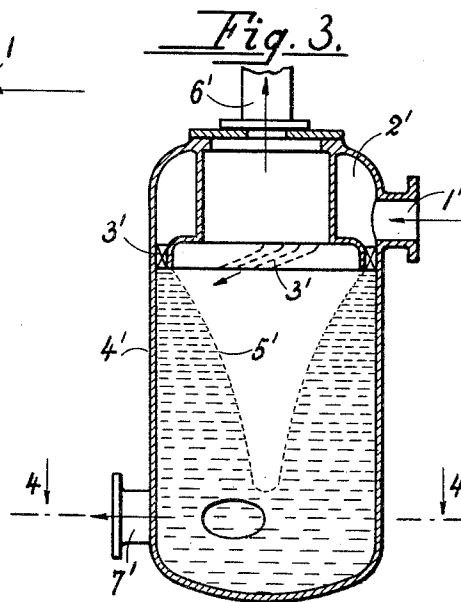
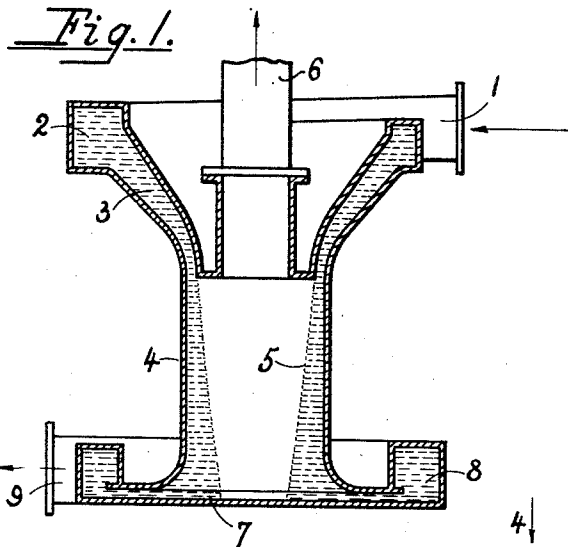


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UNITED STATES PATENT OFFICE

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The present invention relates to a method and means for separating gaseous matters from liquids, more particularly to methods and means making use of centrifugal forces and in which the energy needed for setting up said centrifugal forces in the liquid and gas mixture is recovered.

It is well known to separate liquids and gases or vapors by conducting the mixture tangentially into a hollow, rotund body in which separation is effected by the difference of the centrifugal force set up in the heavier liquid and in the lighter gas. In order to increase the separating effect, the mixture must be introduced into the hollow body at high velocity. The energy needed for doing this was, up to the present, considered to be lost.

The present invention is based on the perception that theoretically the pressure obtained when retarding the liquid after it has released the gas originally contained therein is greater than the pressure required for accelerating the liquid. This is due to the smaller specific volume of the liquid as compared with that of the mixture, no matter whether there was a mixture of gas and liquid before the entrance of the accelerating nozzle or whether the mixture originated by vaporization caused by the expansion in the nozzle. It is therefore possible to raise the pressure of the liquid higher than was the pressure of the mixture before entering the accelerating nozzle or nozzles.

An object of the present invention resides in the provision of a separator for separating by centrifugal force a liquid and a gas from a liquid and gas mixture, whereby the energy imparted to the mixture for generating the centrifugal force is used to raise the pressure of the liquid freed from the gas higher than the pressure prevailing in the separator. The regained pressure head may be used to supply the power for circulating the liquid, for example, through a system of heat exchangers, and to save the otherwise necessary circulating pump or at least to substantially assist such pump.

A further object of this invention is to provide a separator as set forth and having nozzles in which the mixture is accelerated and also nozzles in which the speed of the liquid is retarded and in which last mentioned nozzles recirculation is accomplished, whereby said nozzles are of particular shape in order to improve the efficiency of the recompression. I have found that the accelerating nozzles should be as straight as possible in order to assure good acceleration of the two components of the mixture and that

said nozzles are preferably arranged in the form of a hyperboloid. There is a certain preferable proportion between the length of the nozzles and their cross section, the length of nozzles of rectangular cross section being at least four times as much as the small side of the rectangle. Of similar importance is the arrangement of the retarding channels. The best form is an annular channel in which the liquid moves from the inside to the outside and in which the circumferential component of the speed of the liquid is the smaller, the larger the radius on which the liquid particle moves. Guide vanes or diffuser-like channels may also be used.

