

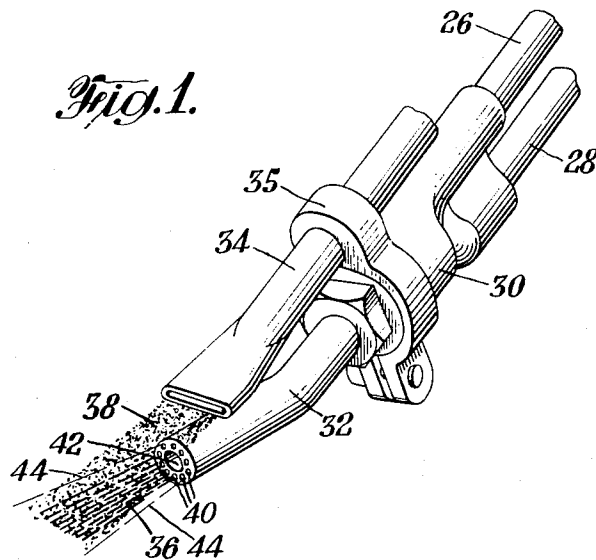
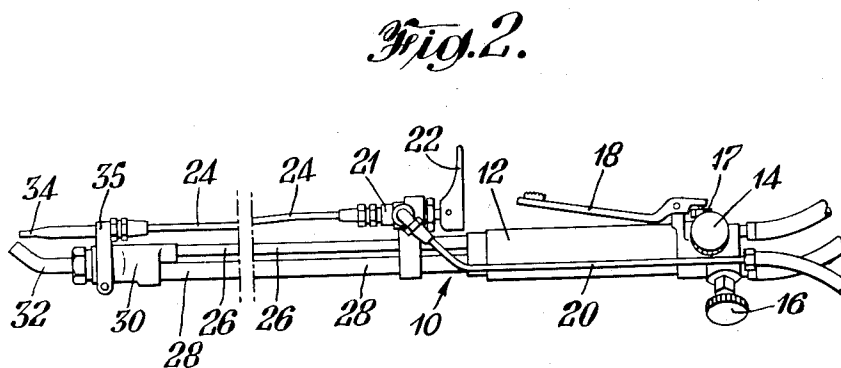
June 7, 1966

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3,254,380

CASTING PROCESS

Filed June 11, 1964



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3,254,380

CASTING PROCESS

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Filed June 11, 1964, Ser. No. 374,533

12 Claims. (Cl. 22—192)

This application is a continuation-in-part of my co-pending application, Serial No. 147,549, filed October 25, 1961, now abandoned.

The present invention relates generally to a process for casting metals and, more particularly, to casting process wherein a shell of casting slag is formed on the inner walls of the casting form.

Heretofore, a variety of casting processes have been proposed wherein a shell of casting slag is formed on the inner walls of the casting mold prior to or simultaneously with the pouring of the metal to be cast. The main purpose of the shell of casting slag is to produce a smooth ingot surface substantially free of imperfections which deleteriously affect worked articles formed therefrom. The smooth ingot surface is produced by employing a casting slag having a melting point below the melting point of the metal being cast so that the molten metal freezes in contact with a fluid shell rather than a solid casting mold. Also, when the shell is pre-formed on the entire inner surface of the mold, splashings from the molten metal being poured melt the inner surface of the shell at the point of impingement and fall back into the pool of molten metal rather than clinging to the mold wall. As a result, the splashings do not form scabs and slivers on the ingot surface. Typical examples of casting processes wherein a shell of casting slag is employed are described in more detail in U.S. Patent No. 2,631,344 to Kennedy and U.S. Patent No. 2,443,394 to Dunn et al.

As mentioned in the Kennedy patent, the shell of casting slag can be formed on the inner walls of the casting mold in various ways. For example, the molten metal to be cast may be poured into a mold partially filled with molten casting slag so that a layer of the molten slag rises on top of the pool of molten metal and forms a shell on successive zones of the mold wall. Alternatively, the entire inner surface of the mold may be covered with a shell of casting slag prior to the pouring of the metal by completely filling the mold with molten casting slag and allowing it to stand until a shell of the desired thickness has solidified on the mold walls. However, in such processes the casting slag must be pre-melted, poured into the casting mold, and allowed to stand before the metal can be poured. Also, the molten pool of casting slag employed in such processes permits very little control of the dimensions of the shell.

