Aug. 16, 1966 W. Z. GIRTON 3,266,485

RECIRCULATING IMMERSION HEATER

Filed April 13, 1964

FIG. 1.

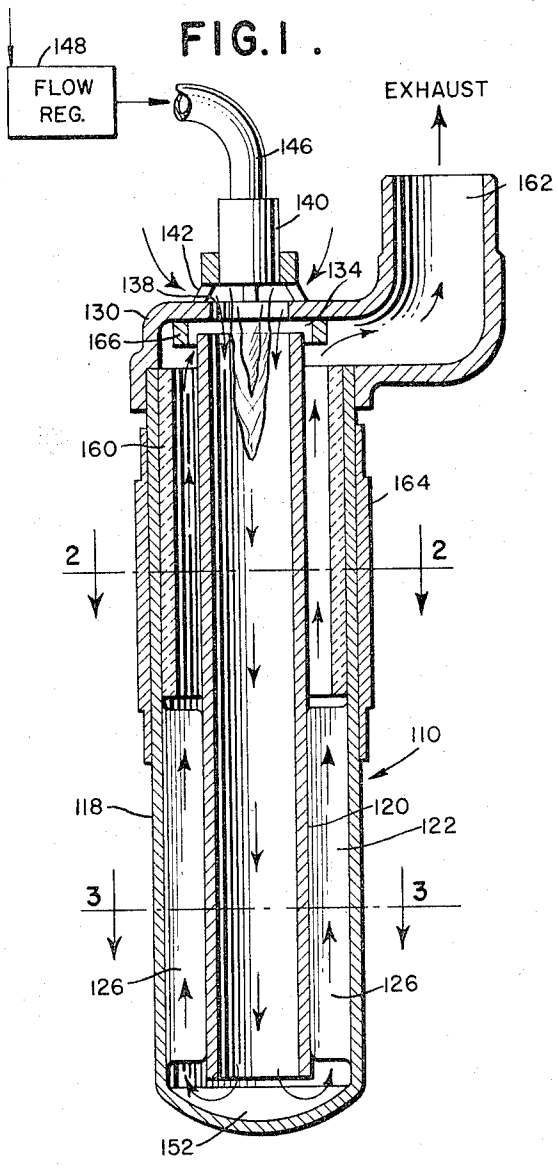


FIG. 2.

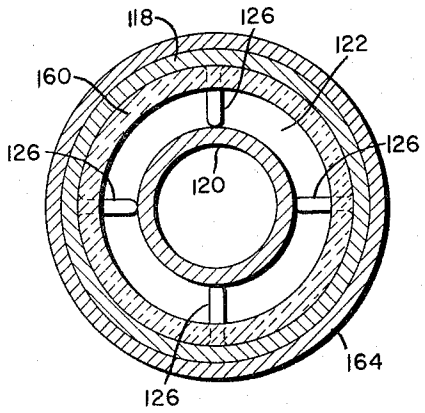
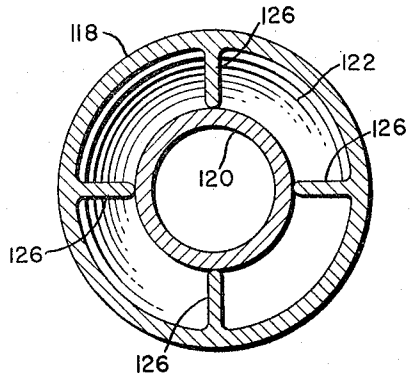


FIG. 3.



INVENTOR

William Zender Girton

BY Stevens, Davis, Miller & Mosher

ATTORNEYS

United States Patent Office 3,266,485 Patented August 16, 1966

3,266,485

RECIRCULATING IMMERSION HEATER

William Zender Girton, Catonsville, Md., assignor to The C. M. Kemp Mfg. Co., Glen Burnie, Md., a corporation of Maryland

Filed Apr. 13, 1964, Ser. No. 359,384
10 Claims. (Cl. 126—360)

This application is a continuation in part of application Serial No. 294,312, filed July 11, 1963, now abandoned.

This invention relates to immersion heating elements of the type which employ fluid fuels for direct firing. More particularly, it relates to a direct firing immersion type of heating element of new and improved construction for melting and heating materials which provides for recirculation by entrainment with the entering fuel stream of a portion of the products of combustion and which maintains a cooler burner operation with consequent reduced corrosion and deterioration to the heater, especially in the area of the dross line.

