

June 1, 1937.

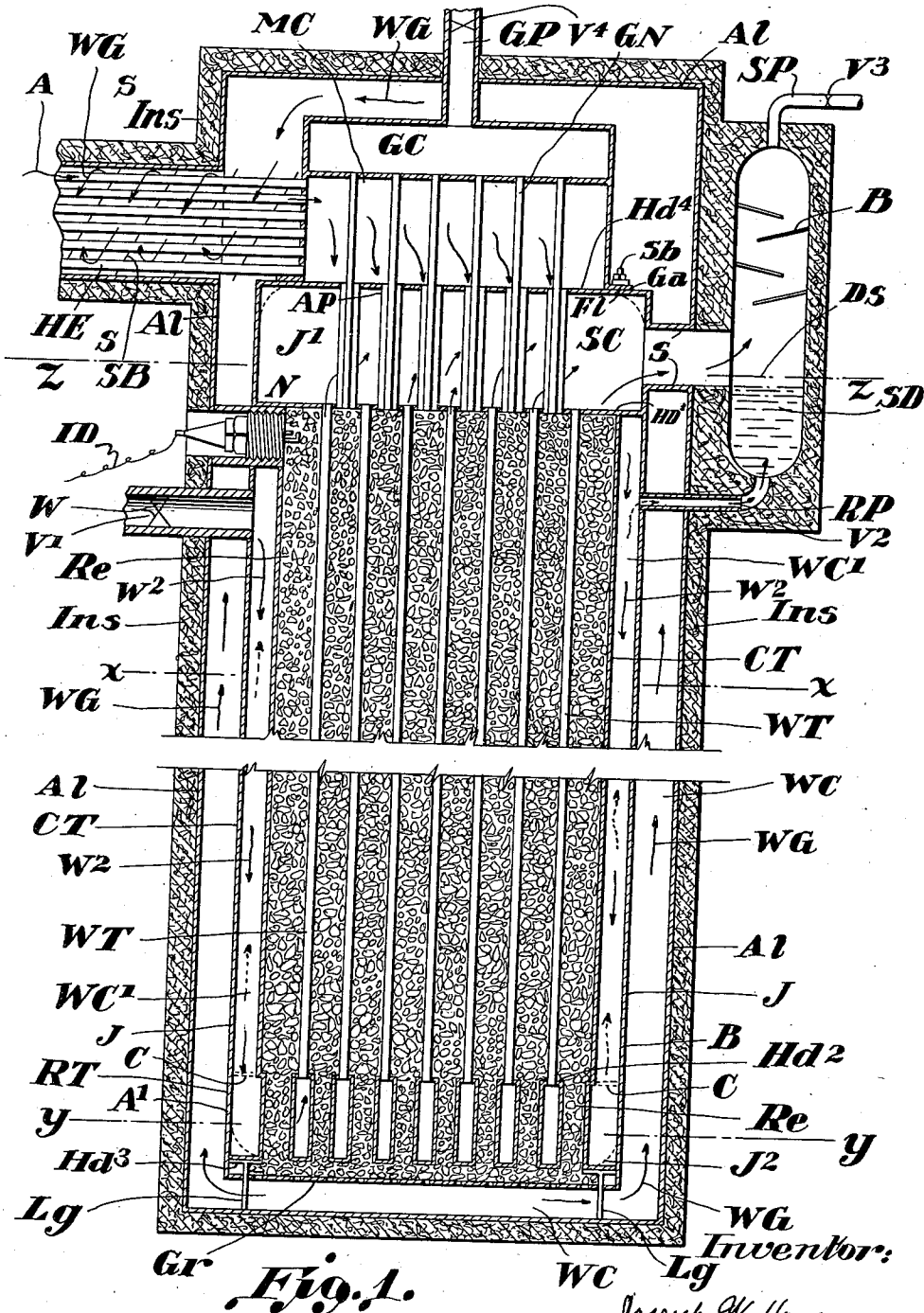
J. W. HAYS

2,082,338

PROCESS FOR THE VERY RAPID HEATING OF FLUIDS

Filed April 13, 1933

2 Sheets-Sheet 1



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Fig. 2.

