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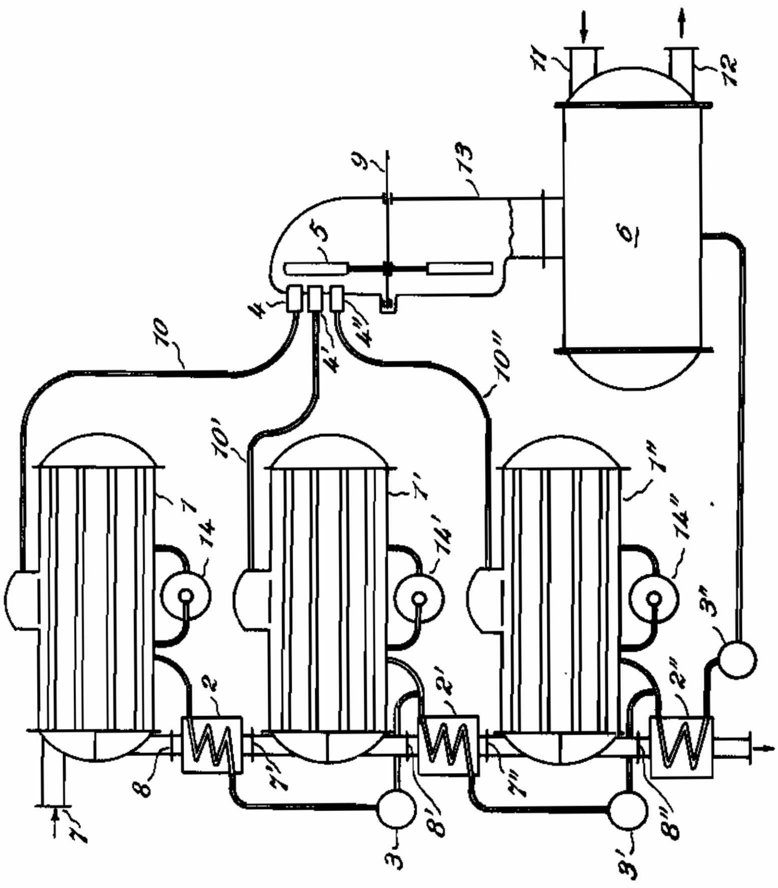

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PROCESS AND DEVICE FOR THE UTILISATION OF THE HEAT CONTAINED IN THERMAL OR ANYHOW WARM WATERS WITH THE OBJECT OF PRODUCING MOTIVE POWER

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The present invention relates to a process for the utilisation of the heat contained in thermal or anyhow warm waters with the object of producing motive power.

Object of the invention is equally a device allowing the realisation of such a process.

Besides thermal waters there may be considered as sources of thermic energy, to be utilised according to the invention, warm waters in general as for instance waste waters of industrial works and the like. The warm water at disposal has to be in presence of a convenient source of cold water or in exceptional cases in presence of cold air.

A form of realisation of the invention is illustrated in the accompanying drawing in which the only figure schematically shows an installation where the heat is utilised for actioning a turbine.

With reference to the drawing the warm water yields heat through metallic walls in a series of evaporators 1, 1', 1'' . . . disposed in a cascade cycle evaporising a fluid of a high molecular weight and having an ebullition point of 760 mm mercury near to the atmospheric temperature considered about 15° C. A convenient fluid may be the normal butane with a molecular weight 58 (18 being the one of water), boiling at the atmospheric pressure of one centigrade. The water is through the connecting piece 7 admitted into the tubes of the first evaporator 1 at the temperature T_1 and exists at outlet 8 after yielding heat to the liquid in ebullition at the temperature $T_2<T_1$. The ebullition temperature of the fluid contained in the body of the evaporator 1 is slightly smaller than T_2 the difference being of some degrees centigrade for the good utilisation of the transmission through the wall. Before flowing to the subsequent evaporator 1', the water at the temperature T_2 feeds a pre-heater 2 of the motive liquid feeding the first evaporator taking the liquid from the second pre-heater 2' by means of a pump 3. The tepid water is then admitted in 7' into the evaporator 1', from which after yielding heat to the fluid thereof exists in 8' at the temperature $T_3<T_2$. The temperature of evaporation in 1' is slightly smaller than T_3 for the said reasons. The water at temperature T_3 flows across a new pre-heater 2' and passes to the thin evaporator 1'' and so on till it is definitively discharged after flowing through a last pre-heater 2'' fed by the condenser 6 through the pump 3''. The number of evaporators may be fixed in an arbitrary way. Each pre-heater takes liquid from the inferior pre-heater in such a quantity that it will be sufficient for all the superior evaporators. The delivery of the different pumps 3'', 3', 3 is consequently decreasing as the temperature of evaporation increases.

The elastic fluid is selected among those with a high molecular weight on the base of the physical principle that the discharging speed of a saturated vapour in an adiabatic expansion between two temperatures is with a good approximation inversely proportional to the square root of the molecular weight of the same vapour; consequently with the butane and isobutane, molecular weight being 58, there may be obtained in the useful interval of temperatures for tepid waters, namely between 100° C and 15° C, discharging speeds about the half of those to be reached with the steam in the same interval of temperature (molecular weight of water being 18).

