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Chao

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[45] July 10, 1973

[54] **APPARATUS FOR PRODUCING METAL POWDER**

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[52] **U.S. Cl.** **425/7**, 264/12
[51] **Int. Cl.** **B29c 23/00**
[58] **Field of Search** 425/6, 7, 10, 317, 425/445; 75/211, 213, 224; 264/11, 12, 235, 346

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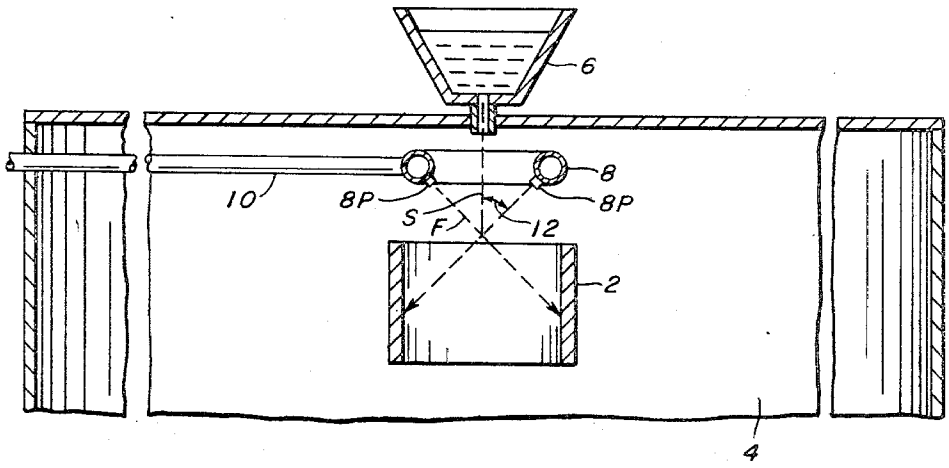
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Primary Examiner—Robert L. Spicer, Jr.
Attorney—Arthur J. Grief

[57] **ABSTRACT**

Molten metal, particularly molten steel, is atomized by directing an atomizing fluid stream against a falling stream of the molten metal. The atomized molten metal is directed against an impingement plate which is positioned relatively close to the point of intersection of the metal stream and fluid stream to obtain a maximum of relatively fine irregular particles and which is positioned relatively far from the point of intersection to obtain the maximum of generally spherical particles. It is preferred to direct a fluid jet downwardly and inwardly into the falling stream from only one side of the falling stream. My preferred apparatus includes a closed tank having an annealing chamber at its bottom. By using a non-oxidizing gas as the atomizing fluid, the pellets produced can be used for powder metallurgical uses without further processing.

5 Claims, 11 Drawing Figures



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FIG. 1.

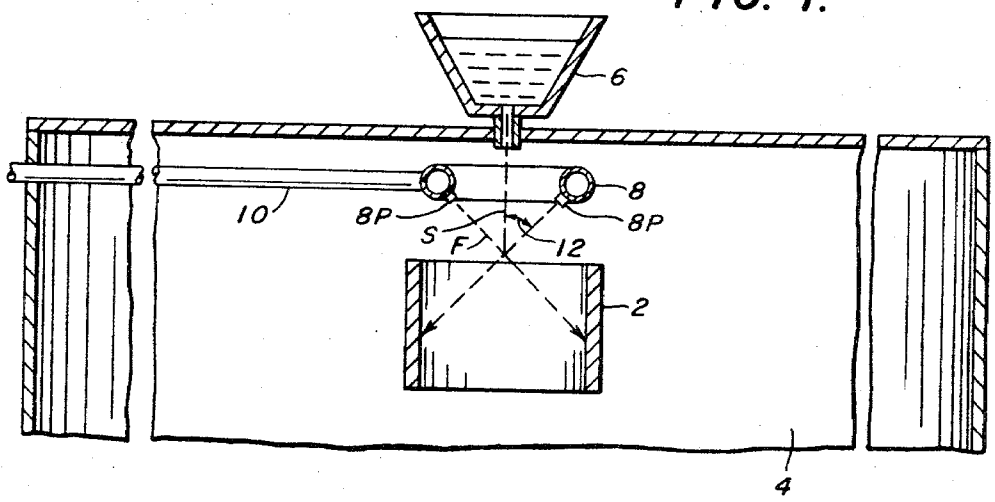


FIG. 2.

