

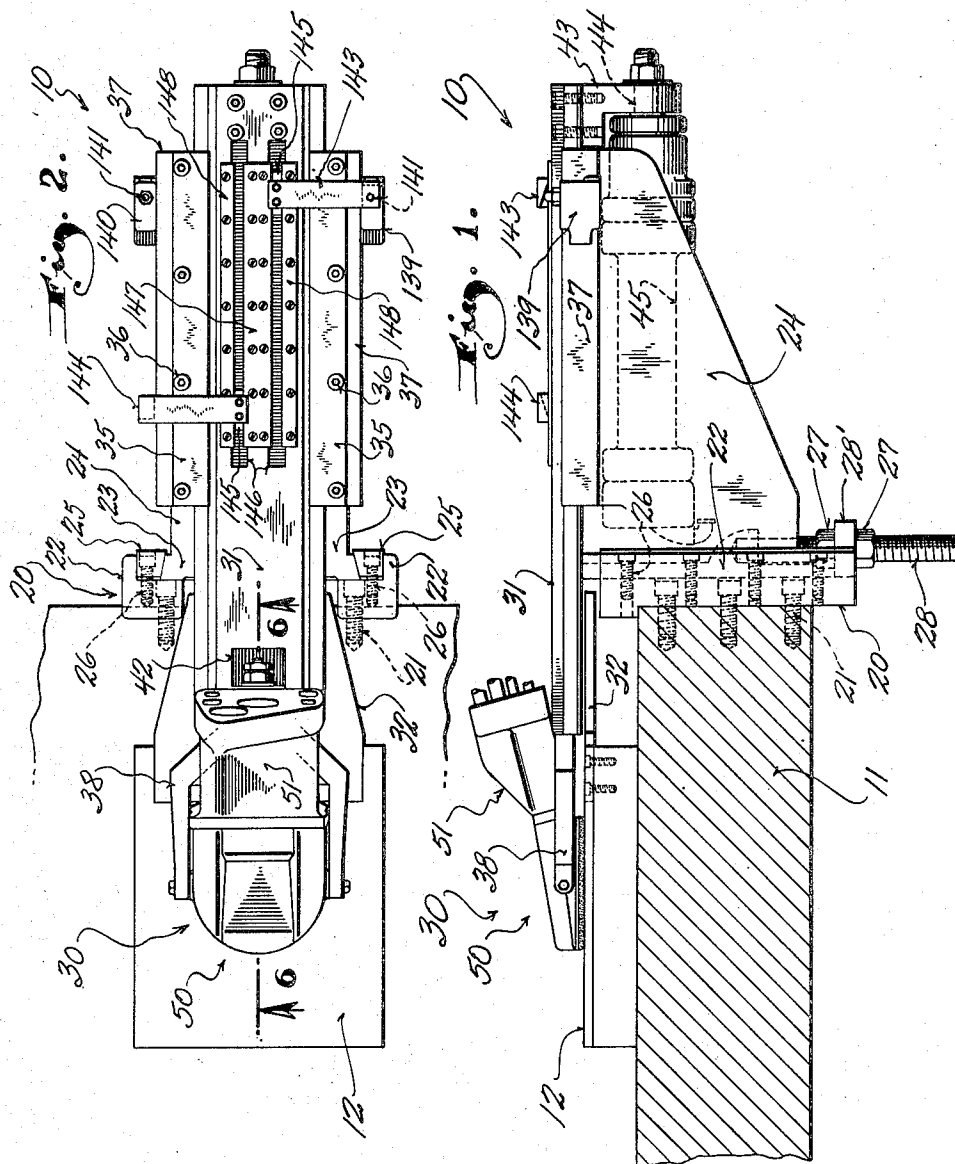
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J. A. HARRINGTON
METAL POWDER FEED MECHANISM

