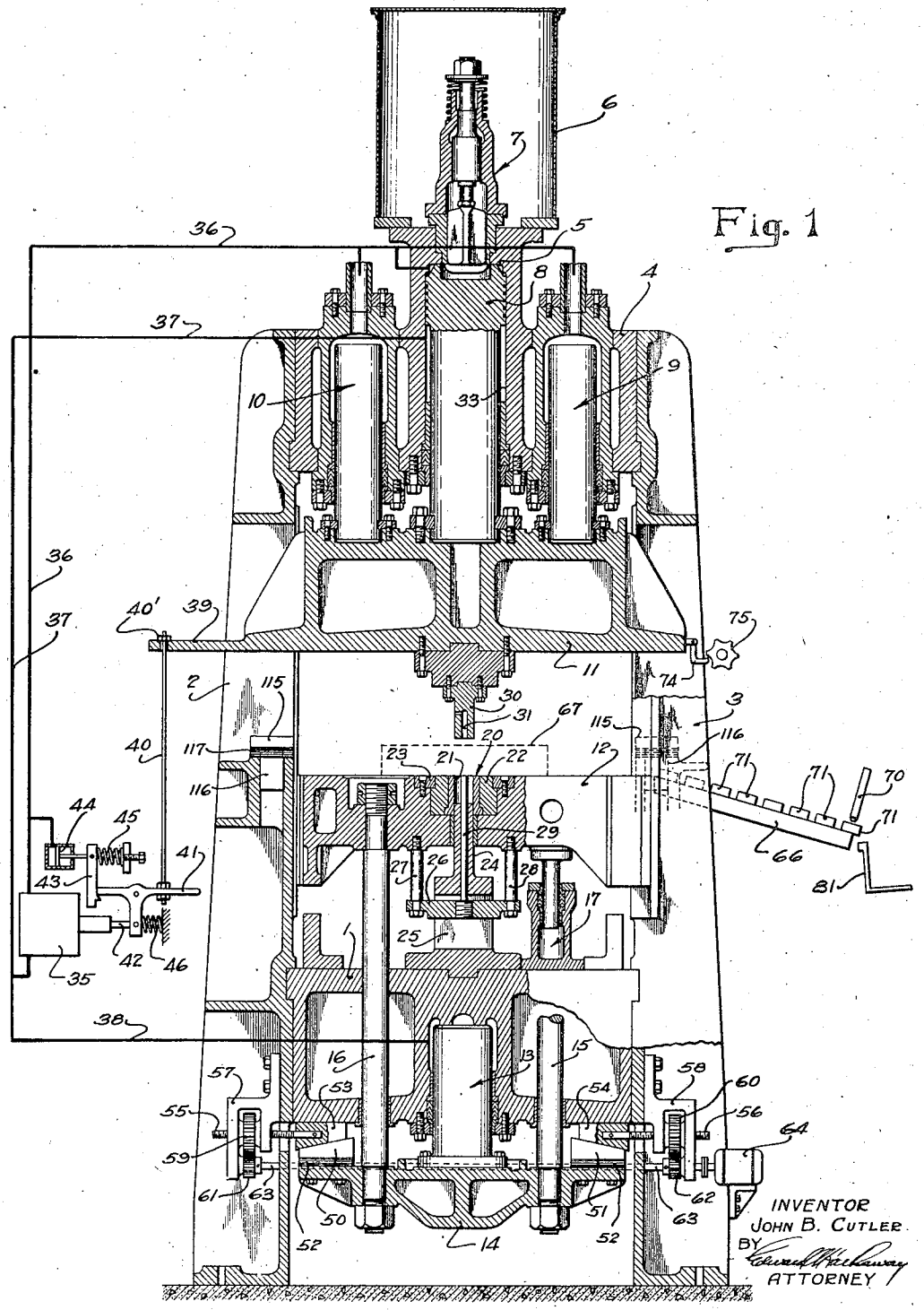
Jan. 4, 1944. J. B. CUTLER 2,338,491

POWDERED MATERIAL PRESS AND CONTROL

Filed Jan. 2, 1941 2 Sheets-Sheet 1

Fig. 1



INVENTOR
JOHN B. CUTLER
BY
ATTORNEY

Jan. 4, 1944. J. B. CUTLER 2,338,491

POWDERED MATERIAL PRESS AND CONTROL

Filed Jan. 2, 1941 2 Sheets-Sheet 2

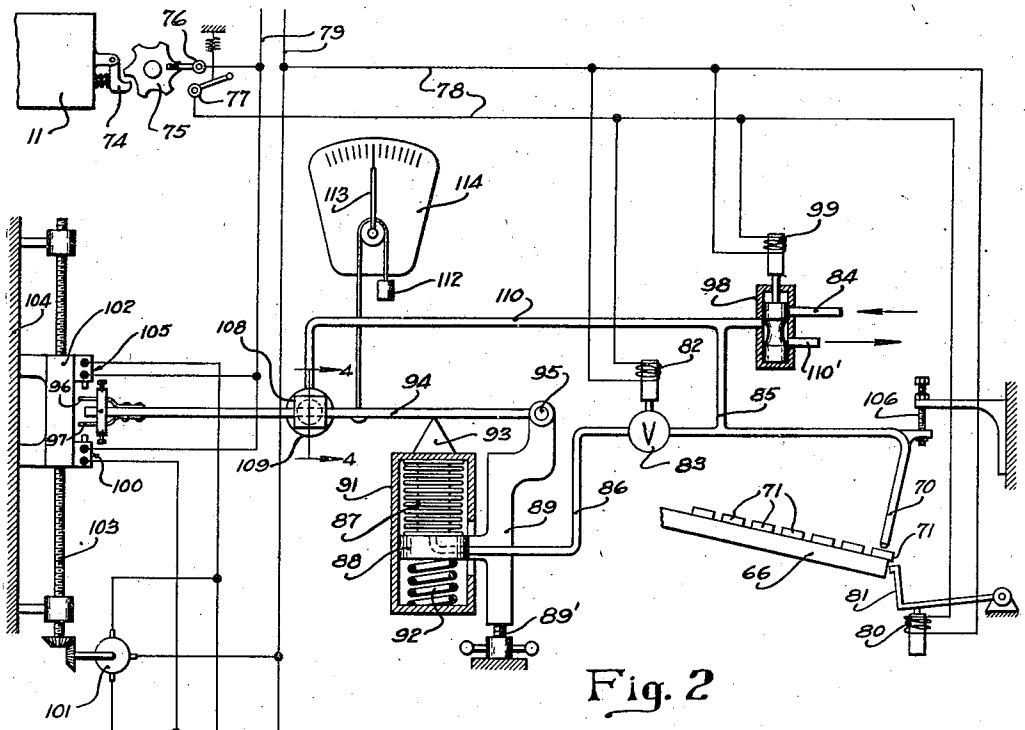
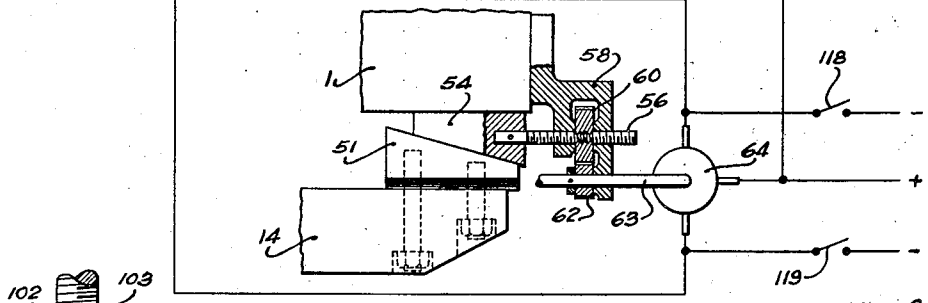


Fig. 2



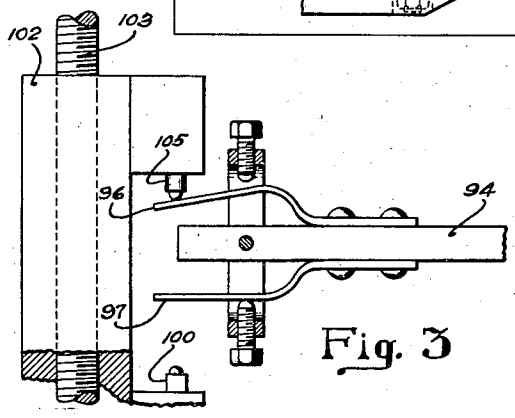


Fig. 3

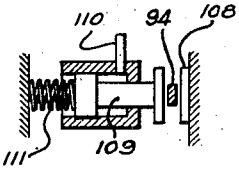


Fig. 4

INVENTOR
JOHN B. CUTLER
BY
ATTORNEY

Patented Jan. 4, 1944

2,338,491

UNITED STATES PATENT OFFICE

2,338,491

POWDERED MATERIAL PRESS AND CONTROL

John B. Cutler, Haddon Heights, N. J., assignor to The Baldwin Locomotive Works, a corporation of Pennsylvania

Application January 2, 1941, Serial No. 372,782

11 Claims. (Cl. 18—16)

This invention relates generally to presses for forming products from powdered material and particularly to means for controlling both the density and size of pieces produced.

