

Dec. 6, 1932.

T. GRISWOLD, JR

1,890,429

MERCURY BOILER

Filed Sept. 20, 1929

4 Sheets-Sheet 1

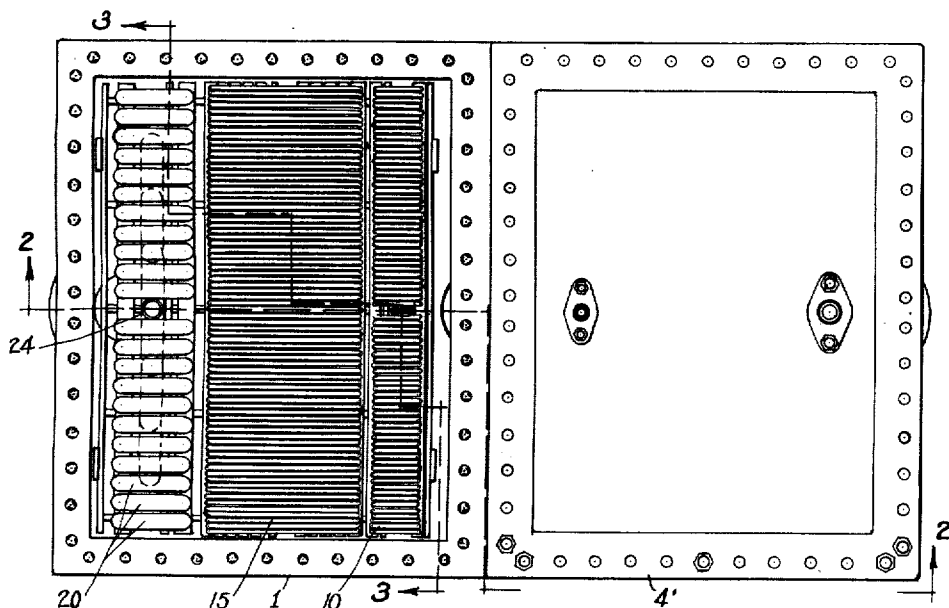


Fig. 1

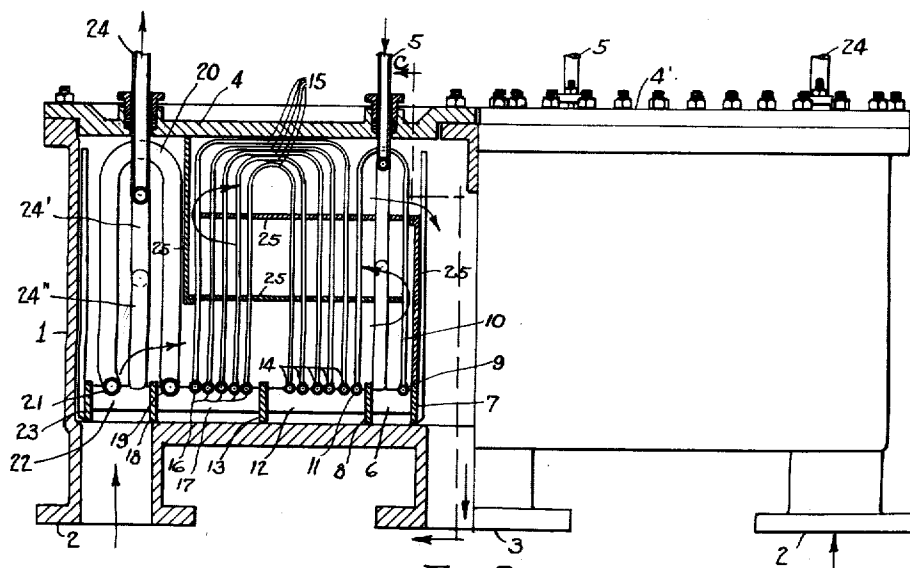


Fig. 2

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4 Sheets-Sheet 2