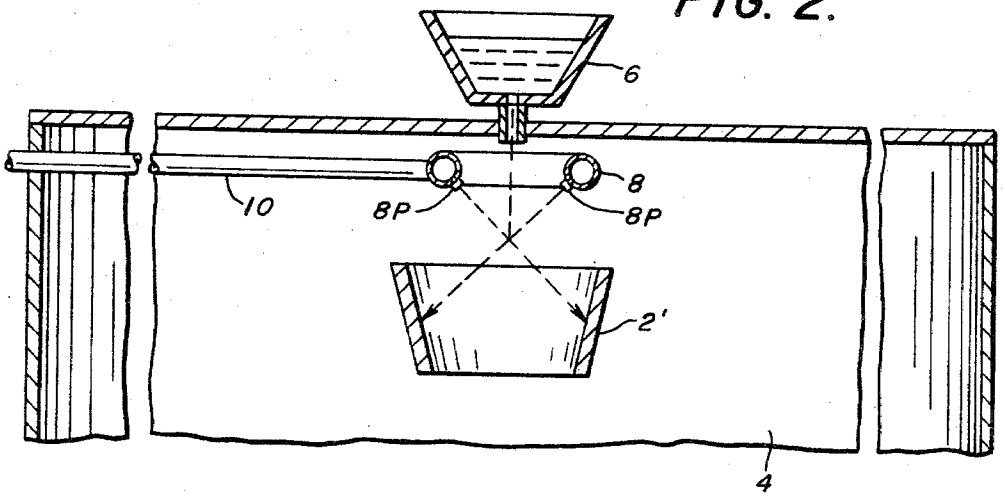
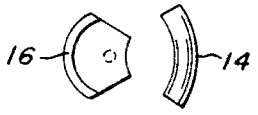
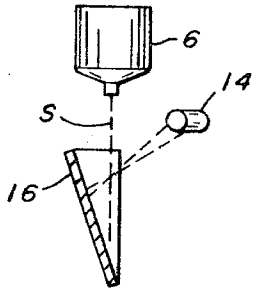


FIG. 3.

FIG. 4.





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FIG. 9.

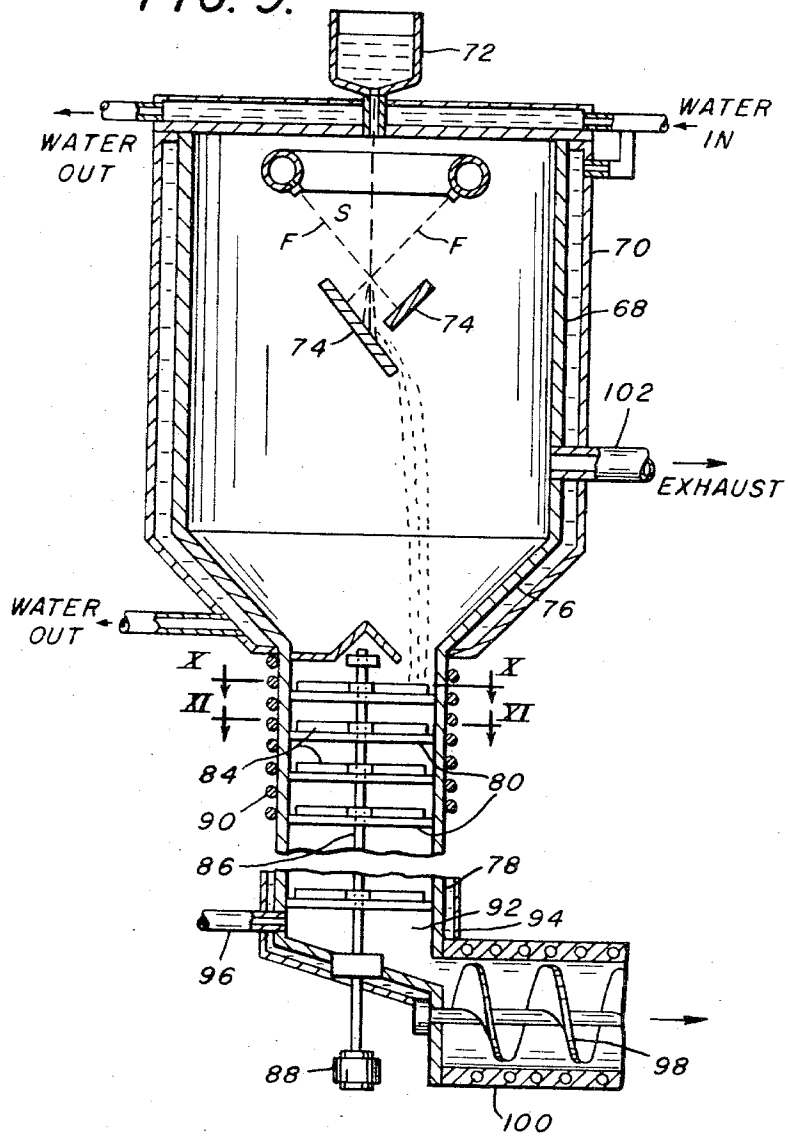


FIG. 10.

