

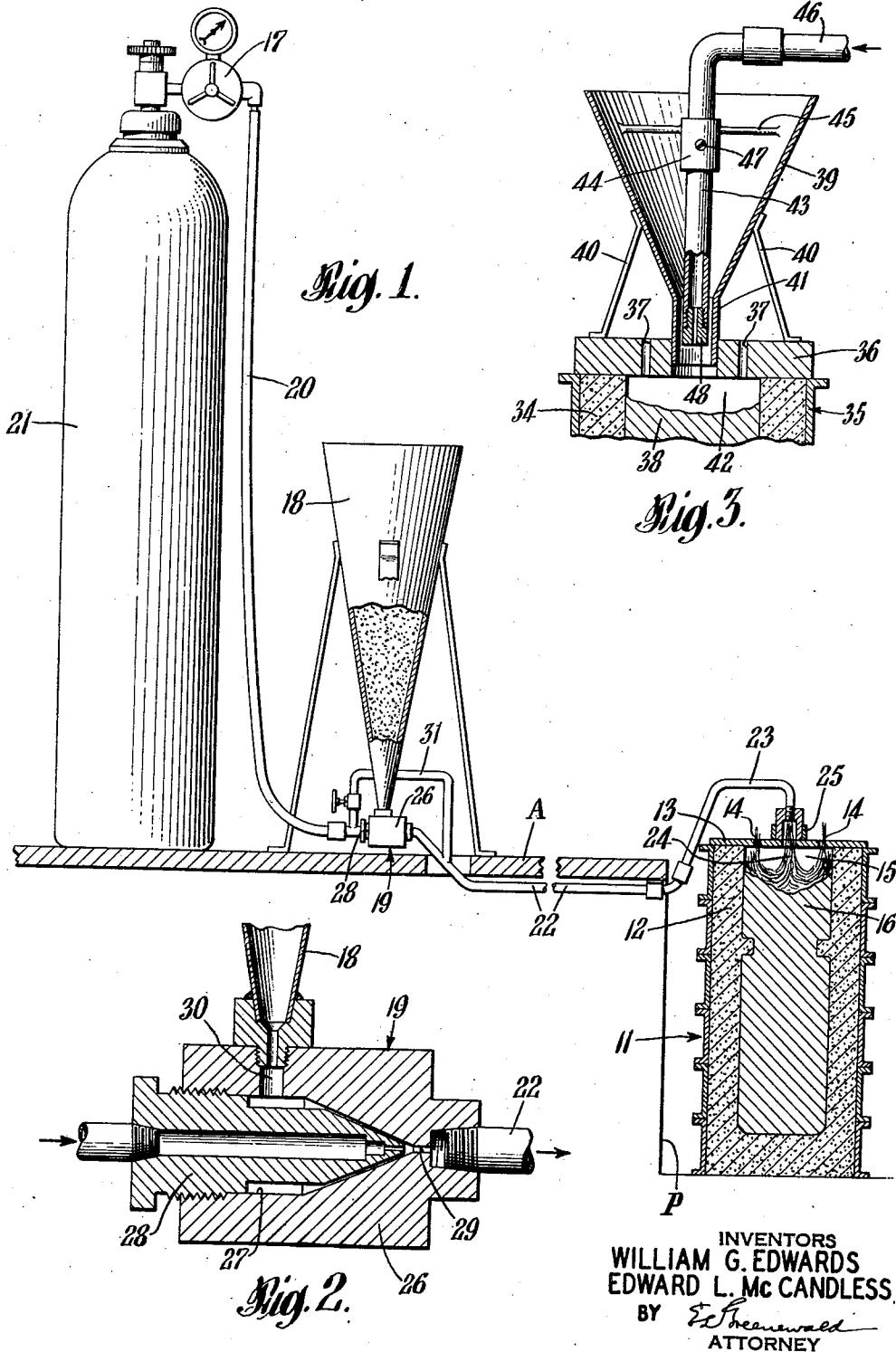
July 18, 1944.