In the heating and melting of metal such as zinc, magnesium, aluminum, their alloys, and the like, for use in the casting of these metals by means of dies, difficulties such as decreased burner and heater life, as well as preignition of fuel, have been experienced in direct fired heaters where the burner and the upper portions of the heater operate at high temperatures. This is particularly true where the burner is subjected to the corrosive and deteriorating effects of hot gases of combustion, as when these gases are recirculated over the burner during operation of the heater. Additionally, where the burner is positioned within the combustion gas conduit and is submerged beneath the surface of the hot metal charge, heat radiated from the surrounding parts of the heater and said metal charge and the high concentration of impurities or dross line near the surface of said metal charge contribute to a hot burner and heater operation with a consequent high corrosion rate and deterioration to said heater. Thus, the tendency of heater deterioration is compounded by the combined adverse effects of prolonged heating at high temperatures and the concomitant fixed surface layers of oxide or scale to which the outer surface of the heater is subjected within the hot metal charge. It is highly desirable therefore to eliminate the deterioration due to the high corrosion rate caused by heat radiation plus the high concentration of dross and provide instead an efficient heating unit which has high resistance to corrosion and consequently a prolonged heater life.

This invention contemplates an improved and simplified heater for direct firing of fuel into the heater conduit wherein a recirculation of combustion gases from the exhaust into the jet of fuel is effected out of contact with the burner. I have found that where a portion of the combustion gases which would otherwise be passed to exhaust is caused to be drawn back into the entering fuel jet for repassage through the heater conduit, there is achieved an increased flow of gases through the heater which in turn provides greater efficiency and lower meteal temperatures with less corrosion and deterioration of the unit. I have also found that by causing a portion of the gases of combustion to be drawn into the entering jet of fuel intermediate the burner discharge face and the main portion of the heater conduit, a recirculatory flow of gases through the conduit may be effected in such a manner that the hot gases recirculated do not pass into direct contact with the burner. This provides a cooler operation of the burner and a superior burner life. In addition, I have also found that by providing an insulating liner within the inner portion of the exhaust conduit and positioned in an area which passes through a high concentration of the impurities of the dross, cooler operation of the heater is thereby provided and corrosion of the main portion of the conduit is reduced in such area. Furthermore, I have found that by providing a sleeve of highly corrosion-resistant material circumferentially positioned around the outer portion of the heater in the area of the dross line, reduction of the corrosion rate and consequently deterioration of the heater is further retarded. I have found, too, that burner construction along the lines set forth above not only reduces corrosion rate and thus the deterioration of the heater but also inhibits pre-ignition of the fuel.

Broadly, the heater construction of this invention has a conduit defining a path for the flow of gases therein. The conduit being formed of inner and outer elongate hollow tubes or tubular elements of any desired cross-sectional configuration. Together, the inner and outer tubes define an annular space or annulus therebetween. The inner tube has openings or passages at both its ends interconnecting it with the annulus. The outer tube being closed at its lower or submerged end and provided at its upper or non-submerged end through a conduit cover means or cap. The outer tube is provided with an inner lining of insulating material and an outer sleeve of corrosive-resistant material, both of which confirming to cross-sectional configuration of the outer tube and longitudinally extending along at least the dross line on said outer tube of the heater, that is, that area common to both the submerged portion and the non-submerged portion of said outer tube. Considering the heater in a vertical aspect, the burner is positioned above the upper cover means and spaced therefrom so that it will fire through an aperture in the cover means into the inner tube. The spacing means may, if desired, provide for adjusting the distance between the burner and conduit.

In use, and when vertically positioned, the gases of combustion pass downwardly from the burner through the cover means and through the inner tube into the lower part of the annulus around the inner tube. The gases then move upwardly in a reverse direction to the flow in the inner tube exhaust through holes provided for this purpose in the cover means. A portion of the gases on reaching the upper end of the annulus is caused to be drawn from the exhaust end of the conduit and passes back into the entering jet or fuel by entrainment with the jet thereby effecting recirculation of the entrained gases through the heater conduit.

