United States Patent

Bliemeister

[15] **3,677,669**

[45] **July 18, 1972**

[54] APPARATUS FOR PRODUCING METAL SHOT

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[22] Filed: **May 5, 1969**

[21] Appl. No.: **825,115**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 773,230, Nov. 4, 1968, abandoned.

[52] **U.S. Cl.** **425/6,** 65/141, 264/9, 264/13

[51] **Int. Cl.** **B22c 23/00**

[58] **Field of Search** 18/2.7, 2.4; 65/141, 142, 143; 264/9, 13

[56] **References Cited**

UNITED STATES PATENTS

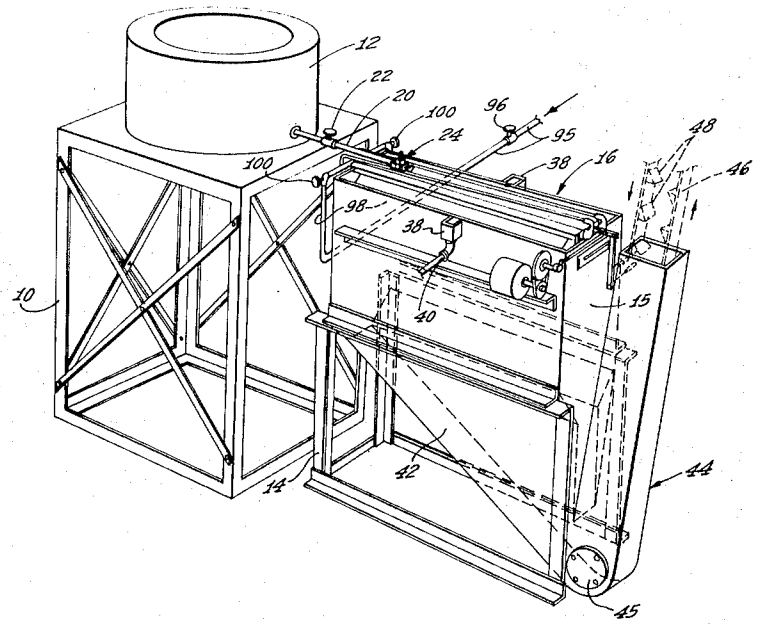
2,978,742	4/1961	Bliemeister	18/2.4 X
2,574,357	11/1951	Stammer et al.	18/2.4 X
2,979,764	4/1961	Andren	18/2.7
3,023,171	2/1962	Smith	18/2.7 X

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[57] **ABSTRACT**

In an apparatus of the character disclosed in the Bliemeister U.S. Pat. No. 2,978,742, a trough for molten metal is heated on both sides and has two rows of orifices to release drops of metal into a body of quenching solution onto submerged interrupter means. The orifices are formed by a stack of orifice plates that are individually slidable for individual thermal expansion. The trough is vibrated by means operating on the principle of a tuning fork.

29 Claims, 13 Drawing Figures



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Fig. 1

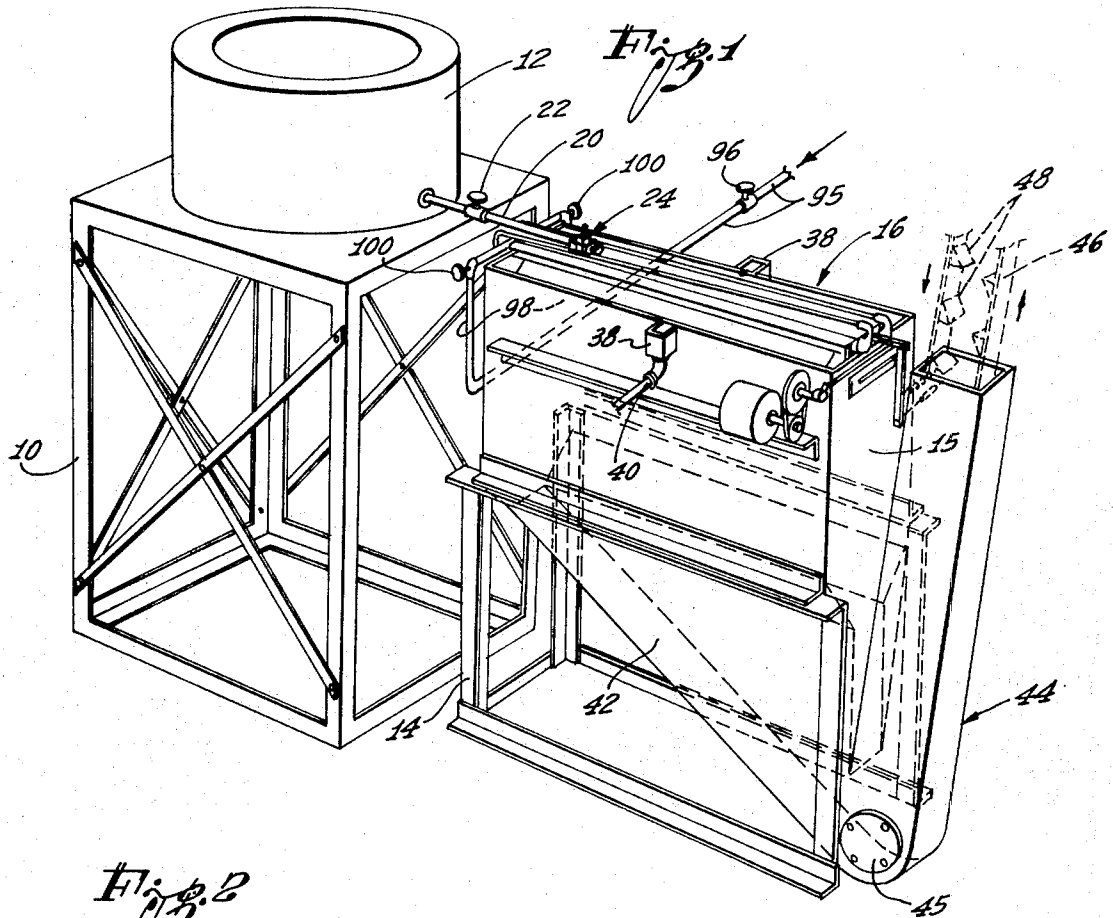
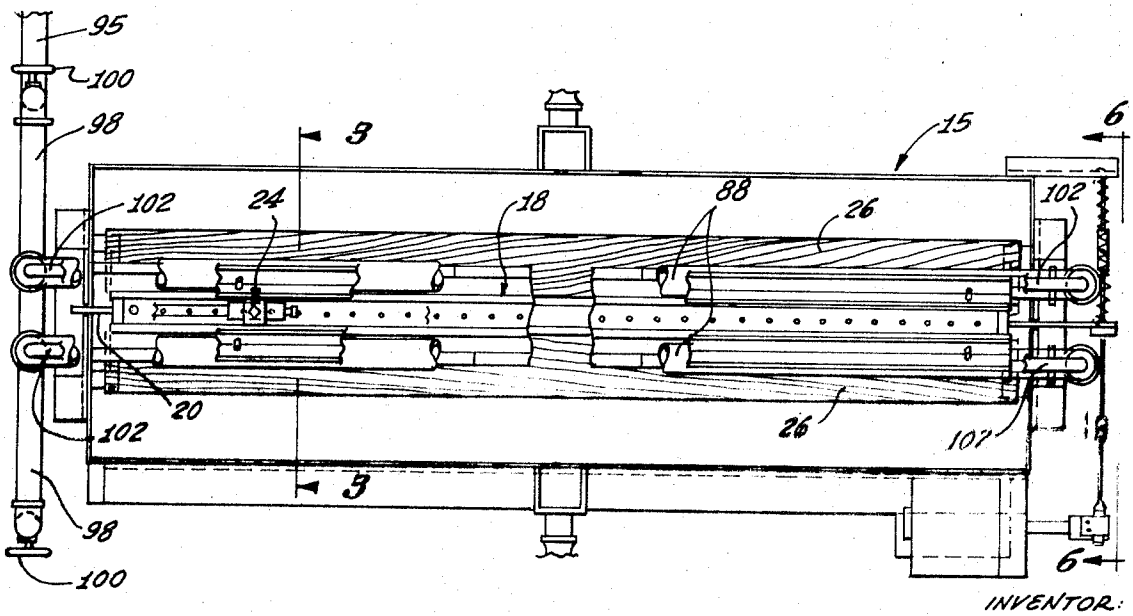