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6 Sheets-Sheet 1



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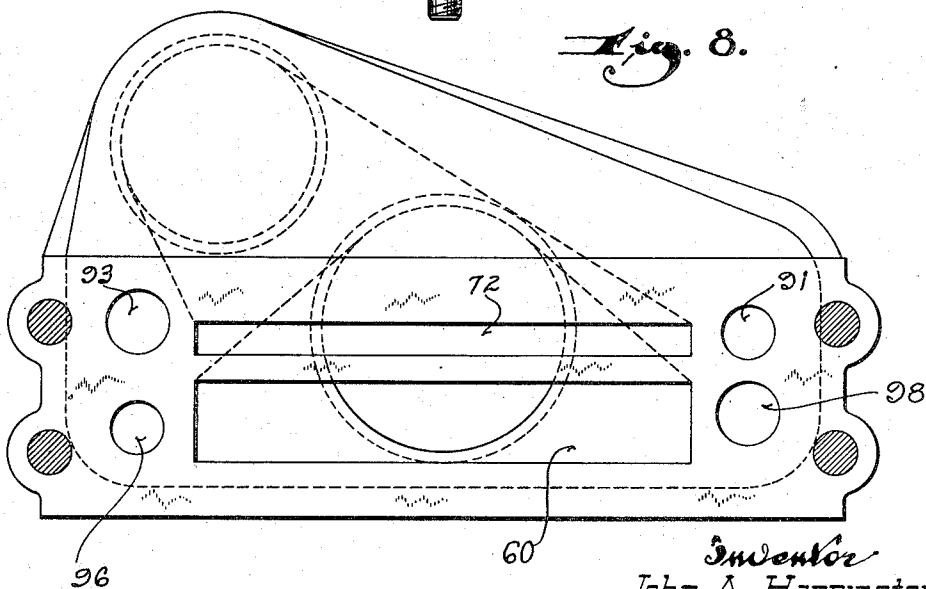
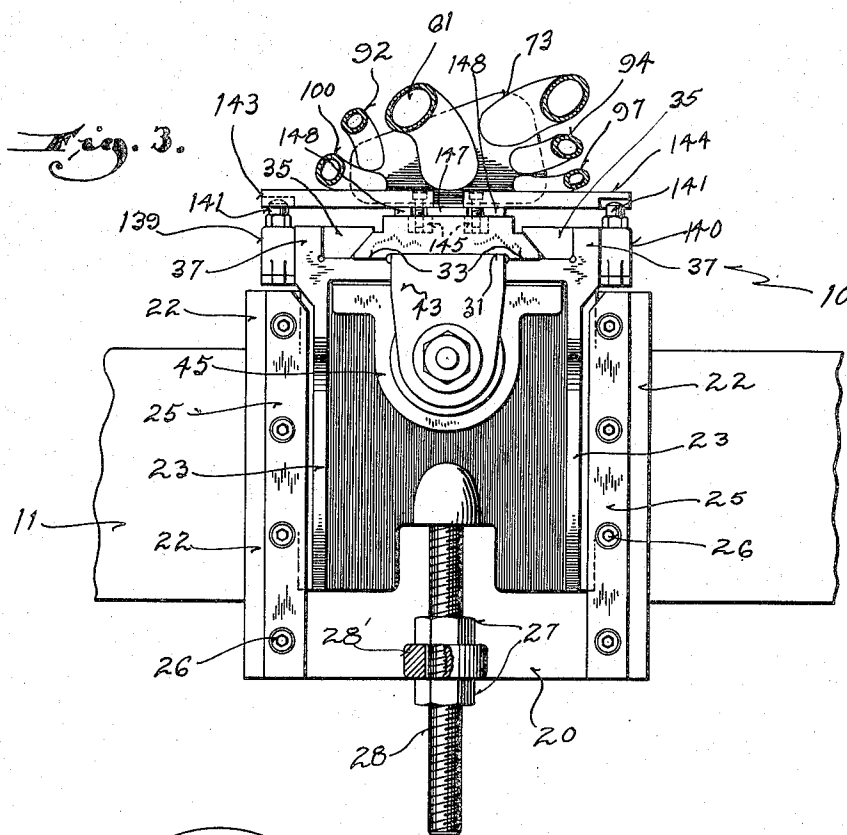
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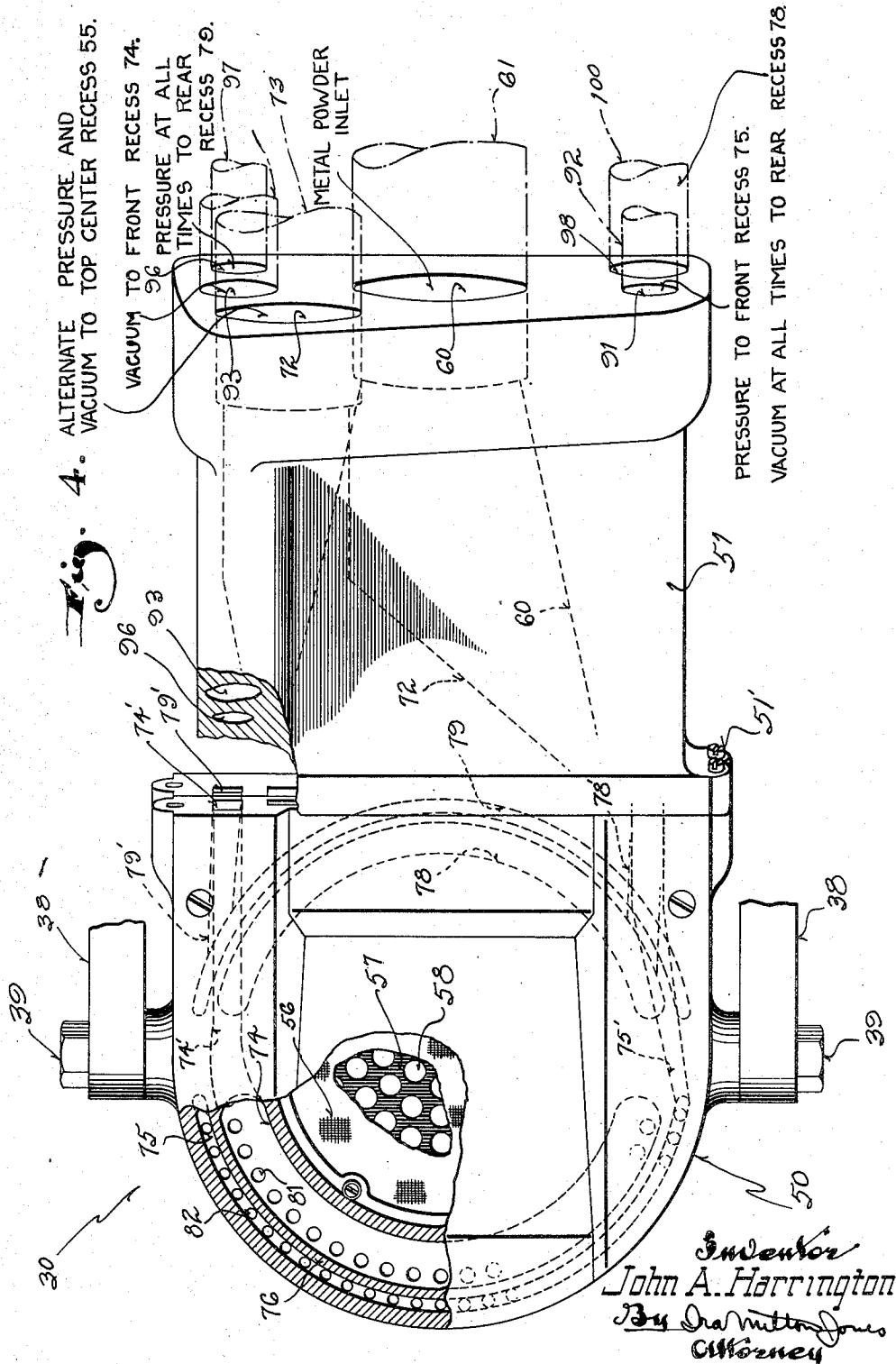
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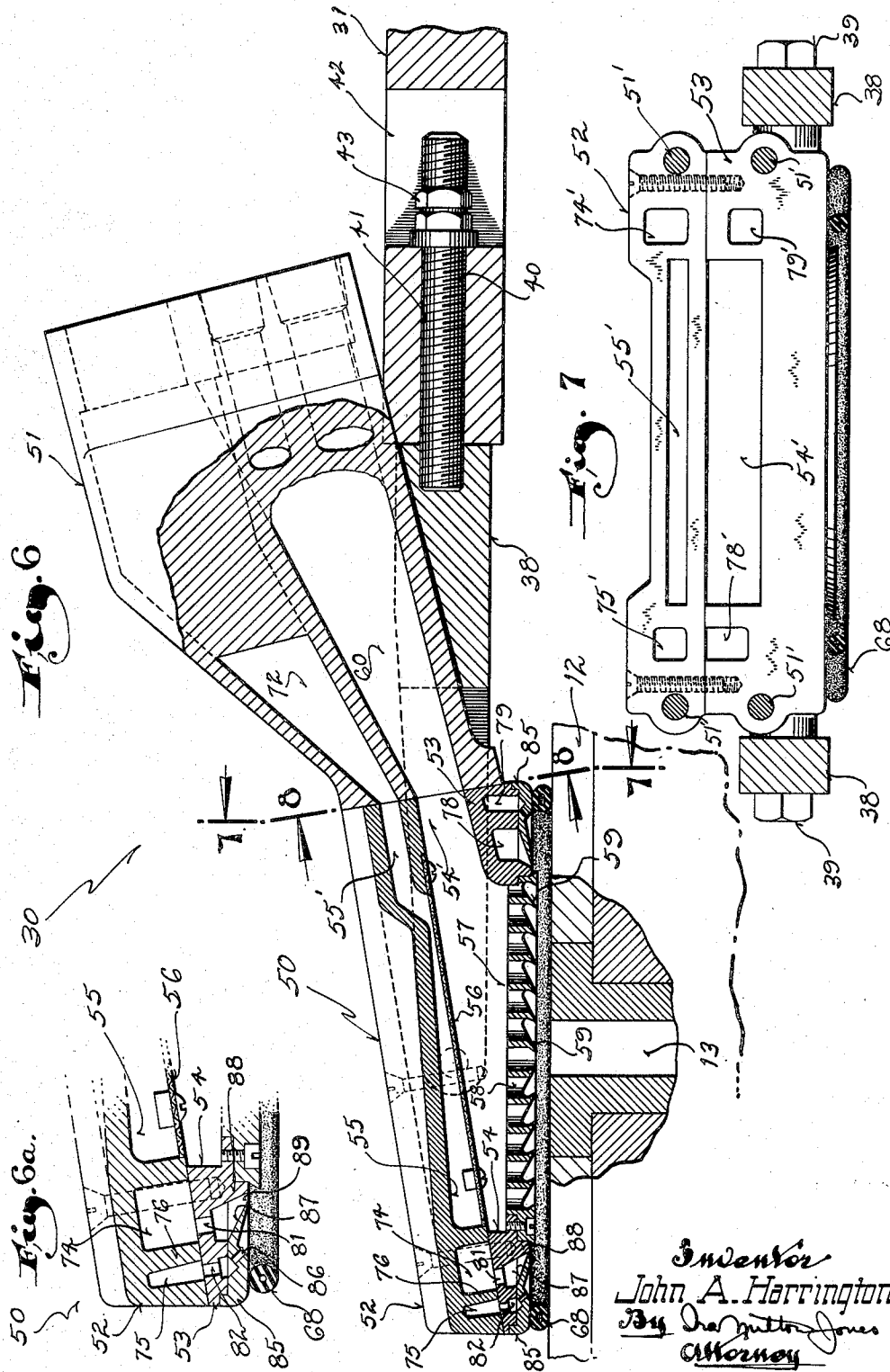
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METAL POWDER FEED MECHANISM

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6 Sheets-Sheet 4



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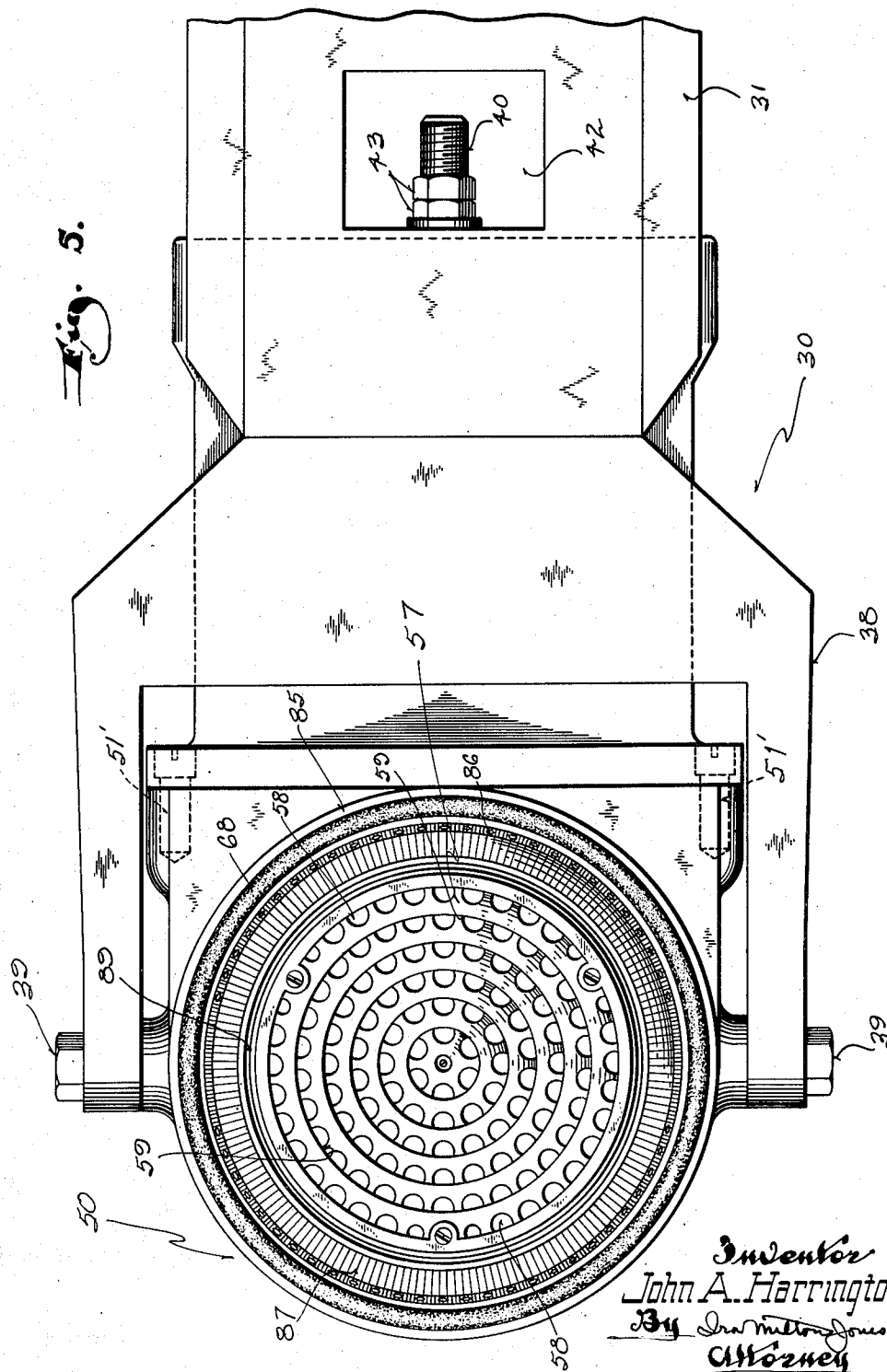
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METAL POWDER FEED MECHANISM

