

Feb. 8, 1949.

G. J. LE BRASSE ET AL
METHOD OF ATOMIZING METAL

2,460,992

Filed Feb. 6, 1946

2 Sheets-Sheet 1

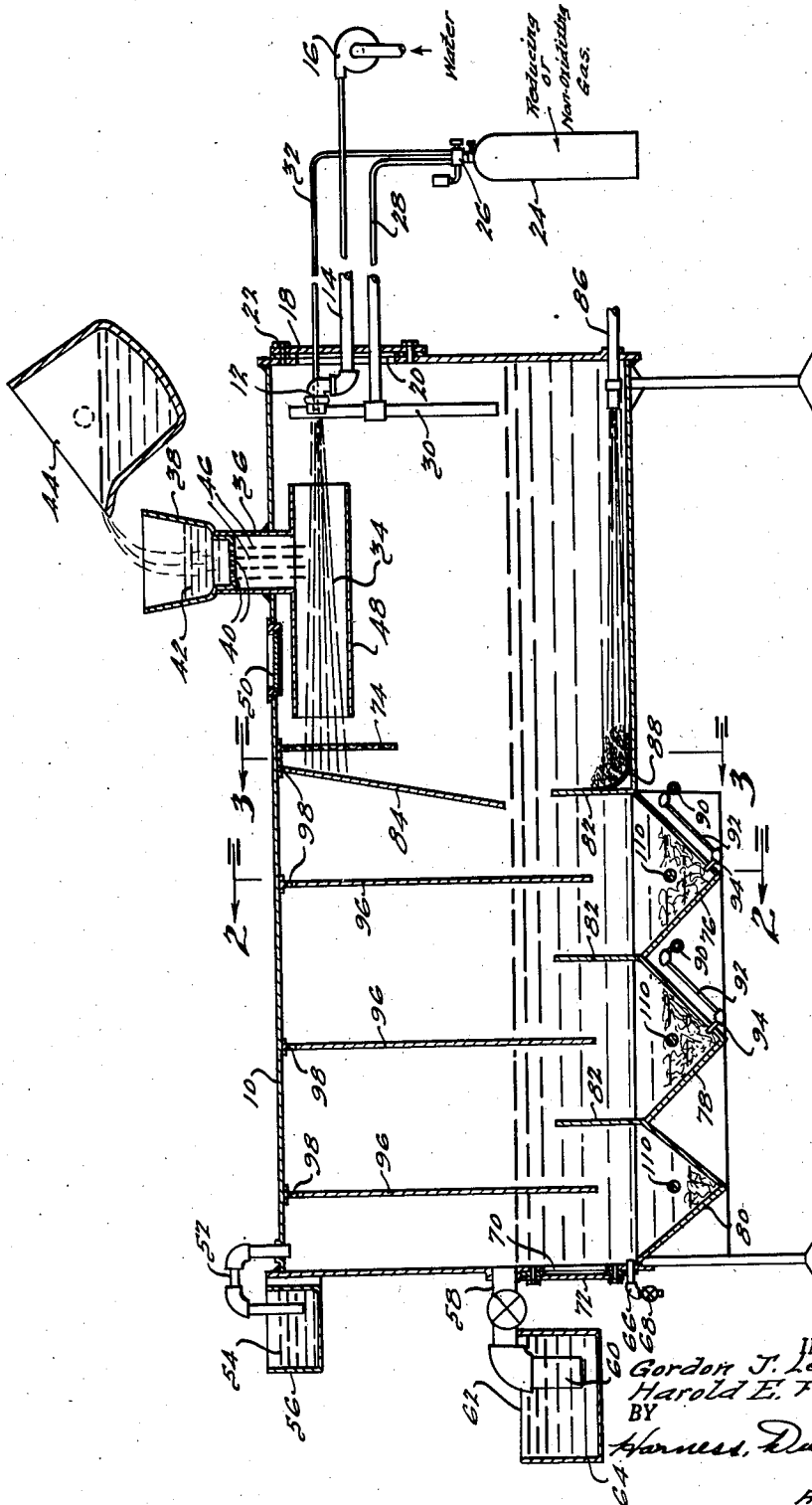


FIG. 1

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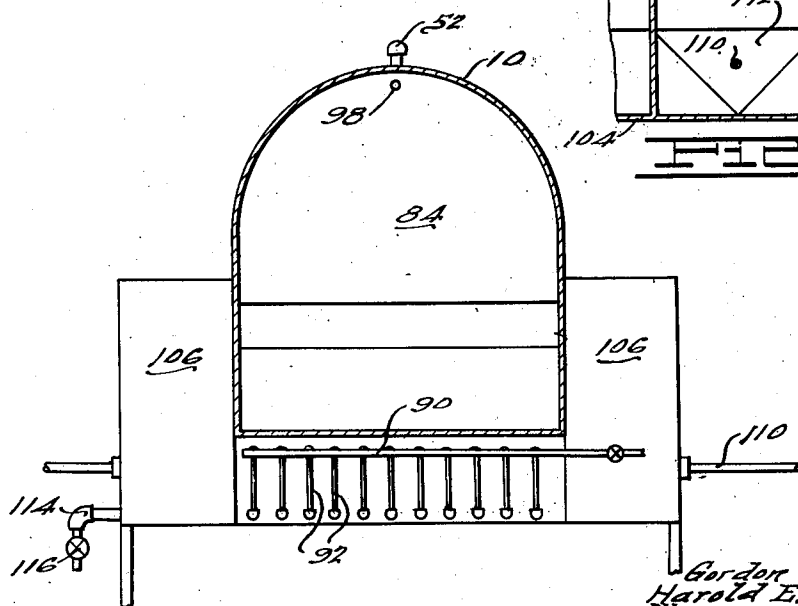
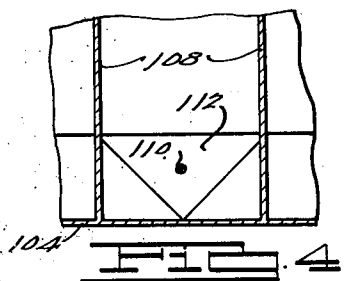
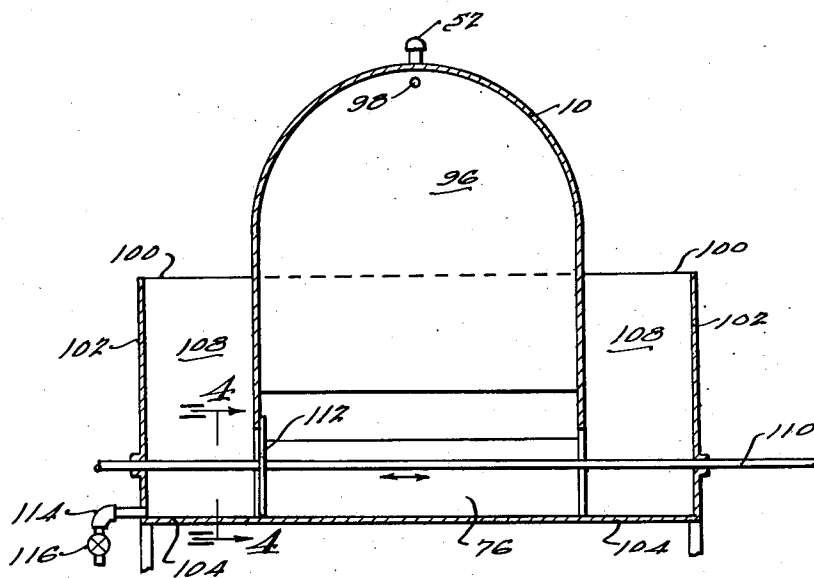
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,460,992

METHOD OF ATOMIZING METAL

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Application February 6, 1946, Serial No. 645,947

2 Claims. (Cl. 18-47.3)

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This invention relates to a method of atomizing metal and has for its principal object the provision of a method of atomizing a metal alloy having as principal elements thereof, copper and lead, and by the practice of which method such alloy may be atomized without the formation of an excessive coating of oxide on the particles produced thereby.

