ABSTRACT

A device is provided for atomizing a molten metal stream whereby a first jet of an atomizing fluid is directed to a molten metal and a second jet is directed to the combined stream of the molten metal and first jet of atomizing fluid; the second jet impinges the combined stream at a certain angular relationship to the molten metal stream; as a result of the specific arrangement of the jets embodied in particular nozzles and their orientation, a fine, very uniform powder is obtained which consists of smooth, substantially spherical particles; the device is operational without any substantial splash-back and the amount of molten metal which may be atomized on basis of the fluid for operating of the jets constitutes an advantageous aspect of the device.

5 Claims, 9 Drawing Figures
DEVICE FOR MANUFACTURE OF A POWDER BY
ATOMIZING A STREAM OF MOLTEN METAL

This is a Division of application, Ser. No. 94,148,
The present invention relates to those processes for
manufacturing powder by atomizing molten material,
in which a stream of molten material is atomized or
broken up into fine drops when it comes into contact
with an atomizing agent, usually a fluid, which is di-
rected under high pressure in the form of jets against
the stream of molten material.
The demands for a powdered or granular product
vary with the field of use. The basic properties of
the powder are determined by its chemical composition,
the shape of the powder particles, distribution of parti-
cles of different size and the microstructure of the
particles.
The method and means according to the present in-
vention are in the first place intended to be used in the
manufacture of a metal powder, and particularly a
powder from high-alloyed steel for producing compact
steel by sintering the powder. However, it may also nat-
urally be used for manufacturing other types of pow-
der. In the manufacture of such high-alloyed steel pow-
der, the desired properties of the powder are deter-
mined by the method to be used for sintering the
powder and also by the desired properties of the steel
bodies to be manufactured from the powder. The prop-
erties of the powder principally desired, apart from its
alloying-material content, may be summarized as:
a. low oxygen content, i.e. the powder may not be ox-
idized on the surface (high-alloyed steel normally con-
tains alloying materials which form very stable oxides
which are difficult to reduce)
b. particles which are spherical in shape with a
smooth surface, i.e. without bubbles or cavities
c. correct size distribution
d. the finest possible microstructure.

When manufacturing metal powder according to the
processes used in the present connections, by atomiz-
ing or granulating molten metal, a stream of the molten
metal is disintegrated by directing one or more jets of
some suitable granulating agent, usually a fluid, for ex-
ample a gas or liquid or a mixture of a gas and a liquid,
preferably under high pressure and at an acute angle,
against the stream, so that the stream of molten metal
is split up into fine particles or drops, which are col-
lected after being cooled to such an extent that they
have solidified and attained such a temperature that
there is no longer any risk of the metal particles thus
formed sticking together. In order to cool the metal
drops sufficiently, arrangements have often been used
in which the powder is collected at the bottom of a li-
quid bath, in most cases consisting of water. However,
similar to a granulating agent which contains oxygen,
such water baths cause the metal particles to become
oxidized on the surface and this method is therefore un-
suitable for manufacturing powder of substances which
form oxides difficult to reduce.
A large number of differently shaped nozzles for sup-
plying a disintegrating fluid to a stream of molten metal
have been suggested and probably the type most often
used is that which surrounds the stream of molten
metal and which, either through an annular slit or
through a number of peripherally arranged nozzle
openings, supplies the disintegrating fluid in the form
of one or more jets which converge conically towards
the stream of molten metal at one or more points.
The present invention relates to a method of granu-
latng a molten metal to fine powder of extremely high
quality, this method having been found to be extremely
advantageous. The invention also covers a special
shape for the nozzle through which a disintegrating
fluid is directed against a stream of molten metal to gra
nulate it.

On studying varying ways for the production of metal
particles with the help of disintegrating fluid which,
in the form of narrow jets, is directed against a stream of
molten metal symmetrically from at least two sides and
at an acute angle to the stream of metal, it has been
found that it is almost impossible to avoid the metal
being thrown to a greater or lesser extent to one side
and slightly upwards from the liquid metal. It has also
been established that this throwing or twisting of the
stream of molten metal during the actual granulation
process is detrimental to the process of breaking up the
stream of metal into the fine drops required in order to
achieve a uniform, fine-grained powder. It is clear that
this twisting of the metal stream is caused because it
cannot be made to meet the fluid jets exactly at their
point of intersection. Instead, the metal stream meets
one or the other of the fluid jets immediately before
they meet each other.