Products of powdered material are formed by filling a mold cavity with finely powdered metal or other material and then compressing the powder to a cohesive state by a plunger. Machines for this general purpose are very old but they have not been capable of producing products under large pressures within precision limits as to dimensions and/or density. The problem of providing a machine capable of such precision operation becomes especially difficult when it is attempted to have the press produce the articles rapidly and particularly when the articles require exceptionally large compressive forming forces. My invention is particularly applicable to powdered metals although other kinds and forms of loose materials may be used and also in the preferred specific embodiment of the invention I employ a hydraulic press although certain features of my invention are applicable to mechanical presses as well.

It is an object of my invention to provide improved means for forming products from loose material with a high degree of dimensional accuracy. It is also an object to provide improved means for controlling the density of the products, especially while maintaining the desired dimensional accuracy of the products.

A further object is to provide an improved press and control therefor whereby precision operation is capable of being obtained under large compressive forces which with my improved apparatus may be upwards of 200,000 or 300,000 pounds.

A further object is to provide improved means for accomplishing density and/or dimensional control automatically during operation of the equipment.

A still further object is to provide a hydraulically operated press with improved means for controlling the press operation so as to obtain the desired dimensional control over the products.

A further object is to provide an improved apparatus that is economical in operation and maintenance and is durable and rugged combined with a positive and yet sensitive operation so as to produce products having a very substantial degree of uniform accuracy as to density and dimensions.

Other objects and advantages will be more apparent to those skilled in the art from the following description of the accompanying drawings in which:

Fig. 1 is a vertical section through a hydraulic press embodying a portion of my improved apparatus;

Fig. 2 is a combined wiring and mechanical diagram of the control apparatus;

Fig. 3 is an enlarged view of certain electrical contacts for determining the tolerance limits within which the products may fall; and

Fig. 4 is a section taken on line 4—4 of Fig. 2.

In the particular embodiment of the invention such as is disclosed herein merely for the purpose of illustrating one specific form among possible others that the invention might take in practice, I have shown in Fig. 1 a hydraulic press having a lower stationary crosshead 1 supported by side columns 2 and 3 which carry an upper stationary crosshead 4. As is usual in hydraulic presses a main cylinder 5, formed in crosshead 4, supports a filling tank 6 from which oil or other suitable liquid under low pressure flows through a filling valve 7, of well-known form and operates, to cylinder 5 during downward movement of a main ram 8. If desired, a pair of additional rams and cylinders generally indicated at 9 and 10 may be employed, all of the rams being suitably connected to an upper movable platen 11 which is guided by the side columns 2 and 3. A lower movable platen 12 is also guided by side columns 2 and 3 and is moved downwardly by a ram and cylinder generally indicated at 13, the cylinder being formed in lower crosshead 1. The ram is connected by a lower movable crosshead 14 to side rods 15 and 16 which are connected to the piston 12. The platen 12 is normally biased upwardly by one or more small constant pressure pushback rams and cylinders such as generally indicated at 17. The press structure so far described is of well-known construction and hence further detailed description is not necessary.

To form a powdered product a die mold generally indicated at 20 is positioned within a suitable recess in platen 12. This mold is specifically shown as having an inner annular wall 21 which specifically forms the mold cavity while an outer relatively thick annular band 22 is shrunk on to the die mold 20. This shrinking operation causes the die 20 to be preloaded under compression stress, thus preventing or minimizing expansion of the die under load and thereby maintaining a high degree of radial dimension of the product. The foregoing novel preshrunk die structure is held in position by a

usual annular keeper ring 23 suitably screwed to the platen 12.