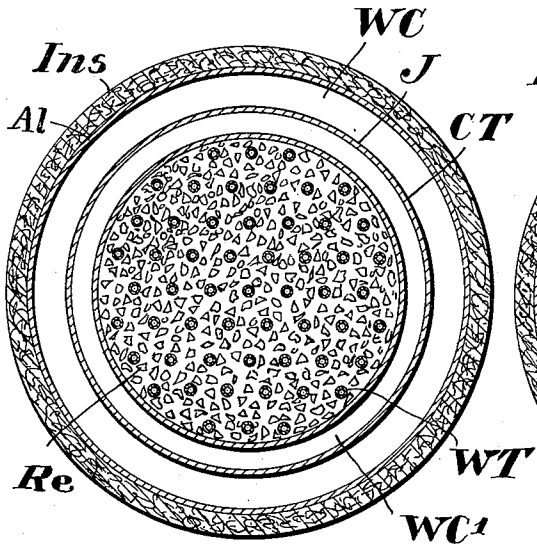


Fig. 3.

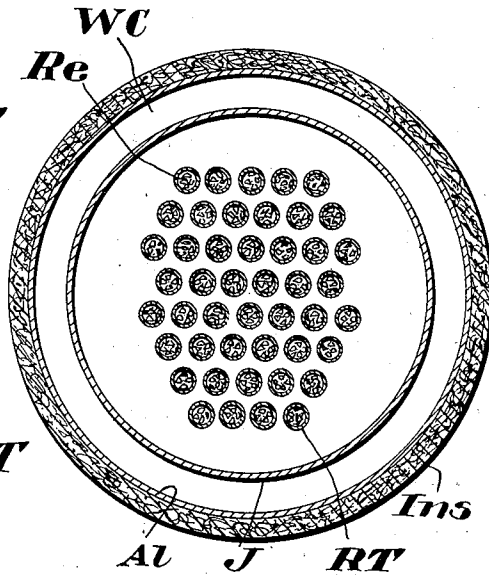


Fig. 4.

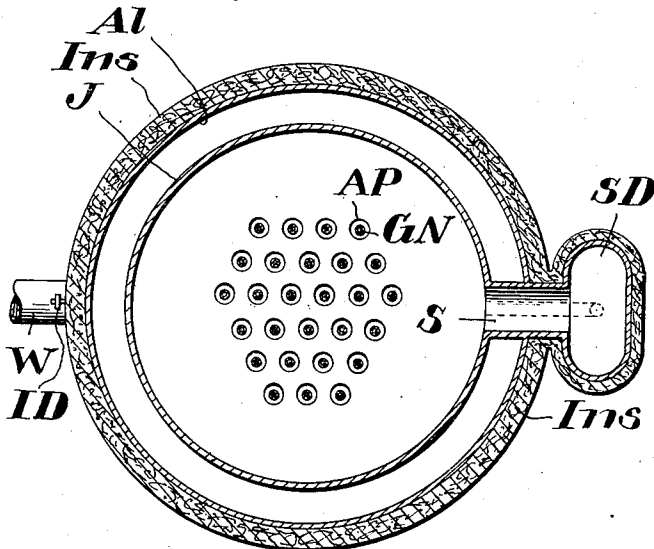
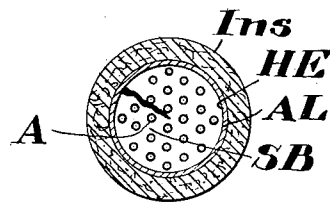


Fig. 5.



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UNITED STATES PATENT OFFICE

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PROCESS FOR THE VERY RAPID HEATING
OF FLUIDS

Joseph W. Hays, Tulsa, Okla.

Application April 13, 1933, Serial No. 665,997

3 Claims. (Cl. 122—367)

The drawings herewith, together with some of the following subject matter, have been borrowed from my copending application of even date herewith, Serial Number 665,998, for patent on improvements in Steam boilers and fluid heaters.

My process contemplates the use of a relatively small-sized boiler, or heater, of extraordinarily high capacity and capable of operating at high pressures, such a boiler as would be suitable for airplanes or automobiles, powered by steam engines or turbines, and for many other uses, whether stationary or mobile.