It has now been found that the granulation result is
considerably improved if a stream of the molten metal,
while it is still a substantially united stream, is deflect-
ed by a first fluid jet which forces the metal to alter direc-
tion and follow the direction of the jet as well as spread-
out the metal to a thin layer resting substantially on top
of the fluid jet, and that this first fluid jet and the
metal resting on top are intersected by a second fluid
jet at such a distance from the point of intersection be-
tween the stream of molten metal and the first fluid jet
that the change in direction and spreading out of the
metal is substantially complete, the second fluid jet
splitting up the metal layer into a shower of fine parti-
cles. It is probable that most of the desired disintegra-
tion into free drops or particles takes place at the de-
flation point between the stream of molten metal and
the first fluid jet, when the original shape and direction
of the stream is altered and it acquires kinetic energy
from the fluid jet. This kinetic energy is converted
partly into surface energy, by which the metal stream
is at least partially split into drops which are acceler-
at ed so that they are broken up: another conversion of
kinetic energy to surface energy takes place in the de-
flation point with the second fluid jet, whereupon the
molten metal and those drops already formed are fur-
ther divided. The second fluid jet is also important in
that it spreads out the particles as an even shower of
fine metal particles which, inter alia, facilitates the
cooling process. Since the first fluid jet is intended,
inter alia, to spread out the stream of molten metal to
a thin layer, wider than the original stream, the first
fluid jet must, therefore, be considerably wider than
the metal stream. The widening of the metal stream in turn
means that the second fluid jet must be considerably
wider than the first. The second jet must always be wider
than the stream of metal. So that the melt from the stream
of molten metal can change direction and spread itself
over the fluid jet at its intersection with the first jet, the
shortest distance from this intersection to the intersec-
tion with the second fluid jet may not be less than twice
the greatest width (diameter) of the metal stream immediately before intersection with the first fluid jet. If the distance between these intersection points is too short, the result will be about the same as with granulating means of the type previously described, in which the metal stream is intended to cut the two fluid jets at their point of intersection, but because of poor centering, it cuts one of the fluid jets just before the point of intersection of the two jets. Poor centering gives rise to a great deal of waste in the form of metal particles splashing out, and the particles obtained are extremely varied in size.

When atomizing in accordance with the invention described above, in which the molten metal is caused to change direction at two distinct deflection points, the best result is achieved if fluid jets are used which have a width which is considerably greater than their thickness. Such fluid jets are obtained with the help of slit nozzles arranged on opposite sides of the metal stream and extending substantially parallel to each other, the jets from them being directed at an angle to the metal stream. The distance between the deflection points should not be so great that the molten metal has time to solidify before the final disintegration takes place, when the layer of molten metal is deflected by the second fluid jet. Of course, those drops which have already acquired the desired size on contact with the first fluid jet may be permitted to solidify before coming into contact with the second fluid jet, but in general it is probably advisable for all the material to be atomized to be in liquid phase when it reaches the second fluid jet. For this reason the longest distance between the intersection points of the fluid jets with the molten metal should generally not exceed 20 times the greatest width of the metal stream immediately before its intersection with the first fluid jet.

Because of the metal particles which splash around during atomization of a stream of molten metal substantially directed against the intersection point of the fluid jets, the angle between the fluid jets and the metal stream had to be kept relatively small, preferably between 20 and 30°. There is otherwise a risk of the metal being thrown back towards the fluid nozzles and clogging them; also the metal particles splashing around disturb the flow of the fluid jets in some other way. This is a serious disadvantage since a large angle between the metal stream and the fluid jets has been found to have a favorable influence on the size and uniformity of the particles.

By means of the process according to the present invention the first fluid jet can operate undisturbed by the second and with great kinetic energy it has become possible to use an angle between the stream of molten metal and the first fluid jet of up to 60°. It has been found that the first fluid jet should form an angle of 30° to 60°, preferably about 40° - 45°, with the metal stream, whereas the angle between the first and the second fluid jets should be 25° - 60°. It should also be noted that the second fluid jet should not assume an angle of more than -10° to the original stream of molten metal. By a negative angle is meant that the original direction of the metal stream and the direction of the second fluid jet diverge. The angles are always calculated between the centre lines or planes of jets having the same main direction. It has been found particularly suitable if the second fluid jet is substantially parallel to the original direction of the metal stream, while the first fluid jet forms an angle of 40° - 45° with the metal stream. The permitted negative angles between the second fluid jet and the metal stream are probably not usually as advantageous as the direction parallel with the metal stream or the permitted positive angles. The negative angles cause a longer distance between the intersection point with the metal and the outlet of the nozzle, which in turn means that the fluid jet loses much of its original kinetic energy.

