

Oct. 27, 1953

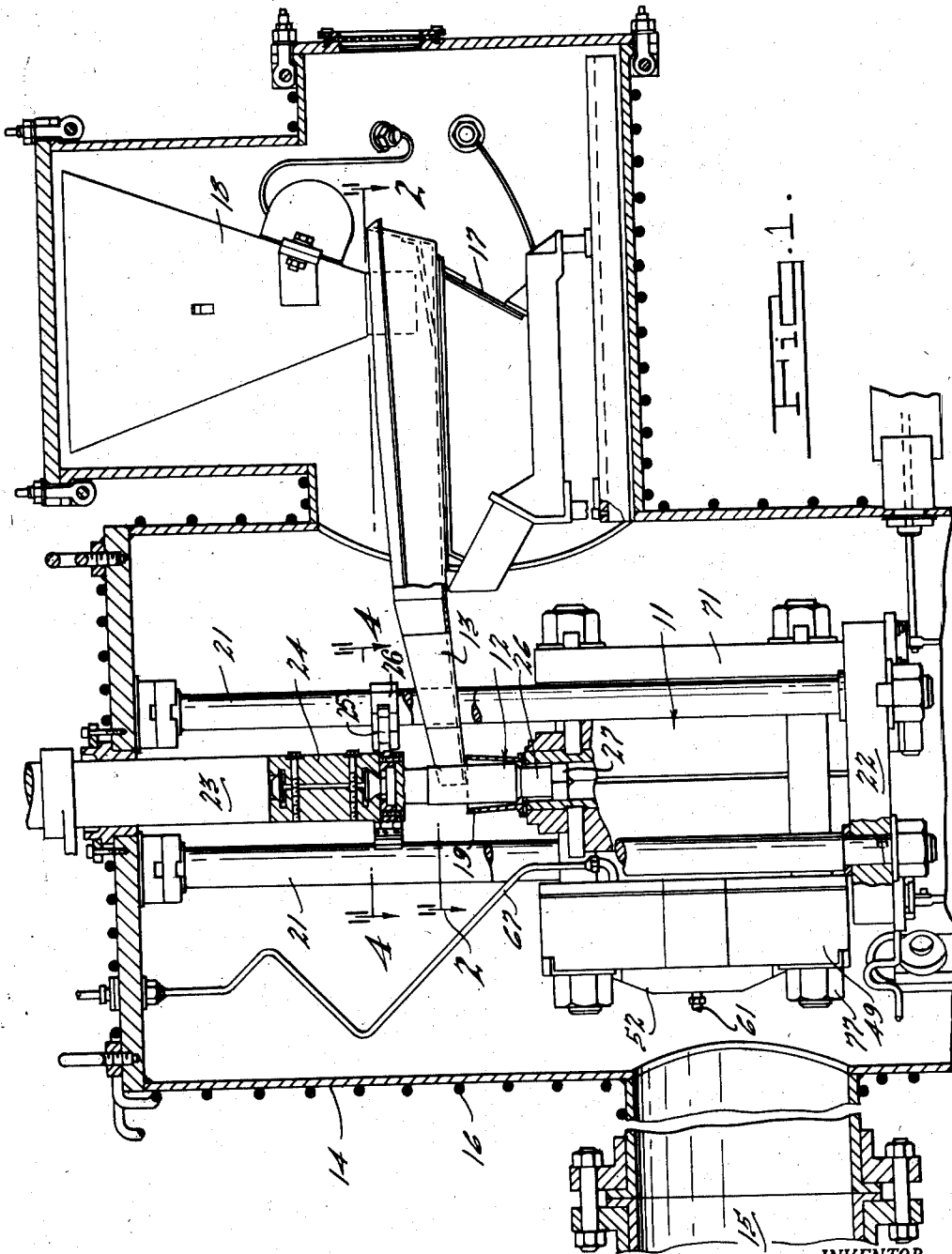
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2,656,743

DIE MECHANISM FOR EXTRUDING COMPRESSED POWDER RODS

Filed Feb. 23, 1951

5 Sheets-Sheet 1



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5 Sheets-Sheet 2

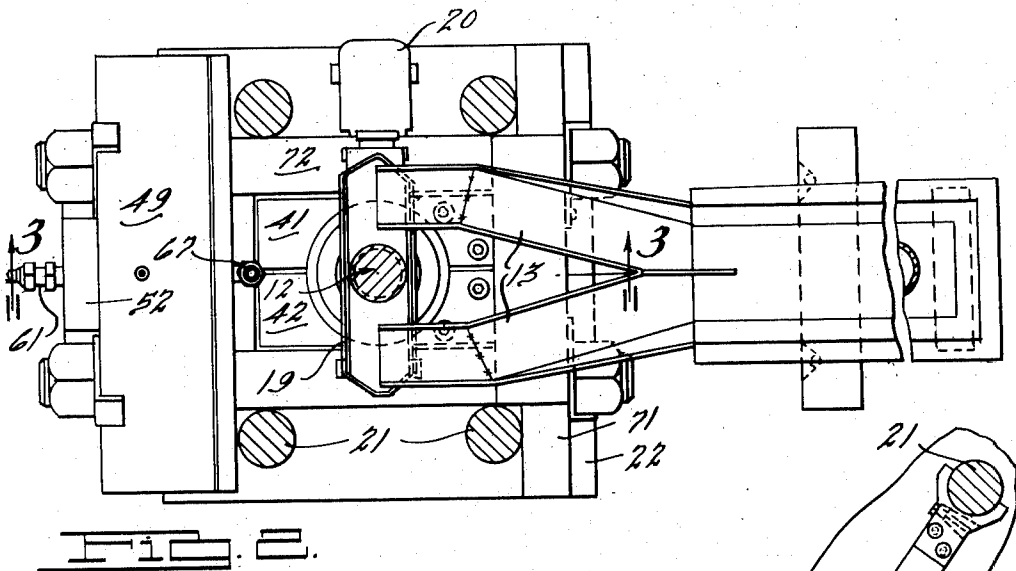


FIG. 2.