Objects of the invention include the provision of a method of atomizing an alloy having as principal elements thereof copper and lead, with or without the addition of tin, so as to form a loose mass of finely divided particles, and by the practice of which the oxygen content of the mass of atomized particles, because of the oxide coating on the particles produced during the atomization, does not exceed 0.5%; the provision of a method of atomizing an alloy of the type above defined in which the alloy in molten condition is subjected to the effects of high velocity water in a non-oxidizing or in a reducing atmosphere; the provision of a method as above described in which the atomization of the metal is carried on in a closed space from which air has been displaced by a non-oxidizing or a reducing gas; the provision of a method as above described requiring the use of a minimum amount of a non-oxidizing or a reducing atmosphere; the provision of a method as above described including the additional step of effecting a separation of the atomized particles in accordance with the size thereof; the provision of a method as above described, including the use of means for dissipating the force of the stream of water after it has served its purpose in breaking up the particles of molten metal being atomized; and the provision of a method as above described by the practices of which metal of the character described may be quickly and economically atomized and in which the resulting particles of metal will have a minimum amount of oxide coating thereon.

The above being among the objects of the present invention, the same consists in certain novel steps of operation to be hereinafter described with reference to the accompanying drawings, and then claimed, having the above and other objects in view.

In the accompanying drawings which illustrate a suitable form of apparatus by means of which the method of the present invention may be carried out, and in which like numerals refer to like parts throughout the several different views;

Fig. 1 is a vertical sectional view taken cen-

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trally and longitudinally through a metal atomizing apparatus by the use of which the method of the present invention may be carried out,

Fig. 2 is a vertical transverse sectional view taken on the line 2-2 of Fig. 1;

Fig. 3 is a vertical transverse sectional view taken on the line 3-3 of Fig. 1, and

Fig. 4 is a fragmentary, vertical sectional view taken on the line 4 of Fig. 2.

While the method of the present invention is believed of value in the atomization of any metal or metal alloy, it is particularly useful in the production of the atomized metal disclosed and claimed in our copending application for Letters Patent of the United States for improvement in Atomized metal, filed on even date herewith, and serially numbered 645,948. The apparatus herein shown as applicable to the carrying out of the present method forms the subject matter of our application for Letters Patent of the United States for improvements in Apparatus for atomizing metal, filed on even date herewith and serially numbered 645,946. The said copending applications deal particularly with an atomized metal alloy in which copper and lead form essential elements and which particles have an oxide coating of a desirably small value, and to an apparatus for producing such atomized particles.

A typical example of a copper-lead alloy in the atomizing of which the present invention is particularly adaptable is as follows:

	Per cent
Lead	10 to 50
Nickel	0 to 2
Tin	0 to 2
Phosphorus	0 to 0.10
Copper	substantially the balance

A typical example of a lead bronze in the atomizing of which the present invention is particularly adaptable is as follows:

	Per cent
Lead	5 to 30
Tin	5 to 12
Zinc	0 to 6
Nickel	0 to 2
Phosphorus	0 to 0.5
Copper	substantially the balance

Atomized particles of such copper-lead alloys find their principal use in connection with the formation of sintered bearings for rotating shafts and the like. When formed in accordance with conventional practice, the alloy is melted and in

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the form of one or more fine streams is discharged into a blast or spray of water simply directed and surrounded by air. The blast of air breaks up the fine streams of molten metal into fine particles and solidifies them so that they produce a mass of loose powder-like material. However, the short time that such particles are exposed to the air in their molten state, as well as to the water, in accordance with conventional practices, is sufficient to produce on each particle a coating consisting of one or more of the oxides of lead. When tin is also an element of the alloy, at least a part of the coating may consist of tin oxide. There are five different oxides of lead, but in view of the temperatures involved it is presumed likely that one or all of the following three lead oxides are present in such coating: PbO , Pb_2O_3 and Pb_3O_4 . Atomized particles produced in the conventional manner thus described will usually be found to have an oxygen content, because of the oxide coating, in excess of 1%, probably averaging about 1.2%. The average oxygen content of the three oxides above listed is 8.6%. If this average figure is used as a basis for calculating the amount of oxide present in a mass of the atomized alloy, then an atomized mass of the alloy having 1% of oxygen would mean that there would be about 11.6% lead oxide present. With an average oxygen content of 1.2%, then there would be about 13.92% of lead oxide present in a mass of the atomized alloys under consideration. This means that for a given amount of such atomized alloy, there is present an average of in the neighborhood of 13% to 14% of the weight of the mass in the form of an oxide coating on the particles.