It has been found that, with the burner positioned out of the path of the recirculatory flow, entrainment occurs in a manner such that combustion gases are passed back through the heater out of contact with the burner for its cooler operation. With this arrangement, higher temperature heating is possible as compared to heaters where the burner is mounted down inside the heater. Also, by recirculation of gases from the exhaust end of the conduit for reflow through substantially the entire conduit as well as by the liner of insulating material provided in said conduit, it is insured that the heater will be cooled in the area passing through the high concentration of impurities or dross line near the surface of the metal charge so that corrosion of the conduit is reduced.

Advantageously, the heater may be positioned vertically in the charge so that the function of combustion gas entrainment for recirculation occurs within unsubmerged portions of the heater above the dross line. This arrangement further cools the gases in the heater area in which recirculation is induced by contact of these gases with cooler portions of the heater which are not submerged in the metal charge. Consequently, an increased cooling of the heater in its upper portions occurs thereby further reducing the effectiveness of the corrosive action on the heater of impurities in the area of the dross line.

It will, of course, be obvious that recirculation of a portion of the combustion gases through the conduit permits extraction of heating units from the gases which would otherwise be lost to the atmosphere. Also, it will be understood that where, by increased flow of gases their velocity and turbulence are increased, the co-efficient of heat transmission will be increased so that there is greater efficiency in transfer of heat from the gases to the walls of the heater between inner and outer portions of the conduit and between the heater conduit and the metal charge. Further, the increase in flow of gases acts to lower metal temperatures near the burner with consequent reduced corrosion and deterioration to the heater.

The upper end of the inner tubular element or tube may, if desired, be spaced downwardly from its corresponding upper end of the outer tubular element or tube so that there will be a fully open space or passage interconnecting the top of the annulus and the inner tube area. This allows for freely unobstructed radial flow of the entrained gases. Similarly, the lower end of the inner tube may be spaced a distance above the lower closed end of the outer tube and the means used to space the inner tube from the outer tube may be arranged at or to extend below the open end of the inner tube. With this arrangement, there is achieved a particularly unobstructed flow of hot combustion gases from the lower end of the inner tube into the annulus between the two tubes thereby contributing to the free movement of the combustion gases through the length of the conduit.

In accordance with the invention, both the liner of insulating material and the sleeve of corrosive-resistant material conform to the cross-sectional configuration of the outer elongate hollow tube or tubular element, which form the heater body. Both of said elements are suitably positioned in that area of the heater body which passes through the high concentration of impurities or dross line of the materials being heated and may, if desired, be extended up the outer tube so as to be disposed along substantially the entire upper or non-submerged end of said outer tube. It is desirable that the outer sleeve or corrosive-resistant material is provided in an area at the dross line but does not extend substantially below said line in order that that portion of the heat positioned within the materials being heated remains unobstructed by said sleeve.

The burner advantageously may be mounted above the upper cover means as by supporting it spaced thereabove by suitable spacer means thus providing for a free flow of the gases of the atmosphere surrounding the burner around and under the burner, to cool it and be entrained with the fuel streaming from the burner into the inner tube. Such arrangement aids in providing the desirable cool operation of the burner.

The foregoing and other objects and advantages will be more apparent when my invention is understood and by reference to the accompanying drawings in which I have, by way of illustration only, shown preferred embodiments of my new heater and in which drawings:

FIGURE 1 is a view in elevation of a cross-section of a preferred embodiment of my heater;

FIGURE 2 is a cross-sectional view taken along line 2—2 of FIGURE 1; and

FIGURE 3 is a cross-sectional view taken along line 3—3 of FIGURE 1.

Referring to the drawings, FIGURE 1 shows a heater **110** to be immersed in a mass of metal or the like for maintaining the metal at a uniform molten temperature. The heater is formed from an outer tube **118** having its upper end open and its bottom closed, and an inner tube **120** positioned within the outer tube, so spaced as to define an annular space or annulus **122** between the two tubes. The inner tube **120** may extend from a point somewhat above the top of the outer tube to a point above the bottom of the outer tube, thereby allowing gases entering the inner tube to pass downwardly through said tube and then upwardly through the annulus **122**. At the upper end of the outer tube **118**, preferably along about half of its length, said outer tube is provided with an insulating liner **160**, one end of which is positioned near or coterminous with the top of the outer tube. The insulating liner is suitably constructed of any heat-resistant material which also demonstrates adequate insulating characteristics. Insulating materials contemplated by the present invention for use in such liner include flexible fibrous ceramic, rigid ceramic, and castable refractory materials, with flexible fibrous ceramic material being preferred. The thickness of the insulating liner is dependent on the construction variables of the heater elements, i.e., the length, diameter, etc., as well as the insulating ability of the material utilized. Accordingly, it has been found that thicknesses of from $\frac{1}{16}$ to $\frac{3}{8}$ of an inch are suitably operable, with thicknesses of $\frac{1}{8}$ to $\frac{1}{4}$ inch being preferred.