In the method described above for granulation it is important that the fluid jets should be as sharp and well-defined as possible, and that the distance between the nozzles for the disintegrating fluid, which is preferably an inert gas, for example argon, and the molten metal is as short as possible, i.e. the fluid should have as much kinetic energy as possible. The width and thickness of the fluid jets, as well as their speed and volume can be altered by altering the breadth and width of the nozzle outlets and by regulating the gas pressure in the nozzles. The width of the stream of molten metal can also be varied within certain limits. With the help of these variables and by altering the angles between the jets, the process according to the invention can be regulated so that particles of the desired shape and size distribution are obtained.

In order to obtain fluid jets as thin and sharp as possible, but sufficiently wide, special slit orifices have been produced. The shape and direction of these orifices in relation to the metal stream also forms part of the invention. These slit orifices may either be provided with a single longitudinal slit, a number of inclined slits, possibly overlapping each other, or a saw-toothed slit. The shaping of these slits is clear from the accompanying examples.

The diameter of the stream of molten metal should not be too great, but it can be varied to a certain extent without altering the particles produced, as long as the speed and volume of the fluid jets is also altered.

The present invention has been developed principally for use in the manufacture of powder from high-alloyed steel for powder metallurgical processes. The diameter of the stream of molten metal for atomizing such steel should be in the order of 8 mm. A large number of metal streams may of course be arranged from one ladle or casting vessel. The fluid jets can then be given such a width that they cover several metal streams. In order to obtain a powder of the highest grade, the particles are suitably cooled during a free fall through a high tower, the atomizing nozzles being arranged at the top of the tower. If the particles come into contact with a solid object before they have solidified sufficiently, they will be deformed and no longer have the desired spherical shape. The cooling of the particles may take place entirely or partially in a fluidized bed. Argon is preferably used as disintegration fluid and the particles should also be cooled in argon atmosphere so that particles are obtained which are completely free from oxide. The powder manufactured according to the present method have proved to be of very high quality, having uniform particle size and substantially round particles, a fact which is of great importance when sintering the powder after compression. Uniform particles facilitate the compression and are thus beneficial for the future use of the powder. The powder manufactured according to the invention may be used, for example, for the pressure sintering of powder bodies.
The method and apparatus according to the invention will be further described with reference to the accompanying drawings and the examples following. The invention is defined in the following claims.

FIG. 1 shows a section through a granulating means according to the invention. FIG. 2 shows a section through a horizontal variant of the apparatus according to FIG. 1. FIG. 3 shows in section a part of the device according to FIGS. 1 and 2. FIGS. 4–7 show in various projections two designs of the disintegrating fluid nozzles and FIG. 8 shows how these are directed in relation to each other. FIG. 9 is a diagrammatic summary of the angles formed between the fluid jets and the metal stream.

The atomizing apparatus shown in FIG. 1 comprises a granulating chamber 1 which may be made of stainless steel, for example. If the particles are to cool during their fall, this chamber must be extremely high. The granulating chamber used in the experiment described below was 8 meters high. In order to enable a shorter chamber to be used the device according to FIG. 1 is provided at its lower end with a fluidized bed 2 which artificially extends the time of suspension of the particles. Said fluidized bed 2 is formed by a number of argon jets introduced into the lower end of the chamber 1 through a plurality of gas inlets 41 situated annularly around the fluidized bed. Around the lower part of the chamber and around the fluidized bed 2 is a water-cooled jacket 3 which is provided with a water inlet 38 and a water outlet 39. This watercooled jacket may also surround the whole granulating chamber. In order to improve the cooling conditions in the chamber 1 this may also be provided with internal cooling members and internal circulation of gas. During the granulating process the chamber 1 should be filled with an inert gas, for example argon, which should also be used to maintain the fluidized bed so that oxidation on the surface of the particles is avoided. A gas outlet 42 for surplus gas is arranged in the wall of the chamber. The finished particles are removed below the fluidized bed through a rotary valve 40. The actual granulating member is arranged at the top of the chamber 1 and consists of a tundish 4 filled with molten metal and provided with a tapping hole 5 through which a stream of molten metal flows between two nozzles 6 and 7. These nozzles 6 and 7 are straight slit orifices extending substantially parallel to each other in a direction perpendicular to the plane of the figure. The shape of the openings may be varied and they may, for example, have the conventional De Laval shape i.e. the nozzle outlet enlarges from a narrow interior section thus increasing the velocity of the gas in the nozzle. FIG. 3 shows nozzles of the De Laval type. The nozzles 6 and 7, which are supplied with argon under high pressure through conduits 8 and 9 are shaped and directed in such a way that the nozzle 6 aims a jet of argon at an angle of substantially 45° to the metal stream so that the stream is deflected in the direction of the argon jet and is then intersected by another jet of argon which is directed by the nozzle 7 substantially parallel to the original direction of the metal stream. The metal stream is thus split up into a shower 10 of free particles which are cooled on their way through the chamber 1 and the fluidized bed 2 and are removed through the valve 40.