Where a powder comprising such atomized particles of lead bearing copper alloys is applied as a coating to a steel strip and passed through a sintering furnace to cause the various particles to adhere to one another and to the steel backing strip, as is a conventional practice in the formation of bearings, the amount of oxide present in the conventionally formed powder is so great as to require reduction of the oxide coating in the sintering furnace, by the combined application of heat and a reducing atmosphere, before a satisfactory bond can be obtained between the various particles and between the particles and the steel strip. As a result, the passage of such strip through a sintering furnace has been considerably slowed down as compared to the speed that would be possible if such oxide coating were initially of no greater value than that at which satisfactory sintering may be produced by heat alone without the necessity of reducing the percentage of oxide present.

We have found that if the atomization of such metal is carried on in a non-oxidizing or in a reducing atmosphere, the production of an oxide coating on the atomized particles may be reduced to a desired extent, the amount of oxide thus produced being substantially limited to the amount of oxygen which the particles pick up solely from the water spray. The amount of oxide coating thus produced on such atomized particles will be so small that the oxygen content of a given mass of particles may be as low as approximately 0.06%, and rarely if ever, over 0.5%. As long as the oxide coatings on such particles do not provide an oxygen inclusion in a mass of such particles greater than the percentage last stated, a satisfactory bond between the various particles, and between such particles and the steel strip may be obtained in a sintering

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furnace without the necessity of further reducing the oxygen content of the mass of powdered metal, and therefore the speed of the sintering operations may be substantially doubled over that where conventionally formed atomized metal is employed as a powdered layer in the manufacture of bearings or the like.

However, the atomization of such molten metal must not only be carried on in a non-oxidizing or in a reducing atmosphere to obtain the desired results, but in order to be commercially practical, the operation must be such that excessive amounts of these non-oxidizing or reducing gases are not used up in the process. This is accomplished in accordance with the present invention by carrying on the atomizing operation within a space substantially sealed against the admission of air into it, which space may be made a relatively small size and from which air has been displaced by a non-oxidizing or a reducing gas, small amounts of which are preferably continuously supplied thereto so as to prevent contamination of the gas by air. As a result, the only oxide coating which may be found on the particles atomized will be caused substantially solely from the oxygen drawn by such particles when in molten condition from the water employed in the atomization step, the amount of oxide formed thus being kept at a minimum.

It will be appreciated that the form of the apparatus to carry out the method of the present invention may vary considerably in accordance with the desires of the particular designer without any particular difference in result as long as the essential steps of the invention are followed. The apparatus shown in the accompanying drawing illustrate one form of such apparatus which has been found satisfactory in the carrying out of the present method.

Referring now to the accompanying drawings, it will be noted that the apparatus comprises generally a tank or container 10 in one end of which and adjacent the top thereof is positioned one or more nozzles, here shown for the purpose of illustration as a single nozzle 12, arranged to direct a stream or spray of water therefrom preferably lengthwise of the tank as shown. It will be understood that the tank or container is either closed or is otherwise sealed against the leakage of air thereinto. The nozzle 12 is connected by a pipe such as 14 with a suitable source of water under pressure, such as the pump 16. Preferably, the pipe 14 projects into the container 10 through a coverplate or manhole cover 18 removably secured and sealed to the corresponding end face of the tank or container 10 over the hole 20 formed therein by means of bolts or screws such as 22.