Another type of process, intended mainly to increase the life of molds, involves providing a mold with a coating of a refractory material which will present a smooth generally glass-like surface to the molten metal. Such coatings or protective linings can be applied by flame spraying refractory particles onto the interior walls of a mold to form a continuous shell of solid refractory in which to cast the metal. Because of the differences in coefficients of expansion of the mold walls and such refractory coatings, the glass-like lining will often break away under the heat of the molten metal to form inclusions in the melt and leave unprotected areas on the mold walls. The splashings of hot metal during pouring will either freeze to such glass-like coatings or cause large chunks of such coatings to fall into the mold. In any case such coating procedures have not been useful in regard to providing a fluid mold casting shell of the type described above. The sprayed on coatings are generally composed of refractory materials having higher melting

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points than the metal to be cast and, as stated above, can not perform as a fluid casting mold.

It is, therefore, the main object of the present invention to provide a casting process wherein a shell of casting slag is easily formed on the inner walls of the casting form which shell will behave as a fluid mold casting shell when molten metal is poured into the mold.

Other aims and advantages of the invention will be apparent from the following description and appended claims.

In the drawings:

FIG. 1 is a perspective view of a preferred flame torch for carrying out the inventive process; and

FIG. 2 is a view in side elevation of the torch of FIG. 1.

In accordance with the present invention, a process for casting metal in a mold is provided comprising directing a stream of particulated casting slag material through a flame to partially fuse the slag particles and directing the stream of partially fused slag particles onto the mold walls for adherence to the mold walls and to each other to form a lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

The above described process provides a simple method for performing the fluid mold casting process, i.e., casting ingots in a shell of fluid casting slag, without the need for preparing molten slag at the mill site and filling molds with the molten slag. By providing a mold with a lining of surface-bonded slag particles and casting metal therein, the shell of fluid casting slag is formed in situ. The application of only partially-fused, i.e., only surface-melted, particles to the mold wall results in the deposition of a semi-porous, surface-bonded slag particle structure. This semi-porous structure of surface-bonded slag particles is more resistant to the thermal shock and expansion caused by the pouring of the intensely hot molten metal into the mold. The application of completely fused or softened slag particles or droplets would result in the formation of a fused layer of slag on the mold walls which would solidify into a solid sheet of slag. Such a solid sheet of slag does not have the necessary thermal shock resistance to resist massive spalling when hot metal is poured into the mold.

The slag lining deposited according to this invention has some degree of porosity, i.e., voids are interspersed between many of the surface-bonded slag particles. This structure which is said to be semi-porous because the voids are not completely continuous, gives the lining an ability to absorb the expansive forces caused by the hot metal. The slag lining produced by this process thus can remain substantially integral until the rising surface of the molten metal reaches successive levels of the slag lining, which is then melted by contact with the hot metal to form the desired shell of fluid casting slag around the body of metal.

Metal splashings which occur during pouring only adhere to and pull away a small portion of the relatively weakly bonded slag particle lining and do not leave large unprotected areas on the mold wall. The low-density surface-bonded slag material which is pulled off the mold walls will rise to the surface of the molten metal and not form inclusions therein.

The semi-porous lining also allows for the escape of gases evolved in the casting operation which otherwise might be trapped in the metal body. The gases are able to pass vertically through the semi-porous lining a dis-

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tance above the surface of the molten metal and thence into the center of the mold cavity as yet unoccupied by metal from whence they can escape to the atmosphere.

The process of this invention allows for the formation of the silicate slag lining in mold walls without the use of harmful binders to hold the slag particles to the mold wall. Such binders tend to generate gases when subjected to the heat of the molten metal and tend to cause spalling of mold linings. The decomposition products of the scorched binders may deleteriously affect the cast metal. In this process binders are not necessary for the partially fused particles adhere to the mold walls and to each other to form a semi-porous lining.