W. G. EDWARDS ET AL

2,353,657

TREATMENT OF CASTINGS

Filed Jan. 29, 1942



UNITED STATES PATENT OFFICE

2,353,657

TREATMENT OF CASTINGS

William G. Edwards and Edward L. McCandless,
Kenmore, N. Y., assignors to The Linde Air
Products Company, a corporation of Ohio

Application January 29, 1942, Serial No. 428,634

6 Claims. (Cl. 22—216)

This invention relates to a novel method of and apparatus for treating freshly cast bodies of metal to reduce the size and depth of pipes and other shrinkage cavities which normally form during the solidification period. More particularly, the method of the invention concerns the treatment of a molten cast body of metal by applying auxiliary heat to the top of such a body to reduce the rate of solidification of the top portion of the casting.

It has long been recognized that a substantial increase in the yield of sound cast metal could be obtained by reducing or eliminating piping in castings. In sand castings, elimination or reduction of piping would permit the pouring of substantially smaller quantities of metal into the risers. In ingots, the elimination or reduction of piping would increase the amount of usable metal available after rolling or forging, and would permit a reduction in the amount of metal poured into hot-tops.

In the past, several methods have been proposed for treating molten cast bodies of metal, especially of steel, by the addition of auxiliary heat to increase the yield by decreasing the size of the shrinkage cavities. For example, the tops of castings have been covered, immediately after pouring, with a thick blanket of a fuel, such as coke or charcoal, and blasts of compressed air or gas flames have been directed against the blanket of fuel to produce intense combustion. Unfortunately, in such a method the thick blanket of fuel not only chills the metal when it is applied and tends to cause crusting, but also acts as an insulator, with the result that the intense heat of combustion may not penetrate through the blanket to the casting itself for some time after the commencement of treatment. In addition, the maintenance of a blanket of powdered fuel on the top of a casting often requires that batches of fuel be added manually from time to time during the treatment of large castings.

The principal object of the present invention is to overcome the above and other disadvantages of prior methods of treating castings. Other objects are to provide a novel method for intensely heating the top portions of freshly poured cast bodies of metal promptly, effectively, and efficiently to reduce the size of the pipes and shrinkage cavities; to provide such a method whereby the advantages of powdered solid fuels burning in oxygen may be obtained without an undesirable heat insulating effect; and to provide such a method which may be performed with the utmost simplicity, and with great safety. Another ob-

ject is to provide novel apparatus for performing the method of the invention.

The above and other objects, and the novel features of the invention, will become apparent from the following description, having reference to the annexed drawing, wherein:

Fig. 1 is a schematic view of a typical arrangement of equipment, partly in elevation and partly in section, for treating a molten casting by the method of the invention;

Fig. 2 is a longitudinal sectional view of a part of the apparatus shown in Fig. 1; and

Fig. 3 is a view in side elevation, parts being broken away and in section, of a modified form of apparatus.

In general, the method of the invention comprises pouring liquid metal, such as steel, into a mold, concurrently flowing gaseous oxygen and a finely-divided unbonded solid fuel into a confined combustion zone or region adjacent to the top of the molten casting, and burning the fuel with the oxygen in the combustion zone. The powdered solid fuel, for example, powdered carbonaceous material or a powdered metallic substance, preferably is introduced in suspension in a flowing stream of substantially pure undiluted gaseous oxygen, and the flame produced on ignition is directed toward and impinges against the top of the casting, and heats the top portion of the casting as solidification proceeds from the bottom of the casting toward the top thereby maintaining a pool of molten metal for feeding down into the main portion of the casting as shrinkage cavities tend to form.

After a predetermined interval of time, depending principally upon the size of the casting, the flame may be extinguished and the casting then allowed to solidify completely in the mold. The rate of solidification after the flame is extinguished usually is relatively slow because heat loss is retarded by a thin gradually accumulated insulating layer on the top of the casting from the burning carbon or other solid fuel. In the case of carbon, this may take the form of a powdery residue. Other solid fuels may form a molten slag. By this method, the intense heat of the burning fuel is made available to the metal immediately, and the labor of making periodic additions of powdered fuel manually is eliminated. Moreover, heat is transferred to the casting most rapidly at the start of the treatment, when the most heat is needed, and the rate of transfer slightly tapers off gradually as the insulating residue accumulates and the need for heat decreases.

The oxy-solid-fuel flames, in the treatment of metal castings, provides important advantages over other known procedures. The finely-divided solid material in the flame is incandescent and at a high temperature so that a large proportion of the heat of the flame is transferred by radiation to the metal, in addition to the transfer by conduction and convection. Also, the direct impingement of hot solid particles against the casting assists heat transfer considerably. Uniform heating of the casting is assisted by the naturally bushy character of the flame, which permits it to cover a large surface area.