The positioning of the inner tube with respect to the outer tube is accomplished by the use of spacers or fins **126** at the lower ends of the tubes. It will be observed that spacers **126** are represented as not extending below the lower end of the inner tube, but may, if desired, extend below said lower end of tube **120** so as to assist in distributing the combustion gases.

The upper end of the outer tube is covered by a heater cover cap **130**. The undersurface of cap **130** and the top inner sidewalls of the outer tube define a space **134** for the mixing of a portion of combustion gases from annulus space **122** with the incoming feed used to heat the system. The cap **130** is solid in configuratiton and thus space **134** forms a central cavity above the annulus **122** which also provides for the passage of the exiting combustion gases from the annulus **122**. The center of cap **130** defines an opening **138**. Positioned above the opening **138** is a burner **140** supported by legs **142**. The legs are arranged around the perimeter of the lower end of the burner and are so spaced as to provide for air to be admitted to the burner. This air flow acts to cool the burner and the upper portion of the heater. The legs may be made of any suitable materials including those having thermal insulating qualities in which event transmission of heat to the burner from the conduit portions of the heater is reduced for cooler burner operation and consequent longer burner life. Fuel is supplied to the burner through line **146** and the desired amount of the fuel is controlled by regulator **148**.

A portion of the combustion gases flowing into space **134** will be entrained with the flow of gases from the burner and caused to recirculate downwardly with the combustion gases entering the upper end of the inner tubular element. The remainder of the combustion gases flow upwardly from space **134** to flue **162** which is provided for conducting the exhaust gases of combustion away from the area above the heater cover cap. However, it is understood that a barrier device, such as a baffle, may be provided at the upper surface of the cap or within the flue for conducting the exiting combustion gases away from the burner (one such baffle **166** is shown in FIGURE 1). When the combustion gases are permitted to flow over the burner or the fuel line, such flow will act to add preheat to the inlet fuel, thereby recovering heat units and aiding in more rapid and complete combustion of the fuel.

It will be appreciated that the height of space **134**; that is, the distance between the upper end of the inner tubular element and the underside of the cap **130**, may be varied as desired for controlling the amount of recirculation of gases from the annular space into space **134** and the upper portion of the inner tubular element.

In operation, fuel is fed to the burner **140** through line **146**. The hot combustion gases flow from the burner vertically downwardly through the central opening **138** in the cap **130** and into inner tube **120**. The gases of combustion flow downwardly through the inner tube

passing from the lower end into the lower space **152** which acts as an interconnecting passage between the lower end of the inner tube and the lower end of the annulus. The gases move radially outward at the lower end of the conduit into the annulus. The gases are aided in an evenly directed radial outward flow from the lower end of the inner tube by the spacers **126** which also act as guides in the gas flow path. I have shown these as four in number and as vertical and planar, but they may be any number or arranged so as to give to the combustion gases a swirling or other motion for adding turbulence or increasing flow for better heat transfer in which case the spacers may be arranged at an angle or may themselves be curved or may have a twist or a compound curvation. The combustion gases in rising through the annulus yield up their heat through the walls of tubular element **118**, thereby heating the mass in which the heater is immersed.

It will be observed that with the heater illustrated in FIGURES 1 and 2 there is provided a sleeve **164** of corrosion-resistant material affixed to the outer portion of tube **18**. Such corrosion resistant sleeve may be constructed of any feasible corrosion-resistant material such as stainless steel, a chromium-nickel alloy, and the like and preferably one which will not alloy with the charge material being melted. The sleeves may be conformed to any suitable configuration and usually will be formed from one or more cylindrical cowls. Said sleeves are preferably integrally attached by welding or other suitable securing means. The thickness of the corrosion-resistant sleeve is dictated by the corrosion resistant of the material employed, per se as well as by the conditions to which the heater element is subjected and therefore may be varied accordingly.