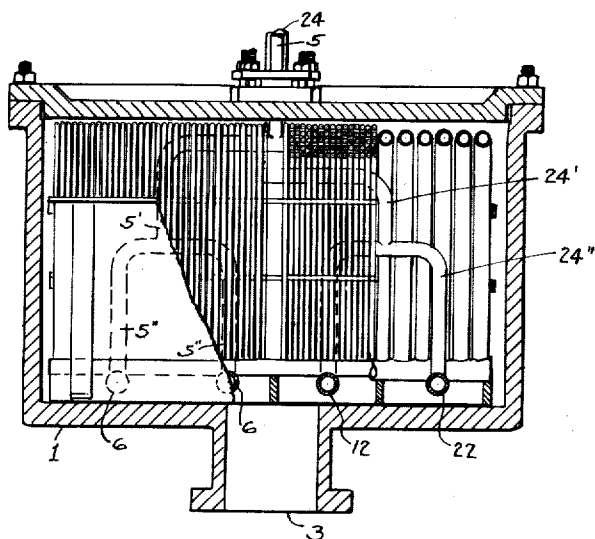


Fig. 3

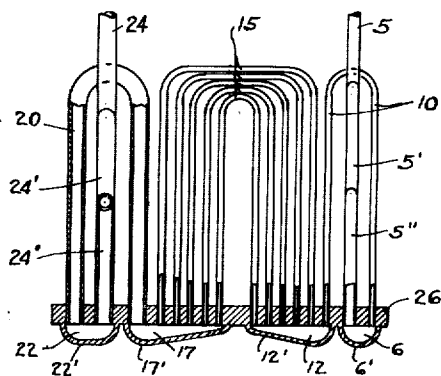


Fig. 6

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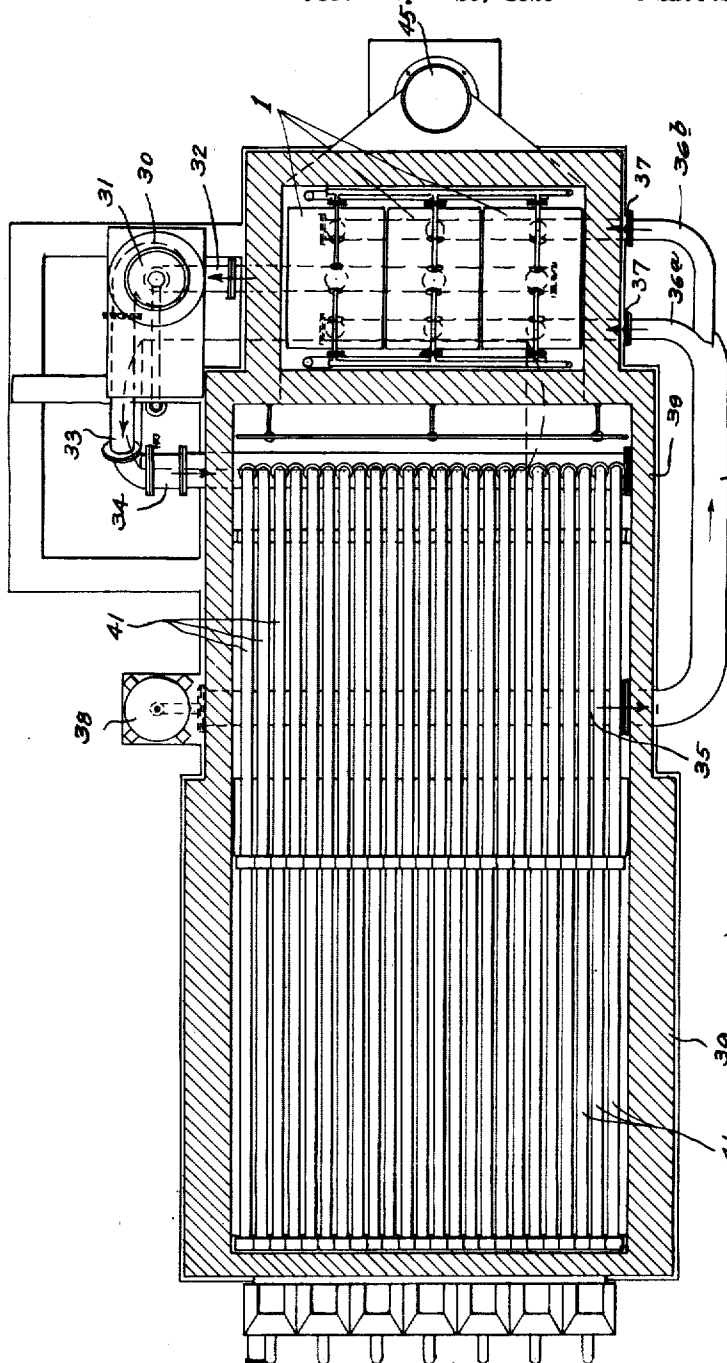
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

