

March 21, 1967

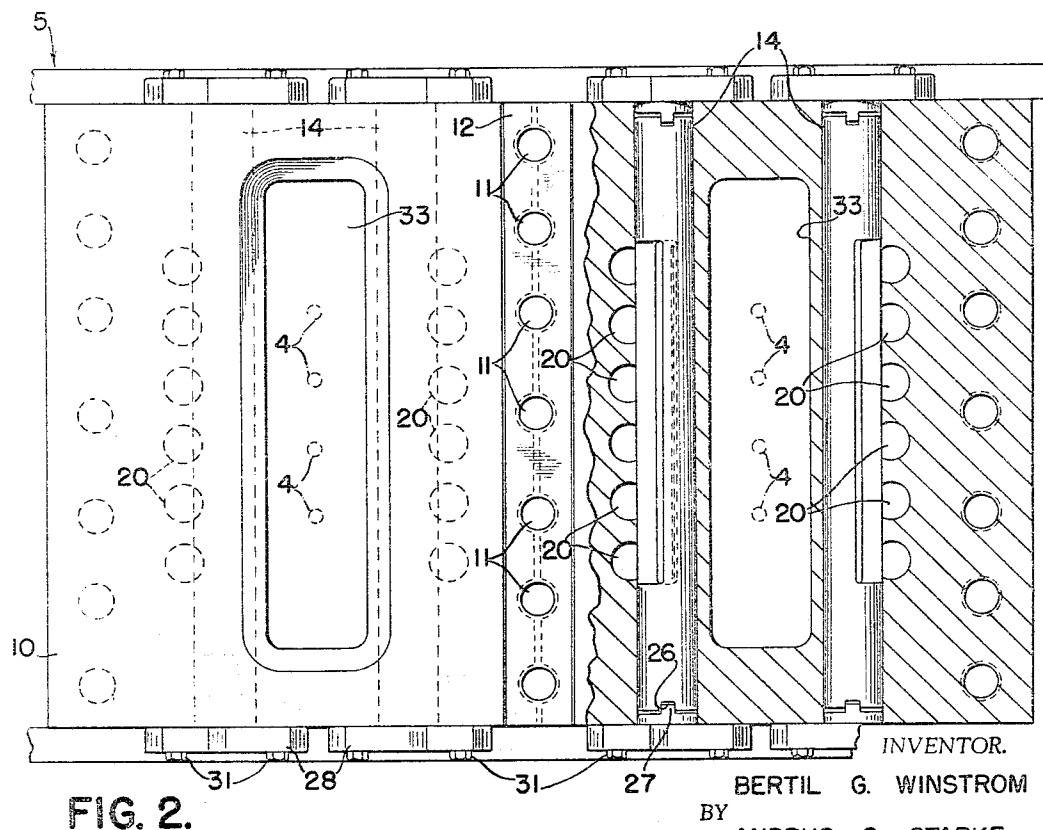
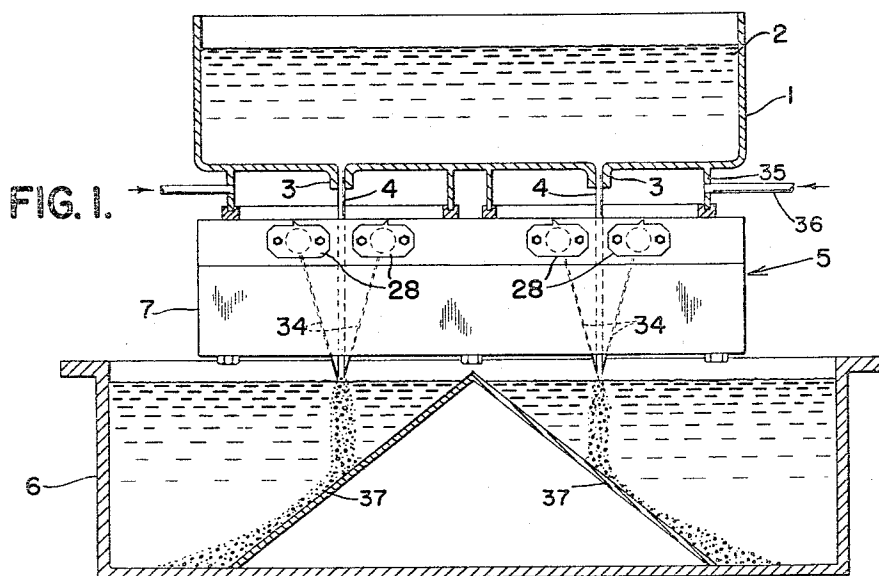
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3,309,733