Fig. 2



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Fig. 3

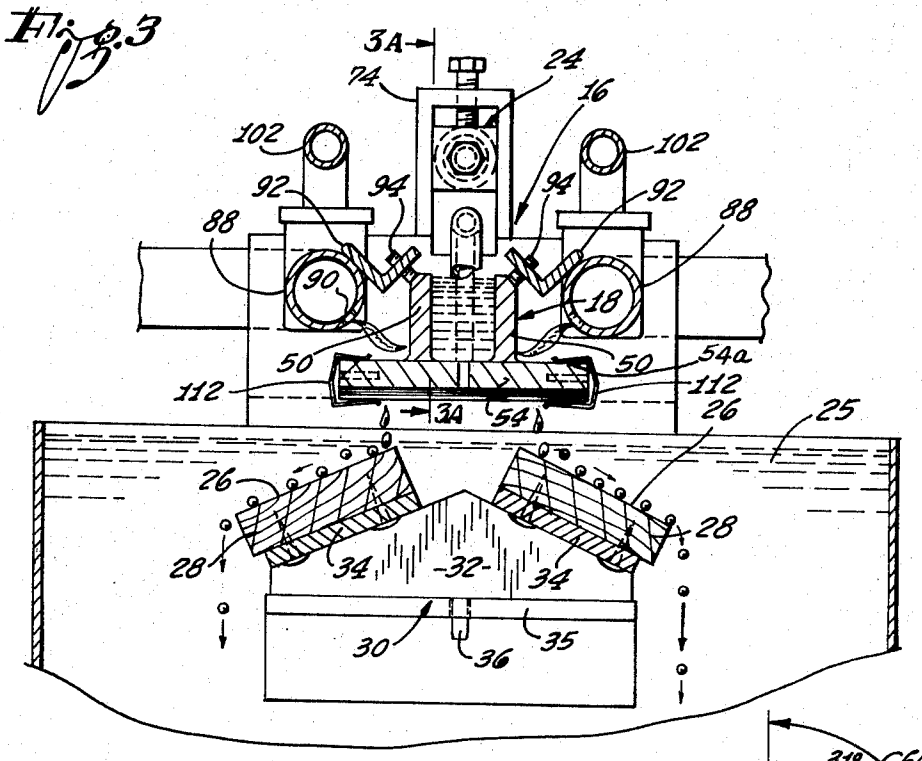


Fig. 4

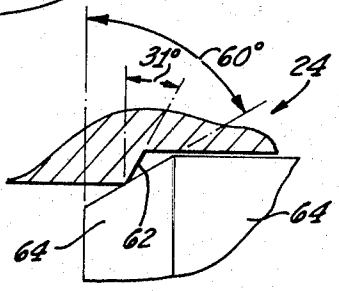


Fig. 3A

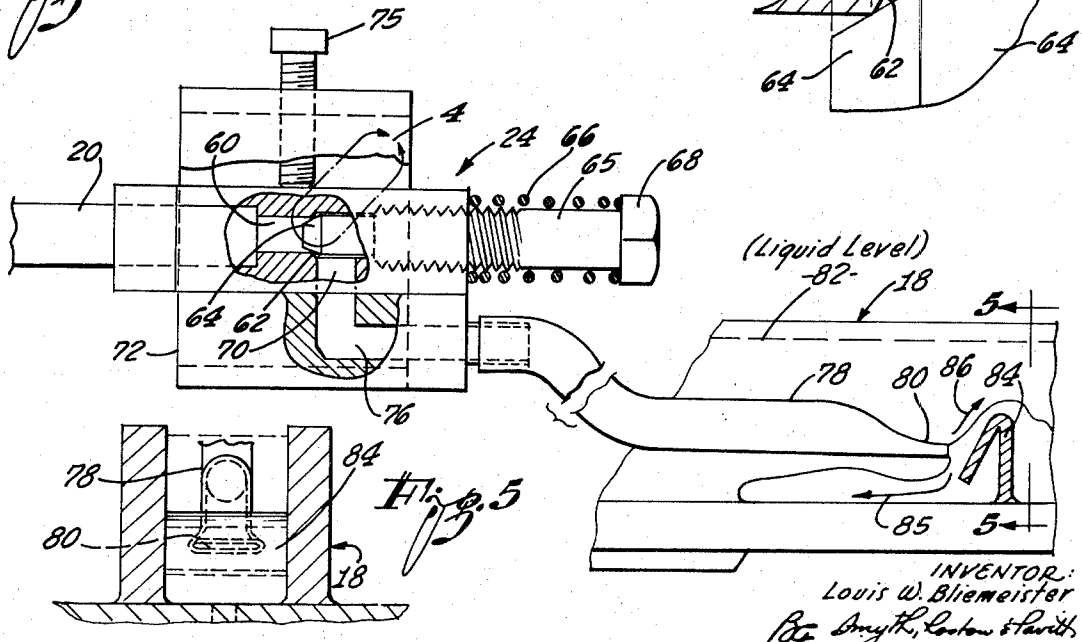


Fig. 5

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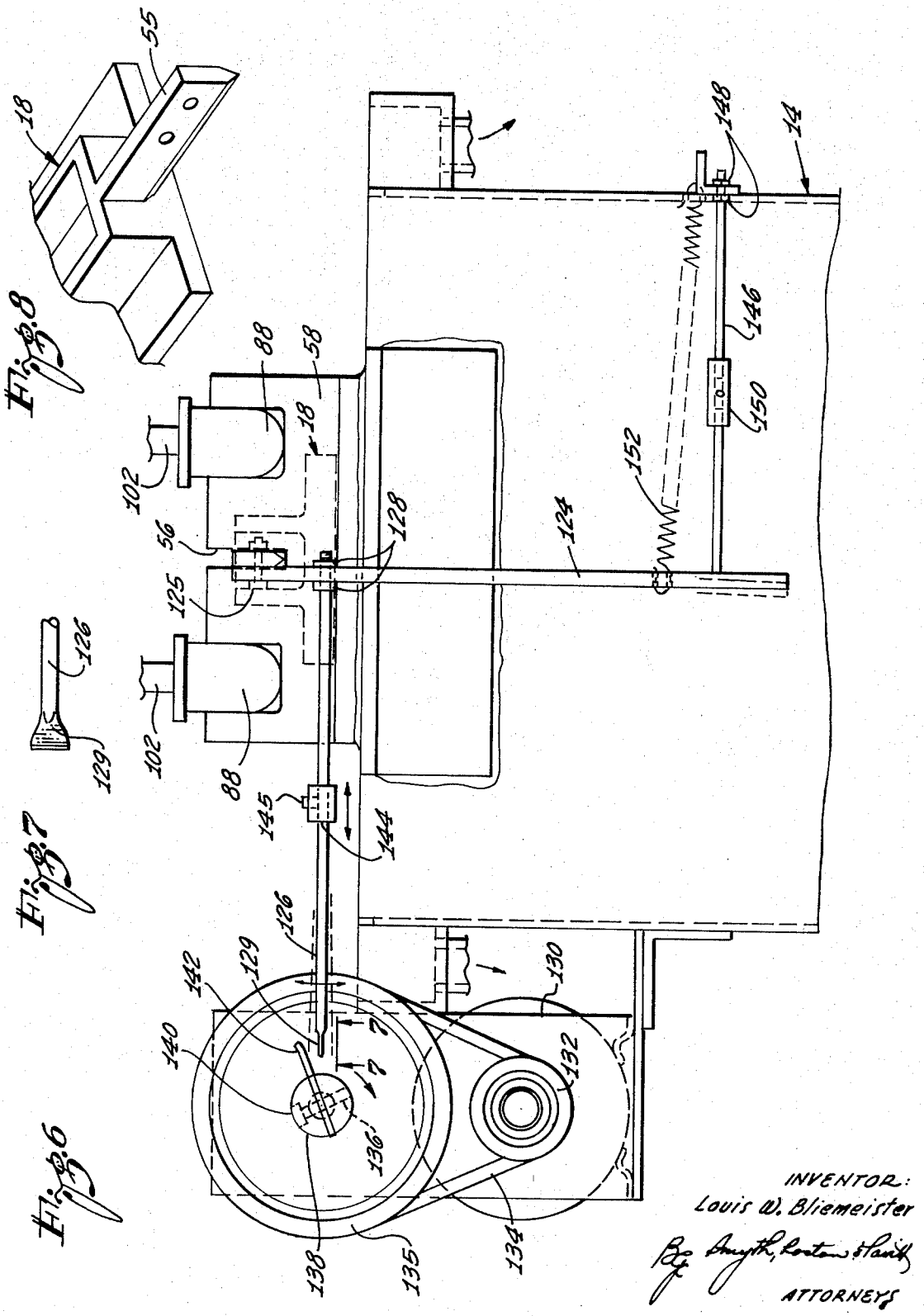


Fig. 9

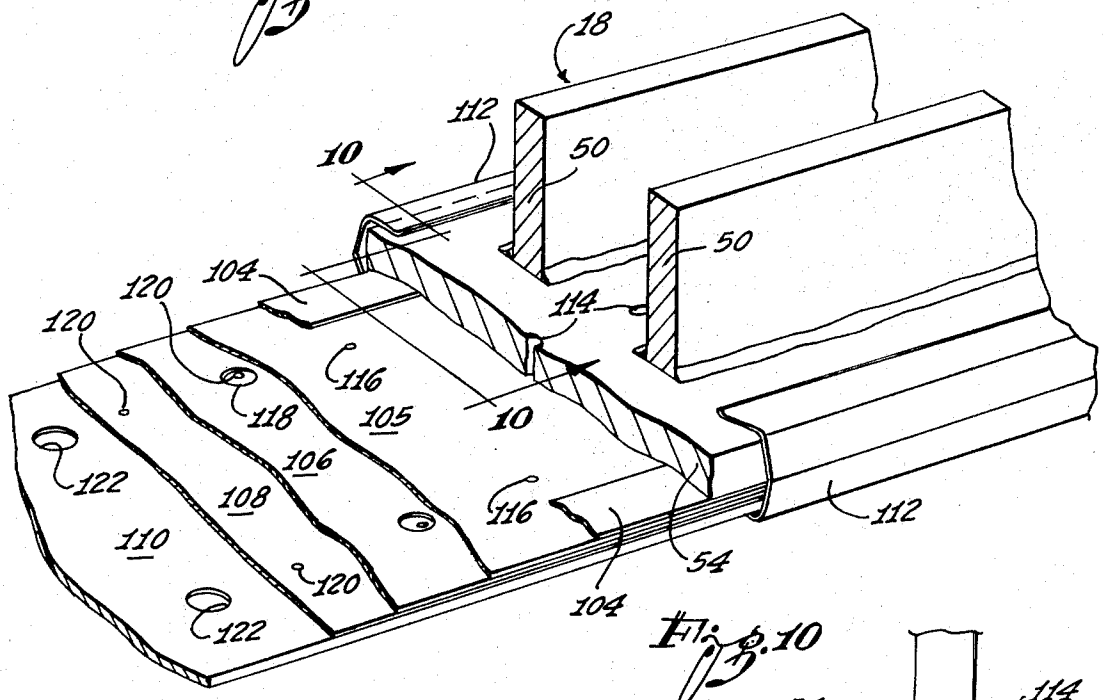


Fig. 10

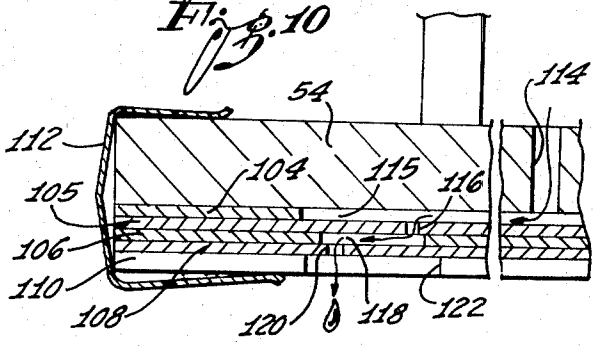


Fig. 11

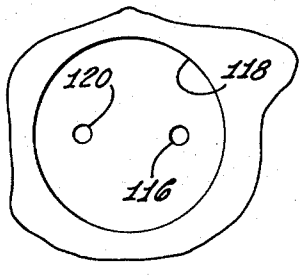
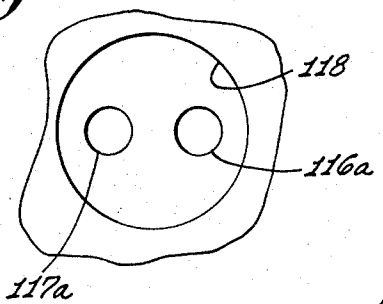


Fig. 12



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APPARATUS FOR PRODUCING METAL SHOT

CROSS-REFERENCES TO RELATED APPLICATION

This application is a Continuation-in-part of my copending application, Ser. No. 773,230 filed Nov. 4, 1968 entitled APPARATUS FOR PRODUCING METAL SHOT, now abandoned.

BACKGROUND OF THE INVENTION

The invention is directed to various needs for improvement on the apparatus disclosed in my U.S. Pat. No. 2,978,742 which disclosure is hereby incorporated into the present disclosure by reference.

One need is to increase the hourly production of such an apparatus without increasing the size of the apparatus.

Another need is to avoid the various consequences of lateral warpage of a stack of thin perforated plates that form the drop-releasing orifices of the feeder head.

