Oct. 24, 1950 M. F. W. HEBERLEIN 2,527,009

GUN FOR MAKING POWDERED METAL AND LIKE MATERIAL

Filed Feb. 13, 1947 2 Sheets-Sheet 1

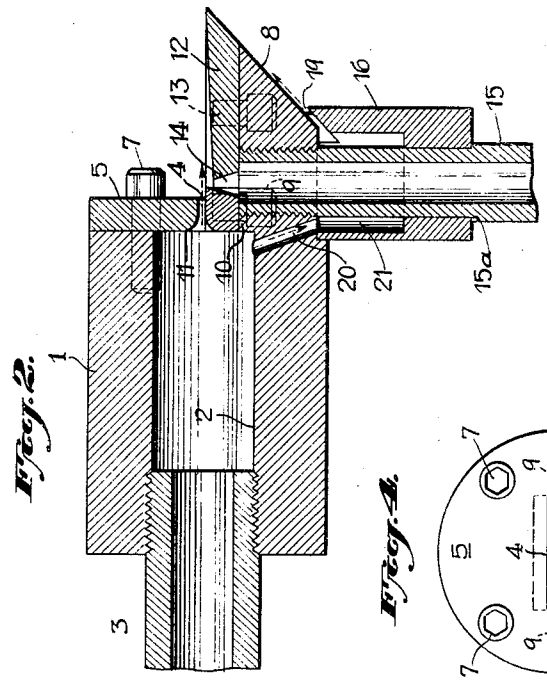


Fig. 2.

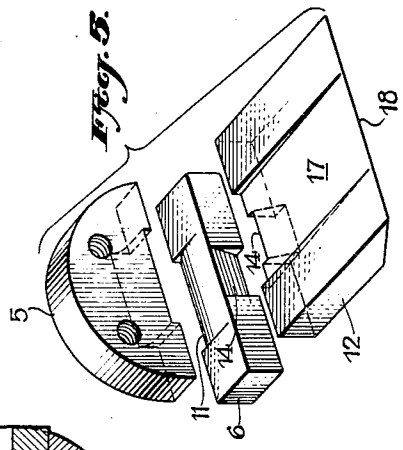


Fig. 5.

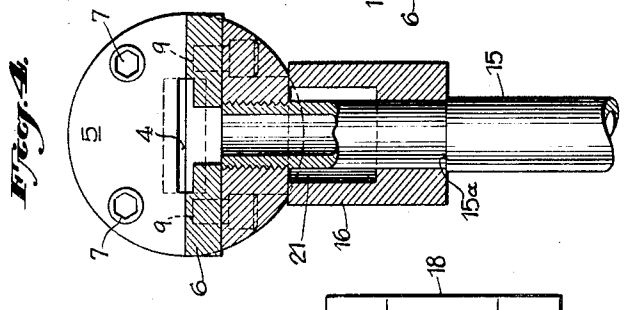


Fig. 4.

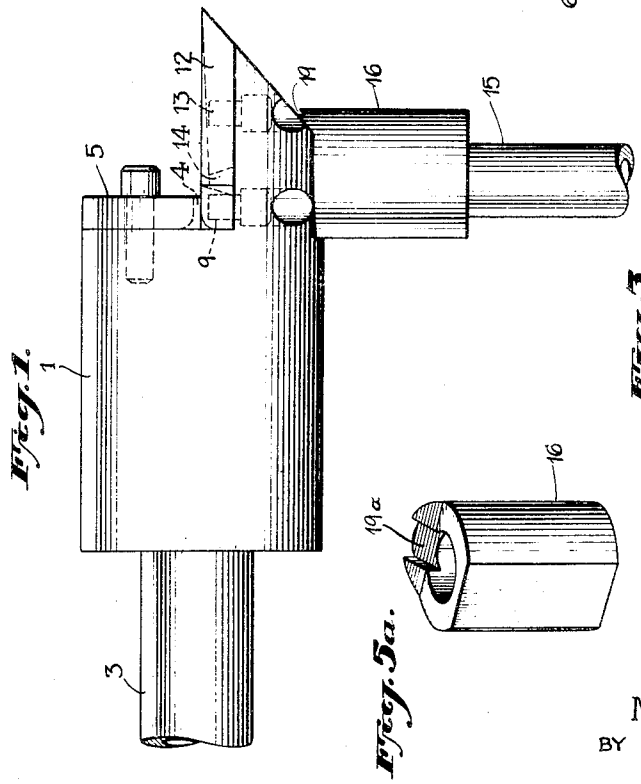


Fig. 1.

