This invention relates to a process and an apparatus for the introduction of a metal into a combustion zone of heating units. Residual fuel oils are used extensively as fuel in large heating units, such as in power plants. These oils generally contain vanadium, sodium, and sulfur combined with other constituents to form complex compounds. Even though the oil may contain these metals in trace amounts, the burning of the oil produces an ash which, if it comes in contact with metals in the combustion zone, causes a greatly increased rate of corrosion. The accelerated corrosion is due in part to the oxidation of the metal. The vanadium and sodium oxides exercise a fluxing action on the protective oxide films of parts exposed to the combustion gases. In this way the protective film normally on the surface of the parts exposed is destroyed so that further oxidation can take place. Since the ash containing these oxides is a liquid or in a semi-liquid state, it is able to come into intimate contact with the protective film. This problem is particularly acute in gas turbine plants where the turbine blades are exposed to the hot combustion gases. In steam generating units, the corrosive nature of the combustion gases are taken into consideration and the construction of the boiler tubes and the thickness of metal exposed to the gases is increased to offset the increased to offset the increased corrosion. Even though the thickness of the metals is increased sufficiently to compensate for the corrosion, the oxides adhere to the metal parts, such as boiler tubes in both the fire box and superheater section, forming an insulating layer which causes a noticeable reduction in heat transfer efficiency.

The sulfur present in the residual fuel oil is oxidized to sulfur dioxide and then catalytically converted to sulfur trioxide by the presence of the vanadium oxides in the combustion gases. In boilers, the sulfur trioxide passes through the hot part of the heating unit without causing much damage, but then it combines with the water of combustion in the air preheater tubes and partially condenses on the tube surface as sulfuric acid. This section generally requires frequent replacement.

It has been found that the certain other metals introduced into the combustion zone will oxidize and will combine with the vanadium and sodium oxides and raise the melting point of the sodium and vanadium ash to such a temperature that the ash will remain dry and powdery and pass through the combustion zone and other units without depositing. Even if the dry ash is deposited, the fluxing and thus the corrosion is appreciably reduced. Also, in combining with the vanadium and sodium oxides, the catalytic effect of the ash on the conversion of sulfur dioxide to sulfur trioxide is appreciably reduced. The metallic oxides which are effective in reducing the corrosion are magnesium, calcium, and aluminum, with magnesium being the most desirable.

Presently, two methods are most commonly used for the introduction of the desired metal oxides, such as those above mentioned, into the combustion zone. The first method used is to intermix the metal or a salt of the metal which upon oxidation in the combustion zone will be converted to the metal oxide with the fuel oil and to burn the slurry in the fuel oil burner. When a higher concentration of the inhibiting metal is necessary, the slurry formed with the fuel oil will cause both the strainers and the burners to plug. Further there is a tendency for the solids to settle out. Thus, it is a problem to maintain the metal or salt uniformly dispersed in the fuel oil as it is being burned.

The second method employed is the introduction of aluminum oxide, calcium oxide, or dolomite into the combustion zone as a dry powder. When the dry metal oxide is added, it is difficult to determine the exact quantity or to maintain close control over the amount added. Further it is difficult to obtain intimate mixing of the powdered oxide introduced with the combustion products of the fuel oil at the point of combustion where the inhibiting metal oxide will readily combine with the vanadium and sodium oxides.

It is, therefore, among the objects of this invention to provide a method and an apparatus for the introduction of a metal into the combustion zones which will overcome the disadvantages above set forth.

According to the invention, a thin strip containing the metal or the metal compound is passed into contact with a heated surface heated to a temperature sufficient to ignite the strip. An air stream is passed over the heated strip to ignite and oxidize the strip introducing fine size particles of the metal in the air stream. The air stream is then discharged into the intake of the combustion zone of the furnace. By introducing fine size particles of the metal in the intake, the metal in the fine particle form is thereby intermixed with the air and pulled into the combustion zone where it is converted to metal oxide if it already is not in the oxide form. The metal oxide is evenly disbursed in the combustion zone and the amount of metal oxide desired can be readily controlled by the rate at which the strip is passed into contact with the heated surface.

The strip containing the metal may be a thin ribbon or wire of the metal, an alloy, or a ribbon of a synthetic non-self-extinguishing flexible thermal plastic material, such as polyethylene and polypropylene oxide, containing the metal or a solid metal compound dispersed therein in a fine particulate form. Thus the term "strip," as used herein, means a comparatively long narrow piece, such as a wire or ribbon. The term "solid" as used herein in reference to the compounds, means compounds which do not melt or sublime at temperatures below 250° C. The features and advantages of this invention may be more readily understood from the following description taken in conjunction with the drawings, in which,

FIGURE 1 illustrates diagrammatically an apparatus embodying the invention.