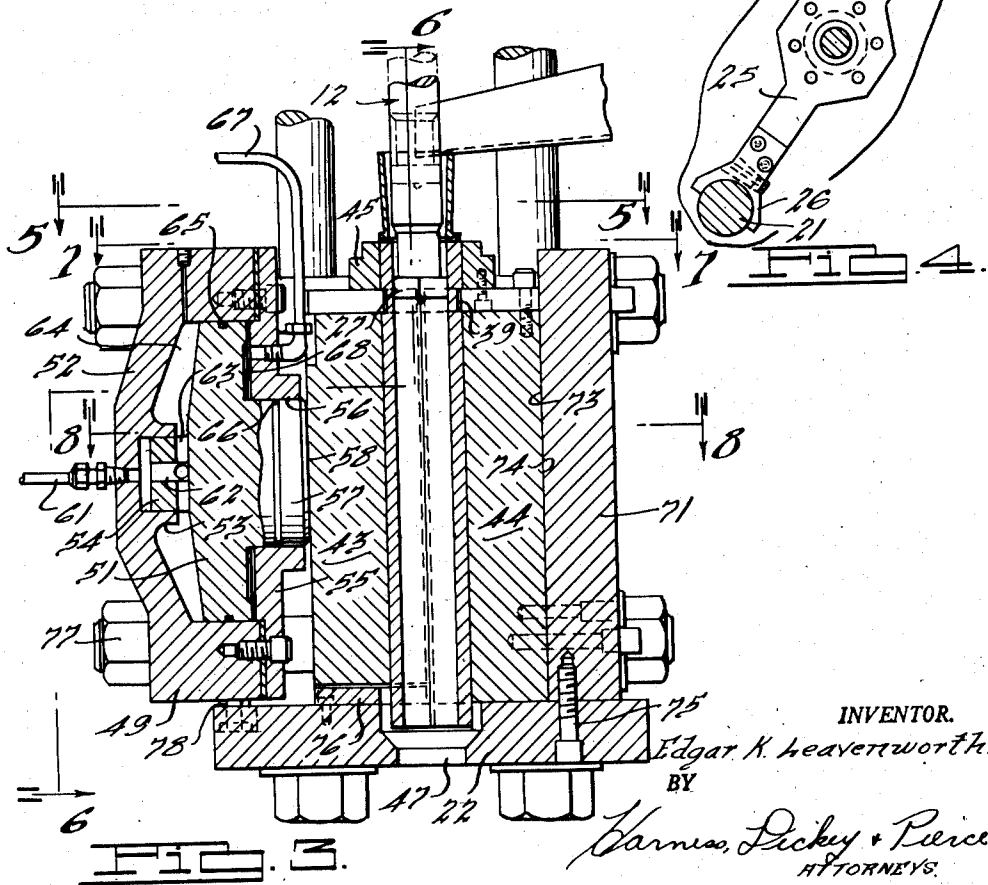


FIG. 3.

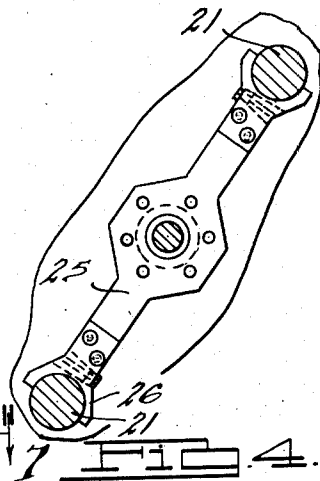


FIG. 4.

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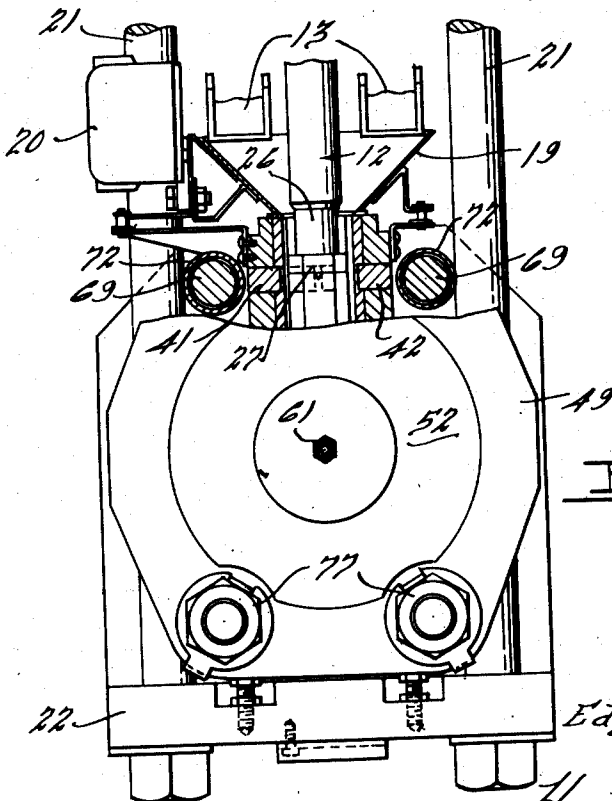
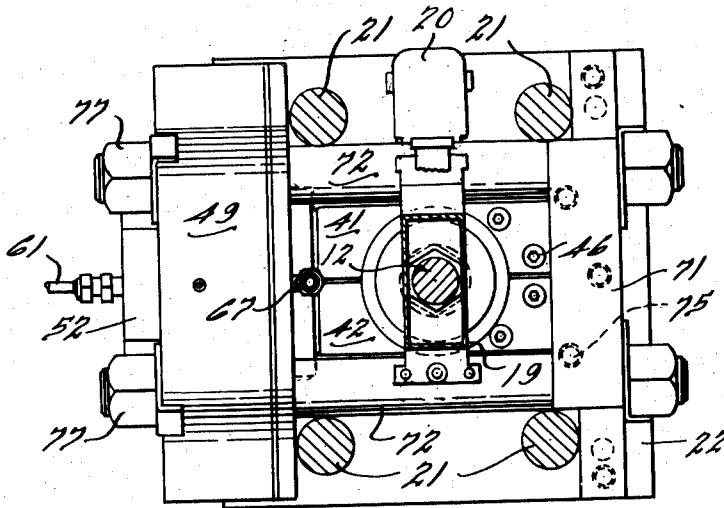
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5 Sheets-Sheet 3