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6 Sheets-Sheet 5



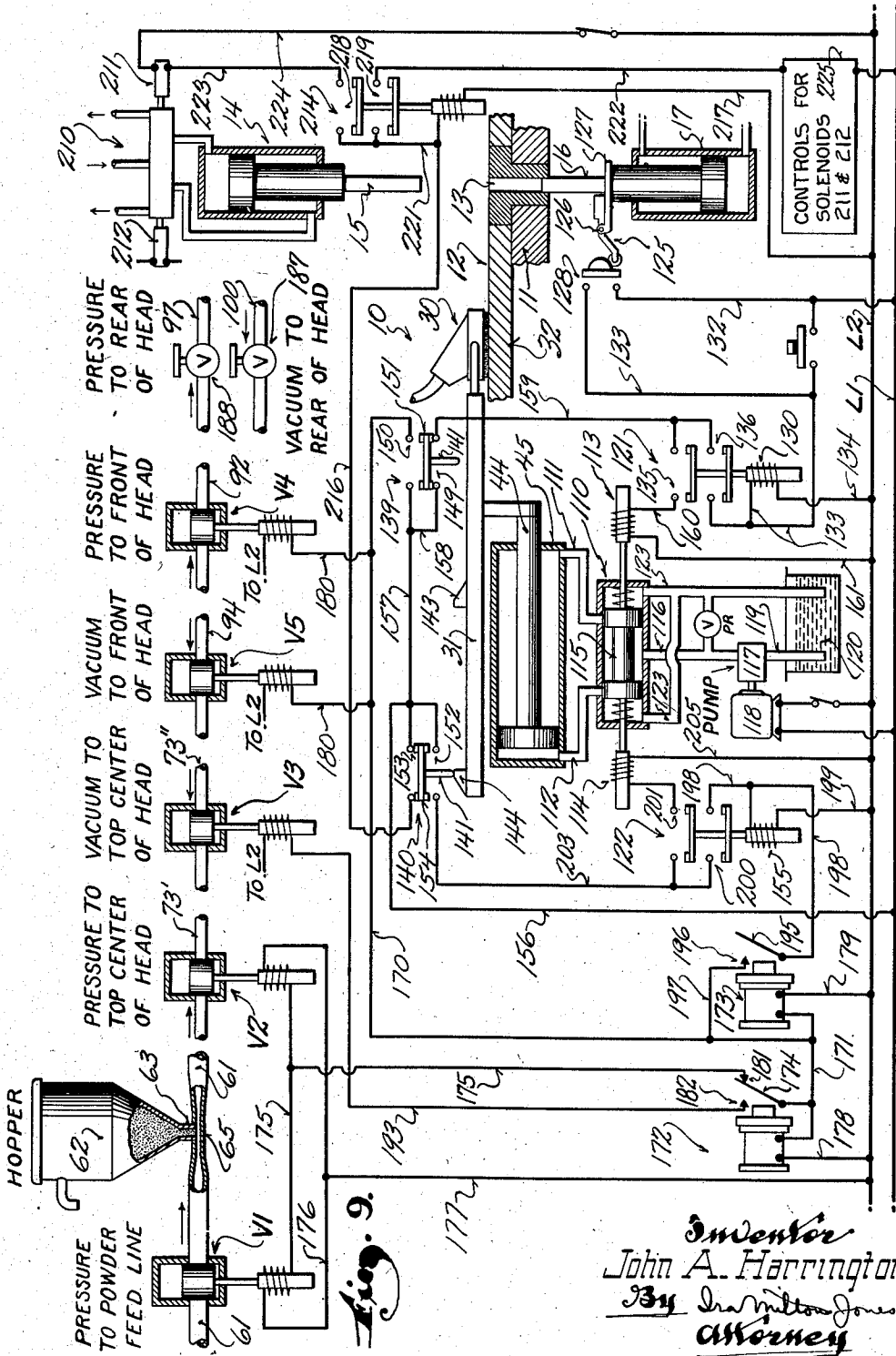
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METAL POWDER FEED MECHANISM

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6 Sheets-Sheet 6



UNITED STATES PATENT OFFICE

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METAL POWDER FEED MECHANISM

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4 Claims. (Cl. 78—.5)

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This invention relates to the art of cold pressing metal powders to form pellets commonly known as "compacts," and has particular reference to mechanism for feeding or charging such metal powders into the die cavities of powder metal presses.

In the past considerable difficulty was experienced in charging the die cavities of metal powder presses due chiefly to the poor flow characteristics of the powder being used and the consequent difficulties entailed in assuring complete filling of the die cavities to uniform densities. In many instances, for example, when using tungsten carbide powders whose flow characteristics are extremely poor, it has been necessary to fill the die cavities of metal powder presses by hand to insure against the presence of void spaces in the cavities at the time of the pressing operation.

Needless to say, such hand charging wastes considerable time and effort and renders the pressing operation quite costly.

Other types of powders used in cold pressing oxidize extremely rapidly and it is almost impossible to fill die cavities with these rapidly oxidizing powders without oxidation to a degree destroying some of the bonding features of the powder which are vital to the cold pressing operation.

With these objections to past practices in mind, it is an object of the present invention to provide feed mechanism by which the charging of die cavities of metal powder presses is greatly facilitated and complete filling of the cavities to uniform densities assured.

It is another object of this invention to provide feed mechanism for charging metal powder into the die cavities of metal powder presses in a much more rapid and uniform manner than heretofore and which is capable of efficiently handling powders having extremely poor flow characteristics.

Still another object of this invention resides in the provision of mechanism for automatically recharging the die cavities of metal powder presses after each pressing operation.

A further object of this invention is to provide feed mechanism for charging the die cavities of metal powder presses which is of unitary design so as to enable the mechanism to be readily attached to and used with any conventional metal powder press.

A still further object of this invention resides in the provision of feed mechanism for charging the die cavities of metal powder presses which will prevent oxidation of metal powders which

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tend to oxidize extremely rapidly so as to preserve the bonding features of the powder so vital to the cold pressing operation.

Another object of this invention resides in the provision of novel feed mechanism by which metal powder is injected into the die cavities of metal powder presses under gas pressure to more positively control the transfer of powder from a source to the die cavities.

A still further object of this invention resides in the provision of feed mechanism by which metal powder is charged into the die cavity of a metal powder press wherein a nozzle-like feed head reciprocable over the die cavity toward and from an operative position above the cavity is employed for the purpose of injecting the metal powder in the cavity.

Another object of this invention resides in the provision of feed mechanism for automatically recharging the die cavities of metal powder presses after each pressing operation in which waste of powder during the charging operation is practically eliminated.

With the above and other objects in view which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangements of parts substantially as hereinafter described, and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate one complete example of the physical embodiment of the invention constructed in accordance with the best mode so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a side elevational view of the feed mechanism of this invention showing the manner of its attachment to a metal powder press only a portion of which is indicated;

Figure 2 is a plan view of the mechanism shown in Figure 1;

Figure 3 is an end view of the feed mechanism shown in Figure 1 looking toward the press upon which the feed mechanism is mounted;

Figure 4 is an enlarged plan view of the feed head assembly (shown in Figure 2) with parts thereof broken away to show the interior construction of the head;

Figure 5 is a bottom view of the feed head assembly shown in Figure 4 illustrating the underside thereof;

Figure 6 is an enlarged longitudinal sectional view through the feed head assembly taken along

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the plane of the line 6—6 of Figure 2 and showing the head in charging position over the die cavity of a metal powder press;

Figure 6a is an enlarged and fragmentary cross sectional view of the front portion of the feed head;

Figure 7 is a view taken on the plane of the line 7—7 of Figure 6 defined by the joint between the feed head per se and the flange coupling attached thereto and looking toward the feed head;

Figure 8 is a view taken on the plane 8—8 of Figure 6 defined by said joint between the feed head per se and the flange coupling looking toward the latter; and

Figure 9 is a combined electrical and hydraulic control diagram by which the feed mechanism is automatically governed to effect recharging of a die cavity after each pressing operation.

