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METHOD FOR THE COMMINUTION OF MOLTEN METALS

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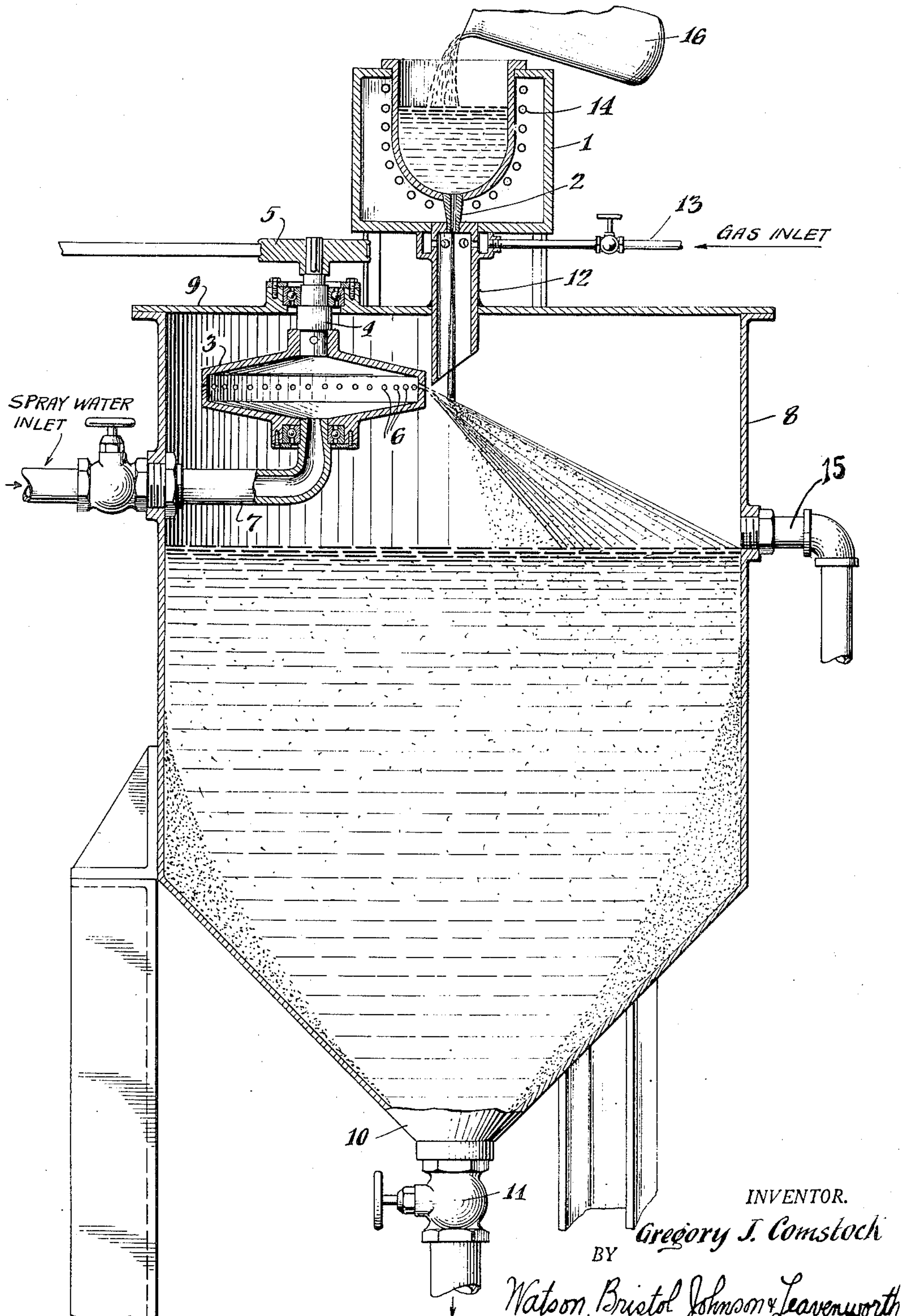

INVENTOR.
Gregory J. Comstock
BY
Watson, Bristol, Johnson & Leavenworth
ATTORNEYS

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METHOD FOR THE COMMINUTION OF MOLTEN METALS

Gregory J. Comstock, Summit, N. J., assignor to F. W. Berk & Company, New York, N. Y., a corporation of Maryland

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The invention relates to a method for comminuting materials, more particularly metals and metallic alloys, and includes correlated improvements and discoveries whereby metals and metallic alloys may be obtained in finely subdivided condition.

