Dec. 15, 1936. S. P. MILLER 2,064,486

METHOD OF HEATING TAR

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Fig. 1.

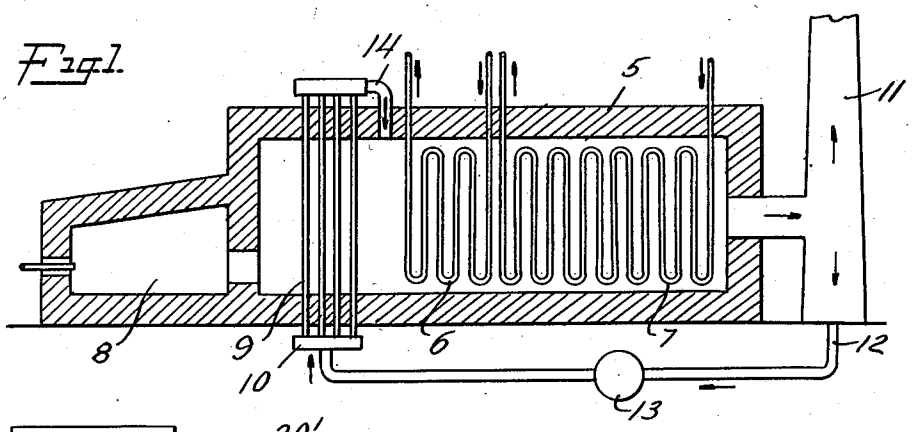


Fig. 2.

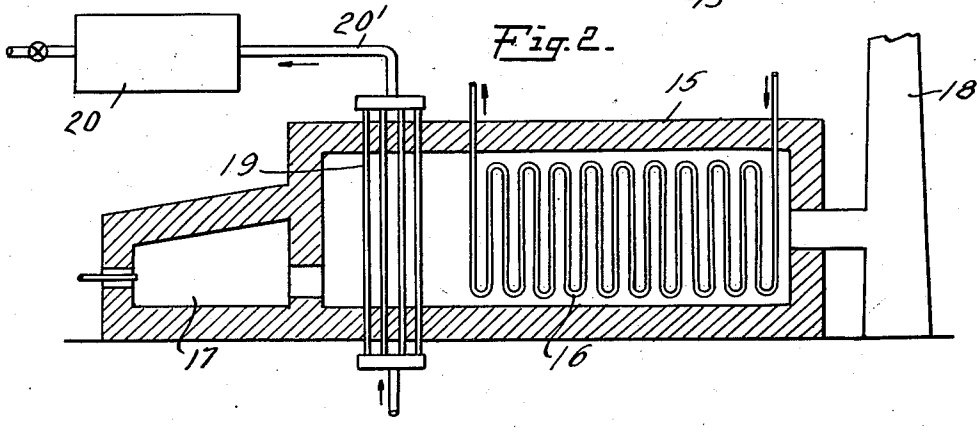


Fig. 3.

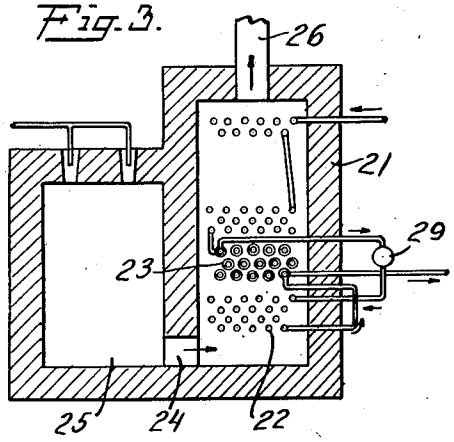


Fig. 4.

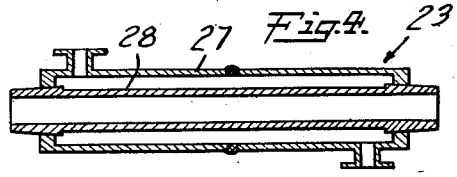
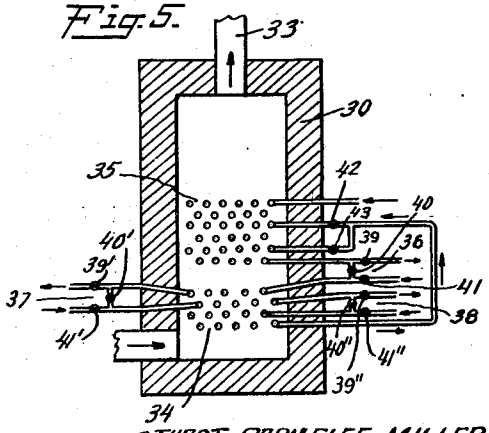


Fig. 5.



