United States Patent

Joyce et al.

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[45] **Oct. 17, 1972**

[54] PARTICLE CASTING

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[21] Appl. No.: **4,144**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 560,462, June 27, 1966, abandoned.

[52] **U.S. Cl.** **264/6,** 264/8, 264/111

[51] **Int. Cl.** **B22f 9/00**

[58] **Field of Search**.....264/8, 13, 111, 6

[56] **References Cited**

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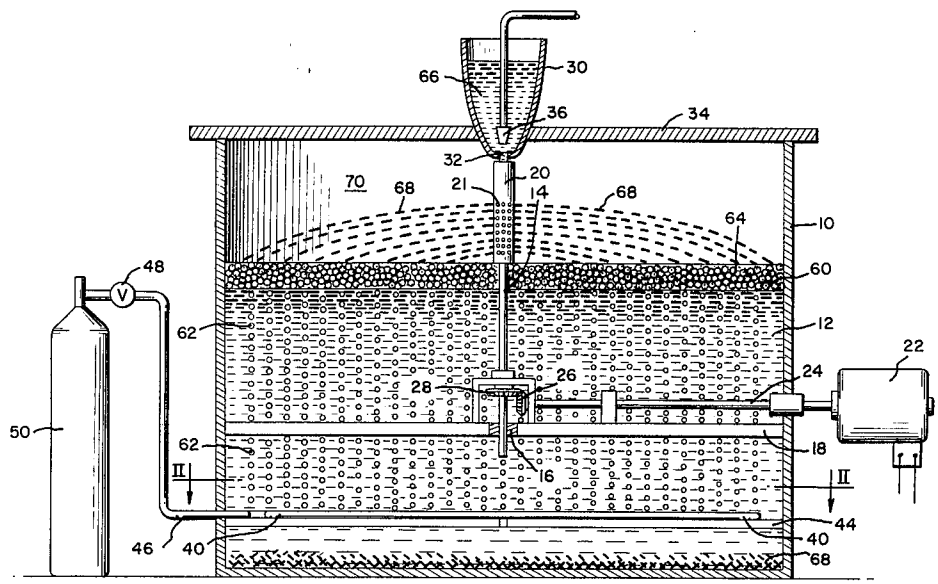
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[57] **ABSTRACT**

In a process of cooling and solidifying molten metal particles, gas substantially free from nascent and molecular oxygen (argon, helium, nitrogen, carbon dioxide and carbon monoxide) is bubbled through a liquid, thereby creating at the surface of the liquid a layer of foam of bubbles containing some of the gas. Additional gas is retained in the space adjacent the foam. Molten metal particles are formed by being centrifugally projected through holes extending through a side wall of a rotating pot disposed within the space. The molten particles are decelerated and cooled by passing into said foam, and rupture some of the bubbles, so that the gas contained within them flows into the space. The particles then leave the foam and pass into the liquid, becoming further cooled, and are thereafter recovered solidified, substantially unoxidized, and with a minimum of distortion, thereby being suitable for forming into strip. New gas-containing bubbles are created by bubbling additional gas through the liquid, so as to maintain the layer of foam.