Means are also provided for introducing a suitable reducing or non-oxidizing gas such as nitrogen, hydrogen, helium, illuminating gas either in its natural or cracked state, or the like, into the tank or container 10, and this may be done in any suitable manner and be obtained from any suitable source. In the drawings, such gas is obtained from a conventional pressure bottle 24 from which it is fed to the tank through a conventional reducing valve or the like 26. In Fig. 1, one tube 28 is shown as extending from the reducing valve 26 through the coverplate 18, to which it is sealed, into the interior of the tank or container 10 where it connects with a cross pipe 30 disposed with its axis vertical and its opposite ends open for the escape of such gas into the interior of the tank or container 10.

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A second pipe or tube 32 is also shown as extending from the reducing valve 28 through the cover 18 to which it is sealed and into the interior of the nozzle 12 where the eduction effect of the stream or spray of water discharged from the nozzle 12 aids in drawing the gas into the tank or container 10 and diffusing it therein. Either one or both of these two means for introducing the nonoxidizing or reducing gases into the tank or container 10 may be employed, or any other suitable means for producing an equivalent result may be employed in place thereof.

The molten metal which is to be atomized is introduced into the tank or container 10 preferably in the form of one or more relatively fine streams which are discharged into the stream or spray 34 of water issuing from the nozzle 12. While any suitable means may be provided for effecting this result, the apparatus shown provides the following described means, as disclosed in Fig. 1. The upper wall of the tank or container 10 is provided with a relatively short open ended cylindrical tube 36 which projects vertically through such wall and is rigidly fixed and sealed thereto as by welding or the like. The lower end of the tube 36 terminates in vertically spaced relation above the stream or spray 34, preferably a substantial distance from the nozzle 12. A suitable crucible 38 is removably received, preferably in more or less fitted relation, in the upper end of the tube 36. The bottom wall of the crucible 38 is provided with one or more fine holes 40 through which molten metal such as 42 introduced into the crucible 38, as for instance from a ladle such as 44, may flow in the form of fine streams 46 into stream or spray 34. The stream or spray 34 may be unconfined below the tube 36 where the molten metal is introduced into it. On the other hand, if desired, the stream or spray 34 at the point where the molten metal is introduced into it may be confined within an open ended tube 48, as shown in Fig. 1, secured to the lower end of the tube 36 and into which the tube 36 opens. Where the tube 48 is not employed, then it may be desirable to provide a window such as 50 directly over the stream or spray 34 on the downstream side of the tube 36 so as to enable the character of the stream or spray 34 to be visually inspected. The window 50 is, of course, sealed at its margins to the tank or container in any suitable manner.

In order to permit the escape of air and gas from the tank or container, an inverted U-shaped tube 52 is provided at the rear end thereof with one leg thereof projecting through the upper wall of the tank as shown in Fig. 1. Preferably, the other leg of the U is projected into a body of water such as 54 carried in an open top container such as 56 so as to provide a water seal for preventing the leakage of air back into the tank or container 10. The rear wall of the tank or container 10 is likewise provided with an overflow pipe 58 and, like the pipe 52, in order to prevent leakage of air through into the tank or container 10, the pipe 58 is preferably provided with a downwardly extending end portion 60 which may be submerged in a body of water 62 in an open top container 64. In this connection, it will be appreciated that the water introduced as the stream or spray 34 will fall to the bottom of the tank, and the pipe 58 serves as an overflow for such water and as a means for maintaining a constant level of water in the bottom of the tank or container 10. Preferably, a drainage pipe 66 is provided leading into the bottom

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of the tank, shown at the rear end thereof in Fig. 1, and provided with a shut-off valve 68 so that the tank may be drained of water when necessary or desirable. Additionally, the rear end of the tank or container 10 is preferably provided with a hole 70 of sufficient size to permit a workman to crawl therethrough to the interior of the tank or container 10 and this opening is normally closed and sealed by means of a removable cover 72.