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DIE MECHANISM FOR EXTRUDING COMPRESSED POWDER RODS

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5 Sheets-Sheet 4

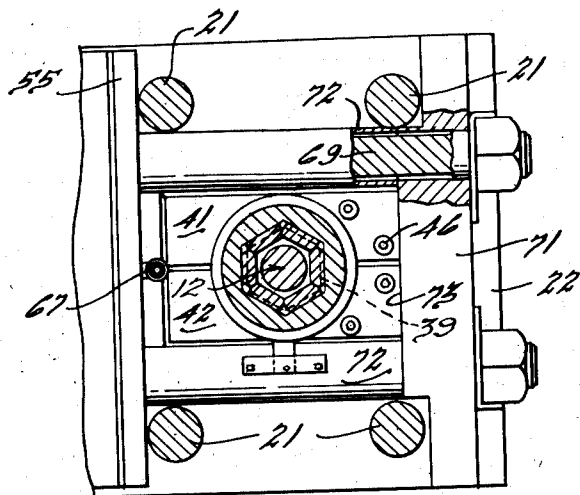


FIG. 2.

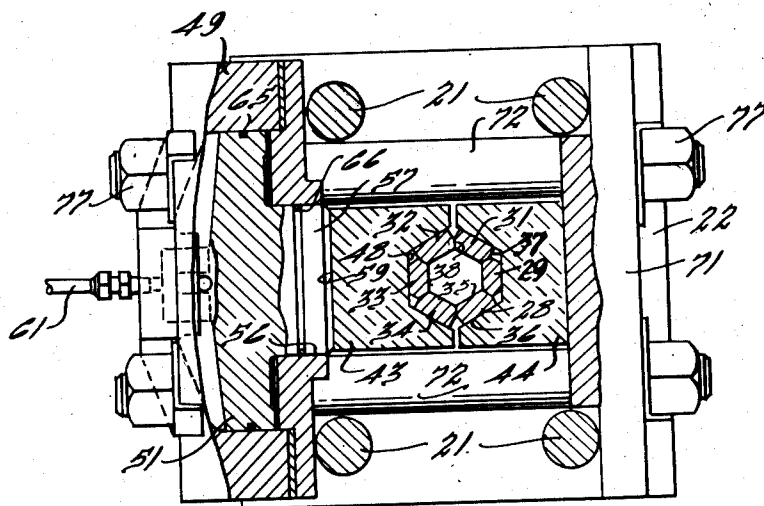


FIG. 3.

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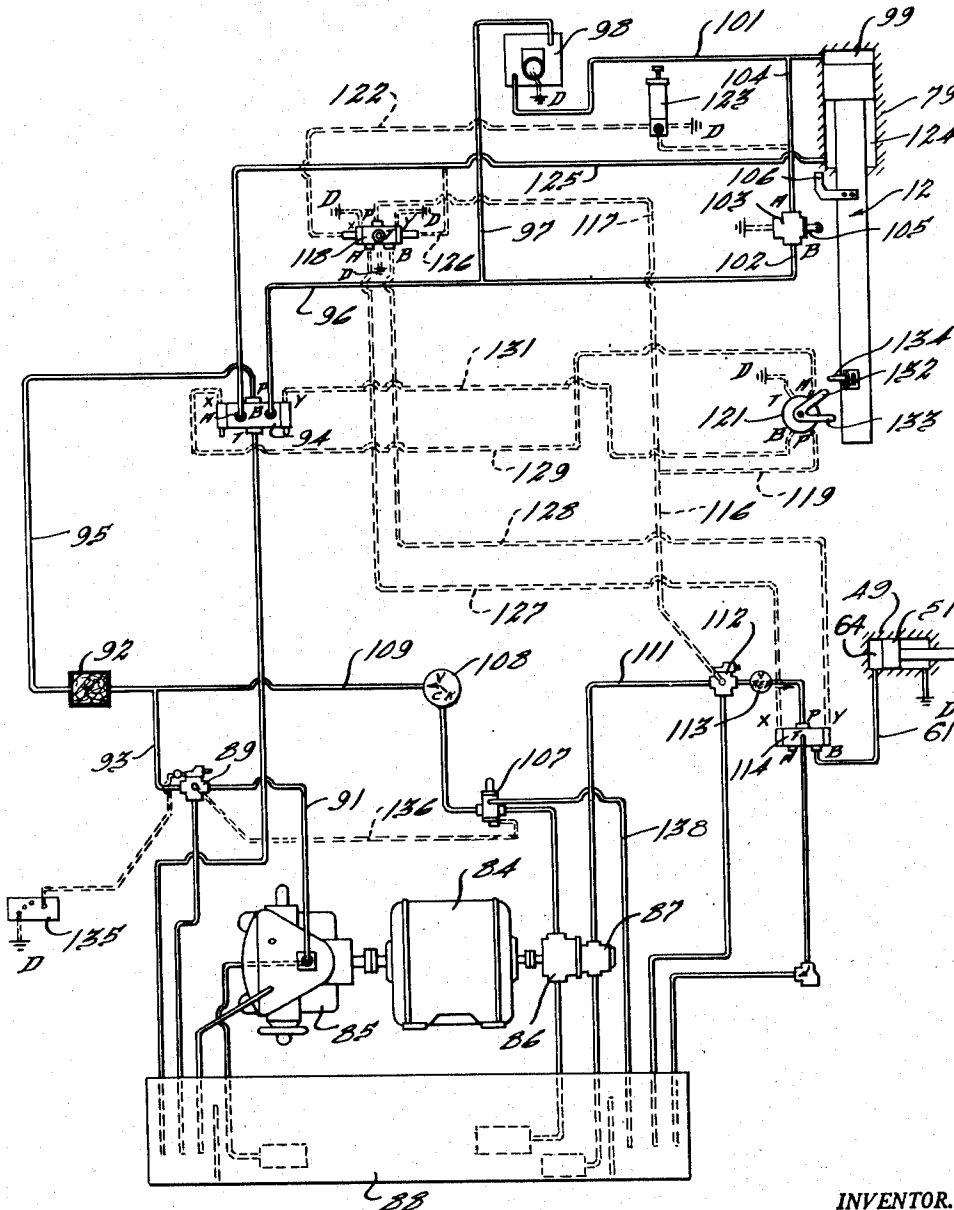
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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