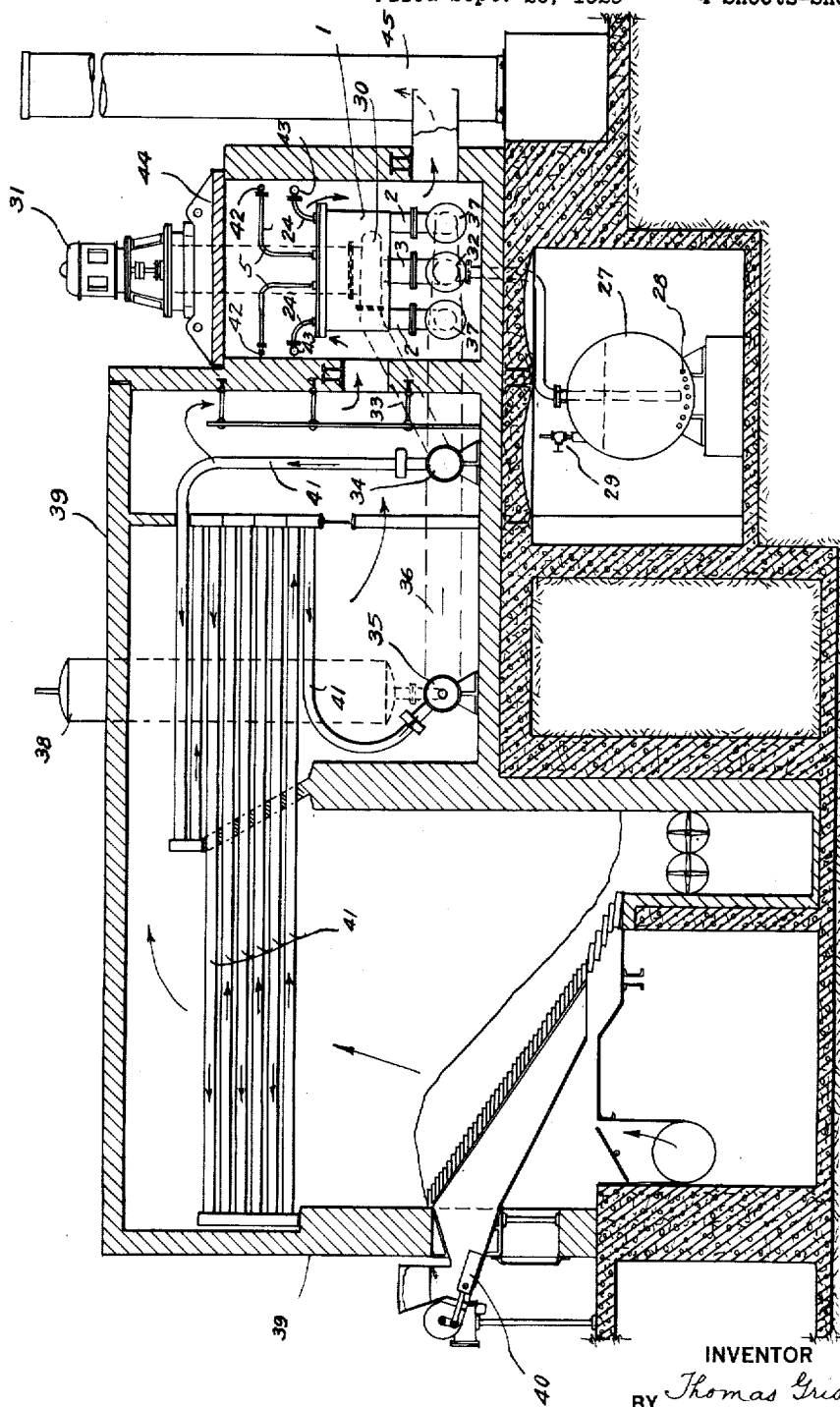


Fig. 5

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UNITED STATES PATENT OFFICE

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MERCURY BOILER

Application filed September 20, 1929. Serial No. 393,884.

This invention relates to a novel form of boiler for vaporizing mercury, employing as heating agent a hot molten metal circulated by mechanical means in heat exchange relation with a source of heat and the boiling mercury.