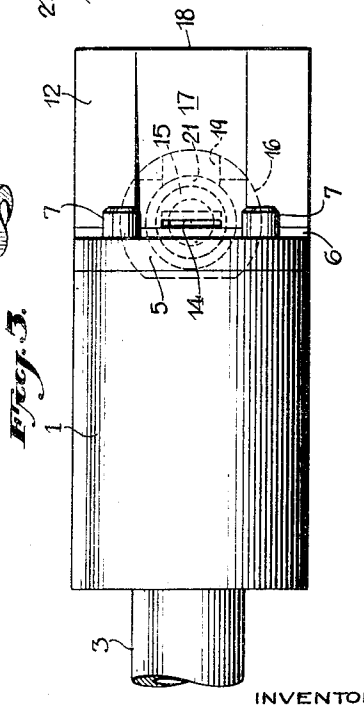


Fig. 3.

Fig. 5a.

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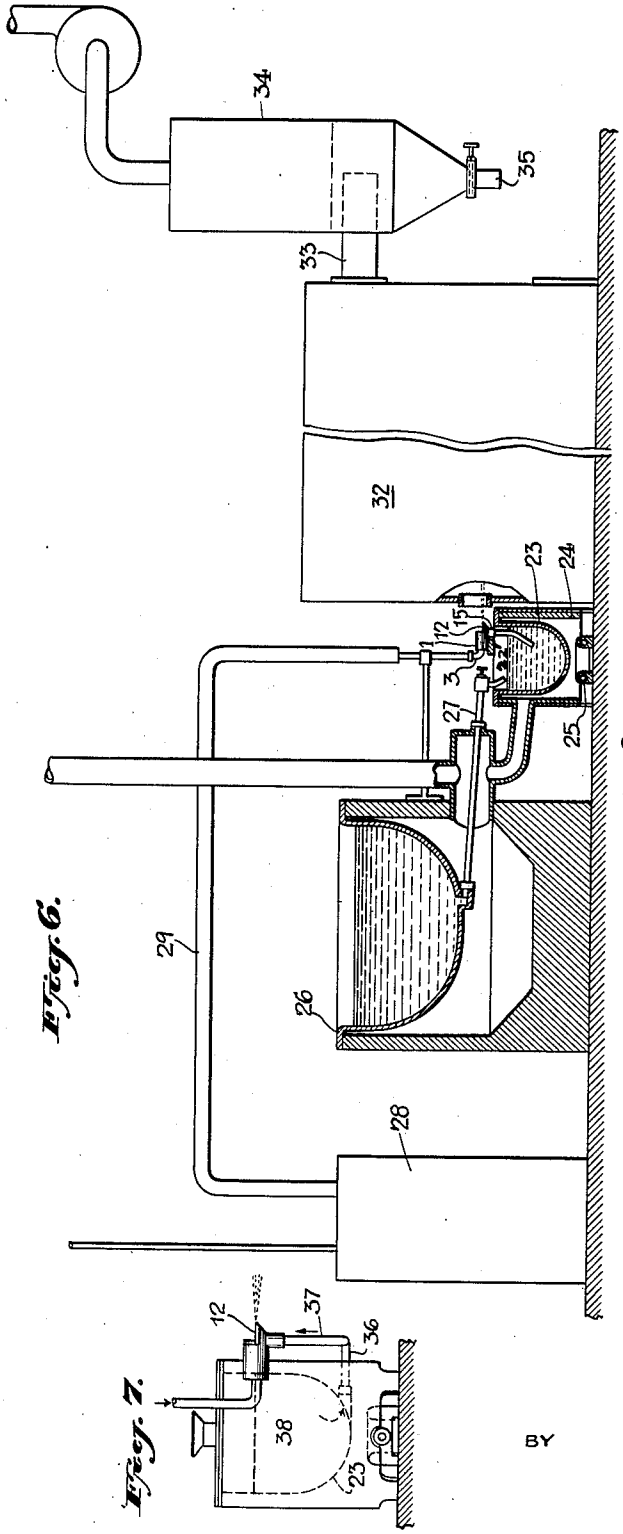


Fig. 6.