Still another need relates to the means for maintaining a constant depth of molten metal in the trough. Heretofore the constant liquid level has been maintained by feeding an excess of molten metal to the trough and disposing of the excess metal by means of an overflow spigot. One disadvantage of such an arrangement is the waste of fuel involved in heating the excess metal that overflows. Another disadvantage is that when the apparatus is shut down, the overflow spigot may be clogged with solidified metal.

A further need for improvement is to reduce the exposure of the molten metal to the atmosphere prior to the release of the molten metal droplets thereby to prevent oxidation of the metal before the metal is formed into droplets. Such oxidation results in defective shot and cause clogging of the drop-releasing orifices.

A still further need for improvement is in the manner in which the orifice plate assembly is vibrated to facilitate the release of the droplets of molten metal. In the patent disclosure vibration is provided by rotating an eccentric mass that is journalled on the frame of the apparatus.

The object of the present invention is to meet these various needs of improvement over the patent disclosure.

SUMMARY OF THE INVENTION

With reference to warpage of the feeder unit that includes the trough and the assembly of orifice plates, a feature of the invention is the concept of substantially eliminating lateral warpage in the planes of the plates by heating the trough uniformly along the two opposite longitudinal side walls of the trough. The problem relating to warpage of the feeder unit is further solved by employing relatively thin orifice plates in combination with the bottom wall of the trough and by clamping together the plates of the orifice assembly by a plurality of spring clamps instead of bolting the plates together. With the feeder assembly heated uniformly along both of its longitudinal sides to substantially eliminate lateral warpage, the only appreciable warpage is in a vertical plane perpendicular to the plane of the assembly and this warpage is minimized because the orifice plates of the stack are free to slide longitudinally relative to each other to compensate for any differences in the rates of thermal expansion. It has been found that employing relatively thin orifice plates in the stack makes it possible for the clamping pressure to prevent leakage of the molten metal notwithstanding the fact that the thin plates slip relative to each other.

One problem is to provide spring clamps that are readily adjustable relative to the clamping pressure and a second problem is to provide spring clamps that will not be annealed and rendered useless by heat from the feeder unit. These two problems are solved by employing U-shaped spring clamps made of one-quarter hard stainless steel.

An important feature of the invention is the discovery that if the feeder unit is vibrated at a much higher frequency than is possible by rotating an eccentric mass, individual valves for the orifices may be omitted. The molten metal is released from the trough through a longitudinal row of bores in the bottom wall of the trough, the released metal entering a thin horizontal distribution space which permits the metal to be distributed to the apertures of a primary orifice plate. The molten metal flows through the orifices of the primary plate into relatively large orifices in a thin spacer plate and from the large orifices in the spacer plate the metal flows into orifices of a secondary orifice plate where the molten droplets are released to fall into the quenching liquid.

The means for vibrating the feeder assembly at a high rate of vibration consists essentially of a resilient metal bar that is rigidly anchored by one end of the feeder unit. Suitable means, preferably in the form of a leather strap on a rotating holder, periodically strikes the resilient bar to cause the bar to vibrate in the manner of a tuning fork. Suitable means is provided to modify and dampen the vibration of the resilient bar in an adjustable manner for improved functioning of the apparatus.

The invention further teaches that the rate of flow of molten metal into the trough may be regulated to precisely the rate at which the droplets of molten metal are formed. Thus the invention eliminates the necessity for the constant overflow of molten metal. For this purpose the invention provides a special manually controllable feed valve for the molten metal.

The elimination of preoxidation of the metal that goes into the molten metal droplets is achieved by supplying the molten metal at a submerged point in the trough. For this purpose a manually adjustable feed valve releases the newly fed molten metal into a discharge nozzle that is submerged in the trough. The discharge from the nozzle is against a submerged baffle which causes the metal to be distributed along the trough in opposite longitudinal directions. The feed valve may be easily and quickly dismantled for ready access to all of its interior surfaces.

A number of features of the invention work together to make possible greatly increased production without corresponding increase in the size of the apparatus. One of these features is the concept of using a laminated orifice assembly under high frequency vibration. This feature makes it possible to space the orifices closer together in a row of orifices to increase the number of molten metal droplets released by the row.

Another feature is the concept of heating the trough of molten metal uniformly along both longitudinal sides of the trough instead of along only one side of the trough. This feature not only eliminates lateral warpage of the laminated orifice assembly but also increases the rate of application of heat to permit the use of two longitudinal rows of orifices instead of a single row of orifices. Thus the use of the new laminated orifice assembly under high frequency vibration together with the addition of a second longitudinal side burner more than doubles the rate at which the molten metal droplets are produced.

The capability of the feeder unit to double the previous production is further explained by an arrangement for vibrating both of the two longitudinal rows of feed apertures in identical manner along arcuate paths of vibration. For this purpose, the feeder unit is mounted for freedom to rotate about a longitudinal axis that is equi-distant from the two rows and the high frequency vibration of the feeder unit is about this longitudinal axis.

The features and advantages of the invention may be understood from the detailed description together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a perspective view of the presently preferred embodiment of the apparatus;

FIG. 2 is a plan view of the feeder unit of the apparatus;

FIG. 3 is a transverse sectional view of the feeder unit as seen along the line 3—3 of FIG. 2;

FIG. 3A is a fragmentary longitudinal section along the line 3A—3A of FIG. 3 showing the manually adjustable feeder valve and the discharge nozzle that is associated therewith;

FIG. 4 is a greatly enlarged fragment of FIG. 3A showing how the valve member of the feeder valve cooperates with a valve seat;

FIG. 5 is a fragmentary transverse section along the line 5—5 of FIG. 3A;

FIG. 6 is a fragmentary end elevational view of the apparatus as seen along the line 6—6 of FIG. 2;

FIG. 7 is a fragmentary bottom plan view of the free end of the resilient vibration rod;

FIG. 8 is a fragmentary perspective view showing how each end of the trough is provided with a longitudinal blade-like extension to support the trough for vibration about a longitudinal axis;

FIG. 9 is a fragmentary perspective view of the laminated orifice assembly;

FIG. 10 is an enlarged fragmentary section of the laminated orifice assembly as seen along the line 10—10 of FIG. 9;

FIG. 11 is a diagrammatic plan view showing how a pair of relatively small primary and secondary orifices are positioned relative to a large orifice of an intervening spacer plate; and

FIG. 12 is a similar view showing how a pair of larger primary and secondary orifices are positioned relative to the large orifice of the spacer plate.

DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

GENERAL ARRANGEMENT

As shown in FIG. 1, the presently preferred embodiment of the invention includes a frame 10 that supports an elevated crucible or pot 12 to serve as a source for molten metal and the apparatus further includes an adjacent frame 14 that supports a quenching tank 15 and a feeder unit, generally designated 16, that is mounted across the open top of the quenching tank. Molten metal supplied by the crucible pot 12 is fed to a trough 18 (FIG. 2) of the feeder unit 16 by means of a supply pipe 20 (FIGS. 1 and 2) that is provided with a cut off valve 22 and which terminates in a manual regulating valve, generally designated 24.

As indicated in FIG. 3, the feeder unit 16 releases two longitudinal rows of droplets of molten metal which fall into a body of quenching liquid 25 in the quenching tank 10 where the two rows of droplets are interrupted by two corresponding oppositely inclined interrupters 26. Each interrupter comprises a plate 28 of suitable wood mounted on a frame, generally designated 30, that includes two vertical end plates 32, the end plates being interconnected by longitudinal support plates 34 on which the wood plates are mounted. In the construction shown, the frame 30 is readily detached from the quenching tank and for this purpose the two ends of the frame 30 rest on two corresponding shelves 35 on the opposite end walls of the tank. Preferably each end of the frame 30 is provided with a downwardly extending pin 36 which removably extends through a corresponding bore in the corresponding shelf 35.

