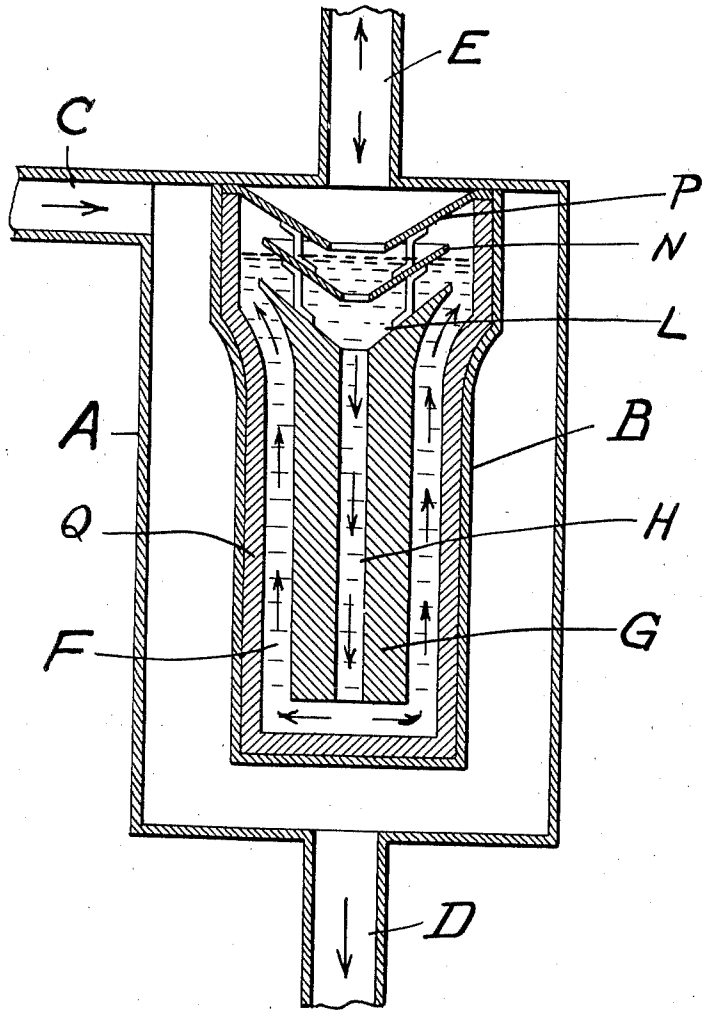
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APPARATUS FOR THE EXTRACTION OF HEAT

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APPARATUS FOR THE EXTRACTION OF HEAT

Original application filed December 15, 1924, Serial No. 755,708. Divided and this application filed August 16, 1927. Serial No. 213,350.

This invention relates to apparatus for the abstraction of heat from high temperature fluids by means of a boiling metal held in thermal contact therewith. It includes improvements and refinements which render possible commercial application of such theoretical operation. Some features included in my previous applications of July 26, 1923, Serial No. 654,054 now Patent #1,760,095 of May 27, 1930, and December 21, 1922, Serial No. 608,347, are amplified in accordance with more recent findings and others are further substantiated by certain phases of this invention correlated therewith.

In view of the improved heat transfer which I have obtained with boiling metals when in contact with metals having surfaces which they wet, I have further extended my equipment design to facilitate such wetting. In pretreating the surfaces I have found it desirable to increase the thickness of the wetted metal until it has sufficient strength to render possible complete elimination of the steel parts previously used.

My invention, therefore, includes the use of commercially pure nickel and nickel alloys, as for example, nickel steel, for use in those parts of the abstracting unit in contact with the high temperature fluid and which transfers heat therefrom. By limiting the use of the parts containing an appreciable percentage of nickel to the main heat transfer surfaces, a substantial reduction in construction cost is possible. Other metals, for example, platinum, which are wetted or form alloys which are wetted, may likewise be used. I have also discovered that ordinary iron can be effectively wetted by liquid mercury, if the iron be first plated with a substance, as for example, copper, with which the mercury will form an amalgam of a nature which will be subsequently dissipated in the body of the mercury. The formation and dissipation of the amalgam permits such intimate contact between the mercury and the iron as to result in wetting of the iron.