The method of the invention, as outlined generally above, is capable of wide application to castings wherein it is desired to eliminate or substantially reduce pipes and other shrinkage cavities, thereby increasing the yield of sound metal. The greatest field for this method lies in the treatment of steel ingots and the risers on steel sand castings, although the method also may be applied to the treatment of castings of all metals which tend to solidify with pipes and cavities. Moreover, although the greatest efficiency may be attained by burning the powdered fuel in substantially pure undiluted gaseous oxygen, which is therefore preferred even though the cost of such oxygen is relatively high, satisfactory results may be obtained by burning the fuel in less expensive compressed air, or oxygen-enriched air, even though it is recognized that the intensity of heating may be less. The term "oxygen" as used hereinafter, therefore, is intended to denote any suitable combustion-supporting gas. Powdered carbon has proved to be an excellent fuel, but good results also may be obtained with other powdered fuels such as powdered metallic substances.

At the start of a treatment of a large casting by the method of the invention, the metal of the casting may be protected to some extent against undesirable chemical reaction with the constituents of the flame by a thin top layer of residual slag poured from the ladle. This layer covers the surface of the metal and in effect forms the top of the casting. A similar layer may also be provided by applying manually a small amount of solid or liquid slagging material as a substitute for or in addition to the slag poured from the ladle. For instance, granulated blast furnace slag may be added, or a quantity of material comprising one or more of the alkali and alkaline earth metal silicates, these melting under the heat of the flame. Another way of adding protective material is to provide at the start of the treatment a thin coating of a powdered oxidizable metallic substance, such as ferrosilicon, ferromanganese, silicomanganese, or silicon-zirconium alloys. These combustible metals furnish heat to the casting when they are oxidized, as well as providing a molten protective slag. Still another way is to use for the fuel a powdered carbon which is high in ash content, such as bituminous coal, so that the ash deposited on the metal melts to form a slag. The casting also may be protected by a thin layer of any of a large number of other materials, such as powdered carbon, sawdust, boiler ash, and the like. In any event, whatever material is used to protect the casting, the layer should be no thicker than is absolutely necessary to prevent chemical reaction of the metal of the casting with the flame, so that any tendency to inhibit the transfer of heat from the flame to the metal will be kept at a minimum. When the fuel is carbon, such as charcoal or pe-

troleum coke, such an initially applied protective layer may be supplemented by the gradual addition thereto of powdery residue from the flame.

Instead of applying manually a layer of protecting material only at the start of the treatment, the fuel in finely-divided form also has been intimately mixed with particles of a different dissimilar solid material which is introduced into the oxygen along with the fuel. A gradual and continuous accumulation of the protective layer then results from deposition of the unburned residue of the mixture on the casting. Any of the previously mentioned protective substances, both inert and oxidizable, may be deposited advantageously in this manner.

A typical arrangement of apparatus for performing the method of the invention is shown diagrammatically in Fig. 1 of the drawing. For simplicity, and by way of example only, the following description will be based on the use of an oxy-carbon flame. A casting mold 11 in the pit P of the pouring room is provided with a vertical riser section 12, formed by a baked sand lining inside a steel flask, the top of which is covered over as by a cover 13 of steel or other heat-resistant material. The cover 13 has a central port for the introduction of an oxy-carbon flame, and a plurality of vent holes 14 arranged adjacent to the inner sides of the mold 11 for the escape of gases from the enclosed chamber 15 formed over the top of the riser 16.

A powder dispenser on the platform A comprises a container such as the conical hopper 19 holding a supply of powdered carbon, and an aspirator 19 at the bottom of the hopper for aspirating the carbon into a stream of high velocity gaseous oxygen. The hopper 19 is open to the atmosphere so that, in the event of a flashback, the burning and explosive mixture will be vented to the atmosphere. The oxygen may be supplied to the aspirator from a source such as a cylinder 21 containing a supply of compressed oxygen, through a pressure regulator 17 and a conduit, such as the hose 20. The suspension of carbon in gaseous oxygen leaves the aspirator 19 through a conduit, such as the hose 22, at a velocity well above the rate of flame propagation in the oxy-carbon mixture and is conducted to a burner or torch 23. It there may be ignited to produce an extremely hot, long, and bushy oxy-carbon flame 24 for heating the top of the riser 16. No auxiliary burning fuel gas or other fuel is necessary to sustain combustion of the carbon.