Water is continuously supplied to the quenching tank 15 and continuously overflows into two opposite overflow receptacles 38 which communicate with corresponding drain pipes 40. The quenching tank is provided with suitable means (not shown) to regulate the temperature of the quenching liquid in the manner disclosed in my above mentioned prior patent. The solidified shot drop onto a bottom wall 42 of the quenching tank which is inclined to cause the shot to move gravitationally to the lower end of an upwardly extending conveyor that is generally designated by numeral 44. The conveyor includes a bottom pulley 45 and an endless conveyor belt 46 that is equipped with suitable conveyor cups 48.

FEEDER UNIT

As indicated in FIG. 3, the trough 18 of the feeder unit has two longitudinal side walls 50, two opposite end walls and a bottom wall 54 that extends laterally outward from both of the side walls to provide the trough with upwardly facing shoulders 54a. It is contemplated that the trough 18 will be removably mounted on the quenching tank 15 in a manner that permits freedom for the trough to vibrate about a longitudinal axis. For this purpose, as best shown in FIG. 8, each end of the trough is provided with a rigid blade extension 55 and as shown in FIG. 6, each of the blade extensions 55 rests in a corresponding vertical slot 56 in rigid upright plate 58 of the corresponding end of the quenching tank. As shown in FIGS. 6 and 8, the lower edge of each of the blade extensions 55 is bevelled and each of the blade extensions is slightly less in width than the width of the corresponding vertical slot 56 to permit the trough to vibrate about a longitudinal axis that is defined by the lower edges of the two blade extensions.

As shown in FIG. 3A, the regulating valve 24 in the form of an elongated metal block is mounted on the end of the pipe 20 for support thereby. The regulating valve has a longitudinal flow passage 60 which forms an annular valve seat 62 for cooperation with the tapered nose 64 of a screw threaded valve member 65. A suitable coil spring 66 acts in compression between the body of the regulating valve and an external head 68 of the valve member 65 to prevent unwanted rotation of the valve member.

The regulating valve 24 has an outlet port 70 that communicates with an out flow passage means in the form of a metal block 72. The contiguous metal block 72 has an integral yoke 74 which straddles the regulating valve 24 and which is provided with an overhead cap screw 75 that is normally tightened against the upper side of the regulating valve to hold the contiguous block in place. The contiguous block 72 has an outlet passage 76 which communicates with an offset pliable copper tube 78 that is flattened at its outer end to form a discharge nozzle 80. As indicated in FIG. 3A, the discharge nozzle 80 is below the liquid level 82 of the molten metal so that the molten metal is fed to the trough 18 without exposure to the atmosphere.

As shown in FIG. 3A, an angular transverse baffle 84 may extend upward from the bottom wall of the trough in the path of discharge from the nozzle 80. The baffle 84 diverts a portion of the stream of molten metal rearwardly of the nozzle 80 towards one end of the trough as indicated by the arrow 85 while the remaining portion of the supply stream passes over the baffle as indicated by the arrow 86 to flow towards the opposite end of the trough. Thus the angular baffle 84 is conducive to equalized distribution of the molten metal along the length of the trough, it being a simple matter to bend the pliable copper tube upwardly or downwardly as required to balance the two opposite streams of molten metal.

As indicated in FIG. 4, the valve seat 62 is bevelled at an angle of 31° relative to a transverse plane that is perpendicular to the axis of the valve seat. FIG. 4 also indicates that the tapered nose 64 of the valve member 65 is tapered at an angle of 60° relative to the same perpendicular transverse plane. It has been found that the substantially line contact between the tapered nose and the valve seat that is provided by these angular relationships makes it possible to adjust the valve member 68 for close control of the rate in which the molten metal is fed to the trough 18. In practice the operator merely glances at the liquid level 82 three or 4 times a day to ascertain whether or not it is necessary to change the adjustment of the regulating valve. This close control of the rate of feed of the molten metal makes it unnecessary to regulate the liquid level by overflow.

A special advantage of the regulating valve 24 is the manner in which it may be quickly and easily dismantled for ready access to all of its interior surfaces whenever it is desirable to clean out the valve for example, in preparation for starting a new run. Loosening the screw 75 permits the contiguous block

72 together with the copper nozzle **78** to be withdrawn for access to the outlet port **70** of the valve and access to the outlet passage **76**. The valve member **65** may then be unscrewed for cleaning and for access to the flow passage **60** and the valve seat **62** therein.

Feeder unit **16** includes two longitudinal gas burners **88** positioned along the two side walls **50** of the trough **18**, each burner being of a commercially available type having a longitudinal slot **90** which is divided by an undulating metal strip into a longitudinal series of burner apertures. As indicated in FIG. **3**, the two burners direct flames against the two side walls of the trough. Also as indicated in FIG. **3**, a pair of baffles in the form of longitudinal angle irons **92** rest on the two burners **88** and the corresponding two side walls **50** of the trough, each angle iron being provided with set screws **94** at their opposite ends which rest on the trough and adjustably space the angle irons from the trough. Thus the set screws **94** space the angle irons from the upper edges of the trough to form flues that serve the function of causing the gas flames and the upwardly flowing heated air to hug the sides of the trough.

Fuel is fed to the two opposite ends of each of the two burners **88** for uniform distribution of the gaseous fuel along the length of the burner. In the construction shown in FIGS. **1, 2** and **3**, the gaseous fuel is delivered by a supply pipe **95** that is provided with a cut off valve **96**. The supply pipe **95** has two upwardly extending angular branches **98** that are provided with manual regulating valves **100** and which are connected respectively to the left ends of the two burners **88** as the burners are viewed in FIGS. **1** and **2**. The two branch pipes **98** are also connected respectively to two corresponding upper feed pipes **102** that lie above the burners and extend longitudinally of the burners to feed the right ends of the two burners **88** as may be seen in FIGS. **1** and **2**.

The relatively thick bottom wall **54** of the trough **18** constitutes the uppermost lamination of a laminated orifice assembly in the form of a stack of orifice sheets or plates. As indicated in FIGS. **9** and **10**, the laminated assembly may comprise the following: a rectangular gasket sheet or plate **104** contiguous to the underside of the bottom wall **54** of the trough; a primary orifice sheet or plate **105** contiguous to the underside of the gasket plate; what may be termed a spacer sheet or plate **106** contiguous to the under surface of the primary orifice plate; a secondary orifice sheet or plate **108** contiguous to the under surface of the spacer plate and finally what may be termed a shield sheet or plate **110** that is contiguous to the under surface of the second orifice plate.

The various plates of the laminated orifice assembly are releasably held together by a plurality of U-shaped spring clamps **112** of suitably resilient metal that engage the external shoulders **54***a* of the trough **18**, there being a row of such clamps positioned end to end on each side of the laminated orifice assembly and two additional clamps across the opposite ends, respectively. It is to be noted that the various laminations below the bottom wall **54** of the trough are relatively thin plates that respond readily to the pressure of the spring clamps **112**, to keep the laminated orifice assembly tight against lateral leakage from the assembly along the interfaces of the laminations.