The inventive process permits relatively close dimensional control of the slag shell by applying the slag to the mold wall in the form of a stream of partially molten slag particles. The slag particles can be applied in a relatively narrow stream, thereby permitting the formation of sharp corners in the slag shell, and yet a shell of any desired thickness can be formed rather rapidly by moving the stream of partially molten slag over the mold wall at a relatively high speed. Even in the case of complex mold shapes, the shell can be made to conform closely to the shape of the mold. Since only the surfaces of the slag particles are melted, and only enough particles to form the desired shell, there is no need to melt a body of slag sufficient to fill all or part of the casting form. Also, since there is no body of molten slag in contact with the partially molten shell, it solidifies quickly without standing for a long period.

The casting slag employed in this process should be generally inert to the metal to be cast and should have a melting point below that of the metal. The casting slag may for special reasons contain elements favorably reactive with the cast body, if they do not otherwise interfere with the casting process. The casting slag also preferably has a density less than the density of the metal to be cast. The compositions of casting slags will vary with the metal to be cast. The general composition of the casting slags include such metallic silicates as the calcium magnesium-aluminum silicates. The silica content of the coating slag should generally be in the range of about 15 percent to about 55 percent by weight, and preferably in the range 40 to 45 percent silica. For example, a slag suitable for use with 1040 steel contains 44% silica, 35% calcium oxide, 5% magnesium oxide, 7% titania, 6% calcium fluoride, 1% manganese oxide, 1% ferrous oxide and 1% aluminum oxide. Compositions of some suitable slags for general use with ferrous metals given below in Table 1:

TABLE 1

Casting Slag	Composition, percent by weight	
	Preferred Range	Typical
A-----	CaO, 33.5 to 36.5-----	34.5
	CaF ₂ , 6.25 to 6.75-----	6.85
	SiO ₂ , 42.5 to 45.5-----	44
	MgO, 4.25 to 5.75-----	5
	TiO ₂ , 6 to 8-----	7
	FeO, 1.5 max-----	0.5
	Al ₂ O ₃ , 2 max-----	0.6
	ZrO ₂ , low-----	0.4
	MnO, <1.5-----	0.5
	Cr ₂ O ₃ , <1.5-----	0.5
	Others, low-----	
	SiO ₂ , 41 to 45-----	42
	CaO, 36 to 40-----	38
	Na ₃ AlF ₆ , 17 to 21-----	20
	Others, low-----	

The above listed casting slags have melting points of about 1200° C. (A) and about 1100° C. (B) and can be used for casting carbon steel and other ferrous metals, including most stainless steels. When casting ferrous metals which contain reactive metals such as titanium, aluminum, and zirconium, an undesirable amount of the reactive metal is lost by reaction with the silica in the

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shell of casting slag, with a corresponding increase in the amount of silicon in the cast body. In such cases it is preferable to use a casting slag having less than 15 percent by weight silica. Titanium oxide and/or aluminum oxide may be substituted for a substantial part of the reduced silica content. The composition of the casting slag could contain oxides of calcium, magnesium, manganese, aluminum, titanium, zirconium, and iron, calcium fluoride and/or sodium-aluminum fluoride and less than 15 percent by weight silica. Suitable compositions of these low silica casting slags are given in Table 2.

TABLE 2

Casting Slag	Composition, percent by weight	
	Preferred Range	Typical
C-----	CaO, 32 to 35-----	34
	CaF ₂ , 6 to 7.5-----	6.5
	SiO ₂ , 8 to 10-----	9
	MgO, 4.5 to 6-----	5
	TiO ₂ , 6 to 7.5-----	6.5
	Al ₂ O ₃ , 30 to 32-----	31
	Na ₂ O, 4.5 to 6-----	5
	Others, low-----	3
	CaO, 33.5 to 36.5-----	
	CaF ₂ , 6.25 to 7.75-----	
D-----	SiO ₂ , 13.5 to 15.5-----	
	MgO, 4.25 to 5.75-----	
	TiO ₂ , 6 to 8-----	
	Al ₂ O ₃ , 30 to 33-----	
	Others, low-----	
	CaO-----	129
E-----	CaF ₂ -----	16.5
	SiO ₂ -----	115
	MgO-----	15
	TiO ₂ -----	112
	Al ₂ O ₃ -----	131
	Others-----	11.5

¹ About.