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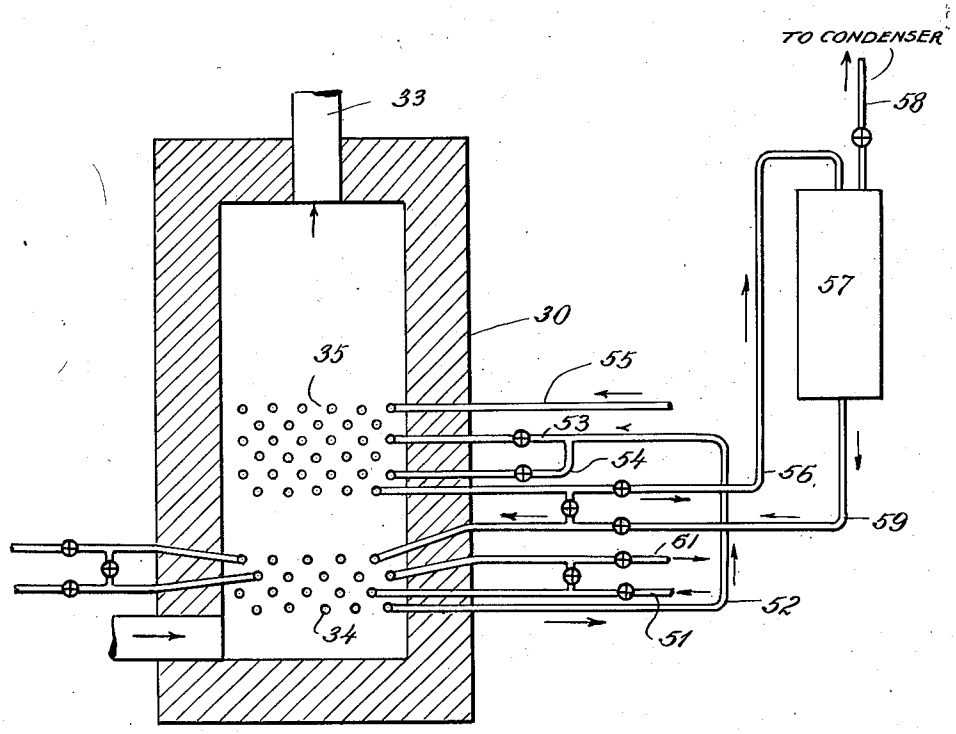
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Fig. 6,



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METHOD OF HEATING TAR

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Application December 1, 1928, Serial No. 323,063

2 Claims. (Cl. 196—76)

This invention relates to the distillation of organic materials such as hydrocarbons including tar, tar oils, petroleum, petroleum oils and the like, and particularly to a method whereby distillation may be conducted without difficulties due to carbonization resulting from decomposition of the material.

In distilling material,—e. g. tar,—in continuous stills, the material is ordinarily pumped through tubes exposed to heat from combustion gases. The material flows counter-current to the heating gases and commonly becomes highly superheated. The superheated tar is allowed to flow into a chamber known as a "flash box" or "vapor box" in which the oil vapors escape from the superheated tar and pass to suitable condensers. The residue remaining in the flash box is commonly withdrawn continuously. In the case of tar, distillation may be conducted in one, two or more stages. If two stage distillation is carried out the tar is moderately heated in tubes positioned in the cooler section of the flues. The oil vapors are allowed to flash off in a vapor box and the residual pitch is returned to tubes in the hotter section of the furnace for completion of the heating.

In either the single or multiple stage systems tar or pitch is highly superheated by indirect exposure to progressively hotter gases. Further, not only is the very hottest tar or pitch usually exposed to the hottest gases but it is also exposed to radiant energy from the source of heat or combustion zone, i. e. the heating tubes through which the hottest tar or pitch is flowing are directly exposed to the flame of the combustion gases and to the high temperature side walls of the furnace.