A stationary plunger 24 extends through the under side of platen 12 into the mold cavity and conforms to the cross-sectiontal shape thereof. The die shape may be such that it has a smooth periphery so as to form bushings or the like or it may have gear teeth to form gears, etc. The plunger 24 is supported upon stationary crosshead 1 and has a vertical slot 25 through which a crosshead 26 extends for connection to platen 12 by rods 27 and 28. If the products such as bushings, gears or the like require a coaxial hole a pin 29 may be removably threadedly secured to crosshead 26 and extend upwardly through stationary plunger 24 into die 21. A movable compressing plunger 30, carried by upper platen 11, has the same conformation as die 21 and also has a suitably vented central bore 31 to receive core pin 29.

To form a product, powdered metal or other material is poured in any usual manner into the mold cavity around the core pin 29 and excess powder is swept off by a usual well-known sweeper arm on the usual feed box. The powder remaining in the mold will be level with the top thereof. Platen 11 is then moved downwardly under hydraulic pressure to force plunger 30 into the mold cavity. When the product is fully compressed the platen 11 is raised by supplying hydraulic pressure to the cylinder space 33 beneath differential piston 8. The product is ejected by supplying fluid pressure to cylinder 13 thereby moving platen 12 and its mold 20 downwardly over the product which rests on stationary plunger 24. It will be understood that during the compression stroke the increasing compressing pressure on the powdered metal causes the frictional contact between the powdered metal and the mold wall to increase and this friction causes platen 12 to yield downwardly against the constant pressure pushback plungers and cylinders 17. This yielding of the platen 12 under the foregoing friction load effects what is known as a floating mold action. This allows the frictional resistance to be less than if the mold remains stationary. In my present invention I provide improved means adapted to variably cooperate with the floating action so as to dimensionally control the products while at the same time obtaining complete freedom of operation of the floating action and also obtaining uniform density of products even though accompanied by the variable dimensional control.

The foregoing cooperative relation is of such a character that I am able to employ therewith improved means for initiating and controlling the actuation of the dimensional control mechanism in response to the dimensions of products ejected from the press.

In many instances in the past it has been proposed to control the dimensions of a product by employing presses having only a fixed stroke for the compressing plunger and then adjusting the depth of the mold whereby more powdered material could be added to increase the axial dimension of the product. However, this involved disadvantages among which is that succesisve products would not necessarily have uniform density. It must be understood that the granules of powdered metal are not of uniform size and hence from one operation to another the depth of the mold cavity may have to be changed to compensate for the varying granule sizes. This operation, however, has heretofore been accompanied by a variable density of the successive products because the density finally obtained was dependent upon the volume of powdered metal and the fixed stroke of the compressing plunger. In my improved arrangement the plunger 30 is adapted to have a variable stroke controlled solely by the density of the individual articles thereby allowing the density of the product to be substantially independent of the quantity of powdered metal within the mold. By utilizing this characteristic I am able to freely adjust the mold platen to obtain dimensional control without sacrifice of density control.

To obtain densification control I preferably employ means responsive to the actuating force applied to the plunger 30 specifically by determining the hydraulic pressure in cylinder 5. When this pressure reaches a predetermined value the supply of hydraulic pressure is discontinued and the plunger 30 is returned upwardly. Hence, the plunger will continue downwardly until the main cylinder pressure reaches a predetermined densifying value, the stroke therefore not being of fixed length. One form of mechanism capable of accomplishing the foregoing densifying control is diagrammatically indicated in Fig. 1 wherein a postive displacement piston pump 35 of the reversible Hele-Shaw type is connected in a usual manner by pipes 36 to the cylinders 5, 9 and 10 and by pipes 37 to the pullback end 33 of cylinder 5 and by pipes 38 to the stripping cylinder 13. Usual valves to compensate for the differential fluid volume to the respective cylinders during up and down operations of their rams are omitted for the sake of simplicity, although such devices are well-known in the art. When the platen 11 is in its uppermost position its arm 39 holds a rod 40 and bell crank 41 in the position shown in Fig. 1 whereby the usual pump control rod 42 shifts the pump substantially to its neutral position. To initiate the down stroke the operator manually rotates the bell crank in the counterclockwise direction until engaged and held by a latch 43. Such counterclockwise movement shifts the pump forwardly to discharge fluid through pipe 36 to the cylinders 5, 9 and 10 and to draw fluid from the pipes 37 and 38. As the plunger engages the powdered metal in mold 21 the pump pressure builds up in the main cylinders and when this pressure reaches a predetermined densifying value a piston 44 is moved against an adjustable spring 45 to release latch 43 whereupon a compression spring 46 shifts the pump through its stem 42 to a reversing position so as to supply fluid through pipe 37 to the differential cylinder end 33 and also through pipe 38 to the stripping cylinder 13 thereby moving platen 12 downwardly to eject the formed product from mold 21. When the press returns to near its upper position it engages nut 40' to lift rod 40 and return the pump to neutral. If desired, the press operations may be continuously repeated without stopping by employing any well-known repeating cycle control. However, for purposes of my invention in regard to the densifying operation the above single stroke operation will suffice.