These casting slags have approximate melting points of about 1250° C. (C), about 1325° C. (D), and 1300° C. (E). These slags generally have a major portion of lime and alumina in their compositions and a silica content less than about 15 percent by weight. The above noted low silica casting slags are useful in casting titanium and aluminum containing steels, as well as stainless steels in general, and the titanium-aluminum precipitation hardened nickel and cobalt superalloys.

In regard to casting other non-ferrous metals and alloys the casting slag is generally made chemically inert to the metal to be cast and has a lower melting point than the metal so that the casting slag is still fluid after the metal has at least partially solidified. In Table 3 some suitable slag compositions for casting copper and its alloys are shown:

TABLE 3

Casting Slag	Composition, percent by weight	
	Preferred Range	Typical
F-----	B ₂ O ₃ , 28 to 30-----	28.2
	SiO ₂ , 41 to 43-----	41.1
	Na ₂ O, 27 to 30-----	29.8
	Others, low-----	1
G-----	B ₂ O ₃ -----	172
	SiO ₂ -----	128

¹ About.

The melting temperatures of these slags are about 540° C. (F) and about 830° C. (G).

The slag material is prepared by standard melting techniques and then crushed into particles for flame spraying. The slag particles should be small enough to avoid clogging the supply line therefor and to adhere to the mold wall when the particles are partially molten. Of course, the slag particles should not have a dimension greater than the desired shell thickness. A particle size between about 20 and about 300 mesh is generally preferred for most applications. The actual particle size distribution

should be such as to yield the semi-porous lining and should not contain an excessive amount of fine particles which would tend to plug the pores.

The thickness of the shell of casting slag deposited on the mold walls is determined mainly by the deposition rate of the stream of partially molten slag particles and the speed at which the stream is moved across the mold wall. The shell should have sufficient thickness to prevent penetration thereof by the molten metal being cast. The shells should have smaller internal dimensions than the external dimensions desired in the final ingot. The slag which is melted from the shell during the pouring operation rides on the rising pool of metal, thereby isolating the metal from the surrounding atmosphere, and allows the ingot to solidify without any outside contamination. It is usually preferred to have a slightly greater shell thickness at the bottom of the mold to provide for the initial impact of the molten metal. Shells of excessive thickness should be avoided, since such shells do not have sufficient body to withstand the heat shock of the molten metal without spalling. Also, excessive shell thicknesses result in small ingots and may interfere with the removal of the ingot from the mold. Preferred shell thicknesses are usually less than about $\frac{3}{16}$ inch.

The inner walls of the shell of casting slag, i.e., the walls which contact the molten metal to be cast, should be at a temperature above the temperature of the outer walls of the shell, i.e., the walls which contact the casting form. Preferably, the inner walls of the shell should be at a temperature approaching the melting point of the casting slag so that metal splashes occurring during the pouring operation liquefy the surface of the shell at the point of impingement and are not retained on the inner surface of the shell. Since the melting of the inner surface of the shell causes the splashes to fall back into the molten metal being cast, they do not form scabs and slivers on the ingot surface. It is also important that the outer walls of the shell be at a temperature sufficiently low to freeze the molten metal so that the molten metal solidifies before coming into contact with the casting form. Since the temperature of the air surrounding the casting mold is normally considerably below the temperature of the molten metal being poured, the desired temperature gradient in the slag shell is usually achieved without the use of cooling or heating devices.

The heating means for partially fusing the slag material may be any suitable heat source which can properly heat the stream of generally gas borne slag particles. Flame and plasma devices are examples of such means although other heating sources are within the scope of this invention. The preferred means for melting the surfaces of the slag particles and applying the slag to the inner walls of the casting mold are flame torches, such as the torches commonly used in the washing, cutting, scarfing, gouging, etc. of cast ingots. A typical flame torch which has been used in carrying out the inventive process emits a round jet of oxygen surrounded by a circle of small flame jets.