Fig. 7.

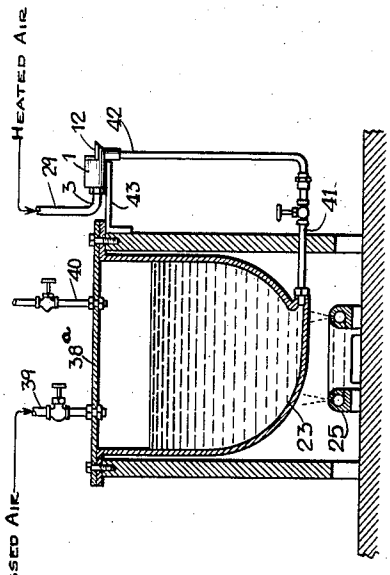


Fig. 8.

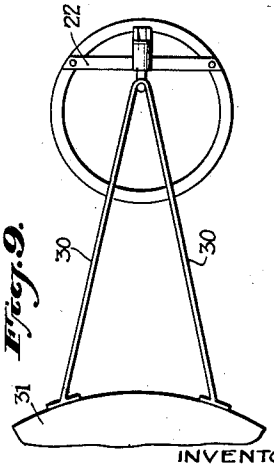


Fig. 9.

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2,527,009

GUN FOR MAKING POWDERED METAL AND LIKE MATERIAL

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Application February 13, 1947, Serial No. 728,259

4 Claims. (Cl. 91—12.2)

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This invention relates to an atomizing gun for making metal powder or the like and particularly one in which the metal is disintegrated by air or other gas blast.

The invention consists of the novel apparatus and combinations thereof, specific embodiments of which are described herein by way of example only and in accordance with the manner in which I now prefer to practice the invention.

In accordance with my invention, I provide a housing having a channel for conveying air or other gas to spray or disintegrate molten metal or other material. In combination with this, I provide a restricted orifice through which the air passes and in front of the housing I provide a lip which has a spray floor. In this floor there is a floor orifice near the air orifice for delivering molten metal into the air stream on the spray platform. The molten metal or like material is there blasted and disintegrated to the extent desired. I convey molten metal or other powderable material into a blast of gas, such as air, etc. The gas and metal are then passed on to a fixed spray floor and the gas and metal then pass under high speed from the spray floor into a collecting chamber.

My invention is illustrated in the accompanying drawings forming part of this specification, in which

Figure 1 is a side elevation of the atomizing or disintegrating gun;

Fig. 2 is a side sectional elevation thereof;

Fig. 3 is a plan view looking from above in Fig. 2;

Fig. 4 is a view of the front end of the device partially in section;

Fig. 5 is a detailed perspective view of the detachable facings used on the front end of the gun;

Fig. 5*a* is a perspective view of the annular collar provided with the slot for the under air supply;

Fig. 6 is a diagrammatic elevation of apparatus including my atomizing or disintegrating gun set up for making metal powder of varying size, in which the molten metal is aspirated onto the spray platform by air passing through the gun;

Fig. 7 is a sectional elevation of a modified form of spray kettle in which the metal is fed under static head to the spray platform;

Fig. 8 is a sectional elevation of another modification of the spray kettle in which a cover is provided and the molten metal or other material is supplied under pressure to the spray platform; and

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Fig. 9 is a plan view of the mounting of the gun on the spray kettle of Fig. 6.

