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METHOD OF PRODUCING METAL SPHERES

Filed Jan. 11, 1960

Fig. 1

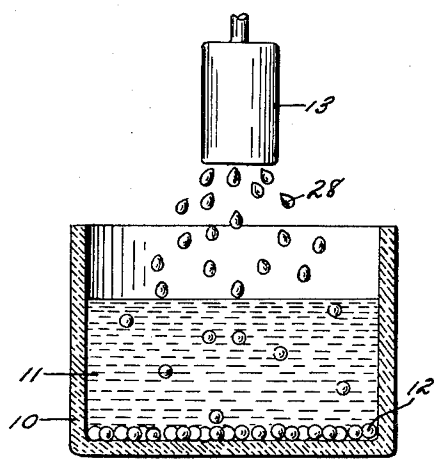
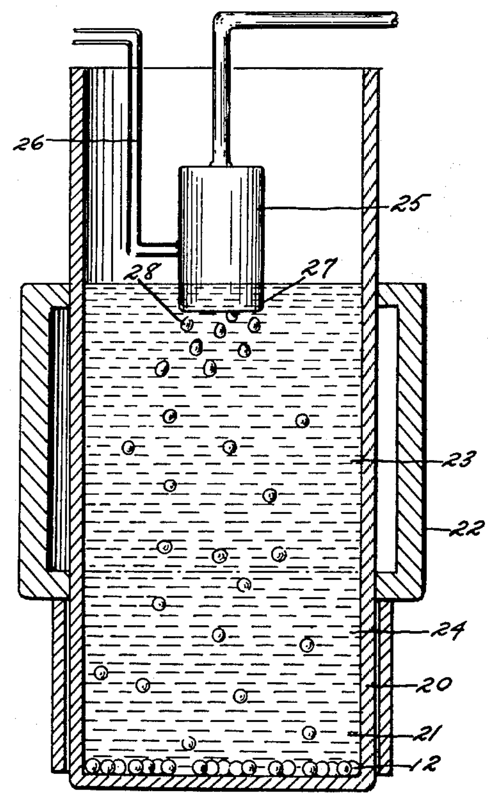


Fig. 2



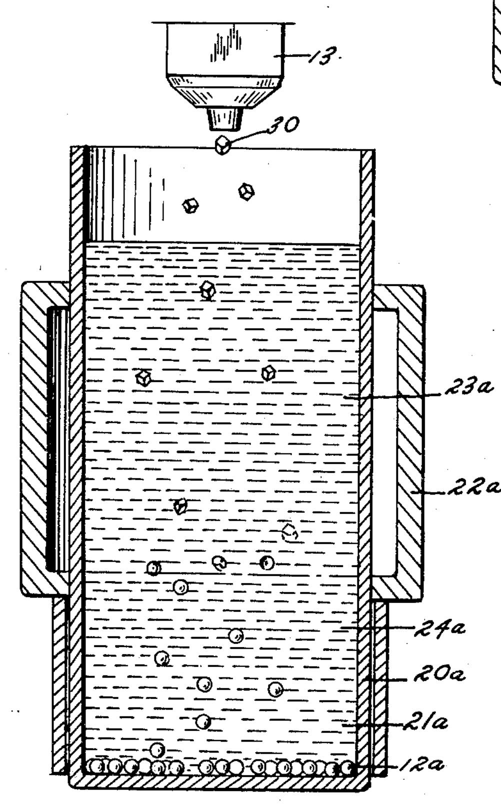


Fig. 3

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METHOD OF PRODUCING METAL SPHERES

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This invention relates generally to the art of shot forming, and more particularly to an improved means and method which permit the formation of metallic spheres using metals and metal alloys having relatively high melting points.

It is known in the prior art to form lead shot by allowing the same to fall in the form of droplets from the top of a shot tower. As the droplets fall, normal surface tension forms the droplets into spheres, and owing to the relatively low temperatures involved with lead and similar metals, the shot has partially hardened by the time it reaches the bottom of the shot tower, at which point it enters a bath of water which completes the hardening process. The relatively free fall of the shot is through air, and while this test has been successful with metals melting at a relatively low temperature, it has heretofore been impossible to form spheres of metals having higher melting points, e.g., above 350° C., owing to the difficulty in handling such metals which oxidize readily at temperatures near the melting point.