The finely divided casting slag particles are fed into the oxygen and flame inlets, whereupon they are discharged with the flame. In order to prevent melting of the mold wall, the distance between the torch and the mold wall must be greater than the distance between the torch and the ingot in a washing or cutting operation. However, the distance between the torch and the mold wall must be small enough to cause the partially molten slag particles to adhere to the mold wall.

A suitable flame torch for carrying out the inventive process will now be described in detail by referring to the drawings:

Referring to the drawings, oxygen and suitable fuel gases for forming the flame jets are fed into the torch 10 through throttle valves 14 and 16 in the handle 12 of the torch. The only requirement on the fuel gas is that it burn at a temperature above the melting point of the par-

ticular casting slag being used. A mixture of oxygen and acetylene is suitable for use with most casting slags. From throttle valves 14 and 16, the fuel gas mixture is passed through pipe 28 to the head 30 of the torch and is finally discharged through an annular series of passages 40 in a nozzle 32. The fuel gas is ignited as it leaves the passages 40, thus forming an annular arrangement of flame jets 44.

The pressure or velocity of the flame jet is controlled by means of the throttle valves 14 and 16.

A carrier gas is fed into the torch through a valve 17, which has a control lever 18 extending forwardly over the handle 12. The carrier gas is preferably oxygen, but may be nitrogen, argon, or any other suitable gas or gas mixture. Some torches may not even use a carrier gas. From valve 17, the carrier gas is passed through pipe 26 to the head 30 of the torch and is discharged through a passage 42 disposed within the annular series of flame-jet passages 40. The pressure or velocity of the resulting jet 36 of carrier gas is controlled by means of lever 18 on the valve 17.

The third inlet to the torch is for the finely divided or powdered casting slag. The slag is supplied through an inlet tube 20 which extends alongside the handle 12 and leads to a powder valve 21 having an upwardly extending finger piece 22 located in front of the lever 18. The powdered slag is forced through the tube 20 by means of compressed air (source not shown). From valve 21, the air-borne powdered slag is passed through a pipe 24 to a flat nozzle 34, which is connected to the head 30 by means of a clamp 35. Since the tubular nozzle 32 is bent toward the flat nozzle 34, as shown in FIG. 2, the powdered slag stream 38 is discharged at an acute included angle into the flame jet 44 and the carrier gas jet 36. The flow rate of the powdered slag is varied by means of the finger piece 22 on the valve 21.

As the powdered slag is discharged into the flame jets and the carrier gas, the slag particles are swept along with the flames and carrier gas and are travelling in the general direction of the flame jets when they leave the flame jets and strike the mold wall. The degree of melting effected in the slag particles as they pass through the flame jet is determined mainly by the temperature of the flame jet, the size of the slag particles, and the length of the period of contact between the slag particles and the flame jet; the period of contact is determined by the velocity of the stream of powdered slag, the velocity of the flame jet and carrier gas, and the length of the flame jet from the point where the powdered slag is introduced therein. In operation, one or more of the aforementioned variables are adjusted so that the slag particles remain in contact with the flame jet just long enough to melt the surfaces of the particles, i.e., to only partially melt the particles. The degree of melting in the slag particles should be just sufficient to cause the particles to adhere to the mold wall and to each other. It is especially important that the layer of casting slag deposited on the mold walls be only partially molten and so form a surface-bonded, semi-porous layer thereon so that the resulting slag shell will withstand the heat shock of the molten metal during the pouring operation. If the slag particles are completely molten so as to form a completely molten layer of slag on the mold, the resulting slag shell is likely to spall or shatter during the pouring operations.