Referring now to these drawings and particularly to Figs. 1 to 5, inclusive, there is shown a metal atomizing or disintegrating gun which comprises in combination a cylindrical housing 1 of cold-rolled steel shafting. This cylindrical housing is bored to provide an air or other gas channel 2 approximately 1 inch in diameter. The external diameter of the housing is approximately 2 inches. Into one end of this channel 2 passes an air pipe 3 which is screw-threaded into the conduit 2, making a tight joint therewith. The opposite end of the conduit 2 is narrowed to an oblong slot 4, whose width is about the diameter of the air channel 2, namely, about 1 inch, but whose height is approximately $\frac{1}{8}$ inch, as here shown. The front wall of the housing 1 is closed by two detachable pieces, one a semi-cylindrical disc 5 which provides three sides of the air slot 4 and a rectangular piece 6 which provides the floor of the air slot 4. The disc 5 is bolted by bolts 7 to the front face of the housing 1 and the rectangular piece 6 is bolted from below to a lip 8 integral with and projecting in front of the housing 1. This rectangular piece 6 is bolted in place by bolts 9. A rear side of the member 6 rests on a shoulder 10, here shown as integral with the housing 1. The rear corners of the slot 4 are rounded on a radius of about $\frac{1}{8}$ inch diameter, as shown at 11. Another detachable piece 12, which is nearly square in plan view and has a 45° beveled front edge as described below, is also bolted by bolts 13 from below to the upper face of the lip 8 completely covering same. This piece 12 constitutes a substantially flat fixed spray floor or stage which will be later described. The three pieces 5, 6 and 12 are of approximately $\frac{1}{4}$ inch thickness. The lip 8 as noted projects in front of the housing 1. The distance from the slot 4 to the outermost edge of the piece 12 mounted thereon, as here shown, is about $1\frac{3}{8}$ inches, where the slot is about $\frac{1}{2}$ inch in width.

As above described, the parts 5, 6 and 12, as well as the lip 8, have been noted as being in front of the housing 1. The expression "in front of said housing" and similar expressions as herein used is intended to refer to the end of the housing opposite the air entrance (through pipe 3) and extending beyond the slot 4 in the direction that air flows through the slot. Similarly, the expression "at the rear of said lip" and similar expressions refers to a position in a direction extending towards the air entrance.

Formed in the spray floor between the front

end of the piece 6 and the rear end of the piece 12 is a floor slot 14, each transverse edge of which is tapered at an angle of about 70° to the horizontal plane, thus having its narrowest breadth where it emerges at the top of the piece 6 and 12. This slot has a width of about ½ inch, and a breadth of about $\frac{1}{16}$ inch. Thus, the breadth and depth, respectively, of slot 14 at the spray floor and slot 4 are about the same, but the width of the respective slots is such that the floor slot is about one-half the width of the air slot. As will be noted, the exit of slot 14 is about $\frac{1}{16}$ inch below the exit of the air slot 4.

Screw-threaded into the underside of the lip 8 is a hollow suction tube 15 of about ⅜ inch inside diameter, as shown in Fig. 2. This tube is arranged to communicate with molten metal or other material to be sprayed and to deliver same through the floor slot 14 onto the spray floor 12. The opposite end of the tube passes through a collar 16, the outside diameter of tube 15 being narrowed to form a shoulder 15*a*, and then, as noted, is screw-threaded to the lip 8, the upper extremity of the tube 15 fitting flush against the bottom of the spray floor 12 and delivering molten metal into the floor slot 14 from the lower side thereof. The shoulder holds the collar in place when the tube 15 is screwed into position.

The three parts 5, 6 and 12 may be made of steel. All parts except the suction tube may also be made of steel, the suction tube 15 being preferably of stainless steel. All steel parts may be chromium plated to avoid abrasive effect of air and metal. The three parts 5, 6 and 12 are detachable and replaceable according to the metal to be sprayed coming in contact therewith and where a material is to be sprayed which is reactive, as for example, zinc, the parts are made of zircon refractory, sillimanite, tungsten or similar refractory substance. In the case of tungsten or other metal, the parts could be made out of pressed powdered metal. Where zinc is sprayed, refractory zircon is preferably used. Liquid zinc in contact with iron or steel at temperatures above about 423° C. (melting point of zinc) will form the compound $FeZn_7$ and may cause difficulties in operating the gun.

The floor slot 14 and air slot 4 are in substantially perpendicular planes to one another and air passing through slot 4 over the exit of the floor slot will suck metal onto the spray floor 12 where it will be disintegrated and reduced to a comminuted or powdered form as described more particularly below. The horizontal plane of the air flow is about parallel to the spray floor 12, as here shown.