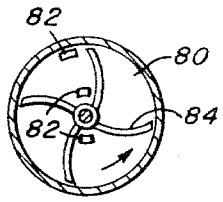


FIG. 11.

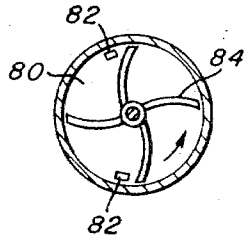


FIG. 5.

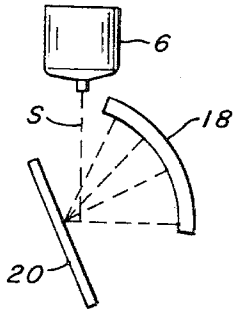
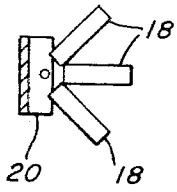


FIG. 6.



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FIG. 7.

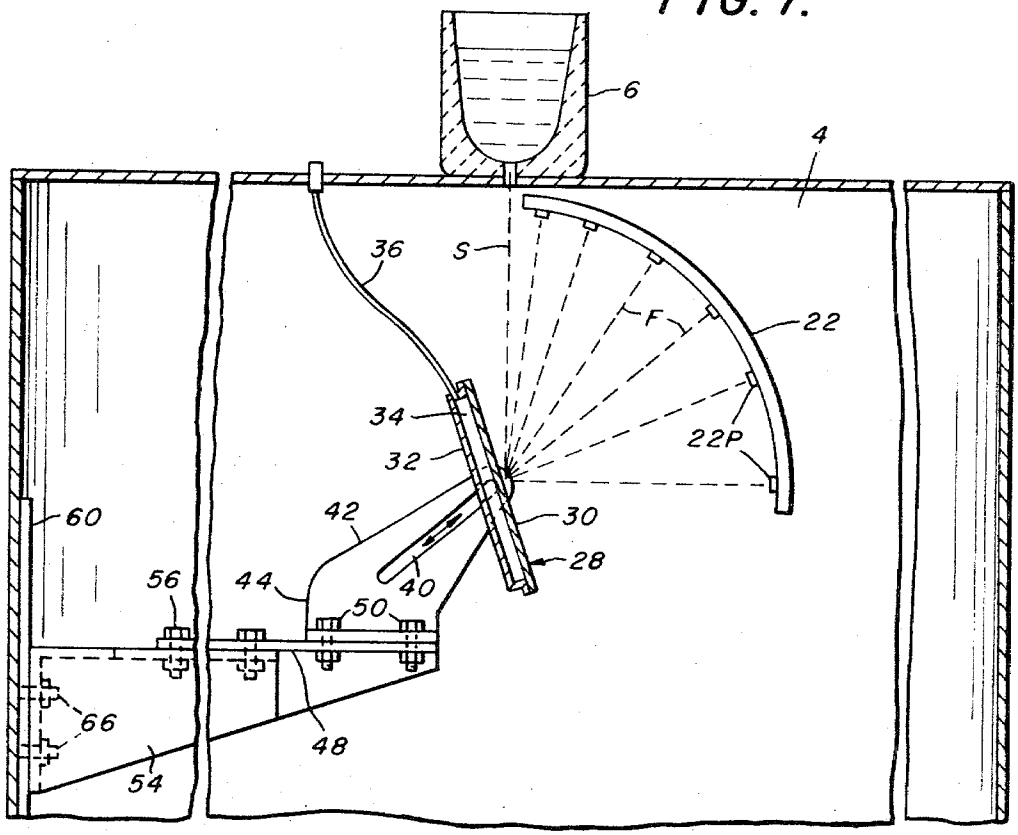
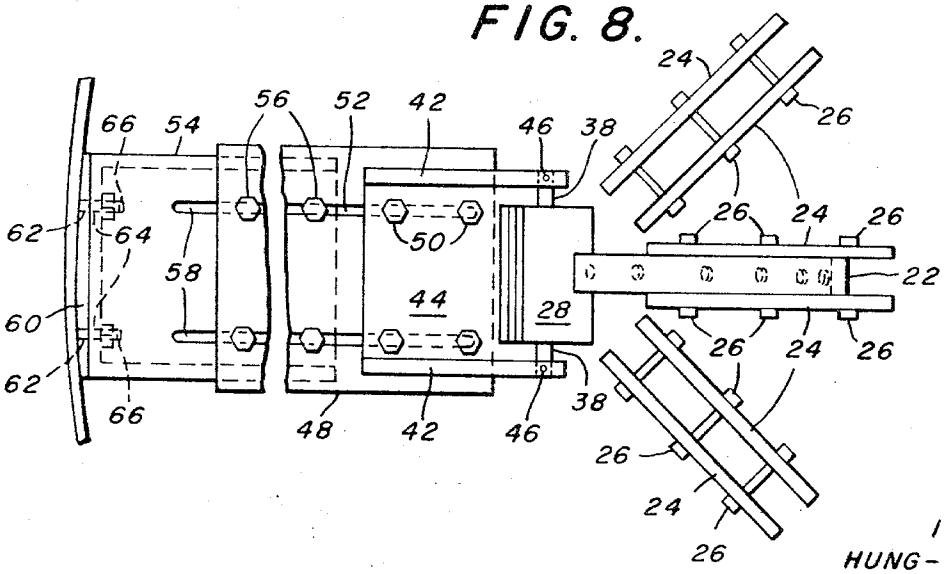