FIGURES 2 and 3 are cross-sectional views of the apparatus shown in FIGURE 1 taken through a plane 2—2 and 3—3, respectively.

As shown in FIGURE 1, the apparatus comprises a rectangular box-like shell 6 having a removable cover 7 closing an idle roll 9, guide and snuffer rolls 10 and 11, drive rolls 12 and 13, and heated surface 14. Cover plate 7 is attached to shell 6 by a multiplicity of screws 8. The idle roll and the drive rolls are at a distance from each other with the guide and snuffer rolls being located between the two. The idle roll, the guide rolls, and the drive rolls are disposed between cover plate 7 and the side wall 16 of shell 6 parallel and distant to cover 7. They are rotatable about an axis perpendicular to wall 16 and cover plate 7. The drive rolls as shown comprise two individual rolls, one disposed vertically above the other being movable with means (not shown) being provided to exert a predetermined force to keep the peripheral surfaces of the rolls together. The guide and snuffer rolls are likewise shown to consist of two rolls movable with respect to each other and means (not shown) provided to apply a predeter-
mined force to keep the surfaces of the rolls together.

An inlet 17 located above the heating element 14 in shell 6 and an outlet 18 located beneath heating element 14 provide means of directing an air stream over heated surface 14. A tank 19 located above shell 6 is connected with the shell 6 by means of pipe 20 which branches into two pipes 21 and 22, respectively before entering the enclosure. A valve 23 located in line 20 provides means of regulating the flow from tank 19 into the enclosure of shell 6. The lines 21 and 22 upon entering the enclosure each connect with a distributing nozzle 24.

The arrangement of the rolls within the box-like shell 6 may be more easily seen in FIGURE 2 wherein the idle roll 9, the lower roll 11 of theguide snuffer rolls, and the lower drive roll 13 are shown. As shown, rolls 9, 11 and 13 are constructed so that the diameter of each of the ends of the rolls is reduced and thus serve as bearings for the rolls. The ends of the idle roll 9 are reduced in diameter to form shafts 26 and 27 which are seated in bearings 28 and 29 located in cover plate 7 and side wall 16 of the box-like structure. The guide and snuffer roll 11 is similarly constructed. Drive roll 13 is similarly seated at one end. The end 30 is reduced in diameter and serves as a shaft in cover plate 7. A shaft 32 is attached to the other end of drive roll 13 which is attached to a variable speed motor 33. The shaft 32 is disposed in bearing 34 located in side wall 16 of the box-like structure.

The heated surface 14 which has been shown comprises a multiplicity of right angle electrical heating elements, such as made of Nichrome wire, placed parallel to each with a space between each to form a heated surface the width of the box-like shell 6. In FIGURE 3 the heating elements are more clearly shown. The individual elements are attached to lead 36 which supplies the current to heat the individual heating elements.

In operation, the apparatus is placed so that outlet 18 is directed into the air intake of the fuel oil burner of the turbine or the boiler (not shown). A reel 37 of a thin strip of metal or of the thermoplastic ribbon in which the metal or metal salt has been dispersed is placed on idle roll 9. The ribbon 38 is passed between the guide and snuffer rolls 10 and 11 and between drive rolls 12 and 13. The current to lead 36 is turned on so that the heating elements 14 are heated to a temperature sufficient to ignite and oxidize the metal or the strip. Variable speed motor 33 is started so that the ribbon 38 is advanced toward the heated surfaces 14 where it contacts the heating elements and is heated to oxidation temperature. As illustrated in FIGURE 18, is placed in the intake of the oil burner, the intake of the boiler, or the turbine, due to an air stream into opening 17 pass the heating elements and into the combustion zone through outlet 18. The strip upon contacting the heated elements is raised to the ignition or oxidation temperature and with the air stream passing over it, is oxidized or burned. When metals or compounds of metals which are readily oxidized are used, the metal or compound is oxidized upon contacting the heated surface creating smoke size particles of the metal oxide. The rate at which it is desirable to introduce the metal or metal oxide may be regulated by the rate at which the strip is advanced into the heated elements. In case of a fast burning metal, for example a thin magnesium ribbon, the metal once ignited may burn rapidly and the oxidation of the ribbon advance up the ribbon toward the rear of the metal. The burning of the ribbon, in this case, would be extinguished by the drive rolls 12 and 13. If for some reason the burning is not extinguished by the drive rolls, it will be snuffed out by the guide and snuff rolls 10 and 11. However, in case of a failure which would result in the fire extending past the guide and snuff rolls and reaching the reel of the metal 37, valve 23 is opened and a synthetic resin or heavy hydrocarbon oil maintained in tank 19 may be admitted into the box-like shell 6 to extinguish the fire.