The spray floor 12 has a depressed path 17 which has the width of the air stream, that is, a width of about 1 inch as it emerges from slot 4. This depressed path is aligned with the slot 4 ad has a sloping bottom sloping from the exit on the floor slot 14 uniformly upwards until it reaches the outer sharp edge 18 of the lip 8. At this edge, the path is no longer depressed and is flush with the upper surface of the piece 12. The edge 18 is substantially rectilinear and is substantially perpendicular to the flow of gas and metal along the spray floor. That part of the platform on either side of the sunken portion has smooth upper faces so that no eddy currents are produced in the metal as it flows across the platform. Generally speaking, the entire stream of combined metal and air will travel only across the platform between the walls of the sunken portion and ordinarily will not override these walls onto the smooth lateral surfaces mentioned. To some extent, they may ride over these walls, but since the lateral surfaces are smooth, eddy currents will be avoided, as mentioned.

An auxiliary air conduit is provided in order to blow air or other gas from the orifice 19 between the collar 16 and the adjacent portion of the lip 8. This conduit consists of a passageway 20 leading to an annular chamber 21 inside the collar 16 and spaced from the pipe 15 at a distance of about ⅛ of an inch on either side thereof. Air is thus fed from the main air channel 2 through the passage 20 into the annular chamber 21 and out through the orifice 19. The orifice has a floor 19*a* which is inclined at about 45° to the axis of the collar 16 and is substantially parallel to the underside of the lip 8. Thus, the air travels along the other side of this pipe to the outer edge 18 and clears the edge of any metal tending to drip over the edge.

It is important to have a projecting lip with the spray floor as indicated in order to produce a smooth air flow, high vacuum and freedom from eddies in the combined metal and air stream. The air passing through the air orifice 4 comes out in a flat stream. This is produced not only by the oblong shape of the orifice, but also by the rounded edges 11 which exist at the entrance of the passage leading to the oblong slot. The high vacuum is produced also by the tapering of the metal slot at an angle of about 70°. With such taper, combined with a flat air flow, considerably greater vacuum can be produced than would be produced by simple passage of a stream of air circular in cross section across a circular tube containing the metal to be aspirated. In addition to this, the vacuum is improved by the fact that the spray floor has a sunken portion 17 so that there is a greater distance between the exit of the metal from the metal slot 14 to the underside of the air stream than would otherwise be the case. The orifice 4 is made broader than the metal slot in order to make sure that metal sucked up through the tube 15 and which might flow laterally onto the floor, will be caught by the air stream. If the air slot were the same size as the metal slot, some metal might flow laterally and not be caught by the air stream. The lower edge of the air slot coincides with the rear edge of the metal slot for a short distance. The air stream from the slot 4 diverges as it leaves the slot downwards, upwards and laterally at about 30°. A plane passing at 30° with respect to a vertical plane passing through the bottom edge of the air slot will strike the depressed portion 17 just ahead of the front edge of the metal slot, as here shown. This arrangement avoids pressure of air from 4 striking directly downwards on metal emerging from slot 14. The relationship of the air slot 4 and the metal slot 14, whose outer edge as shown is depressed below the lower edge of the air slot, is important and critical in accordance with my observations of the operation of the atomizing gun under commercial conditions. As pointed out above, the air passing from the slot 4 in expanding will expand downwardly at about an angle of 30°. It is therefore important that it strike beyond the front wall of the metal slot 14 in order to prevent striking the metal as it comes from the slot, thus tending to drive it back down through the tube 15. The dimensions given for the various parts herein are preferred in accordance with my operations. Any one of these dimensions may be varied, but it is important particularly with respect to the dimensions of the

air slot 4, the metal slot 14 and the positioning of these two slots with respect to one another, that if any variation of one of the dimensions of these parts is made, there should be a corresponding proportionate change in the dimensions of the other associated parts.

As shown in Fig. 6, the atomizing gun is shown as mounted on a bar 22 on the top of a spray kettle 23 held in a frame 24 on the bottom of which is a gas-fired burner 25 for maintaining metal in molten condition. Metal is fed from a melting kettle 26 suitably heated, from which molten metal passes through a valved pipe 27 to the spray kettle 23.