With the increased use of small metallic spheres in a variety of electronic fields, particularly, the field of semi-conductors, there has arisen a need for the formation of small metallic spheres from aluminum alloys, precious metal alloys, and the like. While it is possible to form these spheres mechanically, the cost in achieving a high degree of concentricity is excessive, and cannot be justified except under exceptional circumstances.

It is therefore among the principal objects of the present invention to provide improved means and method for forming spherical objects, resembling in some respects the traditional method of forming shot, whereby the necessity of mechanical abrasion is eliminated.

Another object of the invention lies in the provision of improved means for maintaining shot particles in suspension so that they may have adequate time for perfect formation while in the molten state.

A further object of the invention lies in the provision of accurately proportioned spherical shot formed from metals having a relatively high melting point, in which the cost of fabrication may be of a reasonably low order, thereby permitting consequent wide sale, distribution and use.

A feature of the invention lies in the fact that it may be practiced economically on a relatively small scale.

Another feature of the invention lies in the wide variety of metallic materials which may be employed in the formation of shot particles, as well as the wide variety of mediums through which the shot may be passed during formation depending upon individual requirements.

These objects and features, as well as other incidental ends and advantages, will more fully appear in the progress of the following disclosure, and be pointed out in the appended claims.

In the drawing, to which reference will be made in the specification,

FIGURE 1 is a schematic view showing a first method for forming spherical particles according to the present invention.

FIGURE 2 is a schematic view showing a second method.

FIGURE 3 is a schematic view showing a variation of the method shown in FIGURE 2.

Before entering into a detailed consideration of the

invention, it is believed that a short discussion of the physical principles involved in the formation of shot is in order.

Shot made according to the traditional method, requires a relatively high shot tower, often fifty feet high or more, in order to give the individual shot particles adequate time to form themselves into spherical shape and cool to a degree where they will not be damaged upon striking the water disposed at the lower end of the tower. The lead, having a relatively low melting point (about 327.4° C.) will be sufficiently cool during its fall to effect proper hardness. The spherical shape is achieved by the naturally occurring surface tension present in all liquids, the air providing no substantial resistance which would distort the molten metal from normal spherical shape.

In the present invention, it is proposed to pass the liquid particles in molten state through a medium other than air, more particularly a material having a melting point higher than that of the metal from which the spheres are formed. More particularly, the invention contemplates the use of fused (e.g. molten) salt systems having specific densities only slightly less than that of the metal forming the shoe, so that upon entering the medium, the particles may descend at a relatively slow rate, and have adequate time to form perfect spheres without the necessity of shot towers of great height.

A physical phenomenon, known as Stokes' law, indicates that the velocity of a falling particle in a viscous medium is directly proportional to the difference between the density of the particle and the density of the medium multiplied by the square of the diameter of the particle. The velocity is also inversely proportional to the viscosity, as indicated in the following equation:

$$V=\frac{(D_1)^2\times(d_2-d_1)}{r}$$

where V is the velocity of the particle, D is the diameter of the particle, d_2 is the density of the viscous medium, d_1 is the density of material of which the particle is composed, and r is the viscosity of the viscous medium.

In order for a falling molten particle in a medium hotter than the particle melting point to form a perfect sphere, it must fall at a velocity such that the upward force on the particle caused by the medium as the particle falls, does not exceed the surface tension energy tending to keep the particle in spherical form. If this velocity is exceeded, the sphere tends to flatten and an ellipsoid is formed. On the other hand, if the velocity is too low, the particle develops a cooling pit as it solidifies upon emergence from the heated medium into a colder zone.

