Aug. 7, 1951 O. A. PFAFF 2,563,064

PROCESS AND APPARATUS FOR THE PRODUCTION OF METALLIC SHOT

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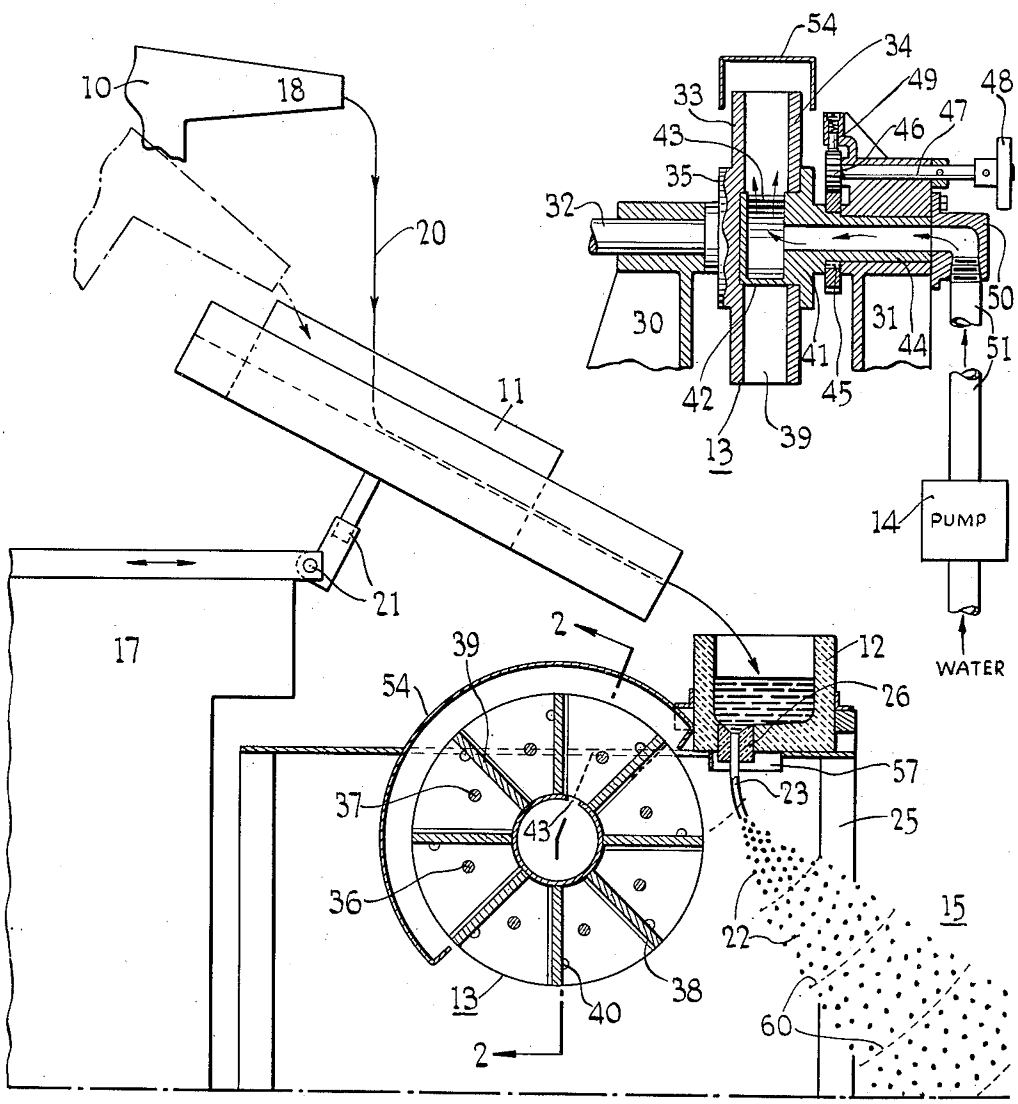
Fig. 1. Fig. 2.



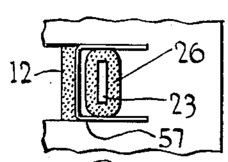


Fig. 3.