The dimensional control mechanism comprises, in one specific form of the invention, a pair of wedge seat members 50 and 51, Fig. 1, bolted or otherwise suitably secured to crosshead 14 and which, if necessary, may be suitably shimmed as indicated at 52. Wedge blocks 53 and 54 are interposed between the seats 50 and 51 and the under surface of crosshead 1.

The wedges 53 and 54 are each provided with non-rotatable threaded shafts 55 and 56 guided in brackets 57 and 58 and have threaded engagement with gear nuts generally indicated at 59 and 60. To simultaneously drive the two gear nuts, a pair of pinions 61 and 62 are secured to a common pinion shaft 63 which is driven by a motor 64. By moving the wedge blocks 53 and 54 inwardly the upper movement of platen 12 is reduced and conversely by moving the wedges outwardly the platen 12 may move to a higher position. Increasing or decreasing vertical movement of platen 12 effects a corresponding increase or decrease of the volume of die 21 inasmuch as plunger 24 remains stationary. The cooperative relation of the wedge mechanism to the crosshead 14 is such that the wedges may be adjusted during continuous operation of the press without stopping the same thereby permitting adjustment between successive products or any selected group of products, this being accomplished while maintaining proper density control for the successive dimensionally controlled products.

The mechanism for automatically adjusting the dimensional control wedge mechanism in response to the successive products ejected from the machine comprises a usual discharge table 66 which is of any well-known form of construction and on to which the products are moved from platen 12 after being ejected from mold 21. There are many well-known devices for moving the ejected product from beneath the plunger 30 on to the discharge table 66 but inasmuch as such devices per se do not constitute part of my present invention it will suffice to diagrammatically indicate such a device by a dotted outline 67. The novel arrangement constituting the improved dimensional responsive means includes an air jet 70 disposed over the path of the discharged products 71. If the axial dimension or depth of the product 71 varies from a predetermined value, then a larger or smaller clearance as the case may be will occur between any given product and the jet orifice and the air pressure within the pipe of jet 70 will increase or decrease accordingly. I utilize the variations in the air pressure, resulting from varying dimensions of the product, to actuate the wedge motor 64 either forwardly or reversely as the case may require. It is also desirable to measure say only every sixth article thereby avoiding too frequent adjustment. To energize the control circuit in response to only a selected number of articles I provide a pawl 74 pivotally and yieldably supported on the platen 11 for actuating a ratchet 75 mounted on the press frame near the upper end of the platen stroke. Hence, as the platen moves upwardly on each stroke it will successively engage the ratchet teeth until finally an electrical contact 76 carried by the ratchet engages a contact 77 to energize a main control circuit 78 from the main line 79. The energized circuit 78 causes a solenoid 80 to raise a stop arm 81 into the path of articles 71 and accordingly stop the first article beneath jet 70. Simultaneously a solenoid 82 is energized to open a valve 83 thereby admitting air pressure from a suitable constant pressure source diagrammatically indicated at 84 through pipes 85 and 86 to a sylphon bellows 87. Supply pipe 84 is connected with pipe 85 simultaneously with the energization of solenoid 80 inasmuch as a valve 98 is raised by a solenoid 99 upon energization of the control circuit 78. The purpose of valve 98 will be explained later. The lower end of the bellows is secured to a stationary base 88 formed as a unitary part of a support 89 which is vertically adjustable by the screw 89'. The upper end of the bellows is secured to a container 91 which is biased downwardly by a spring 92. A fulcrum 93 engages a wedge arm 94 pivoted at 95 while the outer end of the arm carries a pair of resilient wedge actuating fingers 96 and 97.