When tar is being distilled to pitches of low or medium melting point,—e. g. up to 160° F.,—little difficulty due to carbonization of the material flowing through the heating tubes is experienced due to the fact that only a relatively low temperature of tar or pitch is required for distillation and furnace temperatures may correspondingly be lowered. However, when pitches of higher melting point are produced, it is necessary to maintain high furnace temperatures in order to attain the required temperature of preheat of the tar or pitch in the tubes. Carbonization in the tubes exposed to radiant energy from the furnace is experienced. Several factors are responsible for carbonization. Tar or pitch contains materials readily decomposable by contact with surfaces at high temperature,—e. g., temperatures of 700° F. and upwards.

Tar and pitch have relatively low unit heat absorption capacity, their specific heat being only 0.3 to 0.45 and the latent heat of the volatile oils distilled off is only approximately 150 B. t. u. per pound.

At furnace temperatures prevailing during the distillation of tar to produce hard pitch, the rate of heat input to the tubes due to radiant energy is of the order of ten times the rate of heat input due to convected heat.

At the high temperatures prevailing, extreme local overheating of the tar or pitch results due to its low unit heat absorption capacity, and serious decomposition with attendant carbonization on surfaces of the distilling vessel or heating tubes results. The deposit of carbon still further reduces the capacity of the system to absorb heat. Higher furnace temperatures become necessary and tubes finally burn out due to extreme furnace temperatures and excessive carbon deposits.

During the period when carbon is built up in the tubes, distillation capacity of the system is gradually reduced. A serious loss of valuable distillate is experienced due to decomposition. The difficulty experienced is due to absorption of radiant energy at high temperatures via the walls of the distilling vessel or tubes by the tar or pitch therein which is already near the decomposition temperature.

Very little difficulty is experienced from convected heat at high temperatures due to the relatively low rate at which it can be absorbed at the heating surfaces. The tar or pitch being distilled ordinarily has adequate capacity for absorption of convected heat and hence little carbonization of heating surfaces results therefrom.

It is the object of the present invention to shield the material undergoing distillation from the radiant heat and to permit, therefore, a more uniform and satisfactory transfer of heat to the material to be distilled. Decomposition and especially the formation of carbon deposits are avoided, the efficiency of the apparatus is increased, and its life is prolonged with consequent reduction of cost.

I have discovered that the above difficulties may be overcome and the shielding of the material from radient heat accomplished by interposing a suitable fluid medium between the source of heat and the tubes or vessel containing the material undergoing distillation so as to absorb the radiant energy and thus screen the material from the heating effect thereof. The heat absorbed in the fluid may be applied usefully in heating the material undergoing distillation or otherwise. In

the practical application of the invention, the fluid may be gaseous or liquid. A suitable gaseous medium is flue gases discharged from the heating apparatus, a portion of which may be recirculated, caused to absorb the radiant energy, and thereafter to give up heat to the material undergoing distillation. Various liquids may be employed in a similar way. Water, for example, may be circulated in the apparatus in such a way as to absorb the radiant energy, the water being thereby converted into steam which can be utilized in or about the plant for any desired purpose. Similarly a metallic alloy which is fluid at the temperature to which it is subjected may be circulated so as to absorb the radiant energy and may be utilized thereafter as a heating medium for the material undergoing distillation. Likewise liquid of a character similar to that undergoing distillation may be employed to absorb the radiant energy and may be combined thereafter with the material undergoing distillation so as to supply heat thereto.

If the material to be distilled is used for absorption of radiant energy, it will be best to pass a portion of the material directly through the tubes exposed to radiant heat without previous heating by exposure to counter-current flow of the hot gases.

The tar or other material at relatively low temperatures will have a capacity for absorption of heat considerably in excess of that of the highly heated tar or pitch in the usual system. Carbonization in the tubes and losses of oil due to decomposition will be avoided. The heated tar leaving the tubes exposed to radiant energy may be combined thereafter with the remainder of the tar exposed substantially only to convected heat and will preferably, although not necessarily, be combined at a point where the temperatures of the two streams of material are approximately the same.

