

2,883,703

4 Sheets-Sheet 1

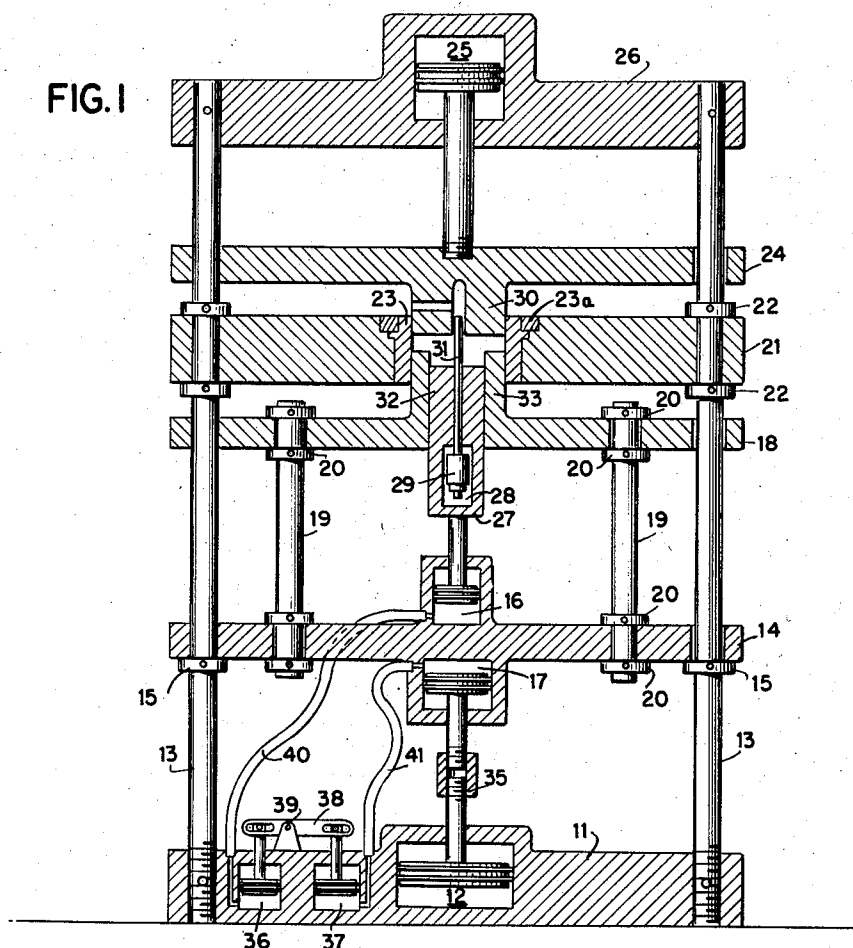
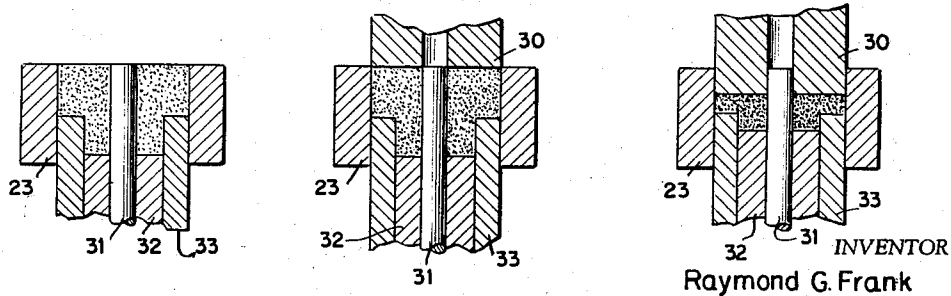