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DIE MECHANISM FOR EXTRUDING
COMPRESSED POWDER RODS

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Application February 23, 1951, Serial No. 212,434

6 Claims. (Cl. 78-0.5)

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This invention relates to die mechanisms for extruding compressed powder rods, and more particularly to mechanisms for forming a continuous rod of compressed powdered metal which is to be sintered prior to melting in an electric furnace.

The die mechanism which is the subject of the present invention is an improvement over that described in applicant's copending application No. 787,797, filed November 24, 1947. In that application, an extrusion die is disclosed having a reciprocating ram or plunger at one end which packs small incremental portions of the powdered material into the die and compresses them at a predetermined consistency. The die is of constant cross-sectional area and is of such a length that the frictional force of the powdered metal against the walls of the die is always sufficient to prevent axial movement of the rod due to the axial force of the ram. The die is further provided with split portions which are normally held against radial expansion, but which by an arrangement of a cone and springs are released for radial movement upon the attainment of a predetermined axial force, thus reducing the frictional force of the rod in the die sufficiently to allow axial movement of the rod.

This mechanism presents inherent disadvantages which it is the object of the present invention to overcome. The springs which are used to counteract the axial force of the ram are very cumbersome and laborious to load. The die is required to have an axial motion, and bearing problems result due to excessive loads on the cone. Furthermore, the springs and cone operate as a friction brake when the compressed rod is moved through the die, thus causing excessive die wear and wasted power.

It is an object of this invention to eliminate these disadvantages and to provide an improved die mechanism which is extremely flexible in its operation and in which the labor involved in replacing or readjusting the parts is greatly reduced. In particular, it is an object to eliminate the spring arrangement and the attendant vertical motion of the die and compressed rod which is required to operate the cone and springs in the previous structure, substituting instead a mechanism which normally exerts a positive force on the split die portions to prevent their radial expansion, together with tripping means for automatically releasing this force when the axial force exerted by ram reaches a predetermined value. In association with this object, it is with-

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in the contemplation of this invention to provide a hydraulic mechanism in the form of a cylinder and piston for exerting the radial clamping forces on the die, and in which the hydraulic pressure in the ram cylinder is used to trigger the release of pressure in the die cylinder, the pressure at which this triggering takes place being adjustable by the operator.

It is a further object to provide an improved hydraulic system for an extrusion die mechanism of the above character, which is fully automatic in its operation and which includes means for varying the die cylinder releasing point without affecting the efficiency or speed of the system.

Other objects, features, and advantages of the present invention will become apparent from the subsequent description taken in conjunction with the accompanying drawings.

In the drawings:

Figure 1 is a side elevational view of the upper portion of an electric furnace installation, showing the location of the die mechanism and its associated subassemblies.

Figure 2 is a plan cross-sectional view taken along the line 2-2 of Fig. 1 and showing the feeding troughs and the die mechanism.

Figure 3 is a cross-sectional view in elevation taken along the line 3-3 of Fig. 2 and showing the die piston and cylinder as well as other elements of the die.

Figure 4 is a fragmentary cross-sectional view taken along the line 4-4 of Fig. 1 and showing the guide for the ram.

Figure 5 is a plan cross-sectional view taken along the line 5-5 of Fig. 3 and showing the location of the die tension bolts.

Figure 6 is a front elevational view, partly in cross-section along the line 6-6 of Fig. 3 and showing the construction of the entering portion of the die elements.

Figure 7 is a plan cross-sectional view taken along the line 7-7 of Fig. 3 and showing the construction of the die segments and the die collar.

Figure 8 is a plan cross-sectional view taken along the line 8-8 of Fig. 3 and showing the die segment clamping blocks; and

Figure 9 is a schematic view of a preferred hydraulic system for carrying out the principles of operation of this invention.

The principles of this invention are shown as embodied in a device for producing a continuous rod of sintered metal which is fed to the crucible or mold of an electric furnace for melting into an ingot or other object. It will be understood

however that these principles may as well be applied to other devices and installations where a continuous rod of compressed powder is desired to be formed. In the illustrated embodiment, after the rod leaves the die in its compressed form it passes through a series of electrodes (not shown) where it is subjected to an electric current which heats the compressed particles sufficiently to sinter them together, thus permitting the rod to continue downwardly toward the furnace and still have sufficient strength to support its own weight. It is of course important to the sintering operation that the density of the material in the rod before sintering have as little variation as possible, so that a uniform electric current will not produce over-sintering in some portions of the rod and under-sintering in others. For this purpose, it is necessary that the amount of powder that forms each increment of the rod be held uniform within reasonable limits, and that the compression pressure for each increment be substantially the same.