An object of the invention is the provision of a method in accordance with which a material in molten condition may be comminuted or subdivided as desired.

Another object of the invention is to provide a method for the comminution of metals and metallic alloys, which may be readily, effectively and economically carried out.

An additional object of the invention is to provide a method for effecting comminution of metals and metallic alloys from the molten condition.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, all as exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

For convenience in description, the term "metal" will be used herein as comprehending not only elemental metal, with or without ordinary impurities, and combinations of metals, but also metallic alloys of various types, and it will be understood that where the term "metal" is used in this specification and in the appended claims, it has this broad significance unless the context otherwise clearly indicates.

The inveniton comprises bringing a material, illustratively a metal, into molten condition and to a suitable temperature, pouring the molten metal in a continuous but comparatively thin stream, and causing bodies of liquid at moderate temperature having high kinetic energy to bombard the stream of molten metal in rapid succession. By this method the molten metal is disintegrated into particles of minute size, each of which is quickly chilled to a temperature below its freezing point. Liquids that may be used include water, carbon tetrachloride, alkaline solutions, as dilute solutions of the hydroxides and carbonates of sodium and potassium, and oils of high flash point and low viscosity, e. g., a hydrocarbon oil of relatively high boiling point.

An apparatus for carrying out the invention comprises means whereby a metal may be brought into a molten condition and to a desired temperature and poured in a continuous comparatively thin stream, in combination with means whereby high kinetic energy may be imparted to bodies of liquid and such bodies caused to bombard the stream of molten metal in rapid succession, together with means for collecting the disintegrated metal and the liquid, which may then be separated.

The invention will be described in connection with an apparatus shown in the accompanying drawing, which is diagrammatic only, but shows the nature and relationship of the components sufficiently to enable those skilled in the art to construct it readily.

In the drawing, 1 designates a melting pot which may be supplied with heat electrically by resistance windings or induction, or by other well known ways. 2 designates an orifice of relatively small diameter at a low point in the bottom of the pot, through which molten metal may be poured in a thin stream. The orifice 2 may be either hot or cold and controlled by a valve (not shown) of any well known type. A hot orifice in many instances is to be preferred in order to obviate chilling and possible solidification of the molten material. Such an orifice may be integral with or separate from the melting pot and may comprise a sintered zirconium oxide nozzle forming the lowermost part of a graphite vessel, as a crucible which may be heated by a suitably positioned electric heater, and enclosed, e. g., in a box containing an insulating material. The construction of the melting pot 1 and the orifice 2 will be chosen so as to be compatible with the metal to be treated and the temperatures involved. If desired, the melting pot may be so arranged that it may be charged at one portion with massive metal in the solid state to be melted continuously and supplied to the orifice for continuous pouring. It may also be provided with means for maintaining the molten metal, prior to pouring, at a desired predetermined temperature, e. g., a coil 14. The melting pot 1 may be so mounted that its position can be adjusted toward or away from the axis of the drum or rotor 3.

3 designates a rotatable drum or rotor supported by a shaft 4 provided with a pulley 5 by which it may be driven rapidly by a suitable source of power (not shown). The periphery of the drum is provided with a plurality of jet nozzles 6 equally spaced around its circumference. Liquid is supplied to the drum while it is rotating by a conduit 7. In operation, centrifugal force drives the liquid supplied to the drum out through the jet nozzles 6 in fine streams, imparting to

each particle of liquid high kinetic energy. The nozzles may be positioned at an angle of about 45°.

8 designates an enclosing container, and 9 a cover. The cover may be made substantially gas tight if the metal being treated requires the presence of a protective atmosphere within the container, and the appropriate gas introduced through suitable connections (not shown). The container 8 may be provided at a low point with a discharge outlet 10 which may be controlled by a suitable valve 11, and also with an outlet 15, suitably positioned, whereby a desired liquid level may be set up and maintained. A hollow conduit 12 may surround the stream of molten metal issuing from the orifice 2 to protect it from spray until it is close to the point where it is to be bombarded by the jets of liquid. A nonoxidizing atmosphere may be set up in the hollow conduit through introduction by a pipe 13 of an illuminating gas, butane, nitrogen and the like, whereby oxidation is obviated. This atmosphere may be of a nature to effect a reducing and/or carburizing action.

In carrying out the invention the metal to be comminuted may be melted in a crucible 16; introduced into the melting pot, and brought to and maintained at a predetermined temperature. Power is applied through the pulley 5 to rotate drum 3 at a high rate of speed, and liquid is supplied to the drum through the pipe 7. Centrifugal force acting on the liquid within the drum forces it out through the jet nozzles 6 in fine streams of high velocity and consequently of high kinetic energy.