The torch should be held so that the stream of partially molten slag particles is directed against the inner walls of the casting form, and then moved back and forth across the walls while being advanced in a direction parallel to the walls. Generally the walls and floor of the mold are covered although in some cases the floor of the mold may be covered with other materials, or left bare. Therefore when it is stated herein that the mold walls are lined with the coating, it is also meant that the floor of the mold is coated if desired. It is preferred to apply

the slag stream to the mold in a direction about perpendicular to the mold walls. As mentioned above, the distance between the end of the torch and the mold walls should be great enough to prevent any melting of the mold but small enough to cause the partially molten slag to adhere to the mold wall. In order to achieve good adhesion of the partially molten slag particles to the mold and to each other, it is often desirable to preheat the mold to a temperature of about 500 to 800° F. prior to the deposition of the slag.

Although the torch described above is the best mode contemplated by the inventor for carrying out the inventive process, a great variety of flame torches are known in the art and are operable in the present process. For example, the powdered slag can be introduced into the flame jet within the flame-jet nozzle before the fuel gas is ignited. As mentioned above, the jet of carrier gas provided by the aforescribed torch is not required in all torches. The basic requirements for the torch are that the flame be hot enough to melt the surfaces of the slag particles and that the slag particles be provided with a sufficient velocity to cause them to adhere to the mold walls.

After the deposited layer of casting slag has solidified into a solid shell, which usually occurs almost simultaneously with the deposition, the molten metal may be poured into the shell at a rate such that only the inner surface of the shell is melted. In other words, none of the molten metal should come into contact with the mold walls. Since the melting point of the casting slag is always below that of the metal being poured, the molten metal always melts some of the slag shell, and the outer surface of the metal ingot is in contact with molten slag when it freezes. Also, a portion of the melted slag forms a protective layer on top of the using pool of slag.

In an example of the inventive process, the torch described above was used to coat the inner walls of a casting mold with a shell of casting slag having approximately the following composition by weight:

	Percent
Silica	44
Calcium oxide	35
Magnesium oxide	5
Titania	7
Calcium fluoride	6
Manganese oxide	1
Ferrous oxide	1
Aluminum oxide	1

The melting point of the casting slag was about 1200° C. and the size of the slag particles fed into the torch was less than 48 mesh, about 85% of the slag particles being between 100 and 300 mesh. The metal to be cast was 1040 steel. The fuel gas was a mixture of oxygen and acetylene and was fed into ten flame-jet passages (number 56 drill holes) at a pressure of about 12 p.s.i. The carrying gas was oxygen and was discharged through a ¼-inch central orifice at a pressure of about 90 p.s.i. The powdered slag was discharged into the flame jets through a ⅜-inch by ½-inch nozzle by means of compressed air (5 p.s.i.). The angle between the slag nozzle and the flame jet was about 30°. The powdered slag was swept into the path of the flame jets and carrying gas and was travelling at a velocity of about 300 feet per second in the general direction of the flame jets when it struck the mold wall. The temperature of the flame jet was about 5400° F., and the distance between the tip of the flame jet and the mold wall was maintained between 4 and 8 inches. This distance was sufficient to cause the slag particles to adhere to the mold wall without melting the mold. The direction of the stream of partially molten casting slag was substantially perpendicular to the mold wall. The rate of deposition of casting slag was about 15 pounds per hour, and the torch was moved back and forth across the mold wall at a speed sufficient to form a shell thickness between

⅛ and ¼ inch. The partially molten slag solidified within a few seconds after it was deposited. After the entire inner surface of the mold had been coated with the slag, the molten 1040 steel was poured into the mold at a rise rate of about 45 inches per minute. The mold opening was about four inches square. After the ingot had solidified, it was removed from the mold and the slag envelope removed therefrom. The surface of the ingot was substantially free of scabs and other defects and was in condition for rolling.

While various specific embodiments of the present invention have been illustrated and described herein, it is not intended to limit the invention to any of the details herein shown, but only as set forth in the appended claims.

While the process of this invention has been described herein in regard to casting ingots in permanent molds, the use of the term molds herein applies also to molds used for foundry casting in general, pressure casting, blow mold castings, lost wax castings, etc., both in permanent and temporary molds, and in general to whatever metal casting operation in which fluid mold casting is operable.