To carry out these purposes, the present invention provides a die mechanism generally indicated at 11 and a ram generally indicated at 12 which reciprocates within the upper or entering portion of the die and upon each reciprocation packs an incremental amount of powdered metal which is fed from a trough 13. Since the mechanism is shown as used in conjunction with an electric furnace, the entire assembly is enclosed by a housing 14 which is evacuated through a conduit 15 and is cooled by coils 16. The trough 13 may be of the conventional vibratory type, being supported at its outer end by vibratory spring 17, and is fed from a hopper 18 mounted above the outer end. The inner end of hopper 13 is forked, as shown in Fig. 2, and leads to both outer ends of an elongated funnel 19 surrounding the ram 12 and surmounting the die 11. A vibrator 20 may be mounted on the funnel to insure a constant flow of powder. The die itself is preferably suspended by means of a plurality of posts 21, the lower ends of which hold a bedplate 22 upon which the die is mounted. The ram 12 is disposed between these posts and comprises a piston 23 extending downwardly from the ram cylinder 79 (shown schematically in Fig. 9) and connected by a split element 24 to the ram proper, thus facilitating removal of the parts. As shown in Figs. 1 and 4, a double armed guide member 25 having oppositely disposed forked ends 26 is secured at the upper end of the ram 12 and slides between two diagonally opposite posts 21, thus preventing lateral buckling movement of the ram and increasing its columnar strength.

At the top of its stroke, as shown by the dot-dash lines in Fig. 3, the reduced portion at the lower end of the ram is disposed within the funnel 19, and the head member 27 is above the upper end of die 11. When in this position, powdered metal will be permitted to flow into entering end of the die and when the ram is lowered, the head member 27 will compress the powder into the die, the final position of the head member being a snug fit within the die as shown in solid lines in Fig. 3.

The die into which the powdered metal is forced by the ram is shown in the illustrated embodiment as having a constant cross-section of hexagonal shape. However, it will be understood that other cross-sectional shapes could be used for the die within the principles of the invention. As is best seen in Figs. 7 and 8, the die comprises six elongated segments 28, 29, 31, 32, 33 and 34 which

together form an elongated rod-forming passageway of hexagonal cross-section. In particular, each of these segments has an inner face 35, and outer face 36 and sides 37 which have matching inwardly inclined portions 38. These inwardly inclined portions are normally in flush relation so that the inner surfaces 35 form the hexagonal passageway. Adjacent the upper end of each of these die segments is an outwardly facing transverse slot 39, and a pair of supporting plates 41 and 42 are engaged in these slots and support the die segments against axial movement, a certain amount of play being permitted between the plates and die in a radial direction, as shown in Fig. 3. Plates 41 and 42 rest upon the upper surfaces of the die segment clamping blocks 43 and 44, which surround the major portion of the die segments below the slots 39 in a manner hereinafter described in detail. A collar 45 is disposed around the die segments above plates 41 and 42, and extends to the upper ends of these die segments. The purpose of collar 45 is to positively prevent at all times any relative movement of the upper portion of the die segments, thus creating in effect an immovable die at this entering portion. For this purpose, the collar 45 preferably has a press fit with the outer faces 36 of the die segments, so that the matching surfaces 38 of the segments are in tight relation to prevent any powder working in between the segments. The height of collar 45 and thus of the solid portion of the die is such that the cavity found inside the die and above the open splits will contain the maximum amount of loose powder which is to be compressed for any one increment.

The die segment supporting plates 41 and 42 are secured to the die segment clamping block 44 by means of bolts 46, but are movable with relation to block 43. The blocks 43 and 44 extend downwardly from the supporting plates 41 and 42 substantially along the remaining length of the die segments, and are supported by the bedplate 22. The bedplate has a clearance aperture 47 into which the lower ends of the die segments extend, and which allows the downward passage of the compressed powdered rod from the die. Blocks 43 and 44 each have an interior clamping surface 48 of such configuration as to simultaneously surround three of the die segments so as to prevent their outward radial movement. In particular, block 44 engages die segments 28, 29 and 31, while block 43 engages the remaining die segments 32, 33 and 34. The blocks are capable however of a releasing movement (block 43 to the left and block 44 to the right relative to the die strips as shown in Figs. 3 and 8) so as to relieve their engaging pressure on their respective die segments, thus reducing the frictional forces on the rod.

To accomplish this action, a die cylinder 49 and a die piston 51 are provided adjacent the blocks and are operatively connected thereto. As is best seen in Figs. 3 and 8, the die cylinder 49 is in spaced relation with block 43 and is so disposed that the cylinder axis is perpendicular to the axis of the die passageway. In the illustrated embodiment, the diameter of cylinder 49 is such that it extends substantially the entire length of the die, the lower end of the cylinder side wall being adjacent but not supported by bedplate 22. It will be understood, however that the relative proportions of the die cylinder are not critical but may be varied to suit the installation. The outer end wall 52 of the die cylinder is flared slightly outwardly, and the central portion thereof is provided with a guideway 53 for slidably supporting

an extension 54 of the die piston 51. The inner end of the die cylinder is provided with a head 55 secured thereto by cap screws, and this head has a central bearing aperture 56 which slidably supports inner extension 57 of the die piston 51. Extension 57 is of substantially greater diameter than extension 54, and has an end face 58 of relatively large area which engages the outer flat face 59 of block 43. An hydraulic pressure connection 61 leads to the outer end wall 52 of the die cylinder, and is connected by axial port 62 and radial ports 63 in extension 54 to the pressure chamber 64 of the die cylinder. Sealing rings 65 and 66 may be provided on the die piston and on extension 57 respectively to prevent oil leakage. The opposite side of die piston 51 is preferably connected by a conduit 67 to a source of vacuum, so that oil leaking in to the chamber 68 will not contaminate the vacuum surrounding the entire pressing mechanism.