The apparatus thus far described is sufficient, in the broader aspects of the invention, for accomplishing the broad purposes of the present invention, and in such case, its operation is as follows: The crucible 38 is initially removed and the top of the tube 36 closed, preferably in a more or less loose manner so as to permit the escape of air upwardly therethrough under the pressure of the non-oxidizing or reducing gas employed. The containers 56 and 64 are filled with liquid. Reducing or non-oxidizing gas is then introduced into the tank or container 10 from the bottle 24, either through the pipe 28, the pipe 32, or both, and is allowed to discharge into the tank or container 10 at a sufficient rate of flow and for a sufficient length of time to insure the bulk of the air being expelled or flushed therefrom, after which the rate of flow is reduced to a point more fully explained later. Instead of expelling the air in this manner the overflow pipe 58 may be closed and the tank or container 10 be filled with water to expel or flush out the air, the pipe 58 thereafter being opened and a non-oxidizing or reducing gas employed to replace the water above the pipe 58 which then drains out. In such case a relatively low rate of flow of the gas is established once the water in the tank 10 has reached its normal level. Thereupon, water is supplied to the nozzle 12 to form the stream or spray 34, whereupon the crucible 38 may be introduced into the upper end of the tube 36 and molten metal introduced into the crucible so that it will be discharged in the small or fine streams 46 into the stream or spray 34. The fine streams of molten metal in being engaged by the stream or spray 34 will be caused to be broken up into finely divided particles, which are rapidly solidified, so that they drop by gravity into the bottom of the tank as a finely divided loose powder or as extremely small particles. The water employed in producing the stream or spray is preferably under a relatively high pressure so as to enhance the breaking up of the fine streams 46 of molten metal into extremely fine particles. A water pressure of 150 pounds per square inch has been found suitable. During the above-described operation, the supply of non-oxidizing or reducing gas from the bottle 24 into the tank or container 10 is continued, but only at a relatively small rate. All that is necessary is that a sufficient amount of a non-oxidizing or reducing gas be introduced into the tank of container 10 to maintain the pressure therein slightly above atmospheric pressure so as to prevent any air on the outside of the tank or container from finding its way into the tank or container through any cracks or apertures that may not otherwise be sealed. However, the tank or container 10 may readily be sealed sufficiently completely so that a very small amount of non-oxidizing or reducing gas is required to be continuously fed into the same. Thus a very small amount of such gas is used up during continued operation.

The apparatus thus described may be operated until a desirable amount of metal has been

atomized and deposited in the bottom of the tank, upon which the flow of metal may be stopped, the gas and water turned off, valve 68 opened so as to drain the tank or container, and then the closure 72 removed and the atomized metal scraped or otherwise removed from the bottom of the tank through the opening 70. Where necessary or desirable, such atomized metal may then be graded to different sizes adaptable for different uses.

In actual practice it is, of course, usually desirable to provide features, other than those above-described as essential, for enhancing the efficiency of the apparatus, to permit continuous operation and for other reasons. For instance, it has been found that if one or more screens such as 74, suitably supported on the interior of the tank or container 10, are provided in the path of flow of the stream or spray 34, it will act to dissipate the force of the stream 34 and aid in cutting down the turbulence imparted to the gas in the tank 10 by the stream 34. It also aids in preventing the water of the stream 34 from splashing back from the baffles hereinafter described, or which otherwise might be picked up by the turbulent gas, from hitting the bottom of the crucible 38 and freezing the metal 42 at the openings 40. Additionally, it is desirable, under some circumstances at least, to provide some means whereby an initial separation of the particles into different sizes may be accomplished in the tank or container 10.

For the last described purpose, the bottom of the tank or container 10 and over the rearward portion thereof may be provided with a plurality of transverse troughs, which may be of any number desired but shown in the drawings by way of illustration as three, namely 76, 78 and 80, with an upwardly projecting baffle or wall such as 82 between each, the baffles 82 terminating below the level of the water within the tank or container 10. When such an arrangement is employed, then some means such as the downwardly extending substantially imperforate baffle 84 is preferably provided rearwardly of the screen 74 but adjacent the forward edge of the forward trough 76 so as to prevent the particles of metal in the stream or spray 34 which pass through the screen 74 from being carried thereby beyond the first trough. In such cases, it is also desirable to provide a baffle 82 along the forward edge of the forward trough 76, as shown in Fig. 1, and then introduce a rearwardly directed stream of water along the bottom of the tank or container 10 from the forward end thereof, as by means of the pipe 86, so as to carry any particles that may be dropped forwardly of the forward baffle 82 over the top thereof. To facilitate this action, a curved sheet metal member such as 88, serving as a fillet, may be provided at the junction of the bottom wall forwardly of the forward baffle 82 and such forward baffle 82, as brought out in Fig. 1.