One problem solved by the invention is to provide such U-shaped clamps that will be immune to the high temperature of the feeder unit and that also may be readily adjusted to the desired magnitude of clamping pressure. The usual temperature of the feeder unit is in the range of 600°–700° F. and if the U-shaped clamps are made of ordinary spring steel they will be annealed by such a high temperature and thus rendered inoperative. It is difficult, moreover, to adjust the gripping pressure of spring steel clamps because of their high elastic limits.

This problem is solved by making the U-shaped clamp **112** of a suitable work-hardened stainless steel. In the preferred practice of the invention quarter hard type **301** stainless steel of a thickness of 0.025 of an inch is employed because it is immune to annealing and because, on the one hand, it is sufficiently resilient to provide the desired clamping action but, on the other hand, has a low enough elastic limit to be readily formed to the U-shaped configuration and to be readily adjusted for the desired clamping pressure.

The operator of the apparatus may adjust the clamping pressure of a U-shaped clamp by simply removing the clamp from the feeder unit and then manipulating the two arms of the clamp. Thus to increase the clamping pressure of a clamp, the two arms of the clamp are manually flexed towards each other slightly beyond their elastic limits and to decrease the clamping pressure the two arms are flexed away from each other slightly beyond their elastic limits. If half hard stainless steel were used, the clamps would have to be bent to relatively large radii of curvature and once formed the clamps would not be so easily adjusted.

As indicated in FIG. **9**, the bottom wall **54** of the trough has a central longitudinal row of bores or apertures **114** which communicate with a thin horizontal space **115** that is defined by the gasket plate **104**. This space **115** may be termed a distribution space because it causes metal that is released through the bores **114** to be distributed over the upper surface of the primary orifice plate. Since the dimension of the distribution space is relevant to the resistance of supply to the orifice plates it should be readily understood how gaskets of different thicknesses may be employed advantageously and in some cases actually eliminate the necessity of the primary orifice plate and spacer plate.

As indicated in FIGS. **9** and **10**, the primary orifice plate **105** has two rows of primary orifices **116** which communicate with two corresponding rows of large openings **118** in the spacer plate **106** and the two rows of large openings **118**, in turn, communicate with two rows of secondary orifices **120** in the secondary orifice plate **108**. The shield plate **110** has no function other than to protect the underside of the secondary orifice plate **108** from splashing quenching liquid, the shield plate having two rows of large openings **122** to avoid interference with droplets of molten metal that form at the secondary orifices **120**.

The primary orifices **116** and the secondary orifices **120** are of different diameters for different sizes of shot but in each instance each pair of primary and secondary orifices **116** and **120** lies within the area of the corresponding openings **118** of the intervening spacer plate **106**. The openings **118** in the spacer plate **106** are relatively large and the corresponding primary and secondary orifices are so positioned relative thereto that each pair of primary and secondary orifices remains within the area of the corresponding opening **118** regardless of the extent to which the plates of the laminated orifice assembly expand and contract in response to changing temperature. Thus FIG. **11** shows how a pair of relatively small primary and secondary orifices **116** and **120** are spaced inwardly from the perimeter of the corresponding opening **118** in the spacer plate **106** and FIG. **12** shows how a pair of larger primary and secondary orifices **116***a* and **117***a* for producing larger shot are spaced from the perimeter of the corresponding spacer plate opening **118**.

In the presently preferred practice of the invention the various plates of the laminated orifice assembly below the bottom wall **54** of the trough are made of stainless steel. The gasket plate **104** is 0.030 inch thick; the primary and secondary orifice plates **105** and **108** are 0.035 inch thick and the thickness of the spacer plate **106** may be 0.005 – 0.035 inch. For No. 9 shot the diameters of the primary and secondary orifices **116** and **120** may be 0.040 inch and 0.018 inch respectively; for No. 8 shot, both the primary and secondary orifice diameters may be 0.021 inch; for No. 7 ½ shot the primary and secondary orifice diameters may be 0.021 inch and 0.0225 inch respectively; for No. 7 shot the diameters of the primary and secondary orifices may be 0.021 inch and 0.025 inch respectively; for No. 6 shot the diameters may be 0.021 inch and 0.032 inch respectively; for No. 5 shot the diameters may be 0.025 inch and 0.040 inch respectively; and for No. 4 shot the diameters of the primary and secondary orifices may be 0.025 inch and 0.052 inch respectively. It is apparent that to change

over from one size shot to another it is merely necessary to substitute one set of primary and secondary orifice plates for another in the laminated orifice assembly and that such substitution may be made quickly and conveniently since the laminated orifice assembly is releasably held together by the U-shaped spring clamp **112**.

As heretofore stated, it is contemplated that different pairs of wooden interrupter plates **26** will be used interchangeably for different size shot. For No. 9 shot the slope of the two wooden interrupter plates **26** may be 21° relative to horizontal; for No. 8, 7 ½ and 7 shot the slope may be 18°; for No. 6 shot the slope may be 15° and for No. 4 shot the slope may be 11°.

It has been found that best results are obtained if the static head of molten metal in the trough **118** is slightly reduced for larger sizes. Thus a static head of five-eighth inch may be used for shot sizes **9** to **8** with the static head decreased to one-half inch for the larger No. 6 and No. 4 shot.

MEANS TO VIBRATE THE FEEDER UNIT

With reference to the means for vibrating the feeder unit, the basic concept is to attach to the feeder unit a resilient means that is free to vibrate at its natural frequency and to strike the resilient means sufficiently often to continually vibrate the feeder unit. This concept may be carried out in various ways in various practices of the invention.

As best shown in FIG. **6**, in the present embodiment of the invention, a dependent metal bar **124** is rigidly connected at its upper end to one of the blade extensions **55** of the trough by suitable fastening means **125**. The required resilient vibratory means is in the form of a slender rod **126** which may be made of steel and which is suitably rigidly attached to the bar **124** to extend laterally therefrom. In the construction shown, one end of the resilient rod **126** extends through a bore in the bar **124** and is anchored thereto by a pair of nuts **128**. Preferably the end portion **129** of the rod **126** is flattened as indicated in FIGS. **6** and **7**.

Any suitable means may be provided to strike the outer end of the rod **126** periodically. In the construction shown, a motor **130** carries a drive pulley **132** which is connected by a belt **134** with a larger pulley **135** on a countershaft **136**. The countershaft carries a metal body **138** that is split longitudinally into two halves, the two halves being interconnected by a diametrical screw **140**. The two halves of the metal body releasably grip a leather strap **142** which extends radially from the metal body to slap against the flattened end portion **129** of the rod **126**. The counter shaft **136** that carries the leather strap **142** may, for example, rotate at approximately 570 rpm.

The present embodiment of the invention is further characterized by means to modify the vibration of the resilient rod **126**. For this purpose, a weight **144** in the form of a collar is adjustable along the length of the rod **125** and may be releasably fixed at any position of adjustment by a set screw **145**. The addition of the weight **144** changes the frequency at which the rod vibrates and it is a simple matter to adjust the weight lengthwise of the rod for optimum effect in jarring molten metal droplets free from the feeder unit.