The granulating device shown in FIG. 2 consists of a tundish 11 filled with molten metal which is delivered through a tapping hole 12 to form a metal stream which is substantially horizontal, at least near the ladle. About the casting opening are two argon nozzles 13 and 14 of substantially the same type as the nozzles 6 and 7 in FIG. 1. Through the nozzle 13 a jet of argon under high pressure is directed against the metal stream at an angle of 45° to the metal stream. The metal stream is thus deflected in the direction of the argon jet and is then met by the second argon jet directed through the nozzle 14 substantially parallel to the direction of the metal stream at the outlet from the ladle. The molten metal is thus disintegrated to form a shower 15 of free particles which are cooled on their way through the granulating chamber 16. The use of a horizontal stream of molten metal and suitable directions and pressure for the disintegrating fluids means that the granulating device can be expanded in length instead of height which, in some cases, may be suitable. The granulating chamber 16 is provided with a cooled, curved surface 17 along which the particles which are unable to remain suspended can roll down to the lowest point 18 of the chamber without being noticeably damaged. At the lowest point 18 the finished particles are removed by means of a screw conveyor 43. A fluidized bed may be arranged here in order to further promote the cooling of the pellets. The chamber 16 is also provided with a gas outlet 44 for surf

FIG. 3 shows in more detail a nozzle design for the supply of granulating agent, in this case argon, to a stream of molten metal. This nozzle design might very well be that used in the device according to FIGS. 1 and 2. FIG. 3 shows part of a plate 19 which may be made of steel or the like, in which there is a hole 20 for the stream of molten metal and two channels 21 and 22 for the supply of argon to the nozzles 23, 24 which are attached to the plate. The nozzles may be attached to the plate by welding or by means of bolts. Connecting channels are drilled between the channels 21 and 22 and the inside of the nozzles. The casting ladle is to be placed on the side of the plate 19 opposite to the nozzle. In the figure given an imaginary main direction of the casting stream is indicated by a dotted line 25. The nozzles 23 and 24 have been produced by a slit 26, 27 being cut in the edge of the nozzle. The slits 26 and 27 extend perpendicular to the plane of the figure and are covered by covering plates 28, 29, also extending perpendicular to the plane of the figure. The plates 28, 29 are provided with nozzles 30 and 31. When the covering plates are fitted over the slits 26, 27, the nozzles 30, 31 form narrow slots for the pressurized argon. The slot 30 is greater in length than the original diameter of the metal stream, and the slot 31 is longer than the slot 30. The covering plates 28 and 29 may be attached to the valve bodies by bolts, not illustrated.

FIGS. 4, 5 and FIGS. 6, 7, respectively, show in horizontal and vertical projection, respectively, nozzles of a somewhat different design. FIG. 8 shows two nozzles in side projection of this type, directed against each other. The nozzles consist of two parts 34 and 35 in which a slot, open at one end, has been cut. The parts 34 and 35 are saw-toothed along part of one edge. If a part 34 and a part 35 are fitted together so that the nozzles form a channel extending in the longitudinal direction of the nozzle, a saw-toothed gap 36 (FIGS. 4 and 5) can be obtained in the junction between the parts, or else a number of inclined gaps 37 (illustrated in FIG. 6) can be obtained. Of course, in order to ob-
tain a gap the saw-toothed edge parts must have a total height which is slightly less than the other edge sides. The type of gap obtained depends on how the parts 34 and 35 are positioned in relation to each other.