Referring to FIGURE 1 in the drawing, there is shown a simple method for producing spheres in accordance with the invention. Reference numeral **10** designates a ceramic or refractory beaker, filled with a molten medium **11** into which molten particles **12** are allowed to fall from a dispensing means **13**, which may be, for example, a foraminous pressurized crucible. Particles falling from the crucible **13** enter the medium **11**, and slowly sink to the bottom of the beaker **10**, where they are buoyed to a limited degree sufficient to permit the particles to maintain a spherical shape. When a sufficient number of spheres **12** have collected, the medium **11** is allowed to cool and solidify, after which the beaker **10** is broken to permit the solidified medium to be immersed in a solvent in which the spheres are insoluble. Dissolving the medium permits recovery of the spheres in undamaged condition.

The method illustrated in FIGURE 1 is particularly useful when using alloys of precious metal which do not readily oxidize. As a typical example, silver and silver alloys and gold and gold alloys may be employed, the very high melting points of these metals permitting the use of almost any molten salt having a boiling point above the melting point of the metals and a melting point below that of the metals. A very suitable medium is a eutectic mixture of potassium chloride and lithium chloride, the mixture having a melting point of approximately 500° C.

Referring to FIGURE 2, there is shown a means and method suitable for continuous production, including a shot tower **20** having a similar medium **21**, the tower being incorporated into an oven **22**. The medium **21** may be the same eutectic mixture described above, the oven surrounding the upper portion **23** thereof serving to maintain the temperature above that of the melting point employed. The lower part **24** is maintained at a temperature above the melting point of the fused salt, but below that of the melting point of the metal. The crucible **25** which is preferably electrically heated by means **26** is so positioned within the medium **24** that the discharge portion **27** is below the surface of the medium **24**. Thus, the particles are extruded directly into the medium to preclude the possibility of oxidation. The particles **28** fall through the upper portion **23** of the medium, and solidify upon entering that part of the medium which is below the melting point of the metal. Magnetic means (not shown) may be provided to attract the formed spheres to the sides of the shot tower, thereby making room continuously for the gathering of additional shot.

Turning now to the third method, as illustrated in FIGURE 3, parts corresponding to those shown in FIGURE 2 are designated by similar reference characters with the additional suffix "*a*."

The method illustrated in FIGURE 3 differs from that shown in FIGURE 2 in the elimination of the pressurized crucible. Instead, small uniformly sized particles of disc-like or cube-shaped in solid form are dropped into the medium, wherein the medium melts the same in the upper portion **23*a*** thereof to produce a substantially similar result. Because the uniformly sized particles, generally indicated by reference character **30**, are in many cases, covered with an oxidized film or skin, it is necessary to add a reducing agent to the mixture which will react with the oxidized portion of the metal, and thereby prevent interference with the natural surface tension of the molten metal, during the formation of the spherical shape.

It will be understood by those skilled in the art to which the invention relates, that the examples given herein are purely exemplary in nature, and not intended as limiting the scope of the invention in any sense. The particular salt or salt mixture employed as a medium may be varied depending upon the metal being employed to form the spheres, and the height of the space occupied by the medium, the specific density of the medium, the size of the sphere desired all contribute to the proper selection of medium, operating temperature, and the like, each bearing the relation as set forth in the above discussed Stokes' law.

I further wish it to be understood that I do not consider the invention limited to the precise details of structure set forth in the specification and drawings, as obvious modifications will occur to those skilled in the art to which the invention pertains.

I claim:

1. The method of forming shot using metals having a relatively high melting point comprising the steps of: (1) providing a shot tower and a molten medium having a specific density slightly less than that of said metal, and a melting point above that of said metal; (2) heating said medium to the molten state; (3) passing solid pellets of metal into said medium of a size sufficiently small to permit melting and forming of spherical droplets due to surface tension of the molten metal; (4) allowing said droplets to rest upon the bottom of said medium after formation; (5) cooling said medium to a solid at a temperature below the melting point of said metal; (6) and dissolving said medium in a second medium in which said metal is insoluble to obtain said spheres.

2. The method as set forth in claim 1, wherein the first mentioned medium is a fused salt.

3. The method as set forth in claim 1, wherein the medium is a eutectic mixture of fused salts.

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