The steam car failed to hold its own with the gas-powered automobile because of its limited boiler capacity. For short distances the steam car, drawing upon its stored energy, could out-power its competitor, but on long runs at high speeds it could not hold its own because of the inability of its boiler to produce steam as fast as required. In the then state of the art a boiler of sufficient capacity to meet the full requirements would have been out of the question because of its size and weight.

In spite of its complicated mechanism and the dangerous characteristics of its fuel, the gasoline engine has hitherto always been supreme in the field of aviation, as well as in that of motor transport.

It is generally conceded by engineers that steam, as a prime mover, has certain marked advantages over all other means of power yet devised by man. Nothing can exceed the simplicity and flexibility of the steam prime mover.

My process makes it possible to adapt steam to the airplane and the dirigible, to motor cars, motor trains, motor boats, and to any other use or purpose where power is required.

My boiler may also be used for the quick heating of water or other liquid, such as oil, for example, and in the large quantities required for process work, and the like. As a heater my invention is also adaptable to the process of cracking.

The objects of my process are attained by means of a part or all of the apparatus illustrated in the accompanying drawings, in which—

Figure 1 is a cross-sectional view of the boiler, or heater, together with a heat exchanger for preheating the air supply for the burner, a mixing device for mixing the air with the fuel (gas or oil vapor), and a steam drum.

Figure 2 is a cross-sectional view on the line, *x—x*, Figure 1.

Figure 3 is a cross-sectional view on the line, *y—y*, Figure 1.

Figure 4 is a cross-sectional view on the line, *z—z*, Figure 1.

Figure 5 is a cross-sectional view on the line, *s—s*, Figure 1.

Similar designations are used for similar parts in the several figures.

The entire apparatus is covered with insulating material, *Ins.*

In Figure 1, *Al* is a sheet-metal support, preferably of aluminum, for the insulating material, *Ins.* *Al* is held in position by the lugs, *Lg*, and by certain fixed parts of the apparatus, such as the pipes, *W*, *S*, *GP*, etc. The boiler, proper, consists of the tubes, *CT* and *J*, the small circulating tubes *WT*, the headers, *Hd¹*, and *Hd²*, into which the small tubes, *WT*, are expanded, or welded, and to which the tube, *CT*, is welded, and the header, *Hd³*, to which the tube, *J*, is welded at one end, the other end being welded to *Hd¹*.

The space about the tubes, *WT*, within the tube, *CT*, and between the headers, *Hd¹* and *Hd²*, is packed with refractory material, *Re*. The combustible mixture, which is composed of air and gas, or air and vapor, burns in the midst of these refractories. The waste gases, *WG*, are discharged through the refractory-packed tubes, *RT*, into the waste gas chamber, *WC*, from whence they make their escape via the annular space between *CT* and *J*, and, finally, to the air through the heat exchanger, *HE*.

Gr is a grid to support the refractories in the tubes, *RT*. *W* is an inlet tube for water and connects the source of water supply with the annular space between *CT* and *J*. On entering this space the water flows with the arrows, *w*, and thus reaches the water tubes, *WT*, where it is converted into steam. *SC* is a steam chamber which is connected with the steam drum, *SD*, by the pipe, *S*. *B* is a baffle arrangement in *SD* to separate any entrained water which may be carried over with the steam. *RP* is a return pipe connecting *SD* with the water circulating space, *WC*. In most cases where the boiler is operated at very high ratings the use of *SD* may be omitted.

The steam chamber, *SC*, is formed by the headers, *Hd¹* and *Hd⁴*, and the tube, *J*. To give greater strength to the structure, *J* may be swaged, as indicated by the dotted lines, *J¹*. *J* may be swaged at the other end also, as shown by *J²*.