While the drawing and the foregoing description have outlined a specific embodiment of the invention and the operation thereof, other modifications may be made in the detail of operation and in the arrangement of the apparatus without departing from the spirit and scope of the invention. For example, in place of electrically heated elements other than may be used of providing a heated surface into which the ribbon may be directed. The snuffer and guide rolls 10 and 11 may also be eliminated and the ribbon from reel 37 extended directly to the drive rolls. However, with the guide and snuffer rolls additional protection is provided in case the ignition of the ribbon extends beyond the drive rolls. Also instead of relying upon the draft created by the intake fan of the turbine or boiler, a blower may be used to blow air through opening 17 over the heated strip, and into the intake through opening 18. The cover plate 7 is shown as attached to the remainder of the box-like shell by means of screws 8. Other means, such as snaps, may be used to attach the cover plate to the structure.

The above apparatus and process is particularly applicable to the introduction of magnesium oxide into the combustion zone. The magnesium in ribbon form may be used or particular form of magnesium or other metals placed into a thermostable type ribbon. Metals, such as aluminum and calcium, or compounds of these metals in particulate form are usually dispersed in a thermostable tape. The particles dispersed should be in fine particulate form having a size which will pass through 300 mesh Tyler standard screen. Larger particles may be used of metals or of compounds which may be oxidized upon contacting the heated surface. The particles of these materials generally oxidize to give smoke size particles which are readily drawn into the combustion zone. It is especially desirable to have fine particles of compounds which have a high ignition and oxidation temperature. These particles must be of sufficiently fine size so that when the thermoplastic material forming the tape and holding them together is burned, these particles are carried into the combustion zone with the air being passed over the heating element. Once the particles are in the combustion zone, they are oxidized to the oxide form. For these compounds in some cases it may be even desirable to have the particles of a micron to a temperature of 108° C. It is desirable to obtain the highest concentration of metal within the thermoplastic material without the plastic material losing its flexibility. Generally from 10 to 70 weight percent of the metal or salts of the metal may be dispersed. The thermoplastic material, such as polyethylene, polypropylene, etc. without materially affecting its brittleness or flexibility. It is preferred to have the metal or salt content to be in the range of 35 to 50 weight percent. With the thermoplastic ribbon containing more than 70 weight percent, the brittleness of the material increases to the extent that it is not desirable, although it is still operable.

Thermoplastic materials, such as polyethylene and polypropylene oxide which are not self-extinguishing are very well suited. A thermoplastic having a relatively high ignition and burning temperature is desired, since the composition of metal dispersed within the thermoplastic material may be more easily oxidized at a higher temperature.

The following examples further illustrate the invention but are not to be construed as limiting it thereto.

**Example 1**

A plastic roll-press was used in the preparation of a ribbon containing magnesium hydride dispersed therein.

The thermoplastic material used was polyethylene which was a high pressure polymerization product having a melt index of 2 (according to ASTM D1238-52T) and a specific gravity of 0.918. It maintained its crystalline structure up to a temperature of 100° C. The thermoplastic was charged to the press at about 120° C. Pow-
dered magnesium hydride which would pass through a 300 mesh but be retained on a 325 mesh U.S. standard screen was slowly added to the molten plastic and a plastic ribbon was obtained. Several ribbons of various thicknesses of from 1 to 4 millimeters were thus made which contained 10, 20, 50 and 70 weight percent of magnesium hydride.

Chemically these ribbons were unaffected by water being non-wetted and had burning characteristics of polyethylene. The only noticeable effect of the magnesium hydride was its burning which occurred during the burning process. With the ribbon containing 70 percent magnesium hydride, the flexibility was considerably decreased.

Example II

In the manner described above polypropylene oxide was used as a thermoplastic material within which magnesium hydride was dispersed. The burning characteristics of this polypropylene oxide ribbon was similar to that of the thermoplastic itself with noticeable sparking as the result of the magnesium hydride in the ribbon.

In place of a magnesium compound, a metal itself, such as magnesium, aluminum, and calcium or a compound of these metals may be dispersed in the plastic strip. In an apparatus similar to that shown in FIGURE 1, the plastic strips or the metal in ribbon or wire form may be oxidized by contacting the strip with a heated electrical heating element, such as Nichrome wire.