In addition to increase in heat transfer, the use of a wetted surface greatly precludes possibility of plugging of passages by oxides of the boiling metal or construction material or such other impurities as might accumulate. This invention further relates to use of this principle in connection with special design of surfaces and passages to insure continuous and highest rate of heat transfer. This matter is of utmost importance in equipment involving metals, the value of which makes necessary the use of passages and voids of maximum volume.

Plugging of the passages is further prevented and improved heat transfer is further obtained by provision for more rapid recirculation of the metal whereby vapor formed at the surfaces of the container is quickly swept away by unidirectional flow thereover of liquid metal, thus insuring a more constant wetting of all portions of the heat transferring surfaces and preventing the formation of a relatively poorly conducting film of vapor. During any given period, the amount of metallic liquid flowing past a portion of a heat transferring surface will be preferably more than two hundred times the amount of vapor evolved during the same period from the surface. Accordingly, notwithstanding the increase in volume of the metal attending vaporization, the liquid will be sufficient in amount to cleanse the surface from vapor. This rapid unidirectional flow of liquid contrasts with the relatively local disturbances produced when liquids are ordinarily heated, from which disturbances there results only a random production of eddies and whirls of the liquid, inoperative to remove vapor films.

By further improving the recirculation rate I have been able to insure practically constant composition in all parts of a boiling mass when mixed metals are involved. Uniform heat abstraction may be obtained with the special means provided for recirculation. With the improved design operating with mixed metals, the more volatile component on being returned to the vessel is sufficiently well mixed to give practically the same boiling point for instantaneous samples at several portions of the metal mass.

A limit to both efficiency and capacity of a heat abstractor is the rate of heat transfer between the metal walls and the fluid on one side

and the boiling metal on the other side. Decided improvement may be obtained with a coating or plating of the walls in contact with the heated fluid such that the boiling metal would wet the said walls. As a further improvement, however, I have developed a means which permits of even better and more permanent results. It consists of greatly increasing the thickness of the special coating until it is sufficiently heavy that the non-wetting metal may be definitely eliminated. For example, pure nickel tubes may be used thus yielding high rate of heat transfer, and lessening the possibility of plugging with impurities.

An economical construction may be had by making only those parts, conducting heat from the hot fluid to the boiling metal, of a metal which is wetted. Spacers and other parts may be made of other metal and improved in operation by a light plating of a wetting metal, although the latter feature is not essential.

While, perhaps, the common construction materials suitable for this improvement in operation of the abstractor are nickel and nickel alloys such as copper and iron containing alloys, other suitable materials may likewise be used. I do not, therefore, limit my claims to metals or alloys containing nickel.

The use of a single special metal rather than a coating for the heat transfer surface insures continuity of operation and eliminates possibility of cracking or peeling by overheating and inequal expansions inherent with a thin coat. The use of the recirculation principle, developed for maintaining uniform mixtures of alloys previously described together with the use of a heavy plate or entire wall of the wetting metal, insures permanent and uniform operation.

Use of a naturally wetted surface not only gives better direct heat transfer results but also exerts a secondary influence on heat transfer rate by greatly facilitating the circulation rate across the surface. The reduction in coefficient of friction obtained when the surface is wetted thus also increases heat transfer and betters the heat abstraction efficiency. Circulation rates much in excess of those heretofore obtained may thus be obtained. By circulation rate is meant the ratio of the total amount of metal passing a particular datum to the weight of that part thereof which is vaporized because of such passage during the same period.

The figure is a sectional view of one form of heat abstractor.

A represents a casing enclosing the hot fluid and containing a heat abstractor consisting of a wall B and a boiling metal F thus held in thermal contact with the hot fluid. C and D are the hot fluid inlet and outlet, respectively.