While as stated previously die piston 51 is operatively engageable, by means of mating faces 58 and 59, with die segment clamping block 43, the die cylinder 49 is connected to the die segment retaining block 44. For this purpose, a plurality of tension bolts 69 are provided, and these bolts are connected at one end to the die cylinder and at their opposite ends to a bearing plate 71. As is best seen in Fig. 6, the side wall of the die cylinder is enlarged at four circumferentially spaced points in order to accommodate these bolts, and the bolts in turn are disposed inwardly from the supporting posts 21. The tension bolts 69 pass freely through die cylinder head 55, and tubular spacers 72 surround the intermediate portions of the bolts between head 55 and bearing plate 71. This bearing plate has an inner face 73 which is engageable with the outer face 74 of die segment clamping block 44. Bearing plate 71 also rests upon bedplate 22 and is connected thereto by cap screws 75. Clamping block 44 also is supported by bedplate 22 although not fastened thereto, and retaining block 43, which as will later be described moves relative to the bedplate, is supported thereby through an intermediate wear plate 76. The lost-motion connection of tension bolts 69 to die cylinder 49 and to bearing plate 71 is by means of outer nuts 77, which permit only a tensile stress to be placed in the bolts. A pair of legs 78 are also provided on bedplate 22 to support the weight of die cylinder 49 which however is not fastened to the bedplate.

The operation of the mechanism thus far described may perhaps best be illustrated by a description of the complete cycle of events during the feeding and packing of one increment of powdered metal. Starting from a condition in which the ram 25 is just beginning its upward or return stroke, the parts will be in a position as shown in the solid lines of Figure 3. When in this position, hydraulic pressure will be applied through line 61 to chamber 64, and die piston 51 will be forced toward the inner end of die cylinder 49. This hydraulic pressure will also cause the die cylinder to be forced against nuts 77, thus creating tension in bolts 69 and tending to move bearing plate 71 inwardly. It will thus be seen that the engagement of die piston 51 with retaining block 43 and the engagement of bearing plate 71 with retaining block 44 will force both of these blocks against their corresponding die segments, thus locking the die segments in their closed position as seen in Fig. 8. This will increase the frictional resistance of the com-

pressed rod within the die to such a degree that it may not be forced downwardly by the action of ram 25. As the ram moves upwardly it will allow powder to flow from funnel 19 into the immovable entrance portion of the die which is surrounded by collar 45.

As the die again moves downwardly in its compression stroke, this powder will be compressed within the immovable die portion so as to form another increment of the compressed rod. During the first portion of this packing movement, the die segment portions within blocks 43 and 44 will also remain immovable, thus maintaining the frictional resistance which prevents axial movement of the rod. However, when a predetermined axial force has been reached, as reflected in the hydraulic pressure within the ram cylinder, the hydraulic pressure within chamber 64 will be abruptly relieved, the means for accomplishing this action being described in detail below.

When the hydraulic pressure within chamber 64 is relieved, the inward forces on clamping blocks 43 and 44 will be slackened, thus reducing the frictional resistance of the powdered rod within the die segments. It will be understood of course that the actual movements of these parts is very slight, the movement required being only that necessary to relieve the radial pressure on the rod. Since the axial force of the ram may now overcome the frictional forces within the die, the rod will be moved downwardly through the die until the ram again reaches the bottom of its stroke. When this position is reached, the hydraulic pressure within chamber 64 will again be built up to its previous degree, thus imposing the frictional forces upon the rod which lock it against axial movement, and the cycle is repeated. It will be noted that during the releasing movement of blocks 43 and 44, bearing plate 71, bedplate 22 and die segment supporting plates 41 and 42 all will move in substantial unison with retaining block 44, although the construction will permit such relative movement between block 44 and the bearing plate and bedplate as may occur due to the reduction of internal stresses. On the other hand, die piston 51 and clamping block 43 move independently of the bedplate and the die segment supporting plates, the latter sliding upon the upper surface of clamping block 43. The play in slot 39 will permit relative movement between the supporting plates and the die segments.

The hydraulic system for controlling the events in the cycle of operation is shown schematically in Fig. 9, it being understood of course that systems other than that shown in the illustrated embodiment could be used. The ram cylinder 79 and the ram 12 are shown in the upper right hand portion of the diagram, and the die cylinder 49 and die piston 51 are shown at the central right hand portion. In the diagram, solid lines are used to represent the main hydraulic conduits, and dotted lines are used for the pilot conduits. Pump motor 84 drives three hydraulic pumps 85, 86 and 87 which are designed to deliver hydraulic fluid at various rates, the pumps being supplied from a tank 88. Pump 85 which is preferably of a variable delivery type, is used as the main supply pump for the ram cylinder 79, and is connected to a pressure regulating valve 89 by a conduit 91, valve 89 being adjusted to deliver a relatively high pressure, say 2,000 p. s. i. Valve 89 is connected to a filter 92 by a conduit 93, and the filter is connected to ram cylinder

valve 94 by means of conduit 95. A conduit 96 leads from port 94B, this conduit having a branch 97 leading through a restriction 98 to the upper chamber 99 of the ram cylinder by means of conduit 101. Conduit 96 also has a branch 102 connected through ram retarding valve 103 and a conduit 104 to chamber 99. Valve 103 always allows free flow from port 103A to port 103B, but shuts off flow from 103B to 103A when cam arm 105 is depressed by cam 106 attached to ram 81, this action occurring during an intermediate portion of the down stroke. Pump 86 is used as an auxiliary pump during the up stroke and during the first portion of the down stroke, and for this purpose is connected to the supply conduit 93 through pressure regulating valve 107, check valve 108 and conduit 109. Valve 107 is set to deliver a relatively low pressure, say 500 p. s. i., so that check valve 108 will close if a pressure higher than this exists in supply conduit 93.

Pump 87 is used to supply hydraulic pressure for the pilot system (shown in dotted lines) through a conduit 111 and a pressure regulating valve 112 set to deliver at an intermediate pressure, say 1,000 p. s. i. This pump also supplies hydraulic pressure to the die cylinder 49 through a pressure reducing valve 113 set at about 500 p. s. i., die cylinder valve 114 and a conduit 61. Pilot system supply conduit 116 leads from valve 112, and has a branch 117 leading to port 118P of die cylinder pilot valve 118 and another branch 119 leading to port 121P of ram cylinder pilot valve 121. Port 118X is connected by control conduit 122 to conduit 124, a variable setting relief valve 123 being inserted in conduit 122 and opening only when the fluid in conduit 124 has reached a predetermined pressure.