Air passing through a preheater 28 is lead through pipe 29 to the pipe 3 leading into the housing 1. This air is under superatmospheric pressure. Pipe 29 adjacent the spray gun is supported by arms 30 attached to the wall 31 which supports the kettle 26. The metal is sprayed into a spray chamber 32 where it settles. Fine particles passing out through the pipe 33 are collected in the filter 34 through which they may be removed through the valved pipe 35 at the bottom. Metal sprayed into chamber 32 may be removed by suitable means, not shown.

In carrying out the operation for disintegrating metal, air delivered through pipe 3 is passed through the oblong orifice 4 and passing over the spray floor orifice 14, aspirates metal from the spray kettle 23 onto the sunken portion 17 of the spray platform. The air is previously heated to about 700–1300° F. and may be under any desired pressure. I have found that with pressures of about 10–40 pounds per square inch, relatively coarse powders are produced, while with 65 pounds or above, tin and other powders with about 80% or more through 325-mesh may be produced. Higher pressures will produce finer powders. With this gun it is possible to atomize the metals at a rate of 200–800 pounds per hour. Slight changes in the dimensions of the spray slot and the air slot will alter the capacity of the gun. The combined air stream coming from the flattened orifice 4 and metal stream coming from the flat orifice 14 pass rapidly to the edge 18 and on leaving the gun, pass into the settling chamber 32. Any metal tending to drip over the edge is caught by the auxiliary stream of air passing upwardly from the auxiliary outlet 19 which meets the combined air and disintegrated metal stream at this edge and prevents metal from collecting on the edge with resulting air eddies producing varying characteristics accordingly in the powdered material made.

With the above type of suction slot employing a hot air blast at 48 pounds per square inch pressure, a vacuum of 12.5 in. mercury has been produced. With increased air pressure, higher vacuum may be produced. For example, at 51 pounds per square inch air pressure, a vacuum of 15 inches of mercury was obtained. The atomizing gun has been employed by me for the disintegration and atomizing of various metals having varying melting points, as, for instance, lead, tin and zinc, and also alloys of lead, tin and antimony, including, for example but without limitation, solder.

Tin has been atomized in accordance with my invention at a metal temperature of 800° F. and a preheated air at 900–1000° F. applied to 90–95 lbs. pressure, while holding the metal level in kettle 23 so that a suction of about 3 inches is provided in tube 15. The average powder from operation under these conditions had the following average screen analysis taken from a long series of runs:

	Per cent
+200 mesh	2.0
+250 mesh	4.2
+325 mesh	5.8
−325 mesh	88.0

Powders of various fineness may be produced by my apparatus and process. Solder powders having the following particle size have been prepared in one operation in accordance with specifications of various manufacturers:

	Per cent
−40+100 mesh	Approx. 5
−100+200 mesh	Approx. 20
−200+325 mesh	Approx. 35
−325 mesh	Approx. 40

In producing such powders, the use of a low air pressure was employed, 12–32 pounds per square inch, and along with this, the molten metal was supplied to the gun without depending on suction which, as indicated above, would require relatively higher pressure. In order to feed the metal in this manner, I have devised a means whereby a constant-level molten metal container feeds metal to the gun through a side tube. The level in the container and at the spray platform may be the same or may be at any differential level desired, the operation being otherwise similar to that heretofore described.

Referring to Fig. 7, there is shown an apparatus for producing such coarse metal powder. In this instance, the feed of the molten metal is provided without relying on the suction power of the air and, accordingly, the molten metal is fed from the bottom of the spray kettle 23 by means of a pipe 36 which conveys metal from the bottom of the spray kettle to an upright pipe 37 which delivers molten metal onto the spray floor 12 by a static head effect. The molten metal is supplied to the spray kettle 23 from a source such as the melting pot 26 in a stream sufficient to maintain a supply such that a quantity of metal, for example designated as 38, is always present in the spray kettle and has a level of supply approximating that of the outlet to the metal onto the spray floor. The metal in the spray kettle is heated as before by a gas burner 25. A depth gage (not shown) or other known device can be used to maintain the desired level in the spray kettle 23.