With the above-described construction the atomized metal which hits the baffle 84 is directed downwardly into the body of water in the bottom part of the tank. This body of water which is made up by the water from the stream or spray 34 and from that introduced to the pipe 86, creates a current of water which is continuously flowing from the front of the tank or container 10 to the rear thereof. The atomized particles of metal are ordinarily small enough to be capable of being picked up by the flow of water and carried along with it, and any particles that are de-

posited forwardly of the forward baffle 82 are forcefully washed by the stream from the pipe 86 over such forward baffle 82. The particles are thus first presented to the space between the first two baffles 82 at the forward and rearward edges, respectively, of the forward trough 76, and at this point the heavier particles will tend to drop into the trough 76. The lighter particles will be carried by the stream of water over the center baffle 82 to the space between the center baffle 82 and the rear baffle 82 where the heavier of the remaining particles will tend to drop out and be deposited in the bottom of the trough 78. Those particles still remaining in the flowing body of water will be carried over the rear baffle 82 and into the trough 80, the latter therefore serving to collect all particles which are not deposited in the troughs 76 and 78.

Some of the lighter particles may also be deposited out in the troughs 76 and 78, that is particles of a smaller size than desirably separated out in these troughs. To aid in preventing such occurrence it is preferable to provide some means for agitating the water in the bottom of the troughs 76 and 78 so that any particles smaller than intended to be deposited therein will be washed up into the moving body of water and be carried on to their proper places of deposit. One means of accomplishing this last effect is to provide a transverse water header such as 90 adjacent each trough 76 and 78 and to connect each such header by a plurality of pipes such as 92 with a similar number of nozzles 94, projecting through the bottom forward wall of the troughs 76 and 78 and directed more or less in parallelism of the rear walls of such troughs. The nozzles 94 for each trough 76 and 78 are preferably arranged in equally spaced relation with respect to each other over the length of such troughs, as brought out in Fig. 3, so that the water projected through the nozzles 94 from the headers 90 will tend to continually agitate the mass of particles in the bottom of the trough and thus cause the lighter ones thereof to be carried up and returned to the body of water flowing along the bottom of the tank from the forward end thereof to the rearward end thereof. In this manner, a more effective separation of the various size particles is possible.

In order to enhance the effectiveness of the above-described separation mechanism, it may be preferable in some cases to extend baffles such as 96 downwardly in the tank with the lower ends thereof projecting downwardly below the top of the baffles 82 and centrally of each of the troughs 76, 78 and 80. This produces the effect of a maze through which the body of water flowing from one end of the tank to the other end must pass and accentuates the tendency of gravity in discharging the particles from the stream into the various troughs. The baffle 84 in particular is preferably extended to the top of the tank so as to confine turbulent currents of the gas in the tank or container 10 resulting from the force of the stream or spray 34 thereon to the forward portion of the tank or container 10. In such case, of course, it is preferable to provide the baffles 96 as well as the baffle 84 with openings such as 98 adjacent their upper ends to aid in insuring complete elimination of the air in the tank or container 10 when the air is flushed from the tank at the beginning of each cycle of operation of the apparatus.