The burner 23 fits within an upstanding sleeve 25 surrounding the inlet port in the center of the cover 13, and the high temperature oxy-carbon flame is discharged into the flame-confining chamber 15 against the top of the molten riser 16, incandescent burning carbon particles actually impinging against the top of the riser to transfer heat with great efficiency. Preferably, the distance between the tip of the burner 23 and the top of the riser 16 is such that the long, bushy, intensely hot oxy-carbon flame will impinge directly against a substantial area of the top surface and will fan out radially along the whole surface to the walls of the chamber 15, which confine the flame laterally, thereby providing uniform heating and a reducing atmosphere.

The aspirator 19, as shown in detail in Fig. 2, comprises a body 26 having a chamber 27 within which is adjustably threaded an injector nozzle 28. A restricted outlet 29 from the chamber 27 is axially aligned with the nozzle 28 and conducts the gas and powder to the conduit 22. Interme-

diate the ends of the chamber 27 is a lateral inlet passage 30 for introducing the powdered fuel into the annular space surrounding the nozzle 28. Gaseous oxygen is discharged at high velocity and reduced pressure from the nozzle 28 toward the outlet 29 of the chamber, and powdered fuel is aspirated rapidly and steadily from the hopper 18 through the inlet 30. It is conducive to steady flow of powder into the chamber 27 through the inlet passage 30 if the included angle of the conical hopper 18 is not greater than about 20 degrees. The proportion of carbon to oxygen in the oxy-carbon mixture leaving the aspirator 19 may be regulated by adjusting the nozzle 28 in the chamber 27; and by causing a part of the gas to by-pass the aspirator through a valve-controlled by-pass 31.

Another arrangement of apparatus for performing the method of the invention is shown in Fig. 3. There, the riser section 34 of a casting mold 35 is covered over the top with a cover 36 having vents 37 near the inner sides of the riser 38, forming an enclosure for substantially enclosing a region adjacent to the top of the casting. A vertically arranged open conical hopper 39, adapted to be filled with a supply of powdered fuel, is supported on the cover 36 by legs 40. The hopper 39 has a cylindrical lower end portion 41 constituting a burner, which extends through a central aperture in the cover 36 for feeding fuel into the enclosed chamber 42 thus formed above the top of the riser 38. A vertical oxygen tube 43, which is arranged axially of the hopper 39 and is mounted for sliding adjustment in a sleeve 44 supported by a spider 45 secured to the inside wall of the funnel 39, extends at its lower end into the outlet portion or burner 41 of the hopper in spaced relation to the internal wall thereof. A stream of oxygen supplied to the tube 43 through a hose 46, from any suitable source, is discharged downwardly through the burner 41 into the chamber 42, carrying with it powdered solid fuel from the hopper 39. The flame formed on ignition of the oxy-carbon mixture impinges against the top of the casting and heats it intensely. The proportion of fuel to oxygen in the flowing mixture may be varied by raising or lowering the tube 43 in the sleeve 44, wherein it is held by a set screw 47; and by replacing the orificed tip 48, threaded in the lower end of the tube 43, by a tip having an orifice of a different size.

Typical powdered carbonaceous fuels which may be used to form an oxy-carbon flame for the method of the invention are petroleum coke, charcoal, anthracite coal, bituminous coal, carbon black, lamp black, and pitch. Powdered readily oxidizable metallic substances, such as powdered ferrosilicon, silicomanganese, ferromanganese, and the like, also may be used in like manner to form a flame. Petroleum coke and charcoal have been found most advantageous among the carbonaceous fuels. Preferably, the fuels are so finely ground that they will pass all through a 100 mesh (.147 millimeter openings) screen. When it is desired to add protective material to the top of the casting along with the fuel, as previously mentioned, the material in powdered form is mixed intimately with the carbon or other fuel and the mixture is then placed in the hoppers of Fig. 1 or 3 for introduction with the oxygen.