Further and other objects of the present invention will be hereinafter set forth in the accompanying specification and claims and shown in the drawing which, by way of illustration, show what I now consider to be a preferred embodiment of my invention.

In the drawing:

Fig. 1 is a diagrammatic, longitudinal, cross sectional view of a separator according to the present invention.

Fig. 2 is a top view of a separator as shown in Fig. 1.

Fig. 3 is a diagrammatic, longitudinal, cross sectional view of another embodiment of the present invention.

Fig. 4 is a cross sectional view of the separator shown in Fig. 3 and taken along line 4-4 of Fig. 3.

Fig. 5 is a diagrammatic lay-out of a separator and fluid circulating system according to the present invention.

Like parts are designated by like numerals in the drawing.

Referring more particularly to Fig. 1 of the drawing: 1 is the inlet for the liquid-gas mixture. This inlet terminates tangentially in the spiral casing 2. In an accelerating means in the form of a channel 3 the mixture is accelerated to high velocity. The total length of channel 3, through which the mixture must pass, is approximately four times as great as the width of the channel, so that liquid and gas leave the channel at approximately the same speed. The vertical central section of the channel is of approximately hyperbolic configuration. The absolute path of the mixture is almost straight, so that an advance separation by centrifugal force is avoided in the accelerating channel. 4 represents the cylindrical separating chamber. 5 represents the surface of the rotating liquid, which liquid is pressed against the outer part of cham-

ber 4, whereby the vapor or gas contained in the mixture leaves the mixture at the surface 5, i. e., the inner parts of the path of the mixture through chamber 4. Pressure recovering means 5 7 are provided in the form of a disc shaped annular channel in which the liquid flows outwards. The cross sectional dimension of the channel available for the flow of the liquid becomes greater, the further outwards the liquid 10 flows; its speed is thereby retarded, and the kinetic energy of the liquid is transformed into pressure. The liquid is collected in spiral casing 8 and removed through outlet 9. The separated gas exits from the apparatus through outlet 15 6.

In the modified separator as per Figs. 3 and 4 of the drawing, 1' represents the inlet for the gas-liquid mixture. This inlet leads into chamber 2'. The mixture is accelerated in the nozzles 20 3', of which there is a great number annularly arranged adjacent to the outer wall of chamber 2'. Separation takes place in the separating chamber 4'. 5' represents the surface of the rotating liquid body. The separated gas exits through conduit 6' and the liquid through the 25 diffuser channel 7' which is tangentially attached to chamber 4' and in which the kinetic energy of the liquid is partly converted into pressure due to the increase in cross sectional area available for liquid flow in the diffuser, which increase 30 causes a retarding of the speed of the fluid and transformation of kinetic energy into static energy.

Fig. 5 illustrates how the present invention can 35 be utilized for producing circulation in an evaporator or steam generator. 11 represents a separator according to the present invention and as illustrated in Figs. 1 and 2 or Figs. 3 and 4 of the drawing. From separator 11, the liquid flows 40 through a heated tube system 17 arranged in heater 13. In system 17, the liquid is heated and may be partly evaporated. The heated liquid or the mixture of liquid and vapor is conducted through conduit 14 back into the separator 11. 45 There, due to the reduction of pressure, vapor is generated and separated and withdrawn for further use through outlet 15 which corresponds to outlets 6 and 6' in Figs. 1 and 3. The liquid returns to the evaporator through conduit 12 for 50 being further heated and vaporized. The kinetic energy recovered in separator 11 takes care of the circulation through circuit

11-12-17-14-11,

55 and, as soon as the process is in operation, no circulating pump or the like is required. If, due to variable supply of heat, the vapor produced in heater 13 varies, an approximately proportional multiple amount of liquid is automatically 60 circulated through tube system 17. The evaporated liquid is replaced by liquid pumped into the system by means of feed pump 16. To assist circulation, for example, when starting up the system, a circulating pump 18 may be provided. 65