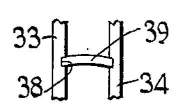
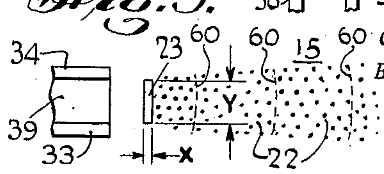


Fig. 4.

Fig. 5.



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PROCESS AND APPARATUS FOR THE PRODUCTION OF METALLIC SHOT

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1

The invention relates to the breaking up or disintegration of molten metal, particularly steels, for the purpose of producing for example, round shot or grit of the type used for metallic abrasive and blast cleaning, cutting, peening, polishing and the like.

General objects of the invention are to provide a simple and improved method, easy to control and use for disintegrating metal; to provide such a method for making iron or steel shot having the characteristics of hardness, solidity and roundness, the greater part of which falls in commercial size classes; to provide such a method which, if desired, will produce a product, the greater part of which falls in classes smaller than commercial size classes and suitable for subsequent grinding into fine powder.

According to a preferred form of the invention, a plurality of successive ribbons or spurts of dispersed water are directed upon a stream of molten metal. The ribbons or spurts of water are conveniently produced from a suitably modified blast wheel having directional control such as now used commercially for imparting blasting velocities to shot or grit for blast cleaning, cutting, peening, polishing and the like. For obtaining proper relationship between the ribbons of water delivered from the blast wheel and the metal stream, a metering dish having a metering orifice is provided. The metering dish assists in providing proper head to the metal stream and the metering orifice imparts proper cross section to the metal stream for efficient action by the water blast.

The invention also consists in certain new and original features and combinations hereinafter set forth and claimed.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, and the manner in which it may be carried out, may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part hereof, in which:

Fig. 1 represents diagrammatically apparatus by which the invention may be practiced;

Fig. 2 represents a section on the line 2—2 of Fig. 1, illustrating the construction of the blast wheel;

Fig. 3 is a bottom plan view showing the metering orifice and guard;

Fig. 4 is a detail illustrating the shape of one type of blast wheel blade; and

2

Fig. 5 is a detail illustrating relationship between water blast and metal stream.

In the following description and in the claims, various details will be identified by specific names for convenience, but they are intended to be as generic in their application as the art will permit.

Like reference characters denote like parts in the several figures of the drawings.

In the drawings accompanying and forming part of this specification, certain specific disclosure of the invention is made for purposes of explanation, but it will be understood that the details may be modified in various respects without departure from the broad aspect of the invention.

Referring now to the drawing, the apparatus for carrying out the method will first be briefly described. This apparatus comprises, in general, an electric melting furnace 10, a movable trough 11, a metering dish 12, a blast wheel 13, and a water pump 14. It will be understood that pump 14 supplies water to the blast wheel 13 which discharges it at blasting speed in the form of a water arc 15 into which a stream 23 of molten metal descends from dish 12. Trough 11 conveys molten metal from furnace 10 to dish 12. The blast of water on the metal stream breaks it up into a plurality of metal particles 22 as discussed below.

The furnace 10 may comprise any well known type of electric furnace suitable for melting steel of the type used herein. This furnace 10 is mounted on base 17 by suitable trunnions (not shown) and has a spout 18 from which the molten steel may be poured into trough 11 by tipping the furnace about its trunnions, as will be understood by those skilled in the art.

The trough 11 may be of metal suitably lined with refractory and may be adjustably mounted on furnace base 17 by adjustment indicated diagrammatically by 21. The function of the trough 11 is to catch the metal stream 20 flowing from the spout 18, in whatever position the latter happens to be, and lead it to the metering dish 12. The adjustment 21 facilitates the trough adjustment for different positions of spout 18 and metering dish 12.

The metering dish 12 is mounted upon a suitable frame 25 and has a metering orifice 26. This orifice may be of square or oblong cross section to present a metal stream 23 of the same predetermined cross section to the dispersing action of the water wheel 13. The metering dish and orifice may be made of metal and have a suitable refractory lining.

Mounted adjacent the frame 25 is the water wheel 13 for delivering the water arc 15. This wheel may be similar to the well known abrasive throwing wheel known as the Wheelabrator, manufactured by American Foundry Equipment Company.