2 Claims, 2 Drawing Figures



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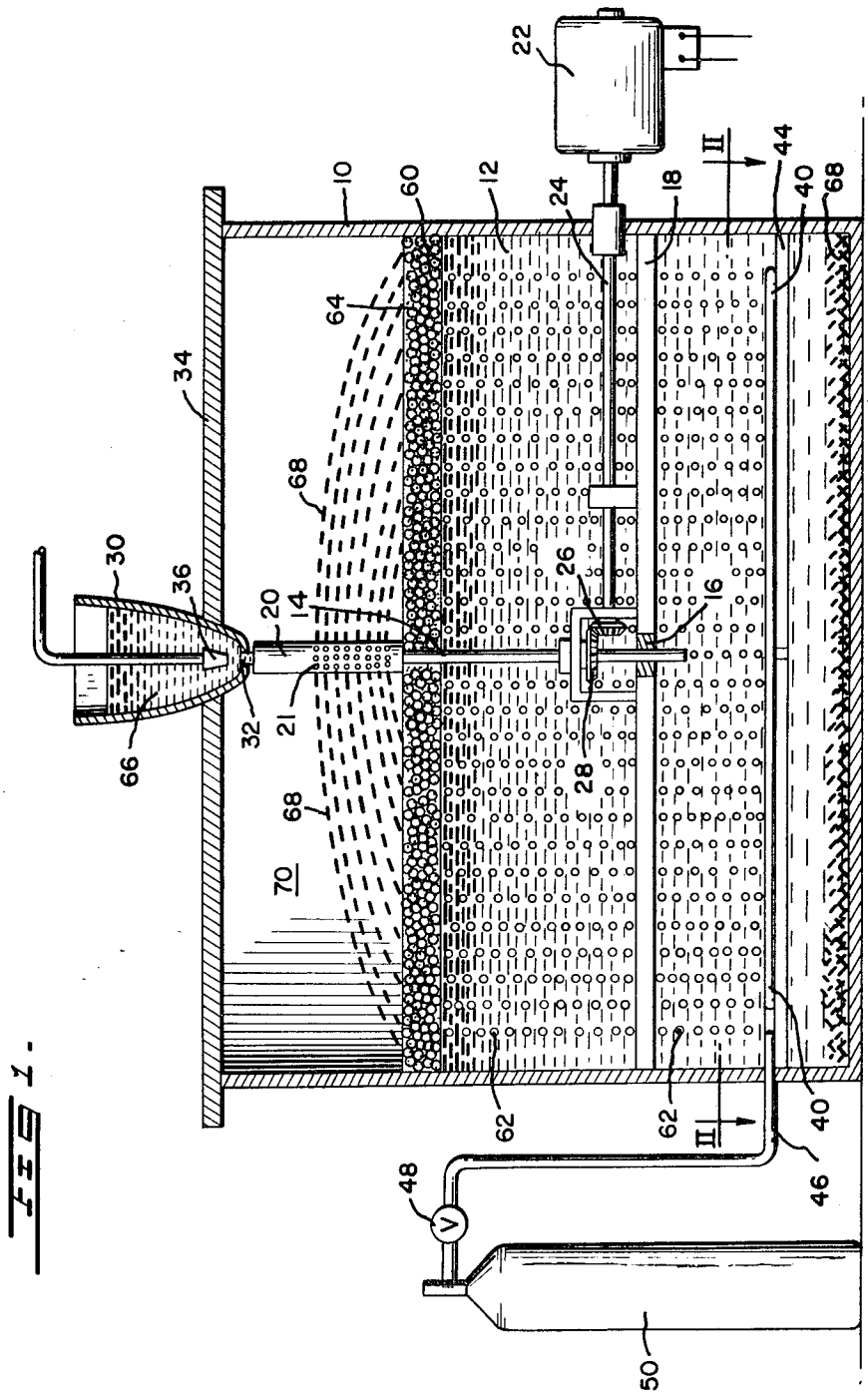


FIG. 1.

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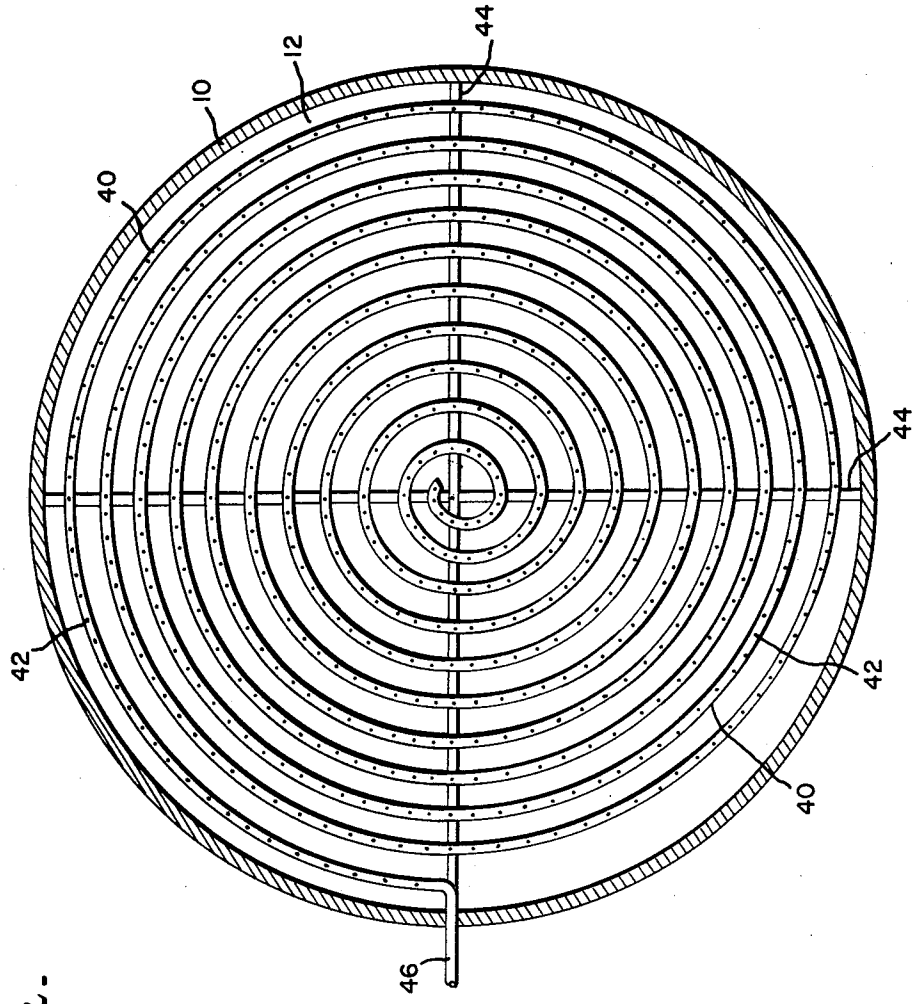