It is to be understood that the primary purpose of the invention is the interposition of a screen between the source of heat and the material undergoing distillation so as to avoid the effect of radiant energy, and that various fluids, including those mentioned, may be employed in apparatus adapted for the accomplishment of the purpose. A suitable apparatus involves a series of tubes through which the material to be distilled is circulated and which are surrounded by hot gases derived, for example, from a furnace which is supplied with fuel and air sufficient to maintain combustion. In such an apparatus a series of tubes adjacent the source of heat and exposed to radiant energy therefrom may be utilized as the screen, and in such tubes the fluids hereinbefore mentioned may be circulated. The utilization of such fluids after they have absorbed heat in the tubes will vary depending upon the character thereof. Thus if flue or other gases are utilized, such gases, after heating, may be delivered to the furnace gases and, mingling therewith, will circulate about the remaining tubes in which the material undergoing distillation is subjected to heat. The gases circulating through the initial series of tubes absorb the radiant energy, and the heat is thereafter distributed and utilized in distilling material in the remaining tubes, the effect of distribution being, however, to avoid overheating of the material in any of the tubes. If water is utilized in the screen, steam will be formed and may be employed as a source of power or for any other purpose to which it is adapted, the heat being thereby utilized and the material undergoing distillation being protected from the radiant energy by absorption thereof in the water. If a molten metallic alloy is used, it may be circulated through the initial series of tubes and thereafter through the jackets of successive tubes in which the material undergoing distillation is subjected to heat transmitted from the molten alloy. The radiant energy is absorbed by the alloy and is distributed through the jacketed tubes to the material undergoing distillation, and overheating of the latter is avoided. If material similar to that undergoing distillation is utilized in the tubes of the initial series, it may be of such a character that decomposition is not readily effected, or its speed of travel may be increased so as to prevent such decomposition. The heated material may be delivered to that which is to be distilled, thus distributing the heat and preheating the material without effecting overheating thereof.

These and numerous other modifications of the method and apparatus can be readily effected, the object being attained nevertheless. It is possible, consequently, to distill materials such as those mentioned effectively and economically and without decomposition such as normally causes excessive deposits of free carbon in the apparatus.

The invention will be more readily understood by reference to the accompanying drawings and the following description. The drawings are diagrammatic and are merely illustrative of apparatus suitable for the practice of the invention. In the drawings—

Fig. 1 is a sectional view of a still adapted to permit protection of the material by circulation of a gaseous medium;

Fig. 2 is a similar view of a still adapted for the utilization of water to absorb the radiant energy;

Fig. 3 is a sectional view of a still in which the radiant energy is absorbed in a circulating metallic alloy;

Fig. 4 is an enlarged sectional view of a jacketed tube for use in connection with the still illustrated in Fig. 3;

Fig. 5 is a sectional view, taken at right angles to the showing of Fig. 3, of a still in which the material to be distilled is itself employed to afford the screen; and

Fig. 6 is a sectional view, taken at right angles to the showing of Fig. 3, of a still in which the material to be distilled is employed to afford a screen.

Referring to the drawings, 5 indicates a suitable enclosure of brick or other refractory material forming the distillation chamber. Pipe coils 6 and 7 are disposed in the chamber and are adapted to receive and to convey the material undergoing distillation through the chamber. It is to be understood that the material is supplied from any suitable source and that the products of distillation are conducted to condensers (not shown) wherein the desired fractions are separated and recovered. Hot gases are supplied by a furnace 8 in which any combustible material may be burned with an adequate supply of air. A plurality of tubes 9 are connected to headers 10, the tubes being disposed at the end of the distillation chamber adjacent the furnace, so that the tubes are subjected to radiant energy therefrom. The gases from the furnace pass the tubes 9 and circulate about the tubes 6 and 7 to effect the desired heating of the material to be distilled. The gases escape to a stack 11 through which they are discharged to the atmosphere. A portion of the

gases may be returned through a pipe 12 and blower 13 to the tubes 9. Circulating through the tubes, the stack gases absorb radiant energy and the heat thereby transmitted to the gases is returned to the distillation chamber by conveying the gases through the pipe 14 which discharges into the chamber. The gases thus mingle with the combustion gases and circulate around tubes 6 and 7, thus heating the material in the tubes.