What is claimed is:

1. A process for the introduction of a metal into a combustion zone of a heat producing unit, which comprises charging a strip containing a member of the group consisting of magnesium, aluminum, calcium, and alloys and solid compounds thereof, into contact with a heated surface heated to a temperature above the oxidation temperature of the strip, passing a stream of air to be used in the combustion of a fuel in the combustion zone of the heat producing unit over the heated strip to ignite and oxidize the strip to obtain a metal in the air stream, discharging the resulting stream of air passed over the surface of the strip containing the metal into the air intake for the combustion zone of the heat unit.

2. A process according to claim 1 wherein the strip is a magnesium ribbon.

3. A process according to claim 1 wherein the strip is a thermoplastic synthetic non-self-extinguishing flexible resin ribbon containing dispersed therein in a fine particulate form a member of the group consisting of magnesium, aluminum, calcium, and compounds and alloys thereof.

4. A process according to claim 3 wherein the dispersed member is a magnesium compound.

5. A process according to claim 3 wherein the magnesium compound is magnesium hydride.

6. A process according to claim 5 wherein the thermoplastic synthetic resin is polyethylene containing from 35 to 50 weight percent of magnesium hydride in part.

7. A process according to claim 5 wherein the synthetic thermoplastic resin is polypropylene oxide containing from 35 to 50 weight percent of magnesium hydride in particulate form dispersed therein.

8. An apparatus, to be used in conjunction with a combustion zone of heating units, for the burning of a strip containing a metal and introducing the metal oxide thus obtained into the combustion zone, which comprises an idle roll, and two drive rolls disposed perpendicular to a common plane at a distance from each other and rotatable about an axis perpendicular to said plane, said drive rolls being disposed movable with respect to each other with means being provided to exert a predetermined force to keep the peripheral surfaces of the rolls together, means to drive at least one of the drive rolls, a heated surface perpendicular to said common plane disposed transversely to a plane passing between said drive rolls at a distance from said drive rolls on side distant from said idle roll, means to heat said heated surface, and a shell encompassing said idle roll, drive rolls, and heating surface, said shell having an outlet and inlet to provide a passageway around said heated surface.

9. An apparatus to be used in conjunction with combustion zones of heating units for the burning of strips containing metal and introducing the metal oxide thus obtained into the combustion zone, which comprises an idle roll, two guide rolls, and two drive rolls disposed perpendicular to a common plane at a distance from each other and rotatable around an axis perpendicular to such plane, said guide rolls being movable with respect to each other with means being provided to exert a predetermined force to keep the peripheral surfaces of the rolls together, said drive rolls being movable with respect to each other and with means being provided to exert a predetermined force to keep the peripheral surfaces of the rolls together, means to drive at least one of said drive rolls, a heated surface perpendicular to said common plane disposed transversely to a plane passing between said drive rolls from said drive rolls on side distant from said guide rolls, with means to heat said heated surface, and a shell encompassing the idle roll, the guide rolls, the drive rolls, and heated surface, said shell having an inlet and outlet to provide a passageway around said heated surface.

10. A process for the introduction of a metal into a combustion zone of a heat producing unit, which comprises charging a thermoplastic synthetic non-self-extinguishing flexible resin ribbon containing dispersed therein a member of the group consisting of magnesium, aluminum, calcium, and compounds and alloys thereof in a fine particulate form sufficient to pass through a 300 mesh Tyler Standard Screen, into contact with a heated surface heated to a temperature sufficient to ignite the ribbon, passing a stream of air to be used in the combustion of a fuel in the combustion zone of the heat producing unit over the heated ribbon to ignite and oxidize the ribbon introducing fine sized particles of the metal in the air stream, discharging the resulting stream of air containing the metal into the air intake of the combustion zone of the heating unit.

References Cited in the file of this patent

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Inventor</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>370,904</td>
<td>Suss</td>
<td>Oct. 4, 1887</td>
</tr>
<tr>
<td>594,594</td>
<td>Bostwick</td>
<td>Nov. 30, 1897</td>
</tr>
<tr>
<td>613,021</td>
<td>Schwartz</td>
<td>Oct. 25, 1898</td>
</tr>
<tr>
<td>673,286</td>
<td>Courtier</td>
<td>May 7, 1901</td>
</tr>
<tr>
<td>1,146,973</td>
<td>Sudilak</td>
<td>July 20, 1915</td>
</tr>
<tr>
<td>2,438,375</td>
<td>Rogow</td>
<td>Mar. 23, 1948</td>
</tr>
<tr>
<td>2,781,005</td>
<td>Taylor et al.</td>
<td>Feb. 12, 1957</td>
</tr>
<tr>
<td>2,890,878</td>
<td>Steinherz et al.</td>
<td>June 16, 1959</td>
</tr>
</tbody>
</table>