The lower chamber 124 of the ram cylinder is connected by conduit 125 to port 94A, and this conduit is used both to supply and to remove the fluid within chamber 124. A control conduit 126 connects conduit 125 to port 118Y, so that the position of die cylinder pilot valve 118 is controlled by the pressure differential between conduits 126 and 123. Pilot valve 118 in turn controls the position of ram cylinder valve 114 by means of conduits 127 and 128 leading to ports 114X and 114Y respectively. The pressure differential between lines 104 and 125, or between the upper and lower ram cylinder chambers, thus in effect controls the movement of die piston 51.

Ram cylinder pilot valve 121 is connected by conduits 129 and 131 to ports 94X and 94Y respectively, so that the position of ram cylinder valve 94 is controlled by valve 121, the latter thus acting as a cycling valve. The cycling valve is of a rotary two-way type having a lost motion connection to the ram 12 by means of forked arms 132 and 133 and cam 134 attached to the ram. The arrangement is such that valve 121 will be moved from one position to another only at the top and the bottom of the respective ram strokes. Valve 94 controls the supply of hydraulic pressure to chambers 99 and 124 of the ram cylinder and it will thus be seen that the position of the ram automatically controls the direction in which it is driven.

The functioning of this automatic hydraulic system may perhaps best be understood by a description of the events which take place during a complete cycle of operations. Starting from an initial condition in which the ram is at the ex-

treme upper end of the stroke, as shown in Fig. 9, the manual start and stop valve 135 may be moved to allow flow of fluid from pumps 85 and 86 through conduits 93 and 109 respectively to conduit 95. A branch line 136 from valve 89 may be provided for the operation of the valve 107, so that valves 89 and 107 may be simultaneously opened. At the time of this initial movement, the pilot system pump 87 will supply fluid through conduits 111, 116 and 119 to ports 114P, 118P and 121P. With the ram cylinder pilot valve 121 in its position as shown in Fig. 9, port 121A will be connected to port 121P, and port 121B will be connected to port 121T, that is, to tank. The resultant pressure in conduit 129 over that of conduit 131 will shift ram cylinder valve 94 to the right as shown in Fig. 9, connecting port 94A with port 94T and connecting a port 94B to port 94P. It will be understood, of course, that the directions of movement of the valves given in this description are merely illustrative, and that the actual movements will depend upon the particular valve port construction. Upon this movement of valve 94, the supply from conduit 95 will flow into conduit 96 and through the branches 97 and 102 thereof to upper ram cylinder chamber 99. This will cause a rapid downward initial movement of ram 12, since the ram cylinder is being supplied by both pumps 85 and 86. During this action, the pressure in chamber 99 will be greater than that in chamber 124 and conduit 104. However the pressure in chamber 99 is not great enough to open valve 123, and this valve remaining closed, the pressure in control conduit 125 will be greater than that in conduit 122. Die cylinder pilot valve 118 will thus be held in its leftward position as shown in Fig. 9, thus connecting port 118P to port 118A and connecting port 118B to tank. Conduit 127 will therefore be pressurized, shifting die cylinder valve 114 so as to connect port 114P to port 114B. It will thus be seen that during the first portion of the ram down stroke, pressure will be supplied to the chamber of die cylinder 49, holding the dies in their locked position.

The ram will continue to move downwardly under the influence of the hydraulic fluid delivered by pumps 85 and 86 until the compressive forces in the ram are such that the pressure in the supply line 109 becomes greater than the setting of pressure regulator valve 107. When this occurs only the fluid from pump 85 will be delivered to the chamber 99, check valve 108 preventing back flow of fluid to pump 86. The fluid delivered from this pump will be returned to the tank via return conduit 138. The ram will continue to move at the slower rate until cam 106 engages arm 105, shutting off the flow from conduit 102 to conduit 104. The supply fluid from conduit 95 will then flow only through branch 97 and through restriction 98 to the chamber 99. The restriction 98 will thus have the effect of further reducing the velocity of the ram as it continues downwardly.

As the charge of powdered metal is compressed to greater density, the axial forces in ram 12, and thus the hydraulic pressure in chamber 99, will steadily increase. Valve 123, which is subject to the pressure in chamber 99, is set to open when this pressure has reached a point at which the proper density of the powder charge is reached. This pressure may be predetermined from tests or by calculation, and the valve 123 is preferably adjustable so that its opening pres-

sure may be varied. Upon its opening, conduit 122, connected to port 118X, will be subjected to the pressure from chamber 99. Conduit 126, which is connected between conduit 125 and port 118Y, is still subjected to the relatively low pressure in chamber 124. The resultant pressure differential will thus shift die cylinder pilot valve 113 to a position such that port 118P is connected to port 118B and port 113A is connected to tank. This in turn will shift die cylinder valve 114, connecting port 114B to tank. The die cylinder 49 will thus be abruptly relieved of pressure, allowing the retraction of die piston 51. As described above, this action will allow the rod to move downwardly under continued axial force of ram 12. It will be observed that since the supply fluid for the ram flows only through restriction 93, the opening of valve 123 will not materially lessen the pressure in chamber 99, so that there is no danger of throwing in the auxiliary pump 99 and thus speeding up the stroke. The rod will thus move downwardly at a controlled rate desirable for the operation of the furnace.