Referring now more particularly to the accompanying drawings in which like numerals indicate like parts throughout the several views, the numeral 10 generally designates the feed mechanism of this invention. The feed mechanism 10 may be attached to the bolster plate 11, with which metal powder presses are provided, alongside the die block 12 which is mounted on the top face of the bolster plate. The die block may contain a plurality of die cavities in its top surface, but only one such cavity 13 has been illustrated.

In the type of metal powder press herein illustrated, a hydraulic compressor cylinder 14 is located above the die block and has a plunger 15 aligning with and fitting the die cavity. The plunger 15 is adapted to be forced down into the cavity when the same is filled with metal powder to compact the powder between it and the plunger 16 of a hydraulic ejector cylinder 17 mounted beneath the die cavity.

Inasmuch as the press forms no specific part of the present invention, only those parts thereof necessary to an understanding of the invention have been indicated in Figures 1 and 6 and in the combined electrical and hydraulic control diagram of Figure 9.

The particular manner of mounting the feed mechanism on the press is clearly shown in Figures 1, 2 and 3 where it will be noted that the unit comprises a supporting plate 20 secured by means of screws 21 to the side of the bolster plate 11. The plate 20 is provided with vertical flanges 22 at opposite sides thereof between which the legs 23 of a supporting bracket 24 are received.

The outside edges of the legs 23 taper inwardly rearwardly of the mounting plate 20 and are spaced a distance from the flanges 22 of the mounting plate such as to enable gibs 25 to be inserted between the legs and the flanges. These gibs have inclined surfaces overlapping the inclined surfaces of the legs 23 so that upon securing of the gibs to the mounting plate 20 as by means of screws 26 a vertical slideway is provided for the legs of the bracket 24 by which the bracket is held in any desired position of vertical adjustment upon the mounting plate 20.

As will be apparent, it is necessary to loosen only one of the gibs 25 for the purpose of freeing the bracket 24 for vertical adjustment of the feed mechanism, and such adjustment is facilitated by turning one of a pair of nuts 27 threaded on a stud 28 anchored in the bracket 24. The nuts 27 are disposed at opposite sides of a lug 28' having an oversized aperture through which the stud passes.

The mechanism 10 includes a feed head as-

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sembly 30 carried by a slide 31 mounted for horizontal reciprocatory motion to carry the feed head assembly from an operative charging position disposed directly over the die cavity 13 as shown in Figures 1 and 6, to a retracted position spaced from the die cavity and disposed over a horizontal apron 32 extending from the die block flush with the top face thereof toward the supporting bracket 24.

The slide 31 rests on the flat horizontal top surface 33 of the supporting bracket 24 and is constrained to endwise reciprocatory motion thereon by being confined between opposite gibs 35 secured onto the top surface 33 of the bracket as by means of screws 36. It is to be noted that the inner sides of the gibs have inclined surfaces substantially overlapping similarly inclined surfaces along the side edges of the slide so as to preclude all motion of the slide relative to its supporting bracket except horizontal reciprocatory motion of the slide. Longitudinal side rails 37 on the supporting bracket projecting up from the top surface thereof provide backing for the outer sides of the gibs 35.

The feed head assembly is connected with the slide 31 to reciprocate therewith by means of a yoke 38. The forked extremity of the yoke embraces the feed head and is pivotally connected to opposite sides thereof as at 39 so as to enable a limited degree of pivotal or rocking motion of the feed head assembly on a horizontal axis transverse to the direction of feed head motion.

The end of the yoke opposite its forked extremity flatwise abuts the adjacent end of the slide 31 and has a single stud 40 projecting centrally rearwardly therefrom toward the slide 31 and received in a hole 41 in the end of the slide. The hole 41 for the stud 40 leads from the outer end of the slide adjacent to the feed head assembly rearwardly to an opening 42 through the slide which is provided to enable a pair of nuts 43 to be threaded onto the outer end of the stud and hold the yoke and feed head assembly drivingly connected with the slide.

The rear of the slide opposite the feed head mechanism extends outwardly beyond the supporting bracket 24 and has a depending connector bracket 43 fixed to its underside by which the slide is connected to the plunger 44 of a hydraulic feed cylinder 45. The cylinder 45 is fixedly supported in any suitable manner from the bracket 24 beneath the top thereof and is connectible with a source of fluid under pressure to effect extension and retraction of its plunger 44 and to thereby cause reciprocation of the feed head assembly toward and from its operative position over the die cavity 13 of the press.

Electric and hydraulic mechanism to be later described is employed to automatically control advancing and retracting motion of the feed head assembly by means of the hydraulic feed cylinder 45 in synchronization with the operation or work cycle of the press.

The feed head assembly as best illustrated in Figures 4, 5, 6, 7 and 8 comprises a nozzle-like head 50, and a flange coupling 51 attached to the rear of the head 50 as by means of screws 51'.

The nozzle-like feed head 50 is comprised of two main castings 52 and 53 secured together flatwise in superimposed relationship with respect to one another. The lower casting 53 has a substantially large central port or hole 54 therein leading from the bottom of the head to the underside of the casting 52 forming the top of the feed head, and the upper casting 52 has a shallow

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central recess 55 in its bottom in line with the hole 54. The recess 55 is separated from the upper portion of the hole 54 adjacent thereto by a screen 56 which has a mesh fine enough to preclude the passage of metal powder there-through.

A circular distributing plate 57 is secured by suitable screws to the bottom of the head casting 53 to extend across the mouth of the hole 54 therein, and has a multiplicity of holes 58 therein located along circumferential but radially spaced center lines.

In addition, the lower face of the distributing plate 57 has a series of annular deflector ribs 59 on its underside located between the adjacent circumferential rows of holes and all of the ribs are inclined downwardly and inwardly toward the center of the plate so that metal powder introduced into the central chamber in the lower casting of the feed head is directed downwardly through the holes 58 and then inwardly by the ribs toward the central axis of the distributing plate and into a die cavity over which the head may be centered.

The hole 54 provides a central feed chamber inside the head beneath the screen 56 into which metal powder is adapted to be introduced and blown from the head through the mouth of the hole 54 and the distributing plate extending thereacross into the die cavity. The concept of blowing metal powders into the die cavities of metal powder presses is one of the main features of this invention for it enables charging of the die cavities with powder without formation of voids and results in filling of the cavities to a uniformity of density heretofore impossible.

Powder metal is conducted to the chamber provided by the hole 54 in the feed head through a passage 54' in the lower head casting 53 extending rearwardly from the upper portion of the hole 54 to the front of the flange coupling 51 where it connects with a powder supply passage 60 leading rearwardly through the entire flange coupling. It is to be understood that the head and coupling are joined together in airtight fashion so as to preclude leakage at the joint therebetween.

A hose 61 attached to the rear of the coupling in communication with the supply passage 60 is provided to supply the nozzle-like feed head with metal powder from a source thereof such as the powder hopper 62, illustrated diagrammatically in Figure 9.

In accordance with the present invention the hose line 61 is adapted to be connected with a suitable source of gas or air under pressure through an electromagnetic valve V1, and the feed hopper 62 has a restricted bottom discharge tube 63 opening into the hose line 61 substantially at the constriction of a venturi 65 therein located between the valve and the feed head assembly.

When the valve V1 is energized to open the same, air or gas under pressure flows through the line 61 and has its velocity increased a substantial amount upon entering the venturi 65 to effect a corresponding reduction in pressure by which powder metal is drawn from the hopper and entrained in the air or gas stream to be carried thereby into the feed head 50 for discharge through the distributing plate and injection under pressure into the die cavity 13.

Powder metal issuing from the apertures of the distributing plate 57 at the mouth of the hole 54 in the feed head is prevented from escaping from the underside of the head by an annular elastic sealing and wiping gasket 68 secured to

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the underside of the head and surrounding the distributing plate 57 in radially spaced relation thereto. The weight of the feed head is sufficient to hold the elastic sealing and wiping gasket under compression between the top face of the die block and the underside of the head to establish an air tight joint therebetween.

The recess 55 in the head above the screen 56 communicates through a passage 55' leading rearwardly therefrom with a passage 72 extending endwise through the flange coupling 51. A hose line 73 connects with the flange coupling 51 in communication with the passage 72 thereof and has one branch 73' thereof connected with a source of air or gas under pressure (not shown) through an electromagnetic valve V2 adapted to be energized and opened at the time metal powder is being conducted to the head and injected into the die cavity 13.