In Fig. 2, the apparatus is modified by providing a chamber 15 of brick or other suitable material enclosing the tubes 16 in which the material to be heated is circulated. A furnace 17 is adapted to supply combustion gases, and these gases, after circulating through the distillation chamber, escape to a stack 18. A plurality of tubes 19 are disposed in the distillation chamber adjacent the furnace so as to be subjected to the radiant heat therefrom. Water is supplied to the tubes 19 from a source thereof, and circulates through the tubes, being thus subjected to the radiant heat. The water is heated and converted into steam, and the steam is conveyed through a pipe 20' to a steam drum 20 from which it may be distributed and utilized. The water may be circulated at such a rate that substantially no steam is formed, the water being merely heated. It may be conveyed thereafter to a boiler (not shown) as "make-up". The steam produced in the boiler may be utilized for any purpose. In this embodiment of the invention the material to be distilled is screened effectively from the radiant heat, and the heat is utilized in an economical manner.

In Figs. 3 and 4 I have illustrated an apparatus adapted particularly for the utilization of a molten metallic alloy as a heat absorber. In this apparatus a chamber 21, preferably constructed of fireproof brick, is provided with tubes 22 and 23. The tubes 22 are disposed adjacent the outlet 24 from a furnace 25 which may be supplied with fuel and air sufficient to afford combustion gases at high temperature. The gases pass through the chamber 21 about the tubes therein and thence to a stack 26.

The tubes 22 are supplied with a molten metallic alloy, for example one consisting principally of lead. The alloy is circulated through the tubes and absorbs the radiant heat from the furnace.

The tubes 23, as illustrated in Fig. 4, consist of jackets 27 which surround the tubes 28. The latter are connected and are adapted to permit the circulation of the material to be distilled. The molten metallic alloy first heated in the tubes 22 is circulated by a pump 29 through the jackets 27 and is thus permitted to give up its heat to the material undergoing distillation. The partially cooled alloy is then returned to the tubes 22 and absorbs additional heat therein. The material undergoing distillation is thus heated uniformly to the desired temperature, and overheating is avoided, the tubes 22 forming an effective screen for the radiant heat.

In Fig. 5, the apparatus is similar to that illustrated in Fig. 3, the distillation chamber 30 being connected to a combustion chamber (not shown) in which combustion gases are produced from the fuel and air supplied thereto. After passing through the distillation chamber the combustion gases escape to a stack 33. Banks of tubes 34 and 35 are provided in the distillation chamber. As indicated diagrammatically in Fig. 5, banks of tubes 34 and 35 are connected in such a way as will allow one or more rows of bank of tubes 34 to be cut off from bank 34 and added to bank 35, thus allowing control of the tube surface used as radiation shield. The tubes are connected as shown somewhat diagrammatically at 36, 37 and 38. If all four rows of tubes in bank 34 are to be used as radiation shield, valve 39 will be open, 40 closed, 41 open, 39' closed, 40' open and 41' closed. By suitably manipulating the valves, as will be understood by one skilled in this art, the material may be delivered through tubes 34 preheated by the radiant energy from the heating source, then passed by connection 42 or 43 into and through tubes 35 where fresh material may be added thereto.

Using all four rows of tubes in bank 34 as a radiation shield, the tar is introduced at 41, passed through the four rows of tubes in bank 34, thence into and through bank 35 at 42 or 43, where the heated tar mingles with the tar passing through the bank of tubes 35, the resultant mixture leaving the still through valve-controlled conduit 39. Employing three rows of tubes in bank 34 as the radiation shield, the tar is introduced through 41', passed through the three lower rows of tubes in bank 34, then through connections 42 or 43 where the heated tar mingles with the tar passing through the bank of tubes 35, the mixture passing through the four lower rows of tubes in bank 35, and if desired, into and through the upper row of tubes in bank 34, leaving the still at 39'. If only two rows of tubes in bank 34 are used as the radiation shield, the tar is introduced through 41'', passes through the two lower rows of tubes in bank 34, thence into the bank 35 at either 42 or 43 where it mingles with the tar passing through the bank of tubes 35. The mixture may leave the bank of tubes 35 at 39 or be passed through the two upper rows of tubes in bank 34, leaving the still at 39''. By regulating the flow of material through tubes 34 and by causing the material to pass through one or more banks of tubes 34 the amount of preheat imparted to the material passing through the tubes 34 may be controlled at will.