My invention includes the use of a metallic inner spacer to both decrease the mercury volume and to furnish definite passages of such design as to assist in the natural circulation. To this end, the spacer "G" is provided with a central opening H, and the slopes and passages so designed as to give definite unidirectional flow of the boiling liquid upward across the surface of B at such a rate that the vapor bubbles are quickly removed. I have found that with one or two hundred times the amount of metal vaporized sufficient metal is circulated to insure practically continuous wetting of the surface, thus eliminating the "flashing" tendency and obtaining the most efficient heat transfer. Vapor is led to a condenser or to a point of use by an attachment to the outlet "E" which may likewise be used for condensate return.

Such continuous treatment of the surface with a unidirectional flow of the metallic liquid is greatly assisted if the surfaces are pretreated so as to eliminate absorbed gases and vapor and permit of actual contact between the wall and the metallic liquid.

A tendency to prevent wetting of the surface exists in commercial installations because of the accumulation of impurities in the liquid metal. A metallic oxide is frequently met and will coat the surfaces and occupy space in chamber B, preventing proper wetting and therefore lowering the heat transfer. To prevent this, the rapidly moving liquid which continuously wets the surface is greatly decreased in volume near its upper surface and before it is started on its downward trip.

This important phase of my invention whereby I inflict differential velocities on the boiling metal has rendered commercial applications possible, as otherwise frequent cleaning of these passages would be necessary. This is a phenomenon not heretofore apparent and which is peculiar only to operation of metallic liquids which are naturally very dense as compared with ordinary liquids, as water and oil.

Continuous wetting of the surface is therefore rendered positive and certain by that phase of my invention illustrated in the figure. Here the volume occupied by F increases towards the top of the column of metallic liquid, thus reducing its velocity as it flows upward. Above the upper edge of spacer G the vertical velocity is at a minimum. The upper end of the channel H may be greatly increased in sectional area as shown at L to insure low velocity as the liquid assumes a downward motion. This low velocity permits the impurities to rise to the surface due to the buoyant effect of the heavy metallic liquid so that they will not be subsequently carried, due to the high velocity of flow, downwardly into the chamber B. They may be skimmed from the surface of the liquid when the apparatus is shut down. The de-

crease in upward velocity by increasing the area of the space occupied by the metal F materially decreases splashing, thus affording a secondary preventitive for downward passage of impurities. Baffles P and N are desirable for high velocities, the former guiding returning liquid to the central down-take section and preventing its return through a region of upflowing material, thus further extending the principle of uniflow necessary to efficient operation.

The application of a "bonded" coating of low melting metal such as lead is shown as Q. This may cover all or part of the shell B and is in contact with parts of the liquid being heated.

One of the features necessary to good design is the fastening of the fingerlike chamber B at one end only, preferably the upper end, that the opposite end is free for expansion. The inner spacer G is likewise fastened at one point with reference to its longitudinal axis that it may be free to expand. Obviously the number of "fingers" B may be multiplied.

These features are of major importance in heat abstractors embodied in this invention because of the high temperature which gives an unusual amount of expansion at a temperature approaching the weakening point of the metals used in the construction of the abstractor.

This application is filed as a division of my application Serial No. 755,708, filed December 13, 1924.

Having now fully described my invention, what I claim and desire to protect by Letters Patent is:—

In a heat interchanger for the transference of heat from a source of heat to a boiling metal, an upright wall interposed between the source and metal, the surface of the wall adjacent the metal being capable of being wetted thereby, means within the boiling metal for producing a rapid upward circulation of boiling metal across the wetted surface, means providing an enlarged space into which the upwardly circulating metal may pass and in which its velocity may decrease to facilitate separation of liquid metal from vapors or impurities, and baffles in said enlarged space.

In testimony of which invention, I have hereunto set my hand, at New York city, on this 13th day of August, 1927.

JUSTIN F. WAIT.