After filling of the die cavity, the valve V2 in the hose line 73' is adapted to be closed to disconnect the recess 55 from said source of pressure and an electromagnetic valve V3 located in a second branch 73'' of the hose 73 opened to cause the recess 55 to be subjected to vacuum from a source thereof (not shown) to which the branch line 73'' leads. This vacuum effects the extraction of as much air or gas as possible from the die cavity and the space beneath the feed head.

During the application of suction to the recess 55 in the head, it is the purpose of the screen 56 to block passage of metal powder upwardly and out of the head through the flange coupling passage 72.

The upper head casting 52 is provided with inner and outer arcuate recesses 74 and 75 opening to its underside adjacent to the lower casting 53 and which extend about the front rim of the upper casting to have their opposite ends terminate just ahead of the fork connection to the feed head. The recesses 74 and 75 are concentric to the axis of the hole 54 which provides the feed chamber and discharge port for the feed head, and are separated from one another by a relatively thin arcuate web 76.

The inner recess 74 has greater width than the outer recess 75 and is adapted to constitute a vacuum manifold while the relatively narrow recess 75 is adapted to constitute a pressure manifold for a purpose to be shortly described.

The lower head casting 53 has similar recesses 78 and 79 opening to the bottom thereof and extending arcuately about the rear of the feed head with their opposite ends terminating just to the rear of the fork connection to the feed head as indicated in Figure 4. The recesses 78 and 79 are likewise concentric to the discharge port 54 of the head and their radial distances from the center of the port 54 are the same as for the front recesses 74 and 75 respectively. The inner recess 78 has greater width than the outer recess 79, and these rear recesses likewise constitute vacuum and pressure manifolds respectively.

It is to be noted that the arcuate recesses 78 and 79 in the rear of the lower head casting 53 open directly to the bottom thereof while the arcuate recesses 74 and 75 in the front of the upper head casting open to the top face of the lower head casting.

In order that the recesses 74 and 75 may be communicated with the space beneath the feed head afforded by the sealing gasket 68, the front portion of the lower head casting 53 is provided with two sets of apertures 81 and 82 closely spaced along concentric center lines directly beneath the

recesses 74 and 75, with the apertures leading around the entire front portion of the lower casting to the opposite ends of the recesses 74 and 75 thereabove.

The feed head 50 is also provided with a bottom ring 85 secured to the underside of the lower head casting 53 in a position surrounding the distributing plate 57 and directly beneath the recesses 78 and 79 at the rear of the lower head casting and beneath the arcuate rows of apertures 81 and 82 in the front portion of the lower head casting.

The sealing gasket 60 which has been previously described may be conveniently secured to the underside of the bottom ring as shown in Figure 6.

The bottom ring 85 has a multiplicity of nozzle-like apertures 86 drilled therethrough at a downward and inward inclination and located along a circumferential center line just inside the sealing gasket 60 and in line with apertures 82 and the outermost recess 79 of the lower head casting, by which gas or air maintained under pressure in the outer recesses 75 and 79 discharges to the space beneath the head inside the confines of the gasket.

The inner peripheral portion 87 of the bottom ring 85 is directed inwardly and slightly downwardly so that it forms a conical surface extending completely around the ring lying beneath the innermost recess 78 in the rear portion of the lower casting 53 and to lie beneath the innermost set of apertures 81 in the front portion of the lower head casting.

The inner periphery 87 of the ring terminates adjacent but in spaced relation to a cylindrical flange 88 projecting from the lower face of the bottom casting 53 and together with the flange defines an annular orifice 89 through which the space beneath the feed head may be subjected to vacuum when the innermost recesses 74 and 78 of the two head castings are connected with a source of suction.

During the charging operation when the feed head assembly is centered over the die cavity 13, air or gas under a light pressure issues from the multiplicity of apertures 86 to agitate or stir up the metal powder collecting on the face of the die block so that such powder may be picked up and exhausted through the annular orifice 89 located radially inwardly from the pressure nozzles 86.

The arcuate recess 75 at the front of the head is supplied with air or gas under pressure through a passage 75' (see Figures 4 and 7) extending rearwardly therefrom through the upper casting 52 at one side of the casting to align and communicate with a passage 91 running rearwardly through the coupling 51. A hose 92 connects the coupling passage 91 with a suitable source of air or inert gas under pressure through an electromagnetic valve V4.

Vacuum is applied to the arcuate recess 74 in the front of the head through a passage 74' thereof (see Figures 4 and 7) extending rearwardly through the upper head casting at the side thereof opposite the passage 75', to align and communicate with a passage 93 running rearwardly through the coupling 51. A hose 94 connects the coupling passage 93 with a vacuum pump, not shown, through an electromagnetic valve V5.

The arcuate rear recess 79 in the lower head casting 53 communicates through a passage 79' leading rearwardly therefrom with a passage 96 running rearwardly through the coupling 51 beneath the passage 93 therein. A hose 97 con-

nects the passage 96 with the source of air or gas under pressure and supplies the rear pressure chamber 79 with such air or gas.

The arcuate vacuum recess 78 in the rear of the lower head casting 53 is communicated through a passage 78' leading rearwardly therefrom with a passage 98 leading endwise through the flange coupling 51 beneath the passage 91 therein, and a hose 100 is provided to connect the passage 98 with a suitable vacuum pump, not shown.

As will be later described, the vacuum and pressure in the arcuate front recesses 74 and 75, respectively, is maintained only for the period of time in which the feed head is substantially centered over the die cavity to charge the same, and is adapted to be automatically shut off by the electromagnetic valves V5 and V4 in the hose lines 94 and 92, respectively, whenever the feed head is in its retracted position or is traveling to or from its operative charging position; and vacuum and pressure in the arcuate rear recesses 78 and 79, respectively, is adapted to be maintained all the time inasmuch as such pressure and vacuum applied to the face of the die block at the rear of the feed head is incapable of interfering with proper charging or wiping of the die block.

Suitable control means diagrammatically illustrated in Figure 9 is employed to automatically determine when the arcuate recesses in the feed head are to be subjected to pressure and vacuum during operation of the feed head, and in addition controls the charging of metal powder into the die cavity by the head and automatically governs reciprocation of the feed head mechanism between its operative charging and inoperative retracted positions.

As herein shown the hydraulic feed cylinder 45 for the feed slide 31 has its opposite ends selectively connectible with a source of hydraulic fluid under pressure through a four way hydraulic valve unit 110 by means of fluid ducts 111 and 112. Fluid under pressure entering the cylinder through the duct 112 effects advance of the feed head, while fluid entering the cylinder through the duct 111 effects retraction of the feed head.

The hydraulic valve unit 110 is of the electromagnetic type and has a pair of solenoids 113 and 114 for shifting the spool-like piston 115 of the valve in opposite directions from its neutral position shown at which it closes off the ducts 111 and 112 of the cylinder 45 to preclude the flow of fluid under pressure to the drive cylinder.

Energization of the solenoid 114 pushes the piston 115 of the valve to the right in the valve casing from its neutral position shown to connect the duct 111 of the cylinder 45 with a duct 116 leading from the outlet of a hydraulic pump 117 through the valve 110; while energization of the solenoid 113 pushes the piston 115 of the valve unit to the left from its neutral position to connect the duct 112 with the pressure duct 116 through the valve.

It is to be understood that the pump 117 is driven by a suitable electric motor 118 and that the inlet of the pump is communicated through a duct 119 with a fluid reservoir 120 to supply liquid to the pump.

When the hydraulic drive cylinder is connected with the source of fluid pressure by energization of the solenoid 114 as described, the plunger 44 of the cylinder is caused to travel to

the left as seen in the diagram and through its connection with the feed slide 31 effects retraction of the feed head assembly 30 from over the die cavity to an inoperative position disposed over the apron 32 (as shown in Figure 9).

Upon de-energization of the solenoid 114 and energization of the other solenoid 113 the spool-like piston of the valve 110 is shifted to the left from its neutral position indicated to disconnect the right hand end of the hydraulic cylinder 45 from the pressure outlet of the pump 116 and to connect the opposite or left hand end of the cylinder with the pressure outlet of the pump through the valve and the pressure duct 112 to produce the advancing stroke of the feed head.

In the present case energization and de-energization of the solenoids 113 and 114 is effected at the dictation of relays 121 and 122, respectively, for the solenoids.

Fluid return ducts 123 leading from the opposite ends of the four way valve unit 110 to the reservoir 120 enable the fluid exhausted from the hydraulic feed cylinder 45 by motion of its plunger to be conducted through one or the other of the ducts 111 or 112 to the reservoir through the valve unit 110 in an obvious manner.

One of the main features of the control system of this invention resides in the fact that it is adapted for automatic operation after each work cycle of the metal powder press to which the feed mechanism is attached.

Since the compressor and ejector cylinders 14 and 17 of the press are operated sequentially and the work cycle of the press customarily carried through automatically, the ejection of the compact after each pressing operation by the plunger of the ejector cylinder occurs substantially at the end of the work cycle of the press and the retraction of the plunger 16 of the ejector cylinder may be considered the final motion of the press to terminate the work cycle.