APPARATUS FOR PRODUCING METAL POWDER

Filed July 14, 1964

3 Sheets-Sheet 1



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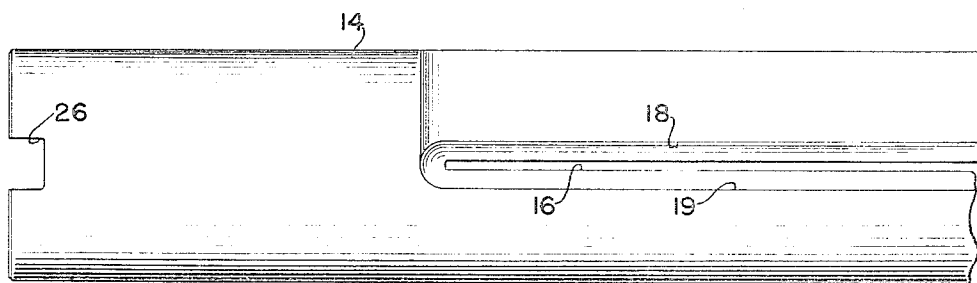
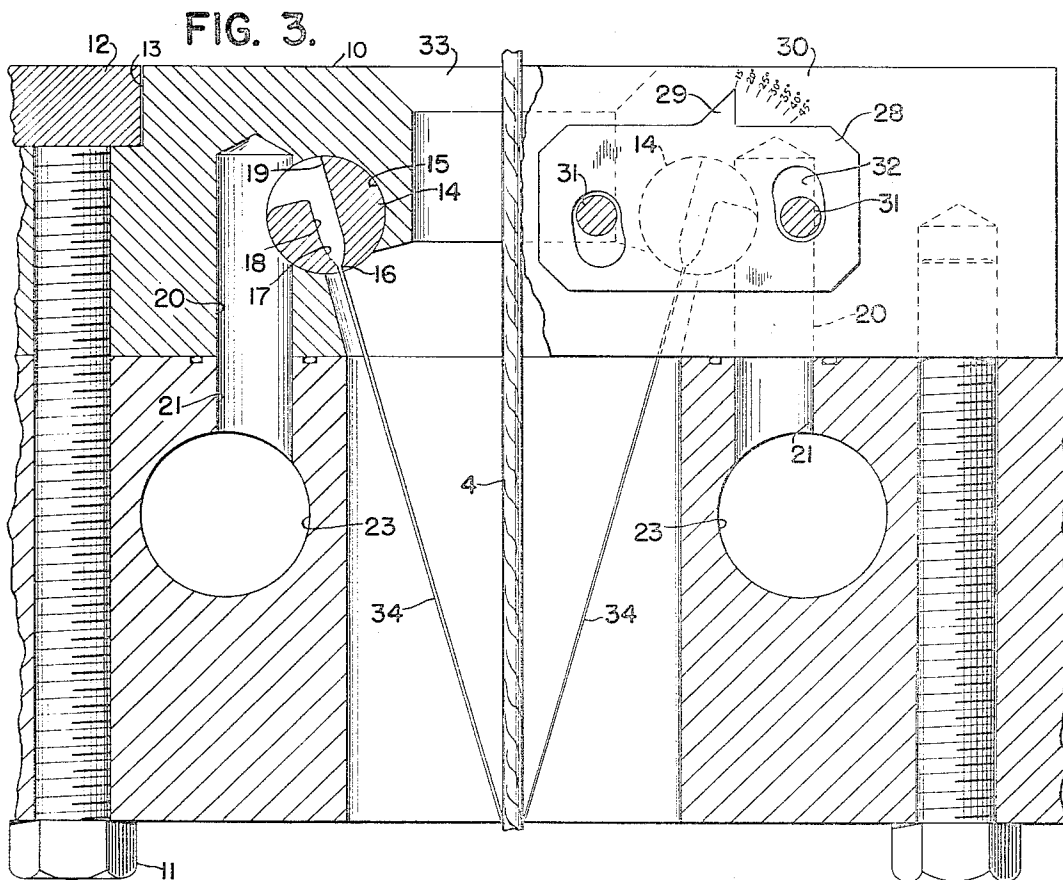
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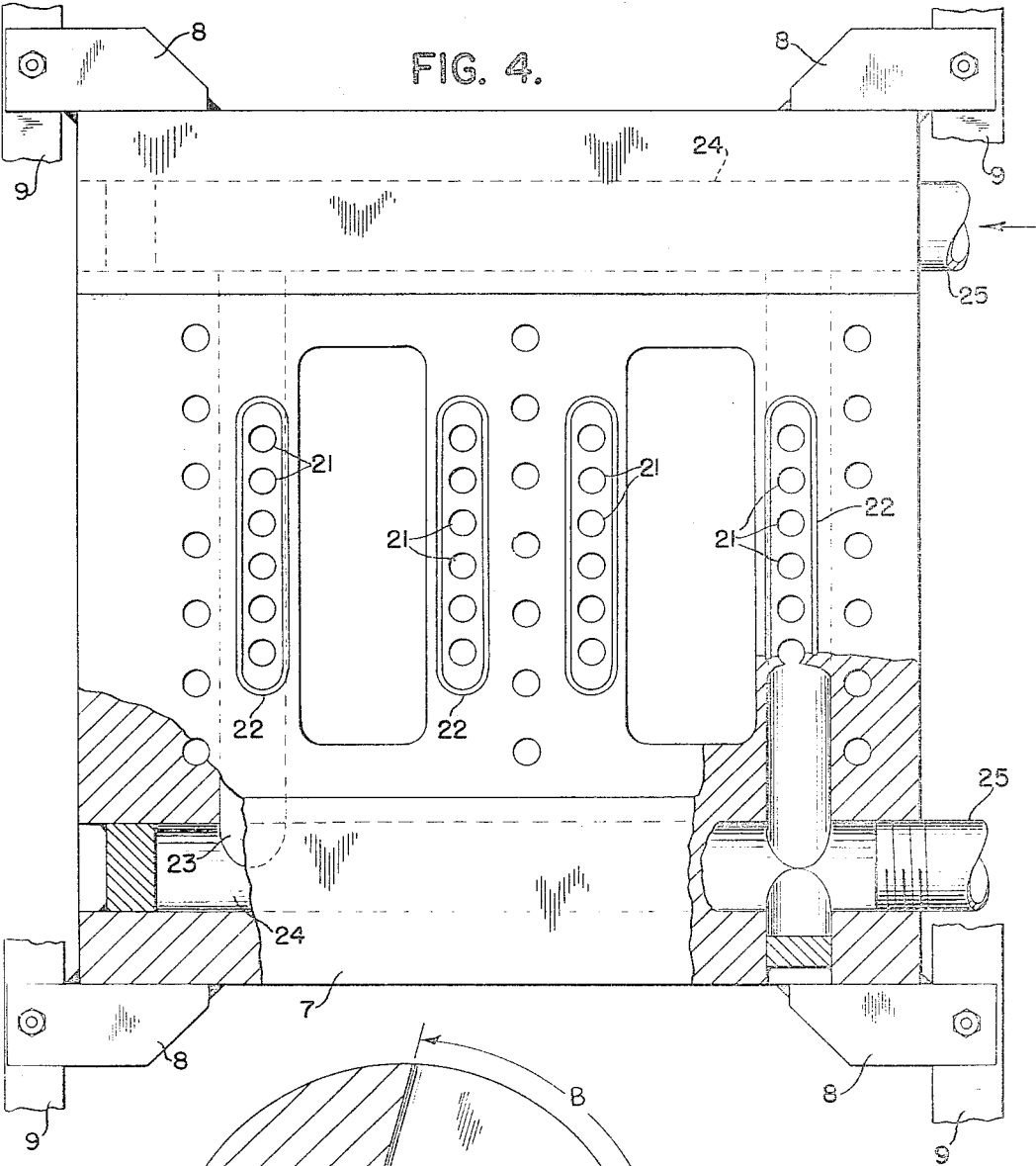
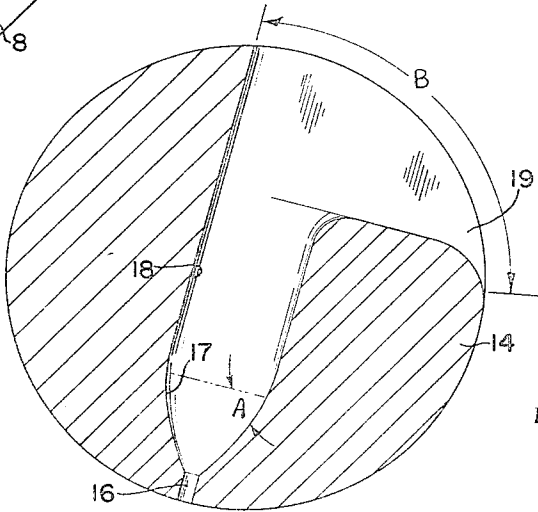


FIG. 6.