FIG. 9 shows the size of the various angles which the stream of molten metal and the fluids may have in relation to each other in the method according to the invention without detracting from the quality of the powder obtained or the function of the apparatus. Obviously the metal stream has a certain diameter (usually in the order of 8 millimeters) and the fluid jets are rather spread, although as thin and narrow jets as possible are aimed at the metal stream. However, the cores of the jets of fluid contain most of the quantity of fluid and are relatively concentrated. In the drawing the various jets are represented by their centre lines, or rather centre planes, and in the following discussion concerning angles, it is the relationship between these centre lines or planes which is discussed. The fluid jets are obtained from two slit orifices of the type already described in connection with FIGS. 1–8 and the jets are imagined to be widest in a plane perpendicular to that of FIG. 9, i.e. the nozzle openings are similar to those in the devices according to FIGS. 1 and 3, being parallel to each other but directing the fluid jets at an angle to each other so that they intersect each other.

A stream T of molten metal falling vertically is deflected by a fluid jet A', which forms the angle a' with the metal stream. As mentioned previously, it has been found that this angle a' may be allowed to vary between 30 and 60° (i.e. a' to a in FIG. 9). These limits for the direction of the first fluid jet A' have been indicated in the figure as A' and A''. The limits of the deflected metal stream, which has to a certain extent already become disintegrated, have been indicated as T' and T''. At a distance from the deflection point between the metal stream T and the first fluid jet, which is not less than twice the diameter of the metal stream, the deflected metal stream is again deflected, this time by a second fluid jet B'' on the other side of the metal stream from the fluid jet A''. As mentioned previously, however, this distance may not be so great that the melt has had time to travel to such an extent that disintegration is impeded. The fluid jets A' and B'' thus form an angle b'' to each other. The angle b'' may vary between 25 and 60° according to our investigations, and the limits within which the direction of the fluid jet B'' may vary has been indicated by B' and B''. The angle between the original direction of the metal stream T and the second fluid jet B'' should not, however, be less than 10°, the negative angles indicating that the fluid jet B'' has the same direction as the fluid jet A'' in relation to the original direction of the metal stream, i.e. the direction of the fluid jet B'' and the original direction of the metal stream diverge. This means that a part of the range within which the angle b'' may vary is further limited. The angle 10° has been indicated in the drawing. The range within which the fluid jets A'' and B'' may therefore be allowed to vary has been sectioned with section lines substantially perpendicular to each other as shown in FIG. 9.

The limits stipulated above for the angles between the stream of molten metal and the first fluid jet, and between the first and second fluid jets, are set because too large an angle between the fluid jet and the melt means that the particles are thrown back too much against the fluid nozzles, with the risk of them becoming clogged. The smaller the angle is between the tapping stream and the fluid jet, the more rapidly will the melt be pushed out of the way and is thus prevented from being thrown back. However, if the angle is too small the particles produced will be too coarse and irregular. In principle, the same reasons limit the angle between the two fluid jets. The negative angles between the metal stream and the second fluid jet is probably not very suitable in general since, i.e. they give rise to too great a distance between the nozzles of the fluid jets and the intersection points of the jets. In order to attain the desired well-defined and sharp fluid jets, the distance between the nozzles and the intersection points of the fluid jets with the melt must of course be kept as short as possible.

In order to produce a jet or stream of molten material having an elliptical cross-section the tundish for the molten material shall have an outlet opening with an elliptical cross-sectional area. Said elliptical opening shall, however, not be too narrow, because it would involve the danger of the molten material solidifying in the opening. Any jet of liquid leaving a nozzle of an arbitrary cross-sectional shape has the tendency of changing its cross-sectional shape into a circle. The distance required for this change is dependant on the pressure of the molten material and, therefore, in the method of the invention, on the height of the body of molten material in the tundish. It is, consequently, desired that the elliptical jet of molten material shall meet the first atomizing jet as soon as possible after it has left the elliptical shape of the jet of molten material from a circle to an ellipse, and orienting said jet of molten material so that the long axis of the ellipse is perpendicular to the direction of flow of the jet of atomizing fluid. The ellipse-shaped cross-section of the jet of molten material makes it possible to reduce the quantity of atomizing fluid required for atomizing a given quantity of molten material. For a given quantity of molten material, and a given quantity of atomizing fluid, the change from a circular to an elliptical cross-section of the jet of molten material will result in smaller particles of the resulting powder. Smaller particles solidify more rapidly in the atomization chamber than do bigger particles, and they are superior to bigger particles for many purposes.