What is claimed is:

1. Process for casting metal in a fluid slag casting mold comprising heating a stream of particulated casting slag material to partially fuse the slag particles and directing the stream of partially fused slag particles onto the walls of a mold for adherence to the mold walls and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

2. Process for casting metal in a fluid slag casting mold comprising directing a stream of particulated casting slag material through a flame to partially fuse the slag particles and directing the stream of partially fused slag particles onto the walls of a mold for adherence to the mold walls and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

3. Process for casting metal in a fluid slag casting mold comprising directing a stream of particulated silicate casting slag material through a flame to partially fuse the slag particles and directing the stream of partially fused slag particles onto the walls of a mold for adherence to the mold walls and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid silicate casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

4. Process for casting metal in a fluid slag casting mold comprising directing a stream of particulated casting slag material through a flame to partially fuse the slag particles and directing the stream of partially fused slag particles onto the walls of a mold for adherence to the mold walls and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, continuing the application of partially fused slag particles until the thickness of the lining is between ⅛-inch and ¼-inch, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

5. Process for casting metal in a fluid slag casting mold comprising directing a stream of particulated casting slag material through a flame to partially fuse the slag particles and directing the stream of partially fused slag particles onto the walls of a mold for adherence to the mold walls and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag, said casting slag material being a particulated slag composition comprising silicates of calcium, magnesium and aluminum.

6. Process for casting metal in a fluid slag casting mold comprising directing a stream of particulated casting slag material through a flame, maintaining the flame temperature and residence time of said particles in said flame at values to partially fused said particles, directing the stream of partially fused slag particles onto the walls of a mold for adherence thereto and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

7. Process for casting metal in a fluid slag casting mold comprising directing a stream of particulated silicate casting slag material through a flame, maintaining the flame temperature and residence time of said particles in said flame at values to heat the surfaces of said particles to their fusion temperature, directing the stream of hot particles onto the walls of a mold for adherence thereto and to each other to form a semi-porous lining of surface-bonded slag particles on the mold walls, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

8. Process in accordance with claim 7 wherein the lining of surface-bonded casting slag particles is between $\frac{1}{16}$ and $\frac{3}{16}$ -inches thick.

9. Process for casting ferrous metal in a fluid slag casting mold comprising directing a stream of particulated casting slag material through a flame, said slag material containing from about 15 to about 55 percent by weight silica and having a melting temperature less than the melting temperature of the ferrous metal to be cast, maintaining the flame temperature and residence time of said particles in said flame at values to partially fused said particles, directing the stream of partially fused slag particles onto the walls of a mold for adherence thereto and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

10. Process for casting ferrous metal in a fluid slag casting mold comprising directing a stream of particu-

lated casting slag material through a flame, said slag material containing from about 15 to about 55 percent by weight silica and having a melting temperature less than the melting temperature of the ferrous metal to be cast, maintaining the flame temperature and residence time of said particles in said flame at values to partially fused said particles, directing the stream of partially fused slag particles onto the walls of a mold for adherence thereto and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold supported shell of casting slag.

11. Process for casting alloys in a fluid slag casting mold comprising directing a stream of particulated casting slag material through a flame, said casting slag containing a major proportion of lime and alumina and less than about 15 percent by weight silica and having a melting temperature less than the melting temperature of the alloy being cast, maintaining the flame temperature and residence time of said particles in said flame at values to partially fused said particles, directing the stream of partially fused slag particles onto the walls of a mold for adherence thereto and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

12. Process for casting copper-containing metals in a fluid in a fluid slag casting mold comprising directing a stream of particulated casting slag material through a flame, said casting slag containing major proportions of boric oxide and silica and being substantially inert to the metal to be cast and having a melting temperature less than the melting temperature of the metal to be cast, maintaining the flame temperature and residence time of said particles in said flame at values to partially fused said particles, directing the stream of partially fused slag particles onto the walls of a mold for adherence thereto and to each other to form a semi-porous lining of surface-bonded slag particles on the walls of the mold, pouring molten metal into the so-lined mold and allowing the heat of the molten metal to fuse the slag lining forming a shell of fluid casting slag between the metal body and the walls of the mold, and solidifying the metal body in the mold-supported shell of casting slag.

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