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APPARATUS FOR PRODUCING METAL
POWDER

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5 Claims. (Cl. 18—2.5)

This application relates to an apparatus for producing metal powder and more particularly to an atomizing nozzle assembly for producing finely divided metal powder for use in powder metallurgy processes.

One common method of producing powdered metal, such as iron powder, is by a water atomization process. In a process of this type, a stream of molten metal is engaged by a high-pressure sheet of water which serves to atomize or disintegrate the stream of molten metal and produce finely divided particles.

The present invention is directed to an improved nozzle assembly for use in a water atomization process for forming metal powder.

According to the invention, the nozzle assembly includes a pair of spaced water nozzles which are in the form of elongated, generally cylindrical bars. Each nozzle bar is provided with an outlet slot through which the water is directed toward the molten metal stream passing between the nozzle bars. The nozzle assembly contains water manifolds or passages which communicate with the slots in the nozzle bars so that water is continuously discharged through the outlet slots against the stream of molten metal in the form of oppositely directed streams or curtains.

In order to adjust the angle at which the water sheets are directed at the molten metal stream, each nozzle bar is mounted for rotation within a socket formed in the nozzle assembly. By rotating the nozzle bar, the position of the outlet slots with relation to the stream of metal can be changed to thereby vary the angle at which the sheets of water impinged against the molten metal stream.

The nozzle assembly of the present invention produces clean, sharp sheets of water which provide a more effective atomization or disintegration of the molten metal into powdered or particulate form. In addition, the design of the nozzle discharge slots and the supply manifolds minimizes the pressure loss through the nozzle assembly which again aids in producing a more effective atomization.

As the cylindrical nozzle bars are rotatable within the nozzle assembly, the angularity of the water sheets can be adjusted with relation to the stream of molten metal so that the most effective angle of engagement can be selected, with the desired angle depending on the thickness of the molten metal stream, the temperature of the molten metal and the composition of the metal. As an added feature, an indicating device is provided on the nozzle assembly which gives a visual indication of the angle at which each water sheet is engaging the molten metal stream.

Other objects and advantages will appear in the course of the following description.

The drawings illustrate the best mode presently contemplated of carrying out the invention.

In the drawings:

FIG. 1 is a schematic representation of the apparatus for producing metal powder;

FIG. 2 is a plan view of the atomizing nozzle assembly with parts broken away in section;

FIG. 3 is a side elevation of the nozzle assembly with parts broken away in section;

FIG. 4 is a plan view of the body of the nozzle assembly with parts broken away in section;

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FIG. 5 is an enlarged fragmentary elevation of a nozzle bar; and

FIG. 6 is a transverse section of the cylindrical nozzle bar.

The drawings illustrate an apparatus for producing metal powder, which comprises a tundish 1 adapted to contain a molten metal 2, such as iron, steel, stainless steel, copper, or the like. The lower surface of the tundish 1 is provided with two rows of orifices 3 and the molten metal flows downwardly by gravity through the orifices in a series of streams 4.

The streams 4 of molten metal pass downwardly through openings in a nozzle assembly 5 and water sheets are directed against the molten metal streams by the nozzle assembly to atomize or disintegrate the molten metal into fine particles or powder which is collected in a container 6 located beneath the nozzle assembly 5.

The nozzle assembly 5 includes a generally rectangular body 7 provided with a series of lugs 8 which are connected by bolts to a supporting structure 9 which serves to support the nozzle assembly beneath the tundish 1.

The upper end of the body 7 is enclosed by a head 10 and the head is secured to the body by a series of rows of bolts 11 which extend upwardly through aligned openings in the body and head. The outer rows of bolts 11 are threaded into the head 10 while the bolts of the central row are threaded into bars 12 located within recesses 13 formed in the upper surface of the head 10. The bars 12 are recessed so that the bolts 11 do not extend upwardly above the head 10. This enables the nozzle assembly to be located closely beneath the tundish 1 and allows the tundish, which contains the molten metal 2, to be moved freely across the top of the nozzle assembly.