A provision for modifying the vibration imparted to the feed unit by the rod **126** comprises an adjustable stop in the form of a rod **146** that is rigidly anchored to the frame **14** by a pair of nuts **148**. The rod **146** is adjustable in length and for this purpose is made in two pieces which are screw threaded at their confronting ends and which are adjustably interconnected by a sleeve **150** having internal left hand and right hand screw threads. The free end of the stop rod **146** confronts the dependent bar **124** in the manner shown in FIG. **6** so that the dependent bar is free to flex in one direction from a central position but is blocked from flexure in the other direction by the confronting end of the stop rod. In the construction shown, a suitable coil spring **152** acting in tension between the rod **124** and the frame **14** biases the bar **124** towards the stop rod **146** and has a damping effect. In the absence of the stop bar **146**, the vibration of the dependent bar **124** by the resilient rod **126** would be sinusoidal but the stop bar cuts off a portion of the vibration and the repeated impact of the bar **124** against the stop rod **146** has a desirable jarring effect that is conducive to the release of the molten metal droplets from the feed unit.

In the disclosure of the above mentioned Bliemeister patent, the orifices through which the molten metal travels from the trough **18** through the laminated assembly are all in coaxial alignment. As heretofore stated, the flow of metal through each set of coaxial apertures is controlled by a corresponding valve member that extends downward through the mass of molten metal in the trough.

In contrast, the present invention teaches that such valve members may be omitted if the orifices of each of the sets of orifices are out of axial alignment, at least one of each set being staggered with respect to the other apertures of the set so that the downwardly gravitating molten metal is retarded by impingement on at least one transverse surface. Thus in FIG. **10**, the metal gravitating downward from the interior of the trough through a bore **114** in the bottom wall **54** of the trough impinges upon a blank portion of the primary orifice plate **105** and then spreads in all directions through the horizontal space **115** for distribution to the various primary orifices **116**. Again the molten metal gravitating downward through a primary orifice **116** encounters a blank portion of the secondary aperture plate **108** and flows horizontally to reach the corresponding aperture **120** in the secondary plate. This labyrinth flow pattern makes it unnecessary to employ a valve member to retard the gravitational flow and, in fact, the flow of the molten metal would be too sluggish in the absence of the vibration that shakes away successive drops of molten metal at each of the secondary apertures **120**.

In practice, an important feature of the invention is the rapidity and convenience with which a change-over may be made from a production run of shot of one size to a production run of shot of a different size and/or different alloy. With the fuel valve **96** turned off and with the molten metal valve **22** closed, the usual procedure is, first, to lift off the loose angle iron baffles **92** and then to swing the two burners **88** upright out of the way. The screw-threaded connections of the burners with the corresponding regulator valves **100** serve as swivel joints to permit the upward swinging movement of the two burners. The coil spring **152** that acts on the downwardly extending bar **124** of the feeder unit is then unhooked to permit the feeder unit to be lifted bodily from the support frame **14**.

The molten metal in the trough **18** of the feeder unit may then be emptied into the crucible pot **12**, and if desirable, the regulator valve **24** may be dismantled for cleaning in the manner heretofore described. The various U-shaped clamps **112** may then be removed to permit changing the orifice assembly, i.e., changing the sheet in the stack of perforated sheets of the feeder unit.

My description in specific detail of the presently preferred embodiment of the invention will suggest various changes, substitutions and other departures from my disclosure.

I claim:

1. In an apparatus of the character described for producing shot by discharging droplets of melted metal into a quenching bath, the combination of:

a receptacle containing a body of the melted metal and being apertured for gravitational flow of the melted metal therefrom;

a stack of sheets of metal in close face-to-face relationship cooperative with the receptacle to receive the molten metal therefrom and to form therewith a feeder assembly,

said plurality of sheets being perforated to provide a plurality of discharge orifices to release droplets of the melted metal for gravitation to the quenching bath; and

clamping means straddling the stack of sheets together with a portion of the receptacle, said clamping means clamping the sheets to the receptacle and clamping the sheets together under sufficient pressure to prevent lateral

leakage of the melted metal from the stack at the interfaces of the sheets with freedom for slippage of the sheets relative to each other and relative to the receptacle in response to thermal expansion and contraction of the sheets to prevent thermal warpage of the stack.

2. A combination as set forth in claim 1 in which said receptacle is provided with upwardly facing external shoulders and said clamping means clamps the stack of sheets to the shoulders.

3. A combination as set forth in claim 1 in which said clamping means is made of metal that is work hardened to be immune to annealing by heat transferred thereto from the receptacle and from the melted metal.

4. A combination as set forth in claim 1 in which said clamping means is resilient U-shaped means for exerting clamping pressure but has a sufficiently low elastic limit to permit adjustment of the clamping pressure by manually flexing the clamping means slightly beyond its elastic limit.

5. A combination as set forth in claim 1 in which said clamping means is made of work hardened stainless steel.

6. A combination as set forth in claim 5 in which said stainless steel is approximately quarter hard.

7. A combination as set forth in claim 6 in which the clamping means is made of type 301 stainless steel.

8. A combination as set forth in claim 1 in which said plurality of discharge orifices are arranged in two substantially parallel rows longitudinally of the receptacle.

9. A combination as set forth in claim 8 which includes a set of a larger number of perforated sheets than the number of sheets in the stack to be used interchangeably for assembling different combinations of stacked plates to produce shot of different sizes.

10. A combination as set forth in claim 9 which includes interrupter means submerged in the quenching bath to intercept the droplets from the two rows of orifices respectively and to cause the droplets to develop spin before falling further through the quenching liquid, said interrupter means being removable;

and which includes a plurality of the interrupter means each to be used interchangeably for producing shot of different sizes.

11. A combination as set forth in claim 8 in which the bottom wall of the receptacle is apertured for gravitational flow of the melted metal therethrough;

and in which the stack of sheets defines a horizontal space below said bottom wall for lateral paths of flow of the melted metal for distribution of the melted metal to said two rows of orifices.

12. A combination as set forth in claim 8 which includes means to heat the receptacle substantially equally along its opposite sides to prevent lateral thermal distortion of the feeder assembly.

13. A combination as set forth in claim 12 in which the heating means comprises two separate heating means at the two longitudinal sides respectively of the receptacle.

14. In an apparatus of the character described for producing shot by discharging droplets of melted metal into a quenching bath, the combination of:

a receptacle containing a body of the melted metal and being apertured for gravitational flow of the melted metal therefrom;

a stack of sheets of metal in close face-to-face relationship cooperative with the receptacle to receive the molten metal therefrom and to form therewith a feeder assembly,

said plurality of sheets being perforated to provide a plurality of discharge orifices to release droplets of the melted metal for gravitation to the quenching bath,

said discharge orifices being arranged in two substantially parallel rows longitudinally of the receptacle;

two heat generating means along the opposite longitudinal sides respectively of the receptacle to heat the opposite sides substantially equally to prevent lateral thermal distortion of the feeder assembly;

said feeder assembly being mounted to oscillate about the central longitudinal axis,

a bar rigidly connected to the feed unit;

elongated resiliently flexible means mounted on the bar and extending laterally therefrom; and

means to strike said flexible means periodically to cause the flexible means to vibrate and thus cause the feeder assembly to vibrate.

15. A combination as set forth in claim 14 which includes stop means adjacent one side of the bar and spring means biasing the bar against the stop means to modify the vibration of the resiliently flexible means.

16. A combination as set forth in claim 1 which includes means to supply the receptacle continuously with melted metal,

said supply means being manually adjustable to balance the inflow into the receptacle with the outflow through the stack of sheets to maintain a substantially constant depth of melted metal in the receptacle.