The economic advantage arising from the use of mercury vapor in methods of generating power, particularly in such methods employing a bi-fluid or multi-fluid cycle is known. Various attempts have been made to so utilize mercury as a power fluid, but serious difficulties have been encountered which to date have restricted development. Among such difficulties may be mentioned the following:—

Owing to the high temperature of vaporization of mercury under pressures economically advantageous, such temperature approaching or reaching a red heat, the boiling of mercury in iron tubes exposed to a fire has been attended with overheating of the tubes and damage thereto. Mercury exhibits the phenomenon of bumping, when boiling, which is particularly objectionable when a considerable depth of mercury is employed. Mercury is expensive and scarce and its general use, if in large relative ratio to the power produced, will become impractical owing to the increasing scarcity consequent upon such use and the high price to which the metal will soar in the market. Methods heretofore employed have necessitated the use of a very considerable relative weight of mercury, which circumstance definitely circumscribes the development of the mercury boiler power system, both because of the large investment and the increased hazard of large loss.

I have invented a mercury boiler and associated apparatus adapted to overcome or materially minimize the difficulties as above recited and others.

To the accomplishment of the foregoing and related ends, the invention, then, consists of the means hereinafter fully described

and particularly pointed out in the claims, the annexed drawings and the following description setting forth in detail certain means for carrying out the invention, such disclosed means illustrating, however, but some of the various ways in which the principle of the invention may be used.

In my invention I employ as heat transfer agent between a source of heat and the mercury, a molten metal such as lead or low melting alloy thereof or sodium metal, which latter is admirably suited to the purpose as is also an alloy of sodium. Such use has been disclosed in a co-pending application, Serial No. 393,867, filed September 20, 1929, by Herbert H. Dow and John J. Grebe. In such disclosed method the heat transfer agent, e. g. sodium metal, is mechanically circulated in heat transfer relation with a source of heat and the boiling mercury.

My invention relates to an apparatus forming a part of the disclosure in the above cited application and adapted to carry out the method therein disclosed and claimed.

In said annexed drawings:—

Fig. 1 is a plan view of a double mercury boiler unit with one of the covers removed to show the heating elements. Fig. 2 is a part longitudinal section on the line 2—2 of Fig. 1. Fig. 3 is a vertical transverse section upon the line 3—3 of Fig. 1. Fig. 4 is a plan view (with covers removed to show circulatory system) of a boiler assembly comprising a heater for a heat transfer agent set in a furnace and three double mercury boiler units of the type illustrated in Figs. 1, 2 and 3. Fig. 5 is a general longitudinal section through Fig. 4. Fig. 6 shows an alternative construction for the mercury boiler.

Referring now to Figs. 1, 2 and 3, 1 is a casing or container which may be of steel or iron adapted to contain a body of the heat transfer agent in which the mercury boiler is immersed. Such casing contains two similar mercury boiler units, one of which is il-

illustrated in detail. In the particular type of boiler here illustrated, such units are comprised of a plurality of hair pin-like tubes, the respective ends of which connect with headers. Said headers in turn connect with cross headers. There are three passes for the mercury, i. e., a preheating pass 10 comprised of a plurality of hair pin tubes, a vaporizing pass 15 comprised likewise of a plurality of hair pin-like tubes, and a vapor superheating pass 20 also comprised of hair pin-like tubes. The mercury to be boiled is introduced via the pipe 5 which is provided with branches 5' and 5'' connecting at their lower ends with four short headers 6. Such headers terminate in the supporting rack bars 7 and 8. The mercury preheating hair pin system 10 connects at one end thereof with the header 9, which in turn is connected with the four headers 6 and connects at the other end with the header 11. The latter in turn connects with the four short headers 12, which are terminated by the rack bars 8 and 13. The headers 9, 11, 14, 16, 19, and 21 are notched, as are also the headers 6, 12, 17, and 22, to correspond, and the first mentioned headers, i. e. those connecting and serving the hair pin tubes are welded to the latter headers, i. e. to those bonding the various sets of hair pin tube assemblies, to form proper flow connections therebetween. Connected with the short headers 12 are five headers 14 into which the ends of the hair pins 15 are connected, the other ends thereof being connected with the five headers 16 connecting in turn with the four short headers 17, which latter are terminated by the rack bars 13 and 18. A header 19 is also connected with the four headers 17 and in turn connects with the vapor superheating hair pin tubes 20, the other ends of which terminate in a header 21 connecting in turn with four short headers 22 terminated by the rack bars 18 and 23. From these four headers 22 rise four vapor pipes 24'', reducing to two vapor pipes 24' and then to one vapor outlet pipe 24. The mercury inlet pipe 5 and the mercury vapor outlet pipe 24 pass through stuffing boxes in the casing covers 4 and 4', as shown. The casing is further provided with two inlets 2 and an outlet 3 adapted to introduce and withdraw a current of a fluid. A system of baffles 25 is provided to cause the entering heat transfer agent to encounter first the super heating passes 20 and then to pass three times across the vaporizing passes 15, as indicated by the arrows, after which it leaves at the outlet 3, said outlet acting for both units contained within the unit boiler casing 1.