In casing 8 of the apparatus shown in Figs. 1 and 2 or 4' of that shown in Figs. 3 and 4, additional space may be arranged which serves as liquid storage room and/or as mud separator. 70 Since the mud, due to the centrifugal action, moves towards the outer wall of chamber 8 or 4', separation of mud from the liquid leaving the apparatus may be attained by attaching the outlet 9 in the apparatus according to Figs. 1 and 2 or the pressure regaining nozzle 7' of the separator 75 as per Figs. 3 and 4 in such manner to the casing

8 or 4', respectively, that the outer layers of the liquid which contain most of the mud are comparatively stagnant, and liquid is withdrawn from the inner layers. In the embodiments of my invention shown in Figs. 1 to 4, inclusive, this is 5 attained by attaching outlets 9 and 7' at a comparatively smaller diameter, whereby dead spaces 19 and 20 are created in which undesired mud collects.

While I believe the above described embodiments of my invention to be preferred embodiments, I wish it to be understood that I do not 10 desire to be limited to the exact details of method, design, and construction shown and described, for obvious modifications will occur to a person 15 skilled in the art.

I claim:

1. The method of separating gas from a liquid in a high pressure gas liquid mixture, comprising the steps of first setting up a tangential flow of the gas liquid mixture to cause subsequent rotational movement thereof, thereafter progressively increasing the rotational speed of the moving liquid by progressively restricting the cross sectional area of the flowing liquid and then causing 25 centrifugal separation of the liquid from the gas, and in thereafter progressively and gradually reducing the rate of flow of the liquid by progressively and gradually increasing the cross sectional area of the flowing liquid to transform the kinetic energy of the liquid into static pressure energy. 30

2. The method of producing and separating vapor from a liquid consisting in subjecting the liquid to heat, in thereafter accelerating the vapor-liquid mixture by progressively restricting the cross sectional area of the flowing mixture, in setting up centrifugal forces in the mixture and thereby separating the vapor from the liquid, and in thereafter progressively and gradually retarding the rate of flow of the liquid freed from the vapor for thereby transforming the kinetic energy of the liquid into static pressure, and in then again heating the liquid under pressure. 40

3. A separator for separating gas and liquid in a gas-liquid mixture, said separator comprising a 45 housing defining a stationary gas and liquid inlet channel, said housing having a stationary circular outer wall, a separating chamber directly connected with said gas and liquid inlet channel and including a second stationary outer wall which 50 has a circular interior and which forms a continuation of the outer wall of the aforesaid housing, the interior of said second outer wall affording a surface along which the gas liquid mixture emerging from the inlet channel is passed circumferentially at high speed to afford separation of the liquid from the gas by centrifugal force, a pressure recovering section comprising another chamber directly connected with the aforesaid chamber to receive flowing liquid therefrom, said other chamber having wall portions which provide a gradually increasing area for liquid flow for gradually retarding the speed of flow of the liquid separated from the gas whereby the pressure of the liquid is gradually raised to transform the kinetic energy of the liquid into static pressure energy. 55 60 65

4. A separator for separating gas from liquid in a high pressure gas liquid mixture, said separator being composed wholly of stationary parts 70 including an inlet chamber housing, a separating chamber housing connected thereto, and a pressure recovering housing connected to said separating chamber housing, means for introducing the gas liquid mixture into the inlet chamber 75

housing, means for withdrawing the liquid from the pressure recovering housing, said inlet chamber housing including wall portions arranged to first set up tangential flow of the incoming gas liquid mixture and then to direct such mixture with a rotational movement into the stationary separating chamber housing, said inlet chamber housing also including portions arranged to progressively increase the rotational speed of the flowing mixture, said separating chamber housing having stationary outer wall portions the interior surfaces of which are so shaped that said rotational movement of the flowing mixture brings about centrifugal separation of the gas from the liquid, said pressure recovering housing having wall portions which are shaped to progressively and gradually increase the cross sectional area of the liquid flowing to the withdrawing means whereby kinetic energy of the flowing liquid is transformed into static pressure energy.