Any suitable means may be provided for periodically or continuously removing the deposits

of atomized powder from the bottoms of the various troughs 76, 78 and 80, and the means hereinafter described and shown in the drawings is illustrative of one way in which this may be accomplished. In the particular form of apparatus shown and as brought out in Figs. 2 and 3, the tank or container 10 is formed with a semi-cylindrical upper portion, with vertical sides and a horizontal bottom wall. At each side of the tank or container 10 and over the length of the troughs 76, 78 and 80 is a trough 100, each of which has a side wall 102 in outwardly spaced and parallel relation with respect to the side walls of the tank or container 10 and the bottom wall 104 of which is on a level of the bottoms of the troughs 76, 78 and 80. The side walls of the tank or container 10 over the lengths of the troughs 100 are extended down to the bottom wall 104, and these are cut out in line with both ends of each of the troughs 76, 78 and 80 so that these troughs open fully at each end into the troughs 100. End walls 106 are provided for each end of each trough 100, and partition walls 108 are provided therein intermediate each adjacent pair of troughs 76, 78 and 80 so that each trough 100 is divided up longitudinally into as many pockets as there are troughs 76, 78 and 80, each pocket being opened to its corresponding trough 76, 78 or 80 and being sealed from the others thereof. The side walls 102 are of sufficient height to extend above the level of the water in the tank or container 10 and to form a water seal for the openings between the ends of the various troughs 76, 78 and 80 and the outer troughs 100, thus preventing the entrance of air at these points during operation.

In the construction shown, an axially movable rod 110, as best brought out in Fig. 2, is projected centrally and lengthwise through each trough 76, 78 and 80, and the opposite ends of each rod 110 project through the opposite side walls 102 and are preferably suitably sealed against leakage therein. Between the side walls of each trough, a scraper blade 112 is fixed to each rod 110. The scraper blades 112 extend transversely of the length of the troughs 76, 78 and 80 and each is of a shape complementary to the cross sectional shape of the corresponding trough, and preferably bears against the converging bottom walls of the corresponding trough. It will be appreciated that when rods 110 are axially reciprocated either manually or mechanically, they will be caused to travel longitudinally of their respective troughs 76, 78 and 80 and in being reciprocated with scrape any deposit of atomized metal in such troughs out into the pockets 100, from which it may be readily manually or otherwise removed. Thus with the apparatus as thus fully described and shown, continuous operation of the apparatus may be carried on.

To permit complete draining of the tank and troughs, it is necessary, in the construction shown,

to provide drainage pipes 114 on the level of the bottom of each trough 76, 78 and 80 and in communication therewith, each of the pipes being provided with a shut-off valve 116.

Having thus described our invention what we claim by Letters Patent is:

1. In the atomization of metal, the steps of flushing air from a confined space and replacing such air with a non-oxidizing gas, maintaining a pressure within said space slightly greater than atmospheric by the continued introduction into said space of a non-oxidizing gas, introducing a stream of water flowing at a relatively high velocity into said space, introducing a relatively fine stream of molten metal into said high velocity stream of water within said space, partially obstructing the flow of said high velocity stream of water after the introduction of said molten metal thereto whereby to dissipate the force of said stream of water, creating a unidirectional flow of water in the lower portion of said space for receiving particles of said molten metal broken up and solidified by said high velocity stream of water, and effecting gravitational separation of said particles into a plurality of different sizes under the effects of said unidirectional flow of said water.

2. In the atomization of a metal alloy of a type in which copper and lead are the principal elements, the steps of driving air out of a substantially confined space and replacing such air with a non-oxidizing gas, introducing a non-oxidizing gas into such space to maintain a non-oxidizing atmosphere therein, continuously projecting a high velocity stream of water into said space, substantially continuously feeding a relatively fine stream of said alloy in molten condition into said high velocity stream of water whereby to cause said molten alloy to be broken up into fine particles and solidified as such, providing a moving body of water in the said space below said high velocity stream of water to receive said water and said particles and carry said particles a distance varying with the weight thereof, and removing said particles from said space while maintaining a non-oxidizing atmosphere therein.

GORDON J. LE BRASSE.
HAROLD E. FRANCIS.

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The following references are of record in the file of this patent:

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2,384,892	Comstock	Sept. 18, 1945

Certificate of Correction

Patent No. 2,460,992.

February 8, 1949.

GORDON J. LEBRASSE ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 2, line 46, for "Tin.....5 to 12" read *Tin..... 2 to 12*;
column 9, line 55, for the word "with" read *will*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of July, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,

Assistant Commissioner of Patents.