17. A combination as set forth in claim 16,

in which said adjustable supply means includes a valve body and a valve member, said valve body having a first passage therethrough formed with a valve seat having an inner circumferential edge, said valve body further having a second passage in communication with the first passage downstream from the valve seat,

said valve member being in the form of a screw positioned coaxially of the first passage in screw-threaded engagement therewith,

the inner end of said screw being tapered to cooperate with said inner circumferential edge of the valve seat for controlling the rate of flow to the second passage,

said valve further including spring means acting between the valve body and the screw to urge the screw in one axial direction to maintain the screw in whatever rotary position it may be adjusted.

18. A combination as set forth in claim 17 which includes passage means adjoining the valve body to deliver flow from said second passage to the receptacle,

the valve body and the passage means being releasably interconnected for separation to permit access to the interiors of the valve body and the passage means.

19. A combination as set forth in claim 18 which includes screw means to releasably clamp the valve body against the passage means.

20. A combination as set forth in claim 18 in which the valve body is bodily removable from the passage means.

21. A combination as set forth in claim 16 in which said supply means includes a nozzle to discharge the melted metal into the receptacle, said nozzle being submerged in the melted metal in the receptacle to minimize oxidation of the melted metal.

22. A combination as set forth in claim 21 which includes baffle means in the receptacle confronting the end of the nozzle to divert a portion of the inflowing stream of melted metal rearwardly of the nozzle towards one end of the receptacle, the baffle being positioned and dimensioned to permit the remaining portion of the stream of melted metal to pass beyond the baffle towards the opposite end of the receptacle.

23. A combination as set forth in claim 22 in which said nozzle is adjustable in elevation relative to the baffle to vary the proportions of the stream of melted metal that flow towards the two opposite ends of the receptacle.

24. A combination as set forth in claim 23 in which the nozzle is made of relatively soft metal for pliability to permit the elevation of the nozzle to be adjusted by flexure of the nozzle.

25. In an apparatus of the character described for producing shot by discharging droplets of melted metal into a quenching bath, the combination of:

a receptacle containing a body of the melted metal and being apertured for gravitational flow of the melted metal therefrom;

a stack of sheets of metal in close face-to-face relationship cooperative with the receptacle to receive the molten metal therefrom and to form therewith a feeder assembly,
said plurality of sheets being perforated to provide a plurality of discharge orifices to release droplets of the melted metal for gravitation to the quenching bath; and
clamping means to clamp the sheets together under sufficient pressure to prevent lateral leakage of the melted metal from the stack at the interfaces of the sheets with freedom for slippage of the sheets in response to thermal expansion and contraction of the sheets,
said stack including;
a first sheet with primary orifices therein;
a second lower sheet with secondary orifices therein offset horizontally relative to said primary orifices, and
an intervening spacer sheet with orifices therein,
the orifices of the spacer sheet being substantially larger than the primary and secondary orifices to provide communication between the primary and secondary orifices throughout the range of relative slippage of the three sheets.

26. In an apparatus of the character described for producing shot by discharging droplets of melted metal into a quenching bath, the combination of:
a receptacle containing a body of the melted metal and being apertured for gravitational flow of the melted metal therefrom;
a stack of sheets of metal in close face-to-face relationship cooperative with the receptacle to receive the molten metal therefrom and to form therewith a feeder assembly,
said plurality of sheets being perforated to provide a plurality of discharge orifices to release droplets of the melted metal for gravitation to the quenching bath,
said plurality of discharge orifices being arranged in two substantially parallel rows longitudinally of the receptacle;
clamping means to clamp the sheets together under sufficient pressure to prevent lateral leakage of the melted metal from the stack at the interfaces of the sheets with freedom for slippage of the sheets in response to thermal expansion and contraction of the sheets;
means to support the feed assembly for oscillation about a longitudinal axis that lies in a vertical plane between the two rows of discharge orifices, said support means forming seats with spaced sidewalls adjacent the opposite ends respectively of the feeder assembly,
the feeder assembly having two opposite end extensions resting in corresponding seats,
the seats being slightly wider than the end extensions to provide limited freedom for vibratory oscillation of the feeder assembly about a longitudinal axis defined by the two end extensions.

27. In an apparatus of the character described for producing shot by discharging droplets of melted metal into a quenching bath, the combination of:
a receptacle containing a body of the melted metal and being apertured for gravitational flow of the melted metal therefrom;
a stack of sheets of metal in close face-to-face relationship cooperative with the receptacle to receive the molten metal therefrom and to form therewith a feeder assembly,
said plurality of sheets being perforated to provide a plurality of discharge orifices to release droplets of the melted metal for gravitation to the quenching bath;
said discharge orifices being arranged in two substantially parallel rows longitudinally of the receptacle,
heat generating means along the opposite longitudinal sides respectively of the receptacle to heat the opposite sides substantially equally to prevent lateral thermal distortion of the feeder assembly;
said feeder assembly being mounted to oscillate about a central longitudinal axis;
a resiliently flexible rod extending laterally from the feeder assembly;
means to strike the rod periodically to cause the rod to vibrate and thus cause the feeder assembly to vibrate; and
a weight on the rod adjustable longitudinally of the rod to modify the vibration of the rod.

28. In an apparatus of the character described for producing shot by discharging droplets of melted metal into a quenching bath, the combination of:
a receptacle containing a body of the melted metal and being apertured for gravitational flow of the melted metal therefrom;
a stack of sheets of metal in close face-to-face relationship cooperative with the receptacle to receive the molten metal therefrom and to form therewith a feeder assembly,
said plurality of sheets being perforated to provide a plurality of discharge orifices to release droplets of the melted metal for gravitation to the quenching bath;
said discharge orifices being arranged in two substantially parallel rows longitudinally of the receptacle;
heat generating means along the opposite longitudinal sides respectively of the receptacle to heat the opposite sides substantially equally to prevent lateral thermal distortion of the feeder assembly;
said feeder assembly being mounted to oscillate about a central longitudinal axis,
elongated resiliently flexible means rigidly attached to the feeder assembly with freedom to vibrate relative to the feeder assembly;
means to strike said flexible means periodically to cause the flexible means to vibrate and thus cause the feeder assembly to vibrate; and
means to hinder the vibration of the resiliently flexible means in one direction to modify the character of the vibration imparted to the feeder assembly.

29. In an apparatus of the character described for producing shot by discharging droplets of melted metal into a quenching bath, the combination of:
a receptacle containing a body of the melted metal and being apertured for gravitational flow of the melted metal therefrom;
a stack of sheets of metal in close face-to-face relationship cooperative with the receptacle to receive the molten metal therefrom and to form therewith a feeder assembly,
said plurality of sheets being perforated to provide a plurality of discharge orifices to release droplets of the melted metal for gravitation to the quenching bath,
said discharge orifices being arranged in two substantially parallel rows longitudinally of the receptacle;
heat generating means along the opposite longitudinal sides respectively of the receptacle to heat the opposite sides substantially equally to prevent lateral thermal distortion of the feeder assembly;
said feeder assembly being mounted to oscillate about a central longitudinal axis,
elongated resiliently flexible means rigidly attached to the feeder assembly with freedom to vibrate relative to the feeder assembly;
means to strike said flexible means periodically to cause the flexible means to vibrate and thus cause the feeder assembly to vibrate;
stop means; and
spring means connected with the resiliently flexible means to urge the resiliently flexible means towards the stop means to modify the vibration of the resiliently flexible means.

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