FIG. 2a

FIG. 2b

FIG. 2c

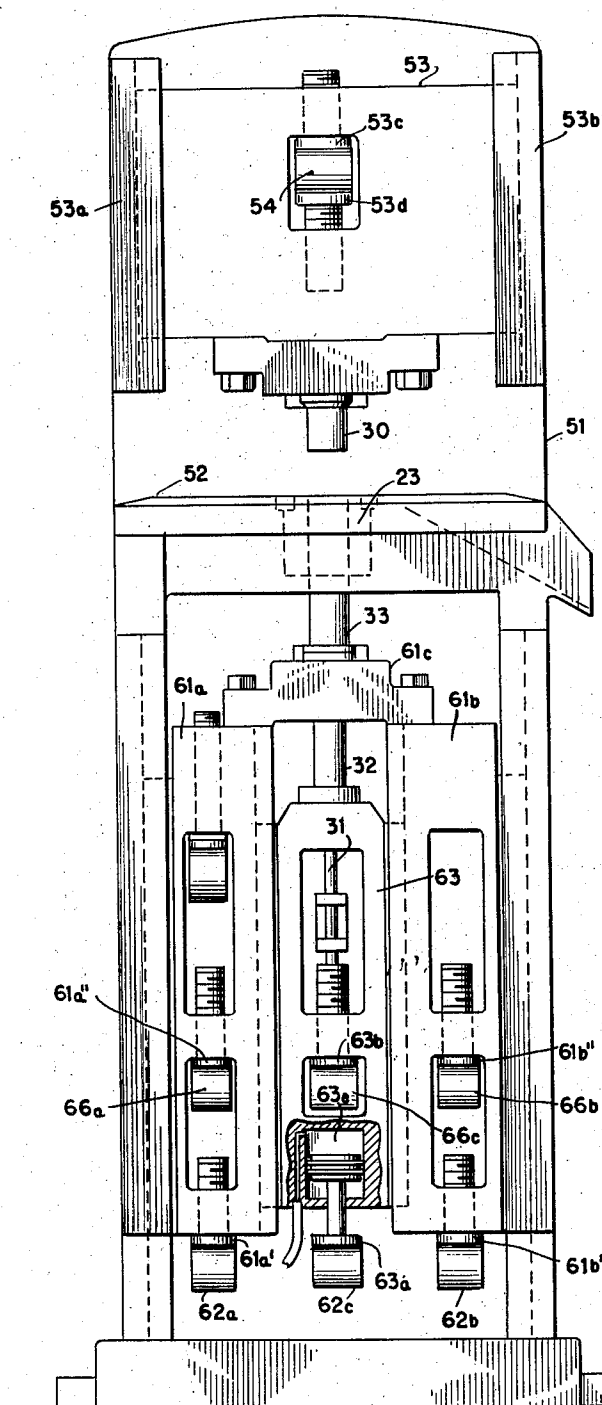


BY
Adams, Forward and McLean
ATTORNEYS

R. G. FRANK

POWDER PRESS WITH PROPORTIONAL PRESSURE CONTROL

4 Sheets-Sheet 2



INVENTOR
Raymond G. Frank

BY
Adams, Forward and McLean
ATTORNEYS

April 28, 1959

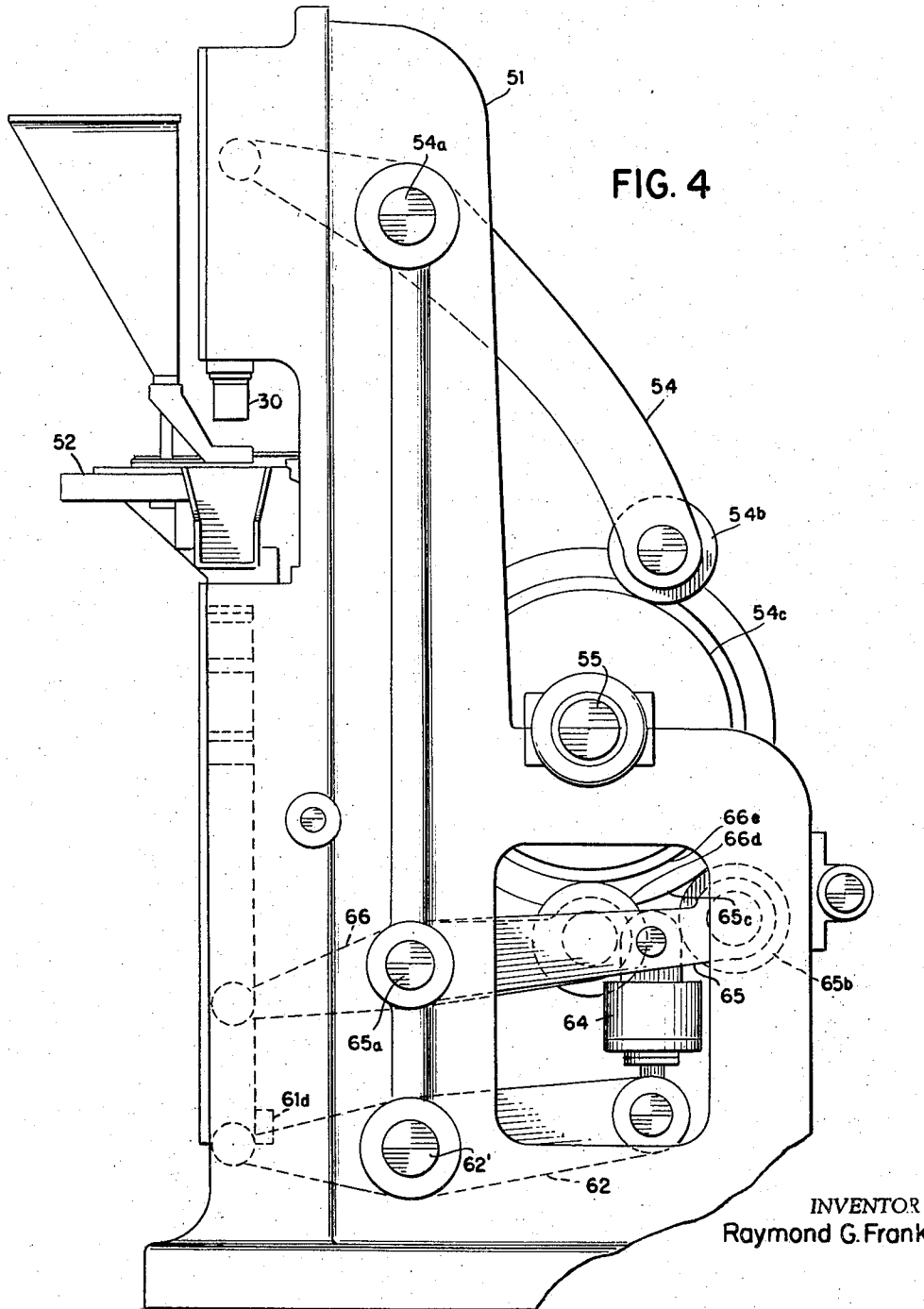
R. G. FRANK

2,883,703

POWDER PRESS WITH PROPORTIONAL PRESSURE CONTROL

Filed March 21, 1957

4 Sheets-Sheet 3



BY *Adams, Forward and McLean*
ATTORNEYS

1

2,883,703

POWDER PRESS WITH PROPORTIONAL PRESSING CONTROL

Raymond G. Frank, Ambler, Pa., assignor to F. J. Stokes Corporation, Philadelphia, Pa., a corporation of Pennsylvania

Application March 21, 1957, Serial No. 647,639

5 Claims. (Cl. 18—16.7)

My invention relates to molding articles having complicated stepped shapes from particulate materials, such as powder metals, ceramics and carbon, and in particular provides a molding press for forming such articles utilizing multiple adjacent punches advanced into at least one end of a die to compress the molding material to different levels in the die.

A method for compressing particulate materials to form stepped articles is described in copending application of Raymond G. Frank, serially numbered 647,604 and filed March 21, 1957. In the method of the aforementioned copending application, which is conveniently known as proportional pressing, the problem of powder transfer from one column to another in front of the multiple punches advancing adjacent to each other in the die is solved by advancing the multiple adjacent punches to compact the powder charge from a position prior to compaction of the powder charge at which the depths of fill in front of the punches are in proportion to the corresponding thicknesses