When the ram 12 reaches the bottom of its stroke cam 134 will strike arm 133, shifting ram cylinder pilot valve 121 so that port 121P is connected to port 121B and port 121A is connected to tank. This action will shift ram cylinder valve 94 so as to connect port 94P to port 94A and port 94B to tank. The pressure differential between chambers 99 and 124 will thus be reversed, and the fluid from pumps 85 and 86 will begin to drive the ram 81 upwardly. At the same time, the pressure drop in chamber 99 will allow closing of valve 123, and the increased pressure in conduit 125 will cause pilot valve 113 to shift back to its original position, again shifting die cylinder valve 114 so as to apply pressure to the die cylinder. During the up stroke, the fluid from chamber 99 will flow freely through conduit 104 and check valve 103 back to the tank. When the ram reaches the top of its stroke, cam 134 will strike arm 132, shifting pilot valve 121 back to its original position which in turn will shift ram cylinder valve 94 so as to again supply pressure to chamber 99, and the cycle will be repeated. It will be observed that the cycle is fully automatic and will repeat until start and stop valve 135 is actuated to cut off the supply from pump 85.

A die mechanism for compressing powdered metal rods is thus provided in which a very high degree of consistency in the density of the rod can be achieved. The releasing motion is accomplished during each stroke by a fully automatic mechanism which is controlled solely by the instantaneous axial force in the ram, the releasing point being easily adjustable for different density requirements.

While it will be apparent that the preferred embodiment of the invention herein disclosed is well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. A die for extruding a continuous rod of compressed powdered metal, said die including six elongated individual segments together forming a hexagonal passageway for the reception and formation of said rod, a collar securing said segments together in immovable relation at one end thereof, a pair of oppositely disposed clamping blocks extending along the remaining portion of

said die, each of said clamping blocks being movable between a clamping position engageable with three of said sections and a retracted position allowing radial expansion of said sections; and means for moving said blocks between their clamping and retracted positions, said means comprising a hydraulic cylinder adjacent said die, a piston within said cylinder and movable between an extended position in operative engagement with one of said blocks and a retracted position out of such operative engagement, and connecting means between said cylinder and the other of said clamping blocks for operatively engaging said other block when said first block is engaged by said piston, whereby both of said blocks are moved simultaneously into their clamping position.

2. The combination according to claim 1, means for supplying fluid under pressure to said cylinder to hold said clamping blocks in their clamping position, and pressure actuated means controlled by the axial force acting on said compressed rod for relieving said fluid pressure when that force reaches a predetermined value.

3. A mechanism for extruding a rod of compressed powdered metal, including a reciprocating ram for packing successive charges of said powder, a die for receiving and forming said charges, hydraulically operated holding means for preventing axial movement of said rod by the axial force of said ram, a holding valve for controlling the flow of fluid to said holding means, a ram cylinder and piston for actuating said ram, a ram cylinder valve for controlling the flow of fluid to both sides of said ram piston and movable between a ram extending and a ram retracting position, a cycling valve controlled by the position of said ram to shift said ram cylinder valve between its said positions, said holding valve being movable between a position in which it actuates said holding means into clamping position and a position in which it allows retraction of said holding means, and fluid pressure actuated means for moving said holding valve from its first-mentioned to its second-mentioned position in response to the attainment of a predetermined pressure acting on said ram cylinder in a direction to extend the ram.

4. A mechanism for extruding a continuous rod of compressed powdered metal, including a die for receiving and forming incremental charges of said powder, a ram movable between a retracted position away from said die and an extended position within said die and compressing one of said charges, a ram cylinder and piston for operating said ram, holding means engageable with said die for preventing axial movement of said rod when the ram is compressing one of said charges, a die piston and cylinder for operating said holding means, a die cylinder valve for controlling the flow of fluid to said die cylinder, said die cylinder valve being movable between a clamping position in which said die piston and cylinder actuate said holding means and a tripping position in which said die piston and cylinder release said holding means, and means for controlling the position of said die cylinder valve, said means comprising valve actuating mechanism responsive to the pressure acting on the extending side of said ram cylinder for shifting said die cylinder valve to its tripping position when said pressure has reached a predetermined value.

5. Apparatus for forming a continuous rod of compressed powdered metal in successive incre-

ments, comprising a die having an opening therethrough which normally is of substantially the same cross section throughout its length, means for supplying powdered metal to the die opening at one end thereof, powder compressing means including a reciprocating plunger operable to compress the powder within said die opening against the previously formed portion of the rod and thus compact to final form successive increments of said rod in a portion of the die opening adjacent said one end, the remaining portion of the length of said die opening receiving a length of the fully formed rod, at least a part of said remaining portion of the die being radially expandable, hydraulic pressure operated mechanism for radially clamping the expandable portion of the die, means for supplying operating fluid to said mechanism at a pressure which will cause the mechanism to clamp the die and hold the compressed rod against movement in the die under the influence of the force exerted by the plunger, and valve means actuated in response to the force exerted by said plunger to compress the powder for reducing the pressure of the fluid supplied to said clamping mechanism when the force exerted by said plunger reaches a predetermined value and thus permit expansion of the split portion of the die and movement of the compressed rod through the die opening after the plunger has completed only a portion of its stroke in the powder compressing direction.

6. Apparatus for forming a continuous rod of compressed powdered metal in successive increments, comprising a die having an opening therethrough which normally is of substantially the same cross section throughout its length, means for supplying powdered metal to the die opening at one end thereof, powder compressing means including a reciprocating plunger operable to compress the powder within said die opening against the previously formed portion of the rod and thus compact to final form successive

increments of said rod in a portion of the die opening adjacent said one end, hydraulic pressure means for reciprocating said plunger, the remaining portion of the length of said die opening receiving a length of the fully formed rod, at least a part of said remaining portion of the die being radially expandable, hydraulic pressure operated mechanism for radially clamping the expandable portion of the die, means for supplying operating fluid to said mechanism at a pressure which will cause the mechanism to clamp the die and hold the compressed rod against movement in the die under the influence of the force exerted by the plunger, and pressure operated valve means actuated in response to the pressure of the hydraulic fluid acting on said plunger to compress the powder for reducing the pressure of the fluid supplied to said clamping mechanism when the pressure of the hydraulic fluid acting on said plunger reaches a predetermined value and thus permit expansion of the split portion of the die and movement of the compressed rod through the die opening after the plunger has completed only a portion of its stroke in the powder compressing direction.

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