In the present case it is the final motion of the press as understood to be the retraction of the ejector plunger 16 to its position defining the bottom of the die cavity seen in the diagram which initiates the feed stroke and consequently the start of the cycle of operation of the feed head mechanism.

As seen in the diagram, the plunger 16 of the ejector cylinder carries an arm 125 medially pivoted from the plunger as at 126 to swing on a horizontal axis. The arm has its inner end adjacent to the plunger 16 weighted to normally rest against a collar 127 on the plunger and thereby hold the outer end of the arm in an extended substantially horizontal position in which it engages the actuator of an automatic start switch 128 and closes the switch on the down stroke of the ejector cylinder.

Engagement of the projecting end of the arm with the actuator of the automatic start switch 128 on the upward ejector stroke of the plunger 16 merely produces pivotal motion of the arm in a counterclockwise direction to cause it to ride over the switch actuator without closing the switch.

The contacts of the automatic start switch 128 when momentarily bridged in this manner establish an energizing circuit through the coil 130 of the relay 121 which upon closure effects energization of the feed solenoid 113 of the electromagnetic valve unit 110. This energizing circuit for the coil 130 leads from line L1 through a conductor 132 to one side of the switch 128 and through a conductor 133 leading from the other

side of the switch connects with one end of the coil 130 of the relay 121. A conductor 134 connects the other end of the coil 130 with the line L2 to complete the energizing circuit for the coil 130 thereby causing the relay 121 to close.

The relay 121 has two sets of stationary contacts 135 and 136 which are bridged upon energization of the coil 130 in the manner described. Bridging of the relay contacts 136 establishes a holding circuit for the relay 121, while bridging of the relay contacts 135 effects completion of an energizing circuit for the feed solenoid 113 of the electromagnetic valve unit 110 to move the spool-like plunger 115 of the unit to the left and thereby initiate the feed stroke of the feed head.

The energizing circuits for both of the valve solenoids 113 and 114, however, depend upon the positions of a pair of double-throw limit switches 139 and 140 mounted on the supporting bracket 24 near the rear thereof but at opposite sides of the bracket.

Each of these limit switches has a depressible plunger-like button 141 extending vertically upwardly therefrom so as to lie in the path of cams 143 and 144 adjustably carried by the feed head slide 31, and to be depressed by the cams in the operative charging and inoperative retracted positions of the feed head.

In order to provide for their adjustment, the cams 143 and 144 are mounted on blocks 145 slidably disposed in adjacent track-like grooves 146 in the top surface of the feed slide running longitudinally thereof. A clamping strip 147 screwed onto the feed slide and common to both grooves overhangs the grooves to exert clamping pressure on the inner portions of the blocks 145, while separate strips 148 screwed onto the slide 31 at opposite sides of the strip 147 engage and exert clamping pressure on the outer portions of the blocks 145.

In this manner, the blocks with cams attached can be individually adjusted to any desired position longitudinally of the feed slide merely by loosening the screws for the clamping strips and held in such position by the clamping strips 147 and 148 when the same are tightened down against the blocks.

For convenience, the limit switches have been shown upside down in the diagram with their contactors biased downwardly to remain in such positions unless actuated by the cams 143 and 144. It will be apparent, therefore, that the limit switches 139 and 140 may be employed to determine the magnitude of reciprocation of the feed head mechanism.

The cam 143 is so disposed longitudinally of the feed slide 31 that it engages and depresses the button of the switch 139 to move the contactor 151 of the switch out of its normal position against biasing force thereon tending to hold the same engaged with one set of stationary contacts 149 of the switch to an actuated position bridging the second set 150 of stationary contacts at the time the feed head reaches its desired charging position shown in Figures 1 and 2.

The cam 144 is so located on the feed slide that it engages and depresses the button of the switch 140 to move the contactor 154 of this switch out of its normal position against a biasing force thereon tending to hold the same engaged with one set of stationary contacts 152 of the switch to an actuated position bridging the second set 153 of stationary contacts of the switch at the time the feed head reaches its retracted position.

With the feed slide 31 in its inoperative re-

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tracted position shown in the diagram, the cam 143 is spaced from its limit switch 139 and consequently the contacts 149 of the switch are bridged by the contactor 151, while the contacts 150 are open. In the retracted position of the feed slide, however, the cam 144 is in engagement with the button of the limit switch 140 to hold its contactor 154 off the normally bridged contacts 152 and in bridging relationship with the normally open stationary contacts 153 of the switch.

It will be readily seen, therefore, that the holding circuit for the coil 130 of relay 121 and the energizing circuit for the feed solenoid 113 of the valve 110 can be completed only in the retracted position of the feed slide at which time the stationary contacts 149 of the limit switch 139 are bridged.

As will appear later, energization of the retracting solenoid 114 of the valve 110 by its relay 122 likewise depends upon bridging of the normally closed stationary contacts 152 of the limit switch 140, which condition obtains in all but the retracted position of the feed slide.

In the retracted position of the feed head shown in the diagram, therefore, the holding circuit for the coil of relay 121 leads through a conductor 156 connected with line L1, onto a conductor 157 joining one of the stationary contacts 153 with one of the stationary contacts 150 of the limit switches 140 and 139, respectively, and through a jumper 158 connecting the conductor 157 with the now bridged stationary contacts 149 of the switch 139, across the contactor 151 of the switch onto a conductor 159 connecting with one of each set of contacts 135 and 136 of relay 121, across the now bridged contacts 136 of the relay and onto the conductor 133 leading to one end of the coil 130, with the circuit through the coil completed by the conductor 134 joining the other end of the coil with the line L2.

Bridging of the stationary contacts 135 of the relay 121 effects energization of the feed solenoid 113 of the valve unit 110 by a circuit leading from line L1 and including the conductors 156, 157, 158, the bridged contacts 149 of the limit switch 139, conductor 159, the now bridged contacts 135 of relay 121, a conductor 160 leading to one end of the solenoid 113, and a conductor 161 leading from the opposite end of the solenoid 113 to line L2.

The plunger 115 of the valve 110 is thus caused to be moved to the left from its neutral position indicated to connect the hydraulic feed cylinder 45 with the outlet of the pump 116 through the duct 112 producing the advancing stroke of the feed head.

The feed head is advanced by the cylinder 45 until the head is brought to its operative charging position centered over the die cavity, at which time the cam 143 on the feed slide depresses the button of the limit switch 139 to open the stationary contacts 149 thereof and effect bridging of the stationary contacts 150 of the switch.

Since the stationary contacts 149 of the limit switch 139 are connected in the holding circuit for the relay 121 as well as the energizing circuit for the solenoid 113 of the electromagnetic valve unit 110, actuation of the limit switch by the cam 143 in this manner immediately effects de-energization of the coil 130 causing the relay 121 to open and also effecting de-energization of the solenoid 113 for the electromagnetic valve unit 110.

Upon de-energization of the solenoid 113, the spool-like piston 115 of the valve returns to its

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neutral position to which it is biased closing the valve ports leading to the ducts 111 and 112 thereby shutting off the hydraulic cylinder 45 from the source of pressure and causing the feed head to remain in its operative position centered over the die cavity 13.

The feed head remains in this position while the die cavity is charged with metal powder during which time the various passages and chambers in the head are subjected to air or gas pressure or vacuum for the control of the charging operation.

Powder metal is delivered to the interior of the feed head for injection into the die cavity upon bridging of the normally opened contacts 150 of the limit switch 139 at the time the feed head reaches its operative position centered over the die cavity. When the contacts 150 are thus bridged, an energizing circuit is completed for the electromagnetic valve V1 located in the hose line 61 between the source of air or gas under pressure and the metal powder hopper 62 so as to cause the valve to open. Air or gas flowing through the hose 61 toward the feed head draws metal powder from the hopper and such powder becomes entrained in the air or gas stream to be delivered to the feed head thereby.

The energizing circuit for the solenoid of the valve V1 leads through the now closed contacts 150 of the limit switch 139 from the conductors 157 and 156 joined to line L1, and includes a conductor 170 which joins with a conductor 171 connecting one end of the coils of a pair of time delay relays 172 and 173, continues through the contactor 174 of the relay 172 onto a conductor 175 which leads to one side of the solenoid for valve V1, and is completed from the other side of said solenoid by a conductor 176 and a conductor 177 joined thereto and leading to line L2.

At the same time that bridging of the contacts 150 of the limit switch 139 effects delivery of metal powder entrained in air or gas under pressure to the interior of the feed head to be blown thereby into the die cavity, energizing circuits are established for the solenoids of electromagnetic valves V4 and V5 in the hose lines 92 and 94, respectively, to cause said valves to open.

Opening of the valve V5 connects the vacuum recess 74 at the front of the head with the source of vacuum through the hose line 94, while opening of the valve V4 connects the pressure recess 75 at the front of the head with the source of air or gas under pressure through the hose line 92. The solenoids of the valves V4 and V5 have one end thereof connected direct to line L2, and are energized by bridging of the contacts 150 by means of conductors 180 joined to the conductor 170 leading through the limit switch 139 to line L1.