FIG 2.

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PARTICLE CASTING

This application is a continuation-in-part of our copending application Ser. No. 560,462 filed June 27, 1966 now abandoned.

This invention relates to improvements in casting solid, free-flowing metal particles from molten metal and metallurgically bonding the particles together.

It is known that discrete, free-flowing metal particles may be produced by depositing molten metal on or into a rotating member, centrifugally projecting the metal outwardly from the member to form molten particles of the metal, and solidifying the particles by receiving them in a cooling liquid. The rotating member may be a disk, a cup, a pot having holes extending through its side wall, or other suitable apparatus. The cooling liquid is necessary to prevent the particles from being deformed and from sticking to each other when they reach the end of their trajectory.

One problem presented by this process has been that the cast particles tend to distort when they strike the surface of the liquid; for example, particles intentionally cast in elongated, "pickle-shaped" form may become spherical, splattered, or otherwise misshapen. Another problem is that certain metals may at their casting temperature react undesirably with a component of the medium between the rotating member and the cooling liquid, with the cooling liquid itself, or with a substance interposed between the rotating member and the cooling liquid surface to prevent the aforesaid distortion. The most likely such reaction is combination with oxygen, causing burning of the particles, or, at the very least, an objectionable metal oxide coating on the surface of the particles which renders them unsuitable for certain further operations.

The present invention, which is directed to either or both of these problems, provides for receiving the cast particles in a foam or froth of bubbles containing a gas which is substantially free from nascent and molecular oxygen. It is believed that the bubbles making up the foam serve to cushion the impact of the particles with the surface of the liquid, cool the particles slightly, and release a protective, non-reactive atmosphere around the particles. Since the bubbles must usually be destroyed in order to perform their function, new bubbles are necessary to replace them. Preferably, the foam is created and maintained at the surface of the cooling liquid by bubbling the gas through the liquid, as the bubbling mechanically agitates the liquid, assisting in the creation of new foam to replace that which has been destroyed. Moreover, the rate of such bubbling can be carefully controlled to produce the desired thickness and distribution of foam. The addition of a small amount of detergent to the liquid increases the quantity of foam produced.

For a better understanding of the invention, and of its other details, objects, and advantages, reference is now made to the accompanying drawings, which show, for purposes of illustration only, a present preferred embodiment of the invention. In the drawings:

FIG. 1 is an elevation view, partially in section, of apparatus according to the invention; and

FIG. 2 is a sectional view taken at 2—2 in FIG. 1.

As shown in the drawing a cylindrical tank **10** contains cooling liquid **12**. Shaft **14** is mounted for rotation within bearings **16** in spider member **18** attached to the tank wall. Hollow casting pot **20** with holes **21** in its side wall is fixed to the upper end of shaft **14**, which is arranged to be driven by motor **22**, driveshaft **24**, and bevel gears **26, 28**. Crucible **30** with a bottom discharge opening **32** is supported and centered directly above pot **20** by spider or solid cover **34** resting on the top of tank **10**. Stopper **36** is arranged to plug opening **32**.

Disposed in liquid **12** near the bottom of tank **10** is a spiral coil of copper tubing **40** provided at its upper surface with a number of small openings **42** and supported by thin spider **44** secured to the wall of tank **10**. Tubing **40** is connected by line **46** through valve **48** to gas cylinder **50** located outside the tank and containing the gas to be bubbled through liquid **12**.