The orifice 2 is now opened and the molten metal is poured in a relatively thin stream into the path of the rotating jets of liquid. As each jet moves across the path of the descending stream of molten metal a small part of the jet bombards the metal and by its high kinetic energy breaks a portion of the metal stream into minute particles, each of which is immediately chilled to a temperature below its freezing point. After each jet has passed the path of the descending stream of molten metal, there is a brief interval of time during which the next portion of the metal stream may descend into position to be bombarded by the next jet. The thus comminuted and solidified metal, together with any liquid which has not been evaporated, falls to the bottom of the container 8, whence the mixture may be discharged at will through the outlet 10. Any suitable method and apparatus may be utilized to separate the liquid from the metal powder and dry the latter or otherwise prepare it for shipment or further use. Furthermore, it will be realized that a plurality of streams of molten metal may be poured.

By this invention small bodies of liquid at moderate temperature but with high kinetic energy are made to give up their kinetic energy to small bodies of molten metal where it is expended in disintegrating the molten metal into minute particles, and simultaneously the heat energy of the molten metal is transferred to the liquid, producing practically instantaneous solidification of each particle. Somewhat more particularly the method for comminution of a molten material, e. g. a molten metal comprises forming a stream of molten material, applying a succession of solid streams of liquid at a pressure not substantially less than 100 pounds per square inch having linear motion and simultaneous transverse motion with respect to the stream of molten material to disintegrate the end thereof with formation of minute particles, the liquid and the positioning of the molten stream with respect thereto being such that there is a solid stream of liquid at the point of contact, successive contacts being at a frequency greater than 200 per second, and the cross sectional areas of the molten stream and of the individual streams of liquid being in a ratio such that substantially the entire end of the stream of molten material is swept by the solid streams of liquid to effect its disintegration into minute particles.

Furthermore, when the speed of rotation is relatively high, the stream or streams of fluid produce the effect of a rotating plane or a truncated cone depending upon the orientation or arrangement of the jets. Each portion of the plane or cone of fluid, as the case may be, is, however, in rapid linear motion in two directions, one being in the direction of rotation and the other at an angle thereto. Also, a regulation of the number of jets and the speed of rotation makes it possible to effect a considerable variety of interruptions of the stream of molten material, as a metal. Thus, only one jet may be employed rotating at a relatively slow speed, or several jets may be utilized with a relatively high speed of rotation. A still further regulation may be accomplished by increasing or decreasing the pressure of the fluid issuing from the jets, the result being to control the force and character of the comminuting effect exerted by the fluid through interruptive bombardment of a stream of molten material. Moreover, superposed series of streams of fluid may be used with which a stream of molten material may be successively bombarded in its downward path, and the streams of the various series may be oriented in the same general direction, or the streams of one series may be directed substantially opposite to those of one or more of the other series.

As illustrations of ways in which the invention may be practiced, the following examples are presented:

Example I

A solder containing 50% lead and 50% tin and having a melting point of about 370° F. was melted, heated to a temperature of about 800° F., poured through an orifice having a diameter of 9/64 inch, and subjected to the action of jets of water emerging from four jet nozzles, 1/8 inch in diameter, positioned about a drum revolving at about 4000 R. P. M. Water was introduced into the drum in volume sufficient to supply an ample amount to the nozzles. The speed of rotation and number of nozzles occasioned about 265 bombardments of the stream of molten metal per second, and a marked comminution of the solder was produced thereby.

Example II

A solder, as described in Example I, was melted, heated to a temperature of about 800° F., poured through the orifice described in Example I, and subjected to the action of jets of water emerging from eight jet nozzles positioned about a drum revolving at about 6000 R. P. M. Water was introduced into the drum, as in Example I. The speed of rotation and the number of nozzles effected about 800 bombardments per second and brought about a disintegration or comminution of the metal.

Example III

A solder, such as described in Example I, was melted and comminution brought about in like manner. However, the temperature to which the solder was heated was about 900° F., it was poured through an orifice $\frac{1}{16}$ inch in diameter, the number of jet nozzles was sixteen, and the drum was rotated at about 6000 R. P. M. The jet nozzles were ⅛ inch in diameter. There was thus effected about 1600 bombardments of the stream of molten metal per second, with a high degree of comminution of the metal.

Example IV

A solder was processed as in Example III, with like conditions, except that the jet nozzles had a diameter of $\frac{1}{16}$ of an inch.