My heater my be constructed of any suitable material, such as metal, and refractories may be employed in its construction such as for lining of portions of the inner tube or elsewhere as found desirable. My heater may be used in almost any application where a vertical down-firing immersion heater is adapted. Examples of such additional uses are in heating of heat transfer salt, oils, water, sludges, and slurries.

While I have described my invention with particular reference to a specific embodiment, it will be apparent to those skilled in the art that various modifications and changes may be made without departing from the spirit and scope of my invention.

What is claimed is:

1. A combustion-type immersion heater for maintaining material in a molten state, which comprises a heater body having an inner and outer countercurrent flow path, insulating means positioned within the upper end of the outer portion of said flow path, burner means for supplying hot products of combustion into the entrance of the inner portion of said flow path, a space in the top of said heater body interconnecting the ends of said flow path for recirculating a portion of the products of combustion exiting from said flow path, and exhaust port means in the top of said heater for removing to the atmosphere the remaining portion of the products of combustion exiting from said flow path, said insulating means preventing heat radiation from the upper portion of said heater whereby dross line corrosion of said heater is reduced.

2. The combustion-type heater of claim **1** in which the inner portion of said flow path is tubular in cross-section and the outer portion is annular in cross-section.

3. The combustion-type heater of claim **1** in which said exhaust port means is a flue communicating with the space in the top of the heater body surrounding the burner.

4. The combustion-type heater of claim **1** in which the space for recirculating a portion of the products of combustion is maintained above the dross line of the material to be maintained in a molten state.

5. A combustion-type immersion heater for maintaining a material in a molten state, which comprises a heater body having a countercurrent flow path formed from inner and outer concentric tubes positioned in spaced relationship to each other; an insulating liner positioned within the upper end of said outer tube; burner means for supplying hot products of combustion into the entrance of the inner portion of said flow path; a space in the top of said heater body interconnecting the ends of said flow path for recirculating a portion of the products of combustion exiting from said flow path; and exhaust port means in the top of said heater for removing to the atmosphere the remaining portion of the products of combustion exiting from said flow path, said insulating liner preventing heat radiation from the upper portion of said outer tube whereby dross line corrosion of said heater is reduced.

6. The combustion-type heater of claim **5** in which a sleeve of corrosion-resistant material is secured to the outer portion of said outer tube at the dross line of the material to be maintained in a molten state.

7. The combustion-type heater of claim **5** in which said exhaust port means is a flue communicating with the space in the top of said heater body.

8. A combustion-type immersion heater for maintaining material in a molten state, which comprises a heater body, said body being formed from an elongated tube closed at both ends, the top end defining a central opening therein; a burner positioned above said central opening for firing hot combustion gases therethrough; an elongated open end inner tube concentrically spaced in said outer tube so as to form an annular space between said tubes; a liner of insulating materials at the upper end of said outer tube, one end of which liner being positioned coterminous with the top of said outer tube; spacing means in the lower end of said heater for holding said inner tube in its concentric position; exhaust port means positioned in the top end of said outer tube and over said annulus space; and a sleeve of corrosion resistant material affixed to the outer portion of said outer tube in the area of the dross line of the liquid to be heated, whereby said outer tube is insulated from the hot products of combustion from said burner flowing within said annular space and whereby the outer portion of said outer tube is protected from corrosion by means of said sleeve.

9. The combustion-type heater of claim **8** in which said corrosion-resistant sleeve is formed from a plurality of cylindrical cowls conforming to the cross-sectional configuration of said outer tube.

10. The combustion-type heater of claim **8** in which said exhaust port means is a flue containing baffle means for diverting the exiting gases away from said burner; said flue communicating with said annular space in the top end of said outer tube.

References Cited by the Examiner

UNITED STATES PATENTS

1,073,587	9/1913	Billings.	
1,080,113	12/1913	Von Kugelgen et al.	126—360 X
1,730,440	10/1929	Smith.	
2,515,618	7/1950	Wallerius	126—360
2,530,271	11/1950	Swindin	126—360
2,556,984	6/1951	Smith	126—360

FOREIGN PATENTS

716,579	10/1954	Great Britain.

OTHER REFERENCES

Marks: Mechanical Engineers' Handbook, McGraw-Hill, New York, 1951, p. 646.

FREDERICK L. MATTESON, JR., *Primary Examiner.*

ROBERT A. DUA, *Examiner.*