In operation according to the invention, tank **10** is filled with liquid, e.g., water, to a level **60** several inches below the bottom of pot **20**, and a small amount of detergent is added to the liquid. The compressed gas is admitted, by adjustment of valve **48**, through line **46** and into tubing **40**. The gas leaves tubing **40** through openings **42**, forming bubbles **62** which rise upwardly through liquid **12**. Upon reaching the surface **60**, the bubbles form a layer of foam **64** of bubbles containing the gas. The layer of foam **64** is desirably several inches thick, reaching approximately to the bottom of pot **20**.

Motor **22** is then operated, causing pot **20** to be rotated at the desired casting speed. With crucible **30** substantially full of molten metal **66** to be cast, stopper **36** is withdrawn from discharge opening **32**, allowing the molten metal to flow into pot **20**. Pot **20** and crucible **30** may be heated by conventional gas burners (not shown). The rotation of pot **20** causes the molten metal to be expelled outwardly through holes **21** to form droplets or particles **68**.

As particles **68** pass through foam **64**, they rupture the gas-containing bubbles, so as to be decelerated and at least slightly cooled, and to release the gas from the ruptured bubbles. Particles **68** then continue through the liquid surface **60** into the liquid **12**, which further cools them to a condition of substantially complete solidification. The particles finally descend to the bottom of the tank **10**. The particles may be removed from the bottom of tank **10** continuously or intermittently by any suitable apparatus, as for example, a discharge system (not shown) which draws off a mixture of liquid and particles, separates them, and recirculates the liquid to the tank.

While any metal which can be cast into particles can be formed into particles in accordance with the present invention, the invention will be found particularly effective when used with such metals which readily react with oxygen at their melting point. Examples of such metals are; magnesium, beryllium, titanium, molybdenum and iron.

Commercial gases which may be used in practicing the present invention include argon and helium for all such metals, and nitrogen, carbon dioxide and carbon monoxide for some of them. Of course, the selection of the gas will depend to some extent upon the particular metal to be cast. After the non-reactive gas is released from the ruptured foam bubbles or otherwise enters the space **70** within tank **10** above foam layer **64**, it is desirable to retain it there as long as possible. This can be done by providing that the gas be heavier than the air, by providing that the crucible support **34** be a cover

to close the top of tank **10**. It must be remembered, however, that the heat of the cast particles may cause some of the aforesaid gases, for example, carbon dioxide and carbon monoxide, to dissociate to form oxygen. When such gases are employed, means should be provided to remove the oxygen as it is produced; for example, quantities of fresh gas could be circulated through tank **10** in space **70**.

It will be clear that a liquid other than water may be used as cooling liquid **12**, so long as it does not react with the hot particles or inhibit the formation of foam layer **64**; for example, alcohol or mixtures of water and alcohol might be used. The liquid may be at any convenient temperature, for example, ambient temperature, or in order to further minimize distortion of the cast particles, a temperature between ambient temperature and the liquid boiling point. Copending U.S. Pat. application Ser. No. 410,363, now U.S. Pat. No. 3,329,746, contains a more detailed discussion of the effect of liquid temperature upon particle distortion.

A significant advantage of the present invention is that by manipulation of valve **48** the rate of formation of new bubbles in the layer of foam **64** may be adjusted to balance exactly the rate at which the bubbles in that layer are being destroyed by the incoming particles. In this manner the layer can be maintained at the desired thickness.

The holes **42** in tubing **40** need not be spaced uniformly along the tubing, but may be distributed in whatever fashion will produce the desired distribution of the foam **64** across surface **60**. For example, the holes per unit tank area might be less near the wall of tank **10**, where relatively few particles reach; on the other hand, the holes **42** might be apportioned so as to produce a foam layer having a surface of a generally concave shape which is more nearly perpendicular to the paths of the particles passing into it.

For other details of casting pot systems, such as pot design and construction, particle removal systems, casting conditions, and the like, reference is made to U.S. Pat. No. 3,241,948, and to copending U.S. Pat. application Ser. No. 539,977, now U.S. Pat. No. 3,442,988.