The wheel 13 is specially modified to handle large volumes of water delivered by water pump 14. The wheel, which is illustrated diagrammatically, comprises suitable bearings 30, 31 in one of which a drive shaft 32 is journaled. The shaft 32 carries end plates 33, 34 between which are disposed removable blades 39, the assembly being held together by a plurality of bolts as explained more in detail below.

Drive shaft 32 is secured to a hub 35 secured to side plate 33. The other side plate 34 is secured in spaced relation to side plate 33 by an assembly of sleeve-like posts 36 through which bolts 37 pass, clamping the side plates 33, 34 rigidly together in spaced relation.

The side plates 33 and 34 have radial grooves 38 in which are disposed removable throwing blades 39 held in place by set screws 40 seating in recesses in the edge of the blade. The drive shaft 32 is connected to a suitable source of power, such as an electric motor, through reduction gear (not shown).

The side plate 34 has a concentric opening in which is disposed a stationary, but adjustable, control cage 41. The cage 41 has a circumferential wall 42 with a discharge opening 43 having a close fit with the inner edges of blades 39.

The control cage 41 has a hollow hub 44 journaled or swiveled in bearing 31. Suitable adjustment for controlling the rotary position of cage hub 44 is provided. This adjustment may take the form of a gear 45 on hub 44 meshing with a gear 46 on control shaft 47 having control wheel 48. A suitable spring pressed latch 49 engaging the teeth of gear 46 serves to hold control cage 41 in proper adjusted position.

For supplying water to control cage 41, a fitting 50 is secured to bearing 31, said fitting having sealing relationship with the adjustable hub 44 of the control cage. Supply pipe 51 connects fitting 50 with water supply pump 14.

The water fed to the wheel 13 is delivered by it, directionally, in an arc-shaped blast 15 whose clockwise position is controlled by the angular position of the control cage opening 43. Substantially all of the water fed to the wheel 13 is delivered in this arc in accordance with the well known directional control properties inherent in a blast wheel of this type. A wheel shroud 54 partially surrounds the water wheel to handle any small amounts of water which the wheel does not directionally control. A U-shaped orifice guard 57 embraces the metering orifice 26 to minimize the windage effect of the rapidly rotating wheel on the metal stream 23.

The metering dish serves not only to provide a metal stream of constant cross section, but also produces clean, slag-free metal having more uniform head and more constant velocity. Since there is a tendency for the molten stream to attain a circular cross section, it is desirable to minimize the vetrical distance or free fall between the metering orifice 26 and the water blast 15 so that the metal stream retains its predetermined cross section, as set by the cross section of the metering orifice, when it is struck by the water blast.

It is desirable that the cross section of the molten stream 23 delivered by the metering orifice be of uniform thickness X and that its width Y (Fig. 5) be of approximately, but preferably slightly less than, the width of the water blast 15 hitting it. The predetermined cross section of molten stream 23 may be of any shape depending upon operating requirements but it has been found in practice that a rectangular shape whose thickness X is less than its width Y gives satisfactory results.

It is desirable also that the density of the water blast delivered by the water wheel be uniform throughout the cross section of the blast, particularly in a direction axially of the wheel. Uniform blasting intensity may be obtained by proper shape of the orifice 43 of the control cage. It may also be obtained by making the forward surface of the wheel blades 39 slightly concave from side plate to side plate, as indicated in Fig. 4.

The water delivered by the blades strikes the metal stream 23 at a point close to the metering orifice 26 and breaks up this stream into metal particles, size and characteristics of which is determined by proper adjustment of the several variables as discussed below. The following explanation, which is partly theoretical, is given in an effort to more clearly explain the operation of the invention and should not be considered in any limiting sense. Regardless of theory, tests have shown the production of metal particles as explained herein.

The water delivered by the blades 39 appears to come off in ribbons or layers indicated by the several dotted lines 60. Thus the metal stream 23 is bombarded by a succession of such water spurts, following in rapid succession, forming a pulsating flow which disintegrates the molten metal stream into the metal particles 22. It will be noted that the water blast 15 spreads or flares in a direction in the plane of the blast wheel as indicated in Fig. 1. The amount of this flare may be controlled as explained below and will be referred to as the length of the water arc. The blast 15 also flares slightly in a direction parallel to the blast wheel axis of rotation as indicated in Fig. 5. It will be understood that the illustration of the formation of the metal particles by the action of the water ribbons is largely diagrammatic.