of the article to be molded. Proportional pressing also contemplates that the multiple adjacent punches will be advanced in the die to compact the powder charge from such initial fill position at rates which are designed to maintain constant the proportionate depths of fill initially established, at least until the molding material ceases to be fluent, which in the usual case will occur at about 10 or 15% of the total force which is applied in forming the finished article.

While it will be readily apparent that cam and hydraulic presses having independent multiple adjacent upper or lower punches, or both, can be set up to accomplish proportional pressing, if the cam profiles are appropriately cut or if the areas of the hydraulic cylinders are in the same proportion as the punch areas, in most circumstances a particular machine will be utilized over the course of time to form a variety of parts having different ratios of thickness and wherein the ratios of punch areas will be changed. Retooling in changing from one set-up to another thus may require the expense of new cams or hydraulic cylinders in order to achieve proportional pressing. This is not ordinarily feasible.

It is a principal object of my present invention to provide a press for accomplishing proportional pressing with a variety of fill ratios and punch areas as may be ordinarily met in the anticipated use of the machine, and in which replacement of cams or hydraulic cylinders will be unnecessary.

This and other objects and advantages of my invention, which will become apparent hereinafter, are essentially derived from my discovery that proportional pressing can be achieved by controlling individual punch motions to hold instantaneous unit molding pressures constant.