FIG. 8.



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APPARATUS FOR PRODUCING METAL POWDER

This invention relates to a method and apparatus for producing metal powder, particularly ferrous metal powder, by atomization. The common manner of making metal powder is to atomize it by directing fluid from an annular arrangement of nozzles against a falling stream of molten metal with the atomized pellets then falling to the bottom of the atomizing tank.

Fuchs U.S. Pat. No. 721,293, dated Feb. 24, 1903, discloses apparatus in which water is delivered through an orifice of a particular configuration to carry molten metal against an impinging plate to granulate the metal. This apparatus and method involves many difficulties and to the best of my knowledge has never been successfully used.

Brasse et al. U.S. Pat. No. 2,460,992, dated Feb. 8, 1949, discloses apparatus for delivering a horizontal stream of water into a falling stream of metal to atomize the metal and then delivers the solidified particles against the screen for the purpose of separating particles of different sizes.

In usual practice, the atomized powder is cooled, then given a conventional anneal, crushed, and ground into the proper size for molding or forging. This, of course, increased the cost of production.

I have found that atomized particles of various shapes and sizes can be obtained by directing the particles while still soft against an impingement plate, and varying the distance between the impingement plate and the point of intersection of the metal and fluid streams. I have also found that by directing the fluid jet downwardly and inwardly into the falling metal stream from only one side of the metal stream, greater efficiency is obtained.

It is therefore an object of my invention to provide a method and apparatus for producing atomized metal powder of various sizes and shapes.

Another object is to provide such a method and apparatus wherein the energy of the atomizing fluid is best utilized.

Still another object is to provide a method and apparatus of producing atomized metal powder ready for use as a molding or forging grade for powder metallurgical applications in a continuous and less expensive manner.

These and other objects will be more apparent after referring to the following specification and attached drawings, in which:

FIG. 1 is a schematic vertical section showing one embodiment of my invention;

FIG. 2 is a view, similar to FIG. 1, showing a second embodiment of my invention;

FIG. 3 is a schematic elevation of a third embodiment;

FIG. 4 is a plan view of the apparatus of FIG. 3;

FIG. 5 is a view, similar to FIG. 3, showing a fourth embodiment of my invention;

FIG. 6 is a plan view of the apparatus of FIG. 5;

FIG. 7 is a vertical section of another embodiment of my invention;

FIG. 8 is a plan view of a portion of the apparatus of FIG. 7;

FIG. 9 is a somewhat schematic sectional elevation of a final embodiment of my invention;

FIG. 10 is a view taken on the line X—X of FIG. 9; and

FIG. 11 is a view taken on the line XI—XI of FIG. 9.

Referring more particularly to FIG. 1 of the drawings, reference numeral 2 indicates a cylindrical impingement plate arranged in an atomization tank 4 with its axis vertical. A stream S of molten steel or other molten mateiral falls from a container 6 in axial alignment with the axis of plate 2. A circular fluid header 8 is centrally positioned above plate 2 and is connected by a pipe 10 to an atomizing fluid source, not shown. The header 8 is provided with ports 8P which are directed downwardly and inwardly. Preferably they are arranged so that the fluid jets F therefrom do not intersect the falling stream S in the same location. Angle 12 between the jets F and stream S is preferably between 5° and 85°.