According to the invention, the nozzle assembly includes a series of generally cylindrical nozzle bars 14 which are mounted for rotation within sockets 15 formed in the head 10. The nozzle bars 14 are arranged in pairs and are adapted to discharge oppositely directed sheets of water against the streams 4 of molten metal which are passing downwardly between the nozzle bars 14 of each pair.

As best shown in FIG. 6, each nozzle bar 14 includes an elongated outlet slot 16 through which the water is discharged toward the streams 4 of molten metal. The walls bordering the outlet slot 16 are generally parallel and the inner end of the slot 16 communicates with a generally tapered middle slot section 17. The inner end of the middle slot section 17 communicates with an inner slot section 18, and the walls of bar 14 defining slot section 18 are generally parallel so that the cross-sectional area of slot section 18 is substantially uniform. The inner slot section 18 has a substantially greater width than the discharge slot 16 and the walls of the tapered slot section 17 diverge inwardly at an angle A in the range of about 50° to 70° and generally about 60°.

Water is introduced into the inner slot section 18 through an elongated recess 19, and the recess extends circumferentially through a sector of about 80° to 120° and generally about 90°, as shown by B in FIG. 6.

As best shown in FIG. 6, slot sections 16, 17 and 18 and the recess 19 extend over a substantial portion of the length of the nozzle bar 14, and the end portions of the nozzle bar are solid and do not contain the slots or recess.

Water is supplied to the recess 19 of each nozzle bar 14 through a series of generally vertical openings 20 in head 10. The openings, as best shown in FIG. 2, are in aligned spaced relation and the lower end of each of the openings 20 communicates with a vertical passage 21 in

the body 7 of the nozzle assembly. To seal the joint between the body 7 and head 10, a generally oval seal 22 is located within a recess formed in the upper surface of the body 7 and the seal extends around the openings 20 and passages 21.

The lower ends of the passages 21 communicate with a cross passage 23 and the ends of the cross passage are connected with longitudinally extending manifolds 24. One end of each manifold is open and a supply conduit 25 is connected to the open end of each manifold. Water, introduced into each manifold 24 through the supply conduits 25, flows transversely through the cross passages 23 and then upwardly through the passages 21 and openings 20 to the recesses 19 in the nozzle bars 14.

By introducing water into both of the manifolds 24, the pressure of the water being discharged from the nozzle bars 14 can be increased with given pumping equipment. It is contemplated, however, that under certain circumstances, the water can be supplied through a single manifold 24, if desired.

The nozzle bars 14 are adapted to be rotated about their axes within the sockets 15 in order to adjust the angularity of the water sheet 34 being discharged through the outlet slots 16 with respect to the vertical streams 4 of molten metal. To rotate the nozzle bars, the ends of each nozzle bar 14 are provided with slots or notches 26, and a ridge 27 of an indicator plate 28 is received within the notches 26. The indicator plates 28 are located on the outer surface of the head 10 and each plate 28 includes a pointer 29 which is adapted to be moved along a calibrated scale or dial 30 having graduations of angularity of the discharge openings 16. The indicator plate 28 and the attached nozzle bar 14 can be rotated until the pointer 29 is at the desired angle setting.

The indicator plates 28 can be locked to the head 10 by bolts 31 which extend through the arcuate slots 32 in the indicator plate and are threaded within openings in the head 10. After the indicator plate 28 and the nozzle bar 14 have been rotated to provide the desired angularity, the bolts 31 are threaded down so that the heads of the bolts engage the indicator plate 28 and lock the plate and the nozzle bar in the desired position.

The molten metal 2 contained in the tundish 1 flows downwardly through the orifices 3 in two rows of streams 4. The nozzle assembly 5 is located immediately beneath the tundish and the molten metal streams pass downwardly through openings 33 in the nozzle assembly. Pairs of nozzle bars 14 are located on either side of each opening 33 and sheets 34 or curtains of water are discharged through the outlet slots 16 in the nozzle bars 14 and engage the molten metal streams. The force of the water, which is generally at a pressure above 500 p.s.i. and usually above 1,000 p.s.i., serves to atomize or disintegrate the molten metal stream to provide finely divided particles or powder which falls downwardly and is collected within the container 6.