Furthermore butane as well as isobutane are chosen owing to their characteristic thermodynamic propriety that in an adiabatic expansion, when starting from a saturated, dry vapour at the temperature T_1 instead of obtaining at the temperature T_2 a damp vapour, an overheated vapour is obtained, the superior limit curve in the entropy temperature diagram having, in the useful interval of temperature, that is between 10 and 100° C, the characteristic of an entropy increasing with the temperature. On the contrary the greater part of the other fluids present the superior limit curve with a decreasing entropy as the temperature increases.

This characteristic propriety allows in those machines which in absence of overheaters supply vapour generally saturated and damp, to produce, after the expansion, vapour deprived of humidity. The absence of humidity allows to suppress the braking and corroding action of the fluid on the turbine impeller, while the low discharging speed of the vapour allows the choice of a pure steam action turbine comprising an only wheel with a simple crown of blades though preserving a very good proportion between the peripheric speed of the wheel and the discharging speed of the vapour, equal to about 0,5. This could not have been possible with water steam reaching in said interval a discharging speed of about 1000 meters a second and a remarkable humidity after the adiabatic expansion.

The different evaporators are not filled with butane or other fluid of the same kind, but they contain water put into active circulation within the evaporator by means of convenient pumps 14, 14', 14''.

The butane or another liquid of the same type is injected by the feeding pumps under the shape of very small drops, that is minutely fractioned, so that there is obtained with the water contained in the evaporator a species of emulsion. In such a way the water contained in the evaporator, owing to the high speed impressed by the circulation pump, relatively to the heating surfaces, allows a high coefficient of heat transmission between water and walls, while the minutely fractioned liquid, to be evaporated, establishes a very large separating surface between water and liquid, which, not being mixable in the water, evaporates with a total great coefficient of transmission.

The different water fed evaporators at a gradually decreasing temperature have consequently evaporation pressures, which, owing to the very small partial pressure of the water steam contained in the evaporator, may be considered as those of the saturated vapours of butane at the temperature taken by the internal water. These evaporation pressures of the butane will be, on their turn, decreasing from the first to the last evaporator. Supposing p, p', p'' . . . are the pressures respectively corresponding to **1**, **1'**, **1''** . . . each evaporator feeds through the tubings **10**, **10'**, **10''** . . . the nozzles **4**, **4'**, **4''** . . . of the only turbine **5** disposed on a circumference concentric with the shaft **9**. In each series of nozzles, the vapour, which may be considered of butane exclusively is expanded from the initial pressure of the respective evaporator to the final p_2, the only one for all, that is the one reigning in the condenser **6** and fixed by the quantity and temperature of the cold water at disposal. This water is admitted in the condenser in **11** and discharged in **12**.

Consequently in the nozzle or series of nozzles **4** the vapour is expanded between the pressure p and the pressure p^2, in **4'** between the pressures p' and p^2 and so on. As the pressures p, p', p'' are decreasing, the drops of pressures in the different nozzles are also decreasing and the discharging speeds of the different series of nozzles are equally decreasing from **4** to **4'** to **4''** . . . . Supposing C, C', C'' to be the respective discharging speeds of the different series of the nozzles, all the series of nozzles feed all together an only action wheel with an only crown of blades **6**. The nozzles are disposed in such a way that they may approach little by little the centre as their respective discharging speed is smaller. In this manner each series actions the blades of the turbine on a circumference of a gradually smaller radius and consequently with a gradually smaller peripheric speed. The distances from the centre of the different series of nozzles are such, that if C, C', C'' are the respective discharging speeds, they hit the blade in such points that

$$U/C,\ U'/C',\ U''/C''\ \ldots = Z$$

U, U', U'' . . . being the respective peripheric speeds in said points, and Z being, for an action turbine with an only wheel and a simple crown of blades, the very good ratio between the peripheric speed and the discharging speed equal to ½ cos α, α being the angle made by the jet with the plane of the wheel.

The blades may be consequently constructed with a constant inclination, that is comprising an only cylindric surface to be easily obtained.

The vapour discharged from the nozzles, after working in the wheel, is discharged at the common pressure p_2 through the channel **13** of the common condenser **6** from which, after the condensation, is sent back through the pump **3''** to the different evaporators through the pre-heaters.

The temperature of evaporation in the different evaporators is fixed as follows:

If T_c is the absolute temperature of the warm water at the admission in the first evaporator and T_f the temperature of the cold water at the exit from the condenser, supposing Δt the minimum diminution of temperature owing to the heat transmission through walls relating to the extension allowable of said temperature, supposing $T_o = T_c - \Delta t$ and $T_b = T_f + \Delta t$, if the evaporators are in number of n the absolute temperatures of evaporation of the 1st, 2nd, 3rd . . . nth evaporator indicated by T_1, T_2, T_3 . . . T_n there result:

$$T_1 = \sqrt[n+1]{T_o^{n} T_b},\quad T_2 = \sqrt[n+1]{T_o^{n-1} T_b^{2}},$$

$$T_3 = \sqrt[n+1]{T_o^{n-2} T_b^{3}},\ \ldots\ T_n = \sqrt[n+1]{T_o T_b^{n}}$$

and for one whatever evaporator x

$$T_x = \sqrt[n+1]{T_o^{n+1-x} T_b^{x}}$$

corresponding to the conditions of maximum efficiency of the system of n evaporators. The number of evaporators may be even reduced to one, the general formula preserving its value.

The present invention has been illustrated and described in a preferred form of realisation but it is understood that constructive changes may be practically introduced therein without surpassing the limits of protection of the present industrial patent.

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