In operation, the fluid F impinges on the stream S to atomize the molten metal S in the usual manner. The atomized particles are then directed against plate 2 to deform the semisolidified particles. The distance between the point of intersection of the fluid F and stream S and the point the atomized droplets hit the plate 2 is designated as the impact distance and is selected in accordance with the desired configuration of the metallic powder to be produced. In conventional atomization a falling stream of molten metal is struck by two or more streams of atomizing fluid, breaking the metal into fine particles which then fall directly to a cooling or quenching zone below the atomizing fluid jets. The utilization of the potential energy of the atomizing fluid is highly inefficient in this method. In this species of my invention an impingement plate 2 is introduced to utilize the residual kinetic energy and further disintegrate and/or deform the atomized liquid droplets by impact of the droplets against the plate. The inpact distance is varied by selecting a plate 2 of the desired diameter.

The embodiment of my invention shown in FIG. 2 is essentially the same as that of FIG. 1 except that a frustoconical impingement plate 2′ is substituted for plate 2. Other shapes of impingement plates may also be used.

I have found that there is a large amount of energy waste in cancellation of the horizontal force of the jets F when the jets are arranged symmetrically about the falling molten metal stream even when they do not intersect each other in the falling stream S. For this reason I prefer to use the arrangements shown schematically in FIGS. 3 to 6. In the arrangement of FIGS. 3 and 4 an arcuate nozzle 14 having a length less than a half circle is used in place of header 8 and a curved impingement plate 16 is used in place of plate 2. In the arrangment of FIGS. 5 and 6 one or more discrete nozzles 18 are used in place of nozzle 14 and a flat impingement plate 20 is used in place of plate 16. In both of these embodiments there is no cancellation of the horizontal force of the jets and in addition the plate 20 can be adjustably positioned rather than having to replace it when it is desired to obtain a different configuration of the particles.

The embodiment of my invention shown in FIGS. 7 and 8 is similar to that of FIGS. 5 and 6, but includes additional details. Thus, it shows an atomizing nozzle manifold 22 having nozzles or ports 22P. The manifold 22 is mounted in tank 4, preferably in curved guides 24 where it is held in place by cap screws 26. By loosening cap screws 26 the manifold 22 can be moved to a different position in guides 24 and the cap screws 26 then tightened. This permits adjustment of the angle and direction of impingement of jets F on stream S. By pro-

viding three sets of guides **24**, as shown in FIG. **8**, the manifold **22** can be moved from one to another so that it will be located at different angles relative to impingement plate **28**. Flow of fluid from the individual ports **22P** can also be controlled by any suitable means, not shown, so that by permitting flow from only one port the angle and direction of impingement of the jet can be varied. The plate **28** preferably consists of a wear plate **30** detachably secured to a flanged back-up plate **32** so as to provide a cooling water chamber **34** which receives cooling water through conduit **36**. The back-up plate **28** has cylindrical end portions **38** which are adjustably received in aligned slots **40** in spaced apart arms **42** of a U-shaped bracket **44**. The position of the plate **28** may be varied by sliding the portions **38** in the slots **40** and also by rotating it about the axes of portions **38**. The plate **28** is held in adjusted position in slots **40** by means of set screws **46**. The bracket **44** is adjustably supported on a bracket **48** by means of bolts **50** received in slots **52** in bracket **48**. In turn, the bracket **48** is secured to wall bracket **54** by means of bolts **56** passing through slots **52** and slots **58** in bracket **54**. A plate or bracket **60** secured to the wall of tank **4** is provided with vertical slots **62** aligned with vertical slots **64** in bracket **54**. Bolts or cap screws **66** passing through slots **62** and **64** hold the bracket **54** in adjusted vertical position. From the foregoing it is apparent that the position of plate **28** can be adjusted vertically, horizontally and angularly so that the impact distance and angle of impact can be readily adjusted depending upon the type of particles desired.