The comminuted material obtained in accordance with the foregoing examples gave the following results respectively upon screen analysis, U. S. Standard screens being employed:

Screen analysis

Example	%+10	−10 [1] %+20	−20 %+40	−40 %+50	−50 %+70	−70 %+100	%−100
I	41.36	31.50	15.10	4.74	2.80	1.82	2.68
II	22.47	39.29	20.83	6.85	4.17	2.68	3.72
III	8.44	31.98	27.92	10.88	7.79	5.36	7.63
IV	26.00	36.53	19.60	6.53	4.27	2.80	4.27

[1] These designations mean, e. g. −10:+20 that the amounts given pass through a No. 10 screen but are retained by a No. 20.

Example V

Copper was melted and heated to a temperature of 2300° F., poured through a heated orifice having a diameter of ⅛ inch and subjected to the action of jets of water emerging from 16 jet nozzles having orifices ⅛ inch in diameter positioned about a drum revolving at about 6000 R. P. M. Water was introduced into the drum at a pressure of about 100 lbs. There were thus effected about 1600 bombardments of the stream of molten metal per second. A high degree of comminution of the copper resulted.

Example VI

Brass was melted and heated to a temperature of 2100° F. and poured through a hot orifice under the conditions prevailing in Example V, resulting in a high degree of comminution of the alloy.

Example VII

Lead was melted and heated to a temperature of 800° F. and poured through a hot orifice under the conditions prevailing in Example V. The metal was finely subdivided.

Example VIII

A mixture of metallic elements consisting of 90% by weight of silver and 10% lead was melted and heated to a temperature of about 2300° F. with constant stirring. The melt was quickly poured through a hot orifice ⅛ inch in diameter and subjected to the action of jets of water similar to that described in Example V. This combination of metals was thereby highly comminuted.

Example IX

A mixture of metallic elements consisting of 90% copper and 10% lead by weight was melted and heated to a temperature of about 2300° F. with constant stirring. The melt was quickly poured through a hot orifice ⅛ inch in diameter and subjected to the action of jets of water similar to that described in Example V. A high degree of comminution of the combination of metals resulted.

Screen analysis

Example	%+10	−10 %+50	−50 %+80	−80 %+100	−100 %+170	−170 %+270	%−270
V	0	17.6	16.6	7.0	17.4	13.4	28.0
VI	4.1	32.2	14.8	6.3	12.7	10.3	19.6
VII	.4	15.2	11.3	5.1	16.8	15.1	36.1
VIII	.3	29.5	18.5	4.6	16.8	11.2	19.8
IX	.5	19.6	18.6	16.3	19.9	13.2	21.9

The foregoing procedures lead to comminution of a molten metal with production of a considerable quantity of fines. Moreover, the material undergoing comminution may be siliceous, as a slag, a cement, a glass, and other meltable ceramic, or metallic, as the various metals and combinations thereof both in the form of alloys, and where the constituents do not form an alloy, more especially lead, tin, cadmium, chromium, copper, aluminum, gold, silver, zinc, cobalt, irons, nickel; alloys, e. g., silver-cadmium, lead-tin, copper-boron, copper-beryllium, copper-zinc, aluminum-magnesium, silver-tin, alloy steels, tin-antimony-copper, bronzes, bismuth-tin-lead, sterling silver and carat golds, and combinations as silver-lead, and copper-lead. It was observed that as the number of jets was increased the amount of fines also increased. When the speed of rotation is about 6000 R. P. M. and the number of jet nozzles sixteen, there is a distinct increase in the amount of fines obtained with an attending decrease in the amount of coarser material. Also, an increase in the amount of fines resulted when the distance between the stream of molten metal and the rotating jet nozzles was decreased. Furthermore, finer comminution of the metal resulted when the size of the stream of molten metal was reduced in comparison with the size of the liquid jets. There is, hence, a definite relationship between the size of the metal stream and the size of the liquid jets.

The invention is characterized by the following factors:

(1) Since the stream of molten metal never comes in contact with anything except a liquid, there is no possibility of the metal sticking to and building up on solid metal parts.

(2) By selection of the number and size of jet nozzles on the drum, and its speed of rotation, and the distance between the nozzles and the stream of molten metal, a desired degree of fineness and a desired distribution of fine and coarser particles may be achieved.

(3) The liquid used may be selected to exert a a desired effect on the metal being treated, e. g., reduction, neutral behavior, oxidation, carburization or decarburization.