In an illustrative example of the apparatus described above, and its use, the casting pot was made of cast iron with an outside diameter of 2.25 inches, an overall height of 8 inches, and a wall thickness of 0.25 **inches**. **A total of** 340 holes of 0.052 inch diameter were spaced equally about the pot in 17 horizontal rows. The pot was mounted in the center of a tank having a 4-foot inner diameter and a 3-foot height, with the top of the pot 2.5 inches below the top of the tank. A 0.5 inch diameter copper tube was connected at one end to a cylinder outside the tank containing compressed argon and wound at its other end into a flat spiral of 18-inch diameter. The spiral end was provided with a number of small perforations and centered under the pot at the bottom of the tank, with the tube leading out of the top of the tank to the argon cylinder. The tank was filled with water to a depth of 23 inches, with the surface of the water being disposed 2 inches below the bottom of the pot. A gas burner was disposed so that its flame was directed upon the side of the pot.

About one pound of detergent sold under the trademark "BREEZE" was added to the water, which was at a temperature of about **65°** F. The argon cylinder valve was then opened, so that gaseous argon was bubbled at a temperature of about **60°** F from the holes in the copper tubing upwardly through the water. Casting was begun about 3 minutes thereafter, when the layer of foam formed on the surface of the water reached the top of the tub (i.e., the layer of foam was about 12 inches thick.) With the pot rotating at 1,000 rpm, molten magnesium of 99.8 percent purity, was disposed in a crucible with a flux (Dow Flux No. 310) upon its surface to prevent oxidation, and underpoured through the bottom of the crucible into the pot at a temperature of about 1,350° F and a rate of about 10 pounds per minute. Once casting was underway, the particles formed destroyed the foam at a rate such that the layer maintained a relatively uniform thickness of about 2 inches. About 15 pounds of metal were so cast. The resulting particles had a fairly bright and smooth surface finish, were elongated with relatively little distortion and in a free-flowing shape, and ranged in size from about minus 10 mesh to about plus 30 mesh (U.S. Standard Sieve).

During another run, the same metal composition was cast by means of a comparable apparatus and process which did not employ the gas as described above. The resulting particles were badly blackened and distorted into shapes having hook-like tails and poor flow qualities, and many adhered to one another to from "multiples."

Metal particles made through practice of the invention can be metallurgically bonded together by compaction to produce solid shapes, such as by extrusion, rolling or other working, preferably at hot forming temperatures (above recrystalization). Rolling should be done under conditions insuring that the particles are in free flowing condition as they enter the nip of the rolls. The ability to roll the particles into strip is particularly significant in the case of metals, such as magnesium, which are difficult to roll down from conventional ingots because of the many intermediate heat treatments required. Magnesium base alloys are particularly difficult to roll down from ingot to strip, and it has been found that particles of these alloys (e.g., AZ–61 Alloy, containing 6 percent aluminum and 1 percent zinc), when preheated to a hot forming temperature (such as about 600° to 900° F) and fed at such temperature and in free flowing condition into the nip of a pair of work rolls, produce fully solidified strip in one pass between the rolls. The strip can be further rolled or processed in accordance with conventional practice, but not much additional rolling is necessary, because the strip thickness originally produced is about one-sixteenth inch to about one-eighth inch depending on roll size and particle size among other variables.

While present preferred embodiments of the invention have been illustrated and described, it will be understood that the invention may be otherwise variously embodied and practiced within the scope of the following claims:

What is claimed is:

1. A process for producing metal strip consisting primarily of magnesium comprising the steps of

a. bubbling a gas which is substantially non-reactive to magnesium through a liquid on a substantially continuous basis in order to establish a layer of

foam on said liquid and a gas atmosphere thereabove of a sufficient height to encompass a source of molten magnesium,

b. projecting droplets of said magnesium sequentially through said gas atmosphere, foam and liquid thereby cooling said droplets of magnesium and forming free-flowable solid particles of magnesium,

c. recovering said particles of magnesium from said liquid,

d. feeding said magnesium particles in free-flowing and preheated condition to a set of work rolls,

e. and rolling said magnesium particles in one pass through the rolls into a solid strip.

2. A process for producing metal particles consisting primarily of magnesium comprising

a. bubbling a gas which is substantially non-reactive to magnesium through a liquid on a substantially continuous basis in order to establish a layer of foam on said liquid and a gas atmosphere thereabove of a sufficient height to encompass a source of molten magnesium,

b. projecting droplets of said magnesium sequentially through said gas atmosphere, foam and liquid thereby cooling said droplets of magnesium and forming free-flowable solid particles of magnesium,

c. and recovering said particles of magnesium from said liquid.

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