To prevent oxidation of the molten metal stream 4 as it flows from the tundish 1 to the nozzle assembly, a shield 35 is positioned around each row of orifices 3 and extends from the lower surface of the tundish to the nozzle assembly. A reducing gas such as hydrogen, carbon monoxide or the like is introduced into each shield through a supply conduit 36. The gas flows downwardly through the openings 33 and serves to shield the molten streams 4 as well as the metal powder produced from the streams 4 from oxidation.

The container 6, in which the metal powder is collected, is substantially filled with water, and the water level is maintained within close proximity to the nozzle assembly 5 so that oxidation of the metal powder by exposure to the atmosphere is minimized. There is a certain amount of back splashing as the red hot powder contacts the water. and the water level should be adjusted so that the

back splashing will not interfere with the atomization of the metal stream.

To prevent the metal powder from piling beneath the nozzle, an inclined ramp 37 is positioned beneath each row of metal streams 4 and the powder will be deflected laterally by the ramps 37 to the side portions of the container 6. The metal powder entering the water in container 6 is glowing red and tends to chunk-up or weld together. The ramps 37 serve to keep the powder in motion in the water and prevent settling of the powder until the powder loses its red heat. Thus, the powder will not weld together and remains, generally, in a loose form.

The nozzle construction of the present invention provides a sharp, clean sheet of water which aids in the atomization of the molten metal. The particular shape of the slot sections 16, 17 and 18 in the nozzle bar 14 insures that the stream of water being discharged will remain thin and will not diverge as it emerges from the nozzle bar. More specifically, the inner slot section 18 has parallel walls and merges into the slot section 17 which in turn leads into the narrow outer slot section 16 having parallel walls. This construction enables the water to be discharged with a minimum pressure loss and in a thin, clean sheet.

As the nozzle bars 14 are mounted for rotation in the sockets 15, the angularity of the water sheets being discharged through the slots 16 can be readily changed without making any change in the water connections or piping within the nozzle assembly. Each nozzle bar 14 can be individually adjusted so that the opposed water sheets can either have the same angularity or a different angularity as desired. In addition, each nozzle bar is provided with an indicator which gives a visual indication of the angle at which the water is being discharged through the nozzle 16, and this enables the operator to readily change or adjust the angularity without calibration or measurement.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. Apparatus for producing metal powder, which comprises a container for holding molten metal and having an opening therein for discharge of molten metal therefrom, a nozzle assembly disposed adjacent to the container and having a nozzle provided from an elongated solid bar, said nozzle bar having a longitudinally elongated slot extending through the nozzle bar generally centrally of the length of said bar from one side of the peripheral surface of the nozzle bar to the other, said slot having an inlet section and an intermediate section, and an outlet section disposed toward the stream of molten metal with the walls of the nozzle bar defining the inlet section being generally parallel and having greater width therebetween than the walls of the bar defining the outlet section of the slot, the walls of the outlet section also being generally parallel to each other, and the walls of the bar defining the intermediate section tapering from a greater width therebetween adjacent the inlet section to a lesser width at the outlet section to provide for gradual constriction of the fluid flowing through the nozzle bar to the outlet section for discharge therefrom in sheet-like form, liquid supply conduit means connected to the inlet section of the nozzle bar to supply liquid to the inlet section of the nozzle bar under substantially high pressure for flow therethrough and discharge from the outlet section against the molten metal to atomize the latter, means engaging the nozzle bar to prevent deflection and lateral enlargement of the slot due to the internal pressure of the liquid passing through the slot, and means to support the nozzle assembly adjacent to the container.

2. The apparatus of claim 1 in which the means engaging the nozzle bar for preventing deflection is dis-

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posed in engagement with the peripheral surface of the nozzle bar and extends over a substantial portion of said surface and for a substantial portion of the length of the nozzle bar to provide an elongated socket for receipt of the nozzle bar.

3. The apparatus of claim 1 in which the liquid supply conduit means includes a series of separate liquid supply passages which communicate with the inlet section of the slot at spaced locations along the length of the slot.

4. The apparatus of claim 1 in which the nozzle assembly includes an elongated socket to rotatably receive the nozzle bar, and means to rotate the nozzle bar in the socket to locate the outlet section of the slot at different angular positions for varying the angularity of the sheet-like discharge of liquid with respect to the stream of molten metal.

5. The apparatus of claim 4, and means for selectively holding the nozzle against rotation at a predetermined angle, and indicator means for visually indicating the angularity of the slot with respect to the stream of molten metal.

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