(4) Where the protection of the molten metal by an inert or reducing atmosphere is desirable provision can readily be made for introducing and maintaining such an atmosphere.

(5) Alloys in powdered form may be produced containing much larger percentages of one or more of the alloying elements than can be obtained by conventional methods of melting and casting. A number of metals which have only limited solubility in other metals in the solid state are soluble to a much greater degree in the liquid state, but segregation takes place upon cooling in conventional processes. When such alloys in high percentages are subjected to the method of the invention, the disintegration of the metal from the molten state is so complete

and the cooling of the disintegrated particles so rapid that the expected segregation does not take place and the powder particles produced appear to be substantially homogeneous. Thus, by the method of the invention powdered metallic combinations may be produced with compositions and properties unattainable by conventional procedures.

Since certain changes in carrying out the above method and which embody the invention may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A method of producing comminuted material which comprises forming a stream of molten material, applying a succession of solid streams of liquid at a pressure not substantially less than 100 pounds per square inch having linear motion and simultaneous transverse motion with respect to the stream of molten material to disintegrate the end thereof with formation of minute particles, the liquid and the positioning of the molten stream with respect thereto being such that there is a solid stream of liquid at the point of contact, successive contacts being at a frequency greater than 200 per second, and the cross sectional areas of the molten stream and of the individual streams of liquid being in a ratio such that substantially the entire end of the stream of molten material is swept by the solid streams of liquid to effect its disintegration into minute particles.

2. A method of producing comminuted material which comprises forming a stream of molten metal, applying a succession of solid streams of liquid at a pressure not substantially less than 100 pounds per square inch having linear motion and simultaneous transverse motion with respect to the stream of molten metal to disintegrate the end thereof with formation of minute particles, the liquid and the position of the molten metal with respect thereto being such that there is a solid stream of liquid at the point of contact, successive contacts being at a frequency greater than 200 per second, and the cross-sectional areas of the molten metal and of the individual streams of liquid being in a ratio such that substantially the entire end of the stream of molten metal is swept by the solid streams of liquid to effect its disintegration into minute particles.

3. A method of producing comminuted material which comprises forming a stream of molten metal, applying a succession of solid streams of liquid at a pressure not substantially less than 100 pounds per square inch having linear motion and simultaneous transverse motion with respect to the stream of molten metal to disintegrate the end thereof with formation of minute particles, the liquid and the position of the molten metal with respect thereto being such that there is a solid stream of liquid at the point of contact, successive contacts being at a frequency greater than 200 per second and at an angle of about 45°, and the cross-sectional areas of the molten metal and of the individual streams of liquid being in a ratio such that substantially the entire end of the stream of molten metal is swept by the solid streams of liquid to effect its disintegration into minute particles.

4. A method of producing comminuted metal which comprises melting an alloy containing lead and tin, pouring the molten metal in a continuous stream, applying a succession of solid streams of liquid at a pressure not substantially less than 100 pounds per square inch having linear motion and simultaneous transverse motion with respect to the stream of molten metal to disintegrate the end thereof with formation of minute particles, the liquid and the position of the molten metal with respect thereto being such that there is a solid stream of liquid at the point of contact, successive contacts being at a frequency greater than 200 per second, and the cross-sectional areas of the molten metal and of the individual streams of liquid being in a ratio such that substantially the entire end of the stream of molten metal is swept by the solid streams of liquid to effect its disintegration into minute particles.

5. A method of producing comminuted metal which comprises melting a mixture of copper and lead, pouring the molten metal in a continuous stream, applying a succession of solid streams of liquid at a pressure not substantially less than 100 pounds per square inch having linear motion and simultaneous transverse motion with respect to the stream of molten metal to disintegrate the end thereof with formation of minute particles, the liquid and the positioning of the molten metal stream with respect thereto being such that there is a solid stream of liquid at the point of contact, the successive contacts being at a frequency of about 1600 per second, and the cross-sectional areas of the molten metal stream and of the individual streams of liquid being substantially equal.

6. A method of producing comminuted metal which comprises melting copper, pouring the molten metal in a continuous stream, applying a succession of solid streams of liquid at a pressure not substantially less than 100 pounds per square inch having linear motion and simultaneous transverse motion with respect to the stream of molten metal to disintegrate the end thereof with formation of minute particles, the liquid and the positioning of the molten metal stream with respect thereto being such that there is a solid stream of liquid at the point of contact, the successive contacts being at a frequency of about 1600 per second, and the cross-sectional areas of the molten metal stream and of the individual streams of liquid being substantially equal.

GREGORY J. COMSTOCK.