Although any of the fuels mentioned are suitable for treating castings from the standpoint solely of reducing shrinkage cavities, it is well to

note that the oxy-carbon flame may sometimes cause a steel casting to pick up carbon in its upper portion. This is undesirable when the affected metal is to be further processed, as in the case of steel ingots which are rolled, forged, or otherwise treated. In such a situation, it is most advantageous to employ a metallic substance as the fuel, thereby preventing undesirable carbon pick-up in the steel.

As an example of the treatment of castings by the method of the invention, two steel crank-web castings, each weighing approximately 2500 pounds and having a 2000 pound riser 30 inches long by 20 inches wide by 16 inches thick, were treated by an oxy-carbon flame immediately after casting was completed, a thin layer of slag first having been applied to protect the metal of the riser from the flame. An arrangement of apparatus similar to that of Fig. 1 was used. After solidification of the castings, the two risers were sectioned and were found to have only small pipes which in each case extended not nearly so far down toward the main body of the casting as in the case of identical but untreated risers.

Specific examples of the method and apparatus of the invention have been described by way of illustration only. It is evident, however, that changes in procedure and construction may be made within the spirit and scope of the invention, as defined in the claims appended hereto.

What is claimed is:

1. Apparatus for treating a freshly cast body of metal, which apparatus comprises a source of gaseous oxygen; a container for finely-divided solid fuel, said container being open to the atmosphere; an aspirator in communication with said container for aspirating said fuel into a flowing stream of gaseous oxygen to form an oxygen-fuel mixture; a conduit connecting said source of oxygen with said aspirator; a burner for burning said oxygen-fuel mixture to provide a heating flame; a conduit connecting said aspirator to said burner; and means providing an enclosed chamber adjacent to the top of said cast body for substantially confining such flame.

2. Apparatus for treating a freshly cast body of metal, which apparatus comprises an enclosure for substantially enclosing a region adjacent to the top of a casting; a hopper in communication with the interior of said enclosure, said hopper being adapted to contain a supply of finely-divided solid fuel, a lower portion of said hopper having an outlet into said enclosure; and an oxygen discharge tube extending within said lower portion of said hopper in spaced relation to the walls thereof, and having an opening in the lower end thereof, for discharging gaseous oxygen into said enclosure whereby solid fuel is aspirated into such gaseous oxygen and a combustible mixture is formed.

3. A method of treating a freshly cast molten body of metal, which method comprises applying to a top portion of such body a flame resulting from the combustion of unbonded finely-divided readily oxidizable metallic material suspended in a flowing stream of gaseous oxygen, thereby heating such top portion and retarding solidification thereof.

4. A method of treating a freshly cast molten body of metal, which method comprises continuously introducing into a flowing stream of oxygen an intimate finely-divided unbonded mixture of particles of carbonaceous fuel with particles of a combustible metal; forming a flame by igniting and burning the burnable portion of

such mixture-laden oxygen; and heating the top portion of said body of metal and gradually building up a layer of protective material thereon, by directing such flame toward the top of said body and accumulating the residue of burning thereon, thereby maintaining a pool of molten metal for feeding down into the main portion of said body as solidification proceeds from the bottom toward the top and shrinkage cavities tend to form.

5. A method of treating a freshly cast molten body of metal, which method comprises continuously introducing into a flowing stream of oxygen an intimate finely-divided unbonded mixture of particles of metallic fuel with particles of an inert material; forming a flame by igniting and burning the burnable portion of such mixture-laden oxygen; and heating the top portion of said body of metal and gradually building up a layer of protective material thereon, by directing such flame toward the top of said body and accumulating both the residue of burning and such inert material thereon, thereby maintaining a pool of molten metal for feeding down into the main portion of said body as solidification proceeds from

the bottom toward the top and shrinkage cavities tend to form.

6. A method of treating a molten metal casting, which method comprises continuously introducing into a flowing stream of oxygen an intimate finely-divided unbonded mixture of particles of a solid fuel with particles of a different dissimilar solid material, said different solid material being adapted to form and gradually build up a protective layer on the top of said casting; forming a flame by igniting and burning the combustible portion of said mixture in said mixture in said oxygen; and heating the top portion of said casting and gradually building up a layer of protective material thereon by directing said flame toward the top of said casting and accumulating the unburned residue of said mixture thereon, thereby maintaining a pool of molten metal for feeding down into the main portion of said casting as solidification proceeds from the bottom toward the top and shrinkage cavities tend to form.

WILLIAM G. EDWARDS.
EDWARD L. McCANDLESS.