Operation of dimensional control.—Assuming that the control apparatus is set for a predetermined dimension of the products 71, when the control circuit is energized by the pawl and ratchet control 74, 75 and 76 the valve 98 is raised and air pressure is supplied to jet 70. If the product 71 has a smaller dimension than desired the clearance between the top of the article and the jet orifice will be larger than normal and accordingly air pressure may flow more freely from the jet resulting in a corresponding drop of pressure in the jet pipe 70 below normal. This reduced jet pressure will disturb the normal balance between the force of spring 92 and the air pressure in bellows 87 and accordingly spring 92 will move container 92 downwardly to a point where a balance is obtained between the spring force and the bellows pressure. Movement of the container 91 downwardly causes wedge arms 94 to move downwardly about a pivot 95 thereby to permit finger 97 to close a micro-switch generally indicated at 100. Closure of the micro-switch establishes a circuit from the supply lines 79 to wedge operating motor 64 and also to a follow-up contact servo-motor 101. The wedge motor 64 causes the wedges to be moved outwardly thereby permitting the crosshead 14 and mold platen 12 to move to a higher position during the next operation. Such a higher position of the mold platen 12 increases the depth of the mold 21 above the top of stationary plunger 24 thereby to increase the axial dimension of the next formed product. To prevent overrunning of the wedge adjustment the follow-up motor 101 operates simultaneously with the wedge motor to adjust a block 102 downwardly, this block having threaded engagement with a screw 103 driven by motor 101. The block 102 is prevented from rotating by having slidable contact with a guide 104. When the block 102 has moved a predetermined distance the micro-switch 100 will move away from finger 97 and accordingly open the switch and thereby discontinue operation of the motor 101 and switch operating motor 64. The press will then make its next stroke and on its up stroke will rotate ratchet 75 so as to break engagement of contacts 76 and 77 thereby to deenergize the control circuit. Upon deenergization of the control circuit the valves 83 and 98 close and solenoid 80 is deenergized to allow stop arm 81 to drop out of the path of the articles thereby permitting the next series of articles to discharge freely from the conveyor 66. When the next predetermined number of articles, specifically shown herein as six, are formed, then the pawl and ratchet 74 and 75 will again reenergize the circuit. Stop arm 81 will be then moved in front of the first article and the air supply will be turned on. If the article is now of greater height than desired, then the clearance between the jet and article will be reduced below normal thereby restricting the flow of air from pipe 70 and accordingly cause an increase of pressure in the bellows with consequent raising of finger 73 and closure of micro-switch 105 by finger 96. Closure of this switch will reversely operate both the switch motor 64 and the follow-up motor 101. The wedges will accordingly

be moved inwardly to decrease the effective length of the mold cavity while the block 102 will be moved upwardly until its switch 105 is opened. The sensitivity of the apparatus as well as the normal position of the jet 70 may be varied by an adjusting screw 106 which raises and lowers jet 70, the contact arm 94 being adjusted by screw 89'. The foregoing plus or minus adjustment of the mold cavity will be repeated as often as is necessary to maintain a uniform dimension and hence it is not necessary to repeat further the successive measuring and adjusting operations.

To stabilize the dimensional control apparatus in between successive measurements of the articles, the switch arm 94 is clamped as shown in Fig. 4 between a stationary back 108 and a spring pressed piston 109. This clamping action is released when valve 98 is raised by energization of solenoid 99 thereby supplying fluid pressure from pipe 84 to a pipe 110 for moving piston 109 outwardly against the spring 111. A small amount of clearance is permitted between the switch arm 94 and the plate 108 and piston 109 when the clamping pressure is released thereby avoiding friction on the switch arm. Conversely, when valve 98 is closed, then fluid pressure on piston 109 is exhausted through valve 98 and pipe 110' whereupon spring 111 clamps switch arm 94 between piston 109 and stationary back 108. To further sensitize the equipment arm 94 is provided with a counterweight 112 having a spring connection extending over a pulley of an indicator pointer 113 thereby to register on a dial 114 the extent of displacement of arm 94 from neutral.

In order to obtain dimensional control without automatic adjustment thereof, the circuit 79 will be disconnected and two adjustable stop pins 115 are placed on side columns 2 and 3 beneath upper platen 11 so as to limit downward movement thereof and thereby definitely establish a fixed dimension for the product. The pins have heads and shanks 116 slidably received in suitable vertical openings found in the side columns. Shims 117 may be inserted to obtain any desired dimension. This dimensional control may be accompanied by density control by manually controlling the adjustment of the wedge stops 53 and 54 through closing one or the other of reversing or forward switches 118 and 119 connected to a suitable source of current. This current actuates motor 64 and thereby adjusts the wedges 53 and 54 so as to adjust the height of the mold cavity 21 and accordingly determine the amount of fill and the density of the product. From this disclosure it is seen that during manual dimensional control through use of stops 115 the adjusting wedges perform a density control function but during automatic dimensional control the wedges perform a dimensional control function, the pins 115 are removed when the automatic dimensional control is employed. During automatic dimensional control, density control is obtained by controlling the hydraulic pressing fluid pressure. Also during automatic dimensional control the switches 118 and 119 permit a preliminary dimensional adjustment of wedges 53 and 54 while the air jet control effects a precision control.