5. A vapor separator and generator for producing vapor from a liquid comprising, in combination, a heated tube system having an outlet and an inlet, a stationary vapor separator comprising a housing defining a stationary gas and liquid inlet channel, said housing having a stationary circular outer wall, said inlet channel being connected with the outlet of said tube system to receive heated gas and liquid therefrom, a separating chamber directly connected with said gas and liquid inlet channel and including a second stationary outer wall which has a circular interior and which forms a continuation of the outer wall of the aforesaid housing, the interior of said second outer wall affording a surface along which the gas liquid mixture emerging from the inlet channel is passed circumferentially at high speed to afford separation of the liquid from the gas by centrifugal force, a pressure recovering section comprising another chamber directly connected with the aforesaid chamber to receive flowing liquid therefrom, said other chamber having wall portions which provide a gradually increasing area for liquid flow for gradually retarding the speed of flow of the liquid separated from the gas whereby the pressure of the liquid is gradually raised to transform the kinetic energy of the liquid into static pressure energy and a conduit connecting said pressure recovering section and said inlet of said tube system for fluid flow, the liquid being caused to flow through said tube system by the pressure recovered in said pressure recovering section.

6. A separator for separating gas from liquid in a gas-liquid mixture, said separator being composed wholly of stationary parts including an inlet chamber housing, a separating chamber housing connected thereto, and a pressure recovering housing connected to said separating chamber housing, means for introducing the gas-liquid mixture into the inlet chamber housing, means for withdrawing the liquid from the pressure recovering housing, said inlet chamber housing including wall portions arranged to first set up tangential flow of the incoming gas-liquid mixture and then to direct such mixture with a rotational movement into the stationary separating chamber housing, said inlet chamber housing including wall portions of substantially hyperbolic configuration to form a substantially hyperbolic mixture accelerating chamber for progressively increasing the rotational speed of the flowing mixture, said accelerating chamber having a large diameter end into which the gas-liquid mixture is tangentially introduced from

said inlet chamber housing and having a small diameter end from which the flowing liquid tangentially enters said separating chamber housing, said separating chamber housing having stationary outer wall portions the interior surfaces of which are so shaped that said rotational movement of the flowing mixture brings about centrifugal separation of the gas from the liquid, said pressure recovering housing having wall portions which are shaped to progressively and gradually increase the cross sectional area of the liquid flowing to the withdrawing means whereby kinetic energy of the flowing liquid is transformed into static pressure energy.

7. A separator for separating gas from liquid in a high pressure gas liquid mixture, said separator being composed wholly of stationary parts including an inlet chamber housing, a separating chamber housing connected thereto, and a pressure recovering housing connected to said separating chamber housing, means for introducing the gas liquid mixture into the inlet chamber housing, means for withdrawing the liquid from the pressure recovering housing, said inlet chamber including wall portions arranged to first set up tangential flow of the incoming gas liquid mixture and then to direct such mixture with a rotational movement into the stationary separating chamber housing, said inlet chamber housing also including portions arranged to progressively increase the rotational speed of the flowing mixture, said separating chamber housing having stationary outer wall portions the interior surfaces of which are so shaped that said rotational movement of the flowing mixture brings about centrifugal separation of the gas from the liquid, said pressure recovering housing having wall portions which are shaped to progressively and gradually increase the cross sectional area of the liquid flowing to the withdrawing means whereby kinetic energy of the flowing liquid is transformed into static pressure energy, said portions of said inlet chamber housing which progressively increase the rotational speed of the flowing mixture being at least four times as long as they are wide.

8. A separator for separating gas from liquid in a high pressure gas liquid mixture, said separator being composed wholly of stationary parts including an inlet chamber housing, a separating chamber housing connected thereto, and a pressure recovering housing connected to said separating chamber housing, means for introducing the gas liquid mixture into the inlet chamber housing, means for withdrawing the liquid from the pressure recovering housing, said inlet chamber housing including wall portions arranged to first set up tangential flow of the incoming gas liquid mixture and then to direct such mixture with a rotational movement into the stationary separating chamber housing, said inlet chamber housing also including portions arranged to progressively increase the rotational speed of the flowing mixture, said separating chamber housing having stationary outer wall portions the interior surfaces of which are so shaped that said rotational movement of the flowing mixture brings about centrifugal separation of the gas from the liquid, said pressure recovering housing having a liquid inlet portion which is concentric with said separating chamber housing and receiving the rotationally flowing liquid from said separating chamber housing substantially tangentially and having wall portions which are shaped to set up spiral outward flow of the liquid and to progres-

sively and gradually increase the cross sectional area of the liquid whereby kinetic energy of the flowing liquid is transformed into static pressure energy, said pressure recovering housing having an outlet section to which said withdrawal means are tangentially connected.