Means for heating the fluid heat transfer agent and for circulating it are shown in Figs. 4 and 5. In said figures a vertical centrifugal circulating pump 30 driven by a motor 31 delivers through the conduit 33 into the header 34 from which a plurality of tubu-

lar heating coils 41 rise and are led to and from the furnace setting 39, terminating as indicated in the header 35. The furnace is shown fitted with a mechanical stoker 40 and a part of the tubular heating surface 41 is exposed to radiant heat and a part to convection heat. From the header 35 a conduit 36 leads by branches 36a and 36b to the headers 37, delivering into three duplex mercury boiler units 1 similar to those already illustrated in Figs. 1, 2 and 3. From these boiler units 1, the header 32 connected therewith leads to the suction end of the pump 30.

Mercury feed headers 42 carry branches 5 entering through the covers of the mercury boiler casings, and vapor pipes 24 issuing therefrom connect with headers 43. Such headers 42 and 43 may be led out through the cover 44 of the chamber enclosing the mercury boilers or otherwise as convenient. The products of combustion of fuel after passing up and down through the bank of heating tubes 41 pass out to the stack 45 through the chamber containing the mercury boilers.

A run-down tank 27 is set below the level of the heating agent circulatory system just described and is connected thereto as shown. Such tank is provided with means for heating which may be electric, employing a resistor 28, or other sources of heat may be used. A gas connection 29 is provided for the tank 27 through which an inert gas such as nitrogen may be introduced under pressure.

An expansion tank 38 is also connected with the circulatory system to accommodate change in volume of the heating fluid. By means of connection 29 the molten metal, such as sodium or an alloy of a metal, may be forced up from tank 27 into the circulatory system, filling same. Sufficient fuel will have previously been burned in the furnace to bring the temperature of the circulatory system walls above the freezing point of the metal. The pump 30 will then be started and will set up and maintain a circulation of the molten metal in the circulatory system. Such circulation will be serially through the heating unit comprising the tubular system 41 and the mercury boiler battery comprised of the individual unit boilers 1.

In order to provide heat for the pump 30, suction pipe 32, delivery pipe 33, and connections outside of the setting, same may be cased and a part of the products of combustion passed therethrough, or heat from other convenient source may be supplied. Such alternative details will be obvious to one skilled in the art.

A modified form of construction of the mercury boiler unit is illustrated in the Fig. 6 in which the reference numerals are identical with those in Figs. 1, 2 and 3, so far as the parts shown are the same. Instead of using, however, tubular headers for the hair pin heating tubes, they, as well as the

branches of inlet pipe 5 and outlet pipe 24, are secured in a tube sheet 26 to the lower side of which are welded a series of iron or other suitable metal sheets 6', 12', 17' and 22' which form with the tube sheet 26, the header passages 6, 12, 17 and 22, respectively.

In this modified form of construction, as well as in that illustrated in Figs. 1, 2 and 3, the tubes will also preferably be welded at their ends to the headers or the tube sheets and the said headers will be welded to the cross headers in Figs. 1, 2 and 3.

Small diameter tubes will be used, preferably, for the mercury preheater and flash boiler passes; such tubes may have an internal diameter of $\frac{1}{4}$ inch or less and the headers connecting therewith will be of minimum cross section considering the requirement for distribution of flow with substantial uniformity to all connecting tubes. By such choice of small cross section, the cubic capacity or content of that part of the boiler containing liquid mercury will be held to a low value, permitting the reduction of the weight of mercury in the system to a very low figure. All mercury and mercury vapor tubing conduits and the like will likewise be of minimum cross sectional area and length for the purpose of further restricting the cubic content of the mercury circulatory system. The use further of flash evaporation will likewise minimize the quantity of mercury in the already reduced cubic content of the system.