The embodiment of my invention shown in FIGS. **9** to **11** includes atomizing tank **68** provided with a cooling jacket **70**. A liquid metal stream S is provided from a container **72** and is atomized by jets F with the atomized metal particles impinging against impingement plates **74**. The arrangement of the jets F and buffer plates **74** may be the same as in any of the embodiments described above. However, the atomizing fluid is a non-oxidizing gas which may be an inert gas and/or a reducing gas such as hydrogen, natural gas, blast furnace gas, or city gas mixtures. Sufficient safety equipment will be provided to prevent explosions or poisoning. High purity metal melts as well as high alloys melted under protective atmosphere or under vacuum, or low metalloid low-carbon steels can be used as the liquid metal to be atomized. The atomizing tank **68** has a tapered or conical bottom **76** to which is attached a cylindrical self heat annealing chamber **78**. The chamber **78** is divided into a plurality of sections by means of trays **80** having openings **82** therethrough. A scraper **84** is supported on top of each tray **80**. The scrapers are secured to a vertical shaft **86** which is driven by a motor **88**. It will be noted that the blades of alternate scrapers are reversed so that the scrapers will move the atomized particles toward the openings in trays **80** to discharge them to the next lower tray. Heat is applied to the upper part of chamber **78** by any suitable heating means **90** and heat is taken from bottom slow cooling section **92** by means of a cooling jacket **94**. Cold high reducing gas having a very low dew point is introduced into section **92** through conduit **96**. An enclosed screw conveyor **98** having a cooling jacket **100** is connected to the bottom of section **92**.

The operation of the embodiment of FIGS. **9** to **11** is as follows: The gas jets F atomize the molten metal in stream S and direct the particles against impingement plates **74**. This results in highly irregular hot particles which pass downwardly into annealing chamber **78** and rest upon top tray **80**. At predetermined time intervals the scrapers **84** are rotated to cause the particles to fall to the next succeeding tray and finally to pass through trays in the cooling chamber **92** from which they pass to the screw conveyor **98**. The particles in the heating zone of chamber **78** are maintained at a given temperature well above the recrystallization and/or transformation temperature of the metal powder. The fully soak-softened powder so obtained is slowly cooled in chamber **92** and on the screw conveyor **98** from which the powder is discharged at ambient temperature. It will be noted that the powder is in a protective atmosphere at all times until discharge. The gas from conduit **96** helps to cool the powder within a protective atmosphere and at the same time the gas is pre-heated before it reaches the constant temperature self-annealing zone. Both this annealing gas and the atomization gas are discharged through an exhaust **102** at the lower part of the otherwise sealed atomization tank **68**. The discharge gas is either treated and re-used or piped to another user.

The method of FIG. **9** is cheaper, less complicated, and has less severe operating conditions than previous methods. For example, the self-annealing chamber **78** can have a temperature much less than a conventional post-atomization annealing furnace. The self-heat soaking temperature for iron and steel powder can be between 1,000° and 1,750° F. The use of the impingement plate **74** helps to produce a large quantity of irregular fine particles and thus avoids the necessity of using water atomization solely for producing irregular particles. Thus, the drying operation is avoided. With high irregularity in particle configuration, no high temperature annealing for agglomeration is necessary to produce powder with green strength at least sufficient for isostatic compactions and for hot forging application. The extra fines also agglomerate to certain degrees at low annealing temperatures to help the green strength requirement. Low metalloid and low carbon steel for example, can be used in this inert or inert plus reducing atmosphere atomization, and no extra carbon is required to take care of certain degrees of oxidation as in the conventional atomization practice. Thus, no long time high temperature annealing under reducing and decarburization atmosphere is required. Perhaps the most important advantage is that this method is continuous rather than the usual batch type of the prior art. As a result high productivity and a high degree of automation is possible at a low cost.

While several embodiments of my invention have been shown and described, it will be apparent that other adaptations and modifications may be made without departing from the scope of the following claims.

I claim:

1. Apparatus for producing metal powder which comprises an atomizing tank, containing means for providing a falling stream of molten metal, an impingement plate near said falling stream, means providing at least one fluid jet directed downwardly and inwardly into said falling stream to atomize said molten metal into small particles and to direct said particles against said impingement plate, and an annealing chamber at the bottom of said tank which includes a plurality of vertically spaced trays having openings therethrough, a rotatable shaft extending through said trays, a scraper

mounted on said shaft above each tray, and means for rotating said shaft.

2. Apparatus according to claim 1 in which all the fluid jets are located within an arc of less than 180°.

3. Apparatus according to claim 2 including a slow cooling zone in said annealing chamber below the bottom tray, and means for introducing a non-oxidizing gas into said cooling zone.

4. Apparatus according to claim 3 including an enclosed screw conveyor connected to the lower end of said cooling zone.

5. Apparatus according to claim 4 including means providing heat to the top part of the annealing chamber and means for cooling said cooling zone and said screw conveyor.

* * * * *