9. A separator for separating gas from liquid in a high pressure gas liquid mixture, said separator being composed wholly of stationary parts including an inlet chamber housing, a separating chamber housing connected thereto, and a pressure recovering housing connected to said separating chamber housing, means for introducing the gas liquid mixture into the inlet chamber housing, said inlet chamber housing including wall portions arranged to first set up tangential flow of the incoming gas liquid mixture and then to direct such mixture with a rotational movement into the stationary separating chamber housing, said inlet chamber housing also including portions to progressively increase the rotational speed of the flowing mixture, said separating chamber housing having stationary outer wall portions the interior surfaces of which are so shaped that said rotational movement of the flowing mixture brings about centrifugal separation of the gas from the liquid, said pressure recovering housing having wall portions which are shaped to progressively and gradually increase the cross sectional area of the liquid flowing to the withdrawing means whereby kinetic energy of the flowing liquid is transformed into static pressure energy, said pressure recovering housing including diverging wall portions which are substantially tangentially connected with said separating chamber housing and progressively and gradually increase the cross sectional area of the flowing liquid to transform kinetic energy of the flowing liquid into static pressure energy.

10. A separator for separating gas from liquid in a high pressure gas liquid mixture, said separator being composed wholly of stationary parts including an inlet chamber housing, a separating chamber housing connected thereto, and a pressure recovering housing connected to said separating chamber housing, means for introducing the gas liquid mixture into the inlet chamber housing, said inlet chamber housing including wall portions arranged to first set up tangential flow of the incoming gas liquid mixture and then to direct such mixture with a rotational movement into the stationary separating chamber housing, said inlet chamber housing also including portions to progressively increase the rotational speed of the flowing mixture, said

separating chamber housing having stationary outer wall portions the interior surfaces of which are so shaped that said rotational movement of the flowing mixture brings about centrifugal separation of the gas from the liquid, said pressure recovering housing having wall portions which are shaped to progressively and gradually increase the cross sectional area of the liquid flowing to the withdrawing means whereby kinetic energy of the flowing liquid is transformed into static pressure energy, said pressure recovering housing including diverging wall portions which are substantially tangentially connected with said separating chamber housing and progressively and gradually increase the cross sectional area of the flowing liquid, and a mud collecting pocket disposed substantially adjacent to the point of connection of said diverging wall portions and said separating chamber housing.

11. A separator for separating gas and liquid in a gas-liquid mixture, said separator comprising, in combination, inlet channel means in which the gas-liquid mixture is expanded and thereby accelerated, a separating chamber comprising a circular wall, said channel means and said separating chamber being so connected that the gas-liquid mixture is passed at high speed around the interior of said chamber whereby the liquid is separated from the gas by centrifugal force, and a liquid flow retarding and pressure recovering means comprising a flat annular conduit the inner part of which is connected for fluid flow with said chamber, a liquid outlet conduit substantially tangentially connected with the outer part of said conduit, and a mud collecting pocket adjacent to the point of connection of said outlet conduit and said annular conduit.

12. A separator for separating gas and liquid in a gas-liquid mixture, said separator comprising, in combination, inlet channel means in which the gas-liquid mixture is expanded and thereby accelerated, a separating chamber comprising a circular wall, said channel means and said separating chamber being so connected that the gas-liquid mixture is passed at high speed around the interior of said chamber whereby the liquid is separated from the gas by centrifugal force, a liquid flow retarding and pressure recovering means comprising a flat annular conduit the inner part of which is connected for fluid flow with said chamber, and a liquid outlet conduit substantially tangentially connected with the outer part of said conduit.

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