It may be shown that in a boiler setting as herein described employing four duplex mercury boiler units in connection with a bi-fluid power system employing the mercury vapor as primary power fluid and steam as the secondary fluid vaporized in a mercury-water-condenser-boiler, a kilowatt hour may be generated with the expenditure of approximately 8,000 B. t. u. and that further the quantity of mercury in the system may be held to less than 0.5 pound of mercury per kilowatt hour capacity. Such a figure offers great advantage in the practicalization of a mercury vapor power generating system. It may be shown further that the entire mercury-boiler-sodium-heater assembly may be made very compact, the one here illustrated having a capacity of approximately 5,000 kilowatts with a plan area approximating 20 x 40 feet.

In such an installation the sodium would be heated to approximately 1200° F. in alloy steel tubes under nominal pressure due to its static head, plus pressure required for the circulation, such nominal pressure permitting safe heating of the tubes to that temperature. The mercury would be vaporized at approximately 180 pounds absolute and the vapor superheated to approximately 1100° F.

Every advantage would also be taken of countercurrent heat transfer between the sodium and the mercury and for superheat-

ing the steam with heat from the sodium. Stage heating and other refinements would also be included in such a highly economical system.

Various detailed modifications of construction may be employed without departing from the spirit of my invention. The sodium heater may be comprised of a plurality of independent heaters having an independent pump for each one, and independent paths for the sodium through the mercury boilers. By such alternative construction the risk of loss of sodium and dangers and nuisance arising therefrom will be minimized, since possible loss of sodium by any one leak or break in the system would be reduced in amount to that contained in the individual sodium circulatory system thereby affected. Modifications in the mercury boiler may obviously be made as, for instance, the separation of the mercury preheating step from the vaporizing step, and also the separation of the superheating step, and if it be desired to employ the sodium as heating agent to superheat steam generated in the mercury-water-condenser-boiler, such a superheater may be included in the sodium circulatory system or systems, preferably in that part between the mercury boiler units and the sodium heater.

Other modes of applying the principles of my invention may be employed instead of the one explained, change being made as regards the mechanism herein disclosed, provided the means stated by any of the following claims or the equivalent of such stated means be employed.

I therefore particularly point out and distinctly claim as my invention:

1. In apparatus of the character described, the combination of a plurality of metallic tube assemblies, each said assembly comprising a plurality of hair-pin tubes welded at their like ends to two tubular headers constituting inlet and outlet conduits therefor, a cross header welded to the several inlet headers, a cross header welded to the several outlet headers, said cross headers constituting respectively an inlet and outlet conduit therefor, a casing about said tube assemblies adapted to hold a molten metal, conduit means adapted to lead mercury to an inlet cross header, conduit means adapted to lead mercury from an outlet cross header, and openings in said casing adapted to receive and discharge a current of molten metal as heating agent for the mercury.

2. In apparatus of the character described, the combination of a preheater tube assembly, a vaporizer tube assembly, and a superheater tube assembly, each said tube assembly being comprised of a plurality of metallic hair-pin tubes connected by welding at like ends to separate metallic tubular headers, a tubular metallic cross header connecting at

least one outlet header of the preheater assembly with at least one inlet header of the vaporizer assembly, a tubular metallic cross header connecting at least one outlet header of the vaporizer assembly with at least one inlet header of the superheater assembly, a conduit adapted to supply mercury to the inlet header of the preheater assembly, a conduit adapted to draw off superheated vapor from the superheater assembly and a casing about said tube assemblies adapted to contain a molten metal as heating agent and having inlet and outlet openings therefor.

Signed by me, this 12 day of September, 1929.

THOMAS GRISWOLD, JR.

CERTIFICATE OF CORRECTION.

Patent No. 1,890,429.

December 6, 1932.

THOMAS GRISWOLD, JR.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, line 102, for "meai" read "metal"; page 3, after line 62, insert the sentence "The mercury vapor after expansion in a suitable power unit would be condensed in a mercury-condenser-water-boiler to generate steam. The steam after use in a suitable power unit would be condensed in the usual manner, e. g. at 70° F."; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 14th day of February, A. D. 1933.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.

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least one outlet header of the preheater assembly with at least one inlet header of the vaporizer assembly, a tubular metallic cross header connecting at least one outlet header of the vaporizer assembly with at least one inlet header of the superheater assembly, a conduit adapted to supply mercury to the inlet header of the preheater assembly, a conduit adapted to draw off superheated vapor from the superheater assembly and a casing about said tube assemblies adapted to contain a molten metal as heating agent and having inlet and outlet openings therefor.

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