Preferably in the distillation of coal tar the tar is preheated by passage through a definite number of rows of tubes in bank 34,—e. g., the 2 rows adjacent to the furnace,—and is then heated to vaporize the lighter oils by passage through tubes in bank 35, the resultant superheated tar being passed into a "flash-box" or "vapor box" in which the oil vapors escape. The resultant pitch is then passed through the remaining rows of tubes in bank 34 and after being heated by absorption of both the residual radiant energy and by convected heat, is withdrawn from the still. Referring to Fig. 6, tar is introduced into the radiation shield through valve-controlled pipe 51 and passes through the two lower rows of tubes in bank 34, thence through pipe 52, as indicated by the arrows, into either valve-controlled pipe 53 or 54. Fresh tar is introduced into the bank of tubes 35 through line 55. The tar from pipe 53 or 54, as the case may be, mingles with that flowing through the tubes in bank 35, this mixture passing from the bottom row of tubes in bank 35 through valve-controlled pipe 56 leading into the vapor box 57. Valve-controlled pipe 58 leads from this vapor box into a condenser (not shown). The pitch from the vapor gox flows through the valve-controlled pipe 59 into the upper row of tubes in bank 34, passing therethrough, the row of tubes immediately therebelow, and leaving the still through the valve-controlled line 61. The flow of pitch through tubes in bank 34 is controlled to prevent decomposition of the pitch therein and to

obtain the desired heavier oils. It will be understood that the material supplied to the tubes which form the radiant energy screen is of such a character, is in such condition, or is circulated at such a rate that decomposition is substantially avoided.

It will be understood that it will not always be necessary to absorb substantially all radiant energy, but that in some cases only that proportion necessary to avoid objectionable decomposition and carbonization will be absorbed. This, as is well known by those skilled in the art, may be accomplished by regulating the flow of the medium through the tubes exposed to radiant heat by control of valves shown, so that all or any desired portion of the radiant energy is absorbed by the medium passing through the tubes.

The several adaptations of the invention as hereinbefore described involve the same principle, to wit, the control of decomposition and carbonization in or on the heating surfaces by the absorption of all or a portion of the radiant energy to which the products being distilled have ordinarily been exposed while at maximum temperature, and the absorption or removal of the excess radiant energy in a fluid medium other than the most highly heated portion of the product undergoing distillation.

The heat may be supplied by combustion or otherwise, for example by electric heaters. In either case absorption of radiant energy by material other than that which has already been heated to a high temperature is effected to avoid undesirable decomposition and the deposition of carbon in the tubes. The life of the tubes is thereby prolonged, and the efficiency thereof is maintained, so that the apparatus may operate continuously and economically. The invention is applicable to the distillation of tar particularly, but it may be used also in distilling other organic liquids, e. g. petroleum oil, or fractions or residues thereof.

Various changes may be made in the procedure and particularly in the apparatus employed without departing from the invention or sacrificing any of the advantages thereof.

I claim:

1. In a method of distilling coal tar the steps which comprise generating combustion gases, passing said combustion gases through a zone where they flow in indirect heat exchange with molten metal, whereby said molten metal acts as a radiant heat screen, passing molten metal from said first zone in a path surrounding the tar being distilled in a second zone while passing said combustion gases from said first zone into indirect heat exchange relation with said molten metal in said second zone, passing said combustion gases from said second zone into indirect heat exchange relation, without the interposition of molten metal, with said tar in a third zone, and passing said tar from said third zone through the path surrounded by said molten metal in said second zone.

2. In a method of distilling coal tar the steps which comprise generating combustion gases, passing said combustion gases through a zone where they flow in indirect heat exchange with molten metal, whereby said molten metal acts as a radiant heat screen, passing molten metal from said first zone in a path surrounding the tar being distilled in a second zone while passing said combusition gases from said first zone into indirect heat exchange relation with said molten metal in said second zone, passing said combustion gases from said second zone into indirect heat exchange relation, without the interposition of molten metal, with said tar in a third zone, passing said tar from said third zone through the path surrounded by said molten metal in said second zone and recycling said molten metal through said first zone.

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