Referring now to Fig. 8, a modification is shown in which the metal is supplied under pressure to the spray platform 12 from the spray kettle 23. In this case, the spray kettle is sealed by a cover 38a through which a valved pipeline 39 for compressed air passes. The metal is admitted to the chamber by a valved pipe 40 as required. The metal passes from the chamber under the air pressure through a valved pipe 41 and an upright pipe 42 to the spray floor 12. Heated air is fed as before through a line 29 and pipe 3 to the spray gun, which is supported on the outside of the casing surrounding the kettle by a bracket 43. The spray kettle is heated by the gas burner 25 as heretofore.

The operation employed where the air or other gas is supplied under pressure is that the metal is forced under the air pressure to the oblong floor slot onto the spray floor and a blast of air at 700 to 1300° F. passes through the oblong air slot and the metal fed on from the floor slot is disintegrated by the air pressure.

Powder varying from a relatively coarse product to a product mainly composed of dust-like material is produced as desired by suitably controlling the air pressure and the rate of feed of the metal. Controlled air pressure is obtained by well-known means and the rate of feed of the metal is controllable by utilizing the features of the gun. For instance, a low metal feed rate is obtainable by causing the metal to be aspirated, and the higher the platform of the gun relative to the metal level in the spray kettle, the lower the metal feed rate for a given air pressure. Thus, very fine material is made with high air pressure and maximum suction head.

Conversely, to produce powder composed mainly of relatively coarse material, low air pressure is combined with a high metal feed rate. The means already outlined and shown in Fig. 7 and Fig. 8 show that high metal feed rates are readily obtained with low air pressure.

The temperatures of the air and molten metal are of secondary importance in respect to particle size of the product but have a bearing on the ease of operation, and depend specifically on the particular metal being atomized.

What I claim is:

1. A gun for disintegrating metal and other materials comprising, in combination, a housing having an air channel providing an air slot, a projecting lip providing a spray floor in front of said housing, a floor slot therein near said air slot, said slots being situated with respect to one another so that air delivered through the air slot is in a stream transverse to the stream of material delivered to the floor slot, a conduit having one end arranged to communicate with material to be sprayed, the opposite end of said conduit adjoining said floor slot and communicating therewith to feed said material onto said spray-floor, and a conduit providing an auxiliary air channel to blow air across the projecting end of said lip into the stream of air and material passing from said slots.

2. A gun for disintegrating metal and other materials comprising, in combination, a housing having an air channel terminating in an air slot, a projecting lip providing a spray floor terminating in a relatively sharp edge in front of said housing, a floor slot therein near said air slot, said slots being situated with respect to one another so that air delivered through the air slot is in a stream transverse to the stream of metal delivered to the floor slot, a conduit having one end arranged to communicate with molten metal to be sprayed, the opposite end of said conduit adjoining said floor slot and communicating therewith to feed said molten metal onto said spray floor, and an auxiliary air conduit to blow air on the underside of said sharp edge to clear metal tending to drip over the edge.

3. A metal atomizing gun comprising, in combination, a housing having an air channel extending therethrough and terminating in an air slot, a projecting lip providing a substantially flat spray floor, a floor slot extending transversely of said floor and of about half the width of said air slot, said slots being situated with respect to one another so that air delivered through the air slot is in a stream substantially perpendicular to a stream of molten metal delivered to the floor slot, said spray floor having a sunken portion slanting slightly upwardly from said floor slot and terminating in a relatively sharp edge at the outermost portion of said lip, and a suction tube having one end arranged to communicate with said molten metal to be sprayed, the opposite end of said tube communicating and feeding molten metal through said floor slot onto said spray floor.

4. A metal atomizing gun comprising, in combination, a housing having an air channel extending therethrough and terminating in an air slot, a projecting lip providing a substantially flat spray-floor projecting to a distance beyond the air slot a distance of the order of about 1⅜ times the width of the air slot, a floor slot extending transversely of said floor and of about half the width of said air slot, said slots being situated with respect to one another so that air delivered through the air slot is in a stream substantially perpendicular to a stream of molten metal delivered to the floor slot, said spray floor having a sunken portion slanting slightly upwardly from said floor slot and terminating in a relatively sharp edge at the outermost portion of said lip, a suction tube having one end arranged to communicate with said molten metal to be sprayed, the opposite end of said tube communicating and feeding molten metal through said floor slot onto said spray floor, and an auxiliary air conduit communicating with said air channel in said housing to blow air on the underside of said edge to clear metal tending to drip thereover.

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