The igniting device, *ID*, which is shown as a spark plug, but which may be anything else answering the purpose, ignites a mixture of air and gas, or air and vapor, and initiates combustion. The air is supplied by a blower, or

by any other satisfactory means, and is delivered under as much positive pressure as desired. The air flows first through the tubes, A, of the heat exchanger, HE, where it is preheated 5 by the waste gases, WG, which, as directed by the baffle, SB, flow spirally across the tubes, A. The preheated air then enters the chamber, MC, and passes through the tubes, AP, flowing around the gas delivery pipes, GN. Gas, or vapor, as the 10 case may be, is delivered to the gas chamber, GC, through the pipe, GP, and is preferably supplied under a pressure as high as the circumstances will admit. The pipes, GN, are of small bore and are swaged to tips at the ends for small nozzle 15 vents, N.

It will be noted that the tubes, AP, are welded to the headers, Hd¹ and Hd²; that the water circulating tubes, WT, are welded to Hd¹ and Hd², and that the tubes, RT, are welded to Hd² and 20 Hd³. All of these tubes act as stays and give the structure great strength.

Pressures much in excess of 1000 pounds per square inch can be maintained with perfect safety in this boiler.

25 The possibilities of "surface", or "flameless", or "catalytic" combustion as a means of burning fuel at high rates with efficiencies not previously maintained were demonstrated as much as twenty years ago, but the process lacked certain things, 30 among others, safety, to make it practicable and workable. In my co-pending applications, Serial Numbers 653,468 and 653,469, I have shown how the process may be made safe and workable when burning fuel at unprecedented rates. The said 35 process consists in burning an explosive mixture of air and gas, or air and vapor, in a bed, or packing, of granular refractory material. When this material becomes highly heated it acts as a catalyst and accelerates the rate of chemical 40 combination to the point where combustion becomes instantaneous, or explosive, in its character. The quantity of an explosive mixture which may be burned is limited only by the abilities of the refractory materials and other parts 45 of the furnace apparatus to withstand the heat produced, or to deliver the heat to some cooling medium, as fast as produced.

Refractories with high catalytic properties and capable of withstanding temperatures as high as 50 3500° F. are now available. (Reference may here be had to my co-pending application, Serial Number 653,470.)

The effects of compression upon combustion are now known and appreciated by automotive 55 engineers, yet such a procedure as that of burning an ordinary fuel, like gas, for the ordinary purpose of producing steam but under a positive pressure of from a few to many pounds per square inch has not been considered very seriously by 60 many engineers, perhaps because of the high costs of producing such pressure. It is quite plain that the higher the moving pressure applied to a gas the greater will be the quantity of the gas moved in a given time. It follows from 65 this that if any process of combustion, such as the catalytic process, is instantaneous, or practically so, then the pressure applied to the air-gas, or air-vapor, mixture may be taken as a measure, or function, of the rate of combustion, 70 because if the volume of a gas varies inversely with the absolute pressure the weight of the gas must vary directly as the same pressure, volume being compared with volume and the temperature remaining constant.

75 While the delivery of the air and gas required

for combustion under what may be considered abnormal pressures may be shown to be uneconomical, as a general rule, for stationary power plants because of the cost of air compression, yet there are cases where such compression costs 5 nothing, as instanced in my co-pending application for patent on Closed system heaters operating under high pressure, Serial Number 672,361. There may be many such instances.

Forced-draft, producing pressures in excess of 10 the atmosphere, has been in quite general use for many years in the transportation field and, to some extent, in the stationary field. Economies are determined by balancing all of the costs of natural draft equipment and operation against 15 those of forced-draft equipment and operation. Weight is a detriment in transportation because it requires as much energy to transport the motive power plant, pound for pound, as it does to carry the revenue-producing cargo. Next to the 20 weight of the plant the space required for its accommodation and for that of the fuel is an important factor, and this is especially true of airplanes and dirigibles.

All moving bodies encounter air resistance, or 25 must move against an air pressure which may be approximately calculated by the formula, (Smeaton) $P=0.005V^2$, in which P is the pressure per square foot, and V is the velocity in miles per hour. A body moving at the rate of 10 miles 30 per hour would, therefore, encounter a resistance of .5 lb. per square foot; at 50 miles, 12.5 lbs.; at 100 miles, 50 lbs.; at 150 miles, 112.5 lbs.; at 200 miles, 200 lbs.; at 250 miles, 312.5 lbs., and at 350 miles, 450 lbs. 35

Formulas by authorities, other than Smeaton, give lower values than 0.005 for the coefficient of V.