According to an embodiment of the invention it is possible to increase the capacity of a powder manufacturing device by arranging two or more streams or jets of molten material close to each other, and having said streams or jets atomized by one single pair of atomizing fluid jets as described above. This way of simultaneously atomizing two or more jets of molten material is made possible by the fact that atomizing jets can easily be produced having a great width and a small thickness. Consequently, two or more jets of molten material can be allowed to impinge upon one of the main surfaces of one single jet of atomizing fluid.

According to another embodiment of the invention it is possible to increase the capacity of a powder manufacturing device by changing the cross sectional outlet opening of the tundish. This is desired also for another reason, viz. that the jet of molten material shall be as hot as possible when it meets the first atomizing jet.

EXAMPLE 1

The device used for the experiment was substantially similar to the device according to FIG. 1. However, no
fluidized bed was used at the lower part of the atomizing chamber. The height of the tower was 8 meters. The experiment was carried out for atomizing high-speed tool steel with a vertical tapping stream. The nozzles for the atomizing fluid had slit-shaped openings, the narrowest part of the slit being 0.60 millimeters. On one of the nozzle-parts the slit was 20 millimeters long and positioned 30 millimeters from the centre line. The gas jet formed an angle of 40° with the vertical line. In the other nozzle the slit was 40 millimeters long, the opening positioned 32 millimeters from the centre line and the gas jet was vertical. The circular tapping hole for the melt had a diameter of 8 millimeters, giving a flow rate of 45 kilogramms steel per minute. Argon was used as atomizing agent. The argon pressure, measured in the supply conduit before the nozzle, was in this case 15 atm for both nozzle parts. The pressure in the nozzle was therefore somewhat lower. The total quantity of gas consumed was 5.5 Nm³ per minute. The powder manufactured in this way consisted solely of spherical particles and gave the following results on being sieved, the quantity which passed through each sieve being indicated in per cent by weight.

<table>
<thead>
<tr>
<th>Particle size, μm</th>
<th>Percent by weight</th>
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<tbody>
<tr>
<td>44</td>
<td>6.0</td>
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<td>61</td>
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<td>315</td>
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<td>400</td>
<td>97.6</td>
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EXAMPLE 2

A molten material was atomized in a device which was substantially similar to the device disclosed in FIG. 1. In the first experiment the outlet opening of the tundish was circular and had a diameter of 6.5 millimeters. In the second experiment said opening was elliptical and had a long axis of 10 millimeters and a short axis of 5 millimeters. The long axis was placed perpendicular to the direction of flow of the first atomizing jet, or, in other words, parallel with the outlet opening of the nozzle producing said first atomizing jet. It was found that the atomizing capacity in experiment 2 increased by 15 percent, as compared to experiment 1, owing to the fact that a higher quantity of molten material flowed through the elliptical opening per unit of time. The average particle size of the powder produced in experiment 2 was 11 percent smaller than that of experiment 1.

What we claim is:

1. A device for atomizing molten material by disintegration of a stream of molten material with fluid jets of inert gas directed under high pressure against the stream of molten material characterized in that it comprises a casting tundish provided with at least one casting opening and two slit nozzles arranged parallel to each other, one on each side of the casting opening, the first nozzle and the first jet being greater in length than said casting opening and so directed in relation to the centre axis of the casting opening that the centre plane of the slit forms an angle of 30° to 60° with this axis, whereas the second nozzle and second jet being wider than the layer of molten material immediately before the intersection with this jet is directed so that it centre plane forms an angle of 25° to 60° with the centre plane of the first nozzle, and that the centre line of the casting opening intersects the centre plane of the first nozzle at a distance from the intersection of the planes with each other, which is not less than twice the diameter of the casting opening.

2. A device according to claim 1, characterized in that at least one of the slit nozzles has saw-tooth slits or consists of a plurality of part-slits, arranged successively, inclined in relation to the centre plane of the slit.

3. A device according to claim 1, characterized in that each of the nozzles comprises two parts and that the slits are formed in the joint between these parts.

4. A device according to claim 1, characterized in that the outlet openings of the slits enlarge from a narrow interior section.

5. A device as claimed in claim 1, in which the casting opening (5) has an elliptical cross-sectional area and is oriented so that the long axis of the ellipse is parallel with the outlet openings of the atomizing nozzles (6, 7).