The vacuum and pressure recesses 78 and 79, respectively, at the rear of the feed head remain connected with their sources of vacuum and air or gas under pressure, respectively, at all times during operation of the feed mechanism, and for this purpose manual valves 187 and 188 are placed in the hose lines 100 and 97, respectively. The valves 187 and 188 are adapted to be opened and left open whenever the feed head mechanism is placed in use.

As will be apparent from the diagram, bridging of the contacts 150 of the limit switch 139 at the time the feed head reaches its operative position also completes the energizing circuits to both time delay relays 172 and 173. As already stated, one end of the coil for each of these re-

lays is connected to conductor 170 leading to line L1 through limit switch 139, and conductors 178 and 179 joining the other ends of the coils of relays 172 and 173 with line L2 completes the circuits for the relays. Bridging of contacts 150 of limit switch 139, therefore, starts the time delay periods for the two relays 172 and 173.

It is to be understood that although the energizing circuits for relays 172 and 173 have been described as being completed at this time these relays have characteristics which prevent response of their contactors except after a suitable and adjustable time delay period.

As noted previously, the contactor 174 for the time delay relay 172 is connected to conductor 171, and in its normally open position engages a stationary contact 181 to which conductor 175 connects, as shown, to complete the energizing circuit for the solenoid of the valve V1 concomitantly with bridging of the stationary contacts 150 of the limit switch 139. The contactor 174 of relay 172 remains in its normally open position maintaining the valve V1 open to effect injection of metal powder into the die cavity until the expiration of the time delay period, which is set for a duration such as to insure complete filling of the die cavity with metal powder.

Concomitantly with energization of the solenoid of the powder feed valve V1 an energizing circuit is likewise established to the solenoid of the electromagnetic valve V2 in the branch 73' of hose line 73 leading to the recess 55 above the screen in the interior of the feed head to connect the recess with the source of air or gas under pressure.

The solenoid of the electromagnetic valve V2 is connected in parallel with the solenoid of the valve V1 across the conductors 175 and 176 which lead to lines L1 and L2, respectively, in an obvious manner. Consequently, the recess 55 is subjected to pressure during the time metal powder is delivered to the feed head to facilitate injection of the powder into the die cavity.

After a suitable period during which metal powder blows from the feed head into the die cavity and of sufficient duration to insure complete filling of the cavity, the delay period of relay 172 expires and its contactor 174 responds by swinging out of engagement with respect to contact 181 and into engagement with a second stationary contact 182. Separation of contactor 174 from contact 181 effects de-energization and consequently closure of the metal powder feed valve V1 and also closure of valve V2 to terminate the powder injection and shut off the pressure to recess 55 in the head.

Since one end of the coil of valve V3 is connected direct to line L2 as indicated, engagement of the contactor 174 with the stationary contact 182 of the time delay relay 172 at the expiration of the time delay period then connects the other end of the coil of the electromagnetic valve V3 with the conductor 170 leading to line L1 by means of a conductor 193 to energize and open the valve V3.

The valve V3 is located in the second branch 73'' of the hose line 73 leading to the recess 55 in the upper head casting 52 and when opened in the manner described connects the recess 55 above screen 56 with the source of vacuum. Hence, the entire interior of the feed head as well as the die cavity is placed under vacuum at the completion of the powder injection period to effect extraction of any air or inert gas which

may have become trapped in the die cavity by the filling operation and to enable the metal powder in the cavity to settle to a uniform density desirable for the cold pressing operation.

The screen 56 separating the recess 55 from the remainder of the hollow interior of the feed head at this time precludes the passage of any metal powder upwardly into the recess 55.

After subsection of the interior of the feed head to vacuum for a short period of time determined by the setting of the time delay period of relay 173, the relay 173 closes so that its contactor 195 swings from an inoperative position into engagement with a stationary contact 196 of the relay. Closure of the time delay relay 173 in this manner effects energization of the coil 155 of relay 122 governing energization of the retracting solenoid 114 of the valve unit 110.

The coil 155 of the relay 122 is energized upon closure of the time delay relay 173 by a circuit leading from line L1 and including conductors 156, 157 and the bridged contacts 150 of limit switch 139, conductor 170 and a branch 197 thereof leading to the stationary contact 196 of the relay and across the contactor 195 engaging said stationary contact, a conductor 198 leading from the contactor 195 to one side of the coil 155 of relay 122, and a conductor 199 connecting the other side of the coil with line L2.

The relay 122 has two sets of normally open stationary contacts 200 and 201 both of which are bridged upon energization of the coil 155. Bridging of the stationary contacts 200 establishes a holding circuit for the coil of relay 122 leading from line L1 and including conductor 156, the now bridged stationary contacts 152 of the limit switch 140, a conductor 203 leading from the limit switch 140 to the now bridged stationary contacts 200 of relay 122, with the circuit continuing across the contacts 200 to the conductor 198 leading to one side of the coil 155, and from the other side of the coil to line L2 through the conductor 199.

Bridging of the stationary contacts 201 of the relay 122 connects the retracting solenoid 114 of the valve unit across the lines L1 and L2 through conductor 156, the now bridged contacts 152 of the limit switch 140, the bridged contacts 201 of the relay 122, and a conductor 205 connecting with line L2.

Energization of the solenoid 114 pushes the piston 115 of the valve unit 110 to the right from its neutral position seen in the diagram, to connect the pressure outlet of the hydraulic pump 117 with the duct 111 leading to the right hand end of the cylinder 45 through the valve 110 to produce the return or retracting stroke of the feed slide.

Upon initial retracting motion of the feed slide the cam 143 is carried away from the button of limit switch 139 to cause the contactor 151 of the switch to leave the stationary contacts 150 and re-engage the stationary contacts 149 of the switch in response to the biasing force on the contactor.

During the start of the return stroke of the feed slide, therefore, the contacts 150 of the limit switch 139 are opened and such opening of these contacts disrupts the energizing circuits to the electromagnetic valves V4 and V5 causing the same to close. Closure of the valve V4 shuts off the pressure to the recess 75 in the front of the feed head, while closure of the valve V5 shuts off the vacuum to the recess 74 at the front of the head.

Disconnection of these chambers at the front of the head from their sources of vacuum and pressure is necessary to prevent disturbing the metal powder injected into the die cavity at the time the front portion of the head travels over the die cavity in the retraction stroke of the feed slide.

In order to effect cleaning off of the surface of the die block in front of the die cavity, however, the cam 143 is designed to hold the button of switch 139 depressed for a short time at the start of the retracting stroke of the feed head but clears the button of the switch just before the annular vacuum port 89 reaches the edge of the die cavity 13 adjacent thereto. Hence, the metal powder lying on the die block between the die cavity and the front of the head is stirred up by the discharge of air or gas under pressure from the nozzles 86 and drawn into the vacuum recess 74 through the annular vacuum port 89 during rearward travel of the front portion of the head toward the die cavity.

The metal powder lying on the top of the die block rearwardly of the die cavity as well as any excess over the die cavity itself is carried rearwardly over the block to the apron behind the block by the wiping action of the resilient sealing gasket 68, to be stirred up by nozzles 86 and drawn off by the vacuum through port 89 at the back of the feed head during the next feed stroke of the head, it being recalled that the pressure and vacuum for the rear recesses in the head remain on at all times.

Separation of the contacts 150 of the limit switch 139 upon initial retracting motion of the feed slide also disrupts the energizing circuits for the time delay relays 172 and 173 which immediately de-energize to effect return of their contactors 174 and 195, respectively, to their normal positions shown in the diagram.

Separation of the contactor 174 from the stationary contact 182 of the time delay relay 172 at this time effects de-energization of the solenoid of the vacuum valve V3 thereby disconnecting the recess 55 in the center of the upper head casting 52 from its source of vacuum, and re-engages the contactor 174 with its stationary contact 181 so that the relay is reset and capable of completing the energizing circuits to the valves V1 and V2 controlling the injection of metal powder into the interior of the feed head and the pressure through the top center of the head upon subsequent closure or bridging of the stationary contacts 150 the next time the feed head is advanced to its operative position.

It is to be understood, of course, that energization of the solenoids V1 and V2 depend upon bridging of the contacts 150 as well as engagement of the contactor 174 with its stationary contact 181 of relay 172.

The solenoid 114 controlling retraction of the feed head effects complete retraction of the feed head, and the retracting stroke of the slide 31 is terminated upon depression of the button of limit switch 140 by the cam 144 on the feed slide to separate the contactor 154 of the switch from its stationary contacts 152 and to bring the contactor into bridging relationship with the stationary contacts 153 of the switch.

Since the holding circuit for relay 122 controlling energization of the retracting solenoid 114 depends upon bridging of contacts 152 of limit switch 140, the relay 122 is immediately deenergized by return of the feed head to its retracted position causing deenergization of solenoid 114

and return of the spool-like piston 115 of the valve unit to its neutral position.

As stated previously, the piston 115 of the valve unit when in its neutral position entirely disconnects the hydraulic drive cylinder 45 from the source of fluid pressure and consequently the feed slide comes to rest with the button of limit switch 140 held depressed and the contacts 153 of the switch bridged by the contactor 154.