These water ribbons are not necessarily homogeneous water since the water is accelerated in traveling from the inner ends to the outer ends of the wheel blades, and thus is dispersed into particles. These water ribbons thus may include water vapor and also entrapped air if air be not excluded from the apparatus. In case an inert or reducing atmosphere is used to exclude air, as discussed below, the water ribbons will include entrapped inert or reducing gas instead of air.

A certain number of ribbons 60 are necessary to provide enough force to break up the metal being metered from the metering dish. This force, or the number of ribbons necessary, is calculated by measuring the distance the molten metal falls down into the water ribbons or layers before being broken up. Thus the number of ribbons of water particles necessary to break up the metal depends upon the amount of force necessary to overcome the metal surface tension which in turn depends upon the density (particles of water per cubic inch) of the water hitting the molten metal and the velocity of the water hitting the molten metal.

The breaking up action of the water on the molten metal is due primarily to the force exerted by the water. Hence it is important that the water blast which strikes the metal stream have sufficient density as well as velocity. Water density and velocity, particularly the latter, determine the size classes of metal particles formed in the break-up of the metal stream.

Generally speaking, a decrease in wheel speed (i. e. decrease in water velocity) results in the formation of a greater percentage of the larger sizes while an increase in wheel speed results in the formation of a greater percentage of the fine sizes. Further, the higher the density of water in the ribbons bombarding the metal stream, the larger the percentage of fine sizes.

Metal particles are formed because the force exerted by the water ribbons is sufficient to overcome the surface tension of the metal stream and to break it into small particles. The surface tension of the molten metal stream is of high magnitude in relation to other liquids and it is necessary to use considerable force to break up the metal stream. After the initial surface tension of the metal stream is overcome and the entire metal stream is exposed to the breaking-up action of the water, any excess force obtained from the water ribbons is used to break up the molten particles into still smaller particles.

Water density of the pulsating blast may be varied (*a*) by changing the volume of water per minute delivered by pump **14** to the blast wheel **13**; (*b*) by changing the width of the wheel; (*c*) by changing the distance of the metal stream from the blast wheel, and (*d*) by changing the length of the water arc. Thus for high water density we should have relatively large volume of water delivered to the blast wheel, a relatively narrow or axially thin wheel, small distance from wheel to metal stream, and short water arc length.

To decrease the length of the water arc, the blade length may be decreased, the circumferential length of the control cage opening **43** may be decreased and the number of blades may be increased.

The total area of the control cage orifice **43** also controls the break-up characteristics of the metal stream. In general, the smaller the orifice, the higher the velocity of the water emitted therefrom.

The particle size pattern of the product is controlled in accordance with the discussions given above. The water velocity and density may be adjusted to cause the greater percentage of the particles to fall within commercial shot sizes running from No. 10 (.156 inch diameter) to No. 30 (.016 inch diameter) or they may be adjusted to cause the greater percentage of particles to fall within classes finer than No. 30. Fine as used herein defines size.

The obtaining of a fine product is advantageous when it is desired to reduce the particles to fine powder form such as used for molded metal. Since a common method of producing powder is to use crushers and ball mills, it is obvious that the smaller the size of the metal particles at the beginning of the grinding operation, the easier the process becomes.

All or part of the process may be enclosed within an inert or reducing atmosphere to prevent oxidation which might otherwise occur, particularly in comminuting molten metal into very fine particles.

When used to produce commercial size pellets, the pellets have good solidity and roundness. They are sufficiently hard for use as shot in shot blast machines either of the old fashioned compressed air blast type or of the modern centrifugal blast type, such as used for cleaning or removing scale or dirt from castings or forgings, for peening the surface of materials to increase their fatigue life, or to produce a pleasing and attractive finish. The shot is also free from dimples.

The process according to the invention also gives good directional control in that the product is directed and concentrated in a limited area from which it may be easily removed. The process is easy to handle without especial danger to workmen from flying metal. The blast of water being projected against the side of the falling metal stream at an acute angle thereto, breaks it up into particles and tend to knock them down in the direction of the movement of the water with comparatively little flying around of particles.