Whatever such pressures may be, it is plain that they may be applied to useful work as a 40 means of producing draft for a fuel burner, and this at no cost at all for, or increase of weight on account of, the equipment.

My present process has nothing to do with 45 any sort of means for producing draft pressure, or for raising the pressure of the gas, or vapor, used for fuel, but it is apropos to show how pressure may be attained to some extent without cost. To this end I have called attention to available 50 air pressures, and I may add that in all cases where an oil, such as a distillate, is used as a fuel for my boiler it will be necessary to vaporize it before introduction to the burner. This may be accomplished by heating the oil in a closed vessel, employing waste heat for such purpose, 55 if available in sufficient quantity and at sufficient intensity. Vapor may thus be produced and the vapor pressure built up to any point desirable.

My process provides a means for producing steam in quantities and at temperatures which 60 are limited only by the pressures which are applied to the combustible mixture. Any such pressure may be employed, ranging from one which is barely above that of the atmosphere to hundreds of pounds per square inch. My process 65 makes this possible. The higher the pressures employed in the combustion zone the smaller the size and weight of the boiler required to produce any stated output of steam within reason.

In order that my invention may be more clearly 70 understood I shall now describe the operation of the boiler in more detail.

I have already called attention to the great strength of the structure shown, which strength is due to the fact that the flat surfaces are 75

braced and stayed by a multiplicity of tubes, AP, WT and RT. The construction is such that relatively light weight materials may be used; while the permissible pressures may be extraordinarily high.

Water is taken into the boiler, or heater, through W. The supply may come from any source and the water may be hot or cold, depending upon the purpose for which the boiler, or heater, is being used. The materials used and the proportions employed in the apparatus may be such that liquids may be taken at temperatures as high as their critical points and that vapors may be taken at cracking or other temperatures, provided in all cases that means are available for producing a circulation of the fluid, which is to be heated, through the tubes and other passages of the apparatus.

The water, which is under pressure from the feed pump, or other source, passes through the tube, W, and downward between the tubes, CT and J, receiving heat from CT and, as will be hereinafter explained, from J, also. The water next circulates around the tubes, RT, which are packed with refractory materials, Re, and then passes upwards at high velocity through the small tubes, WT, where it is heated to a high temperature or flashed into steam, depending upon the temperature at which the water is received into the circulating system and the velocity at which it is caused to flow. The tubes, WT, are surrounded with refractory materials, in the midst of and upon which the combustible mixture of air and gas, or air and vapor, burns without flame, the rate of combustion being accelerated to a very marked degree by the action of the hot refractory catalysts. A very high temperature is produced and the heat, being in the radiant form, passes with great rapidity through the walls of the tubes, WT, and those of the tube, CT, to the water or other fluid which is to be heated.

Assuming that the apparatus is being used to produce steam as a "flash" boiler:

Steam is formed in the tubes, WT, through which it passes, perhaps in a super-heated state, into the steam chamber, SC, thence through S, direct to the engines or turbines, or other destination, where it is to be utilized, the steam drum, SD, not being necessary in such circumstances.

Assuming that the apparatus is operated as a semi-flash boiler:

Mingled steam and water would pass from WT into SC, thence through S into SD, where the water and steam would be separated by the baffles, B, the steam passing out through the pipe, SP, in which there is the valve, V³. SD is connected at the bottom with the water circulating space, WC, by the pipe, RP. The arrangement is such that a disengagement surface, DS, is provided for the escape of steam from the water, while the latter may return from SD to WC through RP, as already stated.

The fuel, gas or vapor, is supplied through the pipe, GP, from any suitable source and under a pressure, preferably in excess of that of the air with which it is to be mixed, such pressure being applied or acquired in any suitable way. GC is a chamber for the gas, or vapor, from which the fluent combustible is distributed to the tubes, GN, which are, preferably, of relatively small size and provided at their discharge ends with small vents, or nozzles, N, through which the gas, or vapor, is discharged at high velocities against the refractory materials, Re.

Air, under pressure reaches the air chamber,

MC, through the pipes, A, and is distributed to the pipes, AP, through which it moves, at high velocity, around the tubes, GN, to impact upon the refractories, Re.