One of the features of the electrical control system of this invention resides in the fact that it is possible to effect initiation of the work cycle of the metal powder press at the time the feed head is brought to its fully retracted position, and this may be accomplished by bridging of the contacts 153 of the limit switch 140.

It will be noted that the compressor cylinder 14 of the press is shown provided with an electromagnetic valve unit 210 similar to the valve unit 110 controlling the drive cylinder 45. The valve unit 210 is provided with pressing and retracting solenoids 211 and 212, respectively, by which the opposite ends of the cylinder are connected with a source of fluid under pressure through the valve to successively produce the pressure and retracting strokes of the plunger 15 of the cylinder. This control mechanism is usually standard equipment on many metal powder presses and hence forms no part of the present invention.

As indicated in the diagram, however, energization of the solenoid 211 is adapted to connect the upper end of the cylinder 14 with a source of fluid under pressure and consequently produce the downward compression stroke of the plunger 15 which enters the die cavity and compacts the powder therein against the upper end of the plunger 16 of the ejector cylinder.

While both solenoids 211 and 212 for the valve unit 210 are customarily provided with control relays, only one such relay 214 has been illustrated. This relay forms part of the control system of this invention and is adapted to be energized to initiate the work cycle of the press.

The energizing circuit for the solenoid of the relay 214 leads from line L1 through conductors 156 and 157 across the contactor 154 of the limit switch 140 which is in bridging engagement with the contacts 153 of the switch and onto a conductor 216 leading to one side of the coil for relay 214, with the circuit completed from the other side of the coil to line L2 through a conductor 217.

The relay 214 has two sets of stationary contacts 218 and 219 both of which are bridged upon energization of the coil of the relay in the described manner. One of the set of stationary contacts 219 leads to line L1 through a conductor 222 while the other connects with the conductor 216 through a conductor 221 which also joins with one of the set of stationary contacts 218 of the switch.

Bridging of the contacts 219 thus establishes a holding circuit for the coil of relay 214 leading from line L1 through conductor 222 and the bridged contacts 219 onto the conductor 221 which leads through the coil of the relay and to line L2 through the conductor 217.

Bridging of the contacts 218 of the relay 214 establishes an energizing circuit for the presser solenoid 211 of the valve unit 210 leading from line L1 through the conductor 222 and serially through both sets of bridged contacts 219 and 218, onto a conductor 223 connecting with one side of the solenoid 211, and through a conductor

224 connecting with the opposite side of the solenoid 211 to line L2.

It is to be understood that the work cycle of the press is carried out automatically by control instrumentalities part of which, indicated at 225, disrupt the holding circuit for the coil of relay 214 after completion of the compression stroke by the plunger 15 of the compressor cylinder, and effect energization of the retracting solenoid 212 for the valve unit 210. These control instrumentalities form no part of the present invention inasmuch as they may be considered standard equipment on the press.

It is sufficient to note that bridging of the stationary contacts 218 of relay 214 at the time of bridging of the stationary contacts 153 of the limit switch 140 effects energization of the coil 211 of the hydraulic valve unit 210 to initiate the pressing cycle.

After ejection of the metal compact by the plunger 16 of the ejector cylinder 17, the electrical control instrumentalities with which the press is provided effect retraction of the plunger of the ejector cylinder and return the same to its lowermost position forming the bottom of the die cavity, and this lowering motion of the plunger 16 may be considered as the final motion of the press.

As stated previously, the final motion of the press is utilized in the present control system to effect momentary closure of the automatic start switch 128 by the arm 125 carried by the plunger 16 of the ejector cylinder 17 so that the next cycle of operation of the feed head is commenced immediately upon retraction of the plunger 16 to its lowermost position.

One cycle of operation of the feed head may be briefly described as follows. The impulse resulting from momentary closure of the automatic start switch 128 operated by the last motion of the sequence of motions of the metal powder press effects energization of relay 121 through the closed contacts 149 of the limit switch 139.

Closure of the relay 121 effects energization of the feed solenoid 113 of the four way hydraulic valve unit 110 causing the feed cylinder to advance the feed head to a position centered over the die cavity 13 and determined by depression of the button of limit switch 139 by the cam 143.

This effects de-energization of relay 121 and the feed solenoid 113 of the valve unit so that the feed head remains stationary over the die cavity, and makes contact in both time delay relays 172 and 173 thereby starting the aforementioned time delay periods.

Depression of the push button of limit switch 139 to bridge its contacts 150 also effects energization of vacuum control valve V5 and pressure control valve V4 both of which lead to the recesses at the front of the feed head.

Concomitantly with bridging of the contacts 150 of the limit switch 139 the solenoids of valves V1 and V2 controlling the delivery of metal powder to the interior of the feed head and the air or gas pressure to the recess 55 in the center of the upper feed head casting 52, respectively, are energized to effect controlled injection of metal powder into the die cavity.

At the end of the time delay period of relay 172, the valves V1 and V2 are closed and the solenoid for valve V3 energized to subject the interior of the feed head to vacuum.

At the expiration of the time delay period for relay 173 the relay operates to effect closure of relay 122 and the energization of solenoid 114

producing the retracting stroke of the feed head. As the head starts to travel toward its retracted position limit switch 139 is reset breaking the energizing circuits for vacuum and pressure valves V5 and V4.

When the feed slide reaches the end of its return stroke, the cam 144 thereon depresses the button of limit switch 140, effecting de-energization of solenoid 114 to terminate the retracting stroke, and also effects initiation of the work cycle of the press by causing relay 214 controlling energization of the presser solenoid 211 on valve unit 210 to close.

The manually operated valves 187 and 188 controlling vacuum and pressure to the rear recesses in the feed head remain open all of the time to cooperate with the sealing gasket in cleaning surplus powder off the surface of the die block.

From the foregoing description taken in connection with the accompanying drawings, it will be readily apparent that the feed mechanism of this invention and the control system therefor operates in an entirely automatic manner to effect a more speedy and efficient charging of the die cavity of a metal powder press after each work cycle of the press.

What I claim as my invention is:

1. A feed nozzle for filling a cavity with powdered material, comprising: a head having an outlet opening at its bottom leading from a chamber in the interior of the head; the head having an inlet passage leading to said chamber and through which powdered material entrained in gas may be delivered to said chamber for discharge through the outlet opening in the bottom of the head; a gasket carried by and projecting from the bottom of the head and encircling the outlet opening therein, said gasket providing a substantially air-tight seal between the bottom of the head and a surface upon which the head is positioned to form an enclosed space for connecting the mouth of the outlet opening with the mouth of a cavity opening to said surface; and the head having an exhaust passage communicating with said space circumscribed by the gasket to vent the same during the charging of powdered material into the cavity.

2. A feed nozzle for injecting powdered material into a cavity which opens to a surface, comprising: a head having an outlet opening in its bottom leading from a chamber in the interior of the head; the head having an inlet passage leading to said chamber and through which powdered material entrained in gas may be delivered to said chamber for discharge through said outlet opening in the bottom of the head; an apertured distributing disc disposed across said outlet opening; a gasket on the head projecting from the bottom thereof and encircling said distributing disc so that upon placement of the head on said surface with the distributing disc over the mouth of the cavity, the gasket together with the bottom of the head and said surface defines a substantially air-tight space connecting the outlet opening in the head with the mouth of the cavity; and means defining an exhaust passage in the head communicating with said space circumscribed by the gasket to provide a vent for the release of gas entering said space during the filling of the cavity.

3. The feed nozzle of claim 2 further characterized by the fact that said gasket is spaced from the periphery of the outlet opening in the bottom of the head; and further by the fact that

the mouth of the exhaust passage extends substantially completely around the outlet opening and opens to the bottom of the head between the periphery of the outlet opening and the gasket.

4. A feed nozzle for filling a cavity with powdered material, comprising: a head having a central chamber in its interior; means defining a discharge passage leading from said chamber, the mouth of said passage opening to the bottom of the head; means defining an inlet passage leading to said chamber through which powdered material entrained in gas may be fed to the chamber for discharge from the bottom of the head; a gasket secured to the underside of the head and completely surrounding the mouth of the discharge passage in spaced relation to its periphery, said gasket projecting from the bottom of the head so that upon positioning the head upon a surface to which the mouth of the cavity opens, the bottom of the head is spaced above said surface and a substantially air-tight space is provided connecting the mouth of the discharge passage with the mouth of the cavity; and means defining inner and outer chambers in the head encircling the mouth of the discharge passage with the innermost of said chambers communicating directly with said space circumscribed by the gasket but near the periphery of the mouth of the discharge passage, and the outermost of said chambers having communication with said

space through ports opening to the bottom of the head near the gasket and pointing inwardly toward the mouth of the discharge passage so that gas under pressure issuing from said ports tends to blow powdered material accumulated on the supporting surface toward the mouth of the discharge passage and whereby suction in the innermost of said chambers draws off such powdered material blown inwardly as well as the gas issuing from the mouth of the discharge passage during filling of the cavity with powdered material.

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