From the foregoing disclosure it is seen that I have provided improved press equipment that is relatively simple and rugged combined with positive operation that has a high degree of sensitivity, accuracy and responsiveness in the production of powdered metal products. It is also seen that my improved automatic adjusting control effectively regulates the amount of fill and that this control is operative to measure finished pieces produced by the machine. Such automatic equipment may be used regardless of the character of material used or of the type of press in which the material is compressed, although in the specific aspect of my invention disclosed herein a hydraulic press is adapted in combination with the densifying responsive means to control the density of the products in cooperation with dimensional control thereof. The dimensional accuracy of the equipment is further enhanced by the cooperative action of the preshrunk ring 22 on the die mold 20 thereby maintaining the radial dimension of the article.

It will of course be understood that various changes in details of construction and arrangement of parts may be made by those skilled in the art without departing from the spirit of the invention as set forth in the appended claims.

I claim:

1. Apparatus for forming products of loose material comprising, in combination, a platen having a mold, means for adjusting the effective depth of said mold to control the axial dimension of a product formed therein, means for measuring the axial dimension of a product discharged from said mold, and means for automatically adjusting the depth of said mold in response to any variation of said axial dimension from a predetermined value.

2. The combination set forth in claim 1 further characterized by the provision of means whereby a given number of products less than the total produced are measured for control purposes.

3. The combination set forth in claim 1 further characterized in that the measuring means includes an air jet directed against a product with a predetermined clearance whereby any product whose dimension causes a variation in said clearance then said clearance will produce a corresponding change in jet pressure, and means responsive to the change in jet pressure from a predetermined value for adjusting the effective depth of the mold.

4. Apparatus for forming products of loose material comprising, in combination, a press having a platen mold, a compressing plunger, power operated means for adjusting the effective depth of the mold to vary the axial dimension of a product formed in the mold, means for measuring the axial dimension of a product discharged from the press, and means controlled by said measuring means for initiating operation of said power means.

5. The combination set forth in claim 4 further characterized in that said means which is responsive to the measuring means includes relatively movable cooperating elements which upon a predetermined movement of one of said elements effects said initiation of the power means, and means also initiated by said predetermined relative movement for causing actuation of the other of said elements until the initial relationship between the elements is re-established thereby to discontinue any further dimensional adjustment of the mold.

6. The combination set forth in claim 4 further characterized by the provision of means for adjusting the measuring means so as to establish a predetermined dimension for the products.

7. The combination set forth in claim 4 fur-

ther characterized in that said measuring means and dimensional adjusting means for the mold are rendered periodically operative automatically in accordance with the number of products produced.

8. The combination set forth in claim 4 further characterized in that said measuring means and said dimensional control means for the mold are controlled by an electrical circuit, and means actuated in accordance with a predetermined operation of the apparatus for controlling said circuit and thereby initiating the measuring operation.

9. Apparatus for forming products of loose material comprising, in combination, mechanism for forming the products including a mold and a plunger, means for adjusting said mechanism to vary a dimension of the products, means for measuring said dimension of the products after they are discharged from said forming mechanism, and means responsive to said measuring means for actuating said dimensional adjusting means when the dimension of the product varies from a predetermined value.

10. Apparatus for forming products of loose material comprising, in combination, a platen having a mold, means for adjusting the effective depth of said mold to control the axial dimension of a product formed therein, means for preliminarily actuating said adjusting means to bring the effective depth of said mold within predetermined axial limits, precision adjusting means for also actuating said adjusting means to vary the depth of said mold, means for measuring the axial dimension of a product discharged from said mold, and means for automatically rendering said precision adjusting means operative in response to said measuring means when the measurement varies from a predetermined value.

11. The combination set forth in claim 10 further characterized by the provision of means for indicating deviation of the dimension of the product from the desired predetermined value.

JOHN B. CUTLER.