By means of the above movements of the air and gas, or air and vapor, the two are thoroughly mixed when the streams are "mush-roomed" by their impingement upon the opposing surfaces of Re. The mixture is ignited by the igniting device, ID, which is here shown as a spark plug, but may be anything else answering the purpose. As soon as ignition has been established ID may be switched out of service.

A very high temperature is produced in Re, as stated, and the heat is passed very rapidly through the walls of the tubes, WT and CT. The gaseous products of combustion pass onward through Re and escape through the tubes, RT, into WC, the temperature of these gases being at least as high as that of the refractories in the tubes, RT. Leaving WC, the waste gases, WG, flow upwards through the annular space formed by J, on one side, and AI, on the other, giving up some of their heat energy which is conducted by J to W². It will be seen that W², which forms in a relatively thin stream through WC, receives heat from two directions.

The waste gases, WG, continue their flow, as shown by the arrows, passing over the confining walls of SC, MC and GC and, finally, make their escape through the heat exchanger, HE, where some of their residual heat is taken up by the air flowing through the tubes, A. The waste gases, WG, flow across the tubes, A, in a spiral manner as directed by the baffles, SB, and finally make their escape to the open air. The tubes, A, and the walls of GC may be made of any light material, such as aluminum, but there must, of course, be sufficient strength to withstand the pressures, whatever they may be.

The structure which forms the walls of MC and GC is provided with a flange, F¹, which is secured to Hd⁴ by means of the stud-bolts, Sd, which are welded to Hd⁴. Ga is a gasket which makes the joint air-tight.

It will be seen from the foregoing that I combine a heat regenerative means with a heat producing means and that this contributes to the efficiency of the apparatus.

It will also be seen that I provide heating surfaces which, in their aggregate areas, are very large in proportion to the size of the whole boiler, or heater, structure, and this contributes to the efficiency and capacity of the apparatus.

It will further be seen that high flow velocities of the fluid to be heated may be attained by reason of the relatively small tubes WT, and the relatively narrow space, WC¹, between the tubes, CT and J.

I do not hold myself as limited in any way to the details of the structures shown. The tubes, WT, may be relatively much larger than shown in my drawings, or much smaller. The space, WC¹, may be relatively wider or narrower than shown. The several dimensions will depend upon the use for which the apparatus is designed and the rate of combustion provided for.

My process is not restricted to the use of all of the parts shown in my drawings. It will be understood that the process would be workable, but with less efficiency, without the use of the heat exchanger, HE; that the tubular jacket, J, might be omitted and the water, or other fluid to be heated, delivered direct to WC and that the waste gases, WG, instead of being used for re-

generative purposes might be delivered direct to the air from the tubes, RT.

It will be seen that many departures and variations may be made from the structures shown without departing from my process, because my process may be employed for numerous purposes, other than that of producing steam, such as refining, and even cracking, oil and for many special heating purposes in other kinds of process work. The fluid which is being heated for treatment may be raised to the exact temperature required merely by regulating the speed of the pump used to force the fluid through the heater.

I claim:—

1. The process of vaporizing a liquid which comprises first flowing the same in an annular stream and in a downward direction while exposed on one side to the heat of an upward flowing stream of waste gases and on the other side to the downward or parallel flow of heat in a high temperature zone, second breaking the said stream into a multiplicity of small streams

and causing the latter to flow upwards through a zone of high temperature wherein the liquid is vaporized.

2. The process of vaporizing a liquid which comprises the preheating of same while flowing downwardly around a zone of radiant heat produced and maintained by the flameless combustion of a fuel in a bed of refractory material of then breaking the liquid into a multiplicity of small streams and flowing the same upwardly through the said radiant heat zone.

3. The process of heating a liquid to the distillation temperature, if necessary to the cracking temperature, which comprises first preheating same by flowing downwardly about a zone of radiant heat, next flowing the preheated liquid upwardly in small streams through the same zone of radiant heat and of regulating the flow velocity of the liquid to insure the predetermined temperature to be attained immediately before discharging from said radiant zone.

JOSEPH W. HAYS.