The product is concentrated by the water blast into a small area in the tank for receiving the particles. The invention is thus superior to certain prior methods where, for example, a stream of metal falls onto a solid stream of water. That manner of combining the water and molten metal tends to produce explosions causing the metal particles to fly all around with consequent danger to workmen and difficulty of collection.

Furthermore, according to the invention, no pond is necessary to receive the solidified particles, although one may be used if desired for subsequent heat treatment or for other purpose.

Oils or other liquids of greater or less density and of greater or less quenching rate may be used instead of water in either the blast wheel or in the pond for quenching purposes.

While certain novel features of the invention have been disclosed herein, and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. The method of disintegrating metal, utilizing a centrifugal throwing wheel having outwardly extending passages, which comprises forming a stream of molten metal, directionally discharging a stream of break-up liquid onto the inner ends of said outwardly extending passages at a predetermined clockdial position of the centrifugal throwing wheel, rotating said wheel to accelerate the break-up liquid received by the passages and to throw such liquid from the outer ends of the passages at a predetermined clockdial position of the wheel, as a controlled directional blast of successive spurts of liquid particles, against said stream of molten metal, whereby to disintegrate said metal stream into metal particles.

2. The method of disintegrating metal, utilizing a centrifugal throwing wheel, which comprises forming a falling stream of molten metal whose axis is in the plane of said wheel with the stream being directed beyond the periphery of the wheel, said stream having a relatively wide and thin cross section, directionally discharging a stream of break-up liquid onto the inner ends of blades of the centrifugal throwing wheel, rotating said wheel to accelerate the break-up liquid received by the blades and to throw such

liquid from the outer ends of the blades at a predetermined clockdial position of the wheel, as a controlled directional downward blast of dispersed liquid particles, against the wide side of said stream of molten metal and at an acute angle to said stream, whereby to disintegrate said metal stream into metal particles.

3. The method of disintegrating metal, utilizing a centrifugal throwing wheel, which comprises forming a stream of molten metal whose axis is in the plane of said wheel, with the stream being directed beyond the periphery of the wheel so as to fall free of the wheel, discharging a stream of break-up liquid onto the blades of the centrifugal throwing wheel, rotating said wheel to accelerate the break-up liquid received by the blades and to throw such liquid from the outer ends of the blades, as a blast of successive ribbons of liquid, against said stream of molten metal, whereby to disintegrate said metal stream into metal particles.

4. Apparatus for disintegrating metal comprising an open top metering dish for receiving molten metal, said dish having a metering orifice in its bottom wall, said orifice being generally rectangular in cross section and having a width which is greater than its thickness, said orifice imparting a corresponding cross section to the stream of molten metal passing therethrough, a blast wheel whose plane of rotation passes through the axis of the falling stream of molten metal and whose axis of rotation is parallel to the width of said metering orifice, said wheel lying entirely beyond said molten metal stream so that the latter falls free of the wheel, said wheel having a series of blades extending from adjacent the axis to adjacent the periphery of the wheel, said blades having a width corresponding to the width of the metering orifice, a conduit having a feed opening for supplying break-up liquid to the blades, said feed opening being disposed adjacent the inner ends of the blades and extending circumferentially over a limited arc with respect to the wheel so as to discharge liquid onto the blades at a predetermined clockdial position, whereby to cause the wheel to discharge, directionally, a blast of liquid against the wide side of the molten metal stream and adjacent the metering orifice.

5. Apparatus for disintegrating metal comprising a container for holding molten metal, said container having a metering orifice for forming a falling stream of molten metal, a blast wheel whose plane of rotation passes through the axis of the falling stream of molten metal, said wheel lying adjacent to but entirely beyond said molten metal stream so that the latter falls free of the wheel, said wheel having a series of blades extending from adjacent the axis to adjacent the periphery of the wheel, a conduit having a feed opening for supplying break-up liquid to the blades, said feed opening being disposed adjacent the inner ends of the blades and extending circumferentially over a limited arc with respect to the wheel so as to discharge liquid onto the blades at a predetermined clockdial position, whereby to cause the wheel to discharge, directionally, a blast of liquid against said molten metal stream.

OTTO A. PFAFF.

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