One mechanism for accomplishing proportional pressing utilizing my present discovery is based on locating hydraulic cylinders in the mechanical linkages connecting each of the multiple adjacent punches to their respective drive units and by providing a hydraulic system for controlling the flow of hydraulic fluid from and to each

2

cylinder to maintain fixed ratios of hydraulic pressures between the cylinders, proportionate to the ratios of the compression areas of the punches controlled by the respective cylinders and to the ratios of the mechanical advantages of the cylinders in controlling the punches. If the hydraulic control cylinders are arranged in the mechanical linkages driving the punches and for every punch there is at least one cylinder which is capable of controlling the force transmitted to the punch, either directly or by difference, the total force applied by the punches can be controlled such that each punch transmits a force to the compact which will compress the compact with the same instantaneous unit molding pressure as each other punch, and the punches will move during compression at rates compacting their respective powder columns with a uniform increase in density thereby assuring that no transfer of molding powder will occur from the column in front of one punch to the column in front of another.

I have found that this movement of the punches corresponds substantially to the movement described above as proportional pressing and the ratios of decrease in depth of fill in front of multiple adjacent punches will be held constant provided, of course, that the depth of fill in front of each punch before compaction occurs is in the same proportion to the depth of fill in front of each other punch as are the corresponding dimensions of the final article to be formed.

It should be noted that in a hydraulic press, the control cylinders can be the hydraulic cylinders driving the punches.

Two embodiments of my invention are illustrated in the accompanying drawings in which:

Figure 1 is a diagrammatic view in vertical section showing the relationship of the principal elements of a press embodying the present invention;

Figures 2a to 2c, inclusive, illustrate the various stages in the operation of the punches;

Figure 3 is a front view of a cam operated press embodying the present invention;

Figure 4 is a side view of Figure 3;

Figure 5 is a diagrammatic illustration of the cam operated press of Figures 3 and 4; and

Figure 6 is a diagrammatic view of an adjustable control device for adapting the presses shown in the preceding figures to form articles of different dimensions.

Referring to Figure 1, a base structure or block 11 has mounted therein a hydraulic pressure cylinder 12 having a connection to a source of suitable hydraulic fluid (not shown). Cylinder 12 and other hydraulic pressure cylinders hereinafter mentioned are fluid pressure motors which are well known as comprising reciprocable pistons having exteriorly extending piston rods. Block 11 is substantially rectangular and has threaded bosses in the corners thereof in which are vertically mounted tie rods 13 extending upwardly from the block 11 and defining a main press frame.

The corner rods 13 have mounted thereon a vertically reciprocable pressure plate 14 which is limited in its downward movement by collars 15 which are affixed to corner rods 13 beneath plate 14. Centrally mounted on plate 14 are upper and lower hydraulic pressure cylinders 16 and 17, respectively.

A centrally apertured pressure plate 18 is mounted on the corner frame rods 13 above pressure plate 14. Rigidly interconnecting pressure plates 14 and 18 are push rods 19 which are connected at their ends to the pressure plates by means of collars 20. Thus, pressure plates 14 and 18 are maintained in positively fixed relation to each other by rods 19 and reciprocate vertically as a unit. Suitable stops (not shown) are provided in a conventional manner to limit vertical movement of pres-

sure plates 14 and 18 for fill, compression and ejection functions.

A die table 21 is mounted above plate 18 fixed in position on corner rods 13 by locking collars 22. Table 21 has a central vertical bore formed with a plurality of rabbets near its upper end to receive die 23 into which the punches enter in compacting the article and to receive a clamp ring 23a for securing the die in position.

A pressure plate 24 is mounted above die table 21 on the frame rods 13 for vertical, reciprocating movement to bring an upper punch into and out of the die 23 in the table 21. Movement of the plate 24 is guided by the rods 13 and is produced by motor means in the form of a fluid pressure cylinder 25 similar to cylinders 12, 16, and 17. Suitable stops (not shown) are fastened on rods 13 to limit movement in both directions of plate 24 and hence the upper punch. Pressure cylinder 25 is mounted in a head plate 26 in which the upper ends of corner rods 13 are affixed and completes the frame of the press. The cylinder 25 is provided with a piston having a depending rod affixed at its lower end in a socket in the plate 24. Plate 24 is formed with a depending upper punch generally designated 30.

A frame (not shown) is mounted on a base to one side of the press structure described above and forms supporting and enclosing means for pumps and their drives, for pipes connecting such pumps with cylinders 12 and 25, and for control valves by which distribution of pressure to such cylinders is controlled. Upper hydraulic pressure cylinder 16 mounted on pressure plate 14 has an upwardly extending piston rod on which is mounted an inner punch holder 27 which has a vertical slot 28 formed therein toward its lower end. Stops (not shown) are fastened to punch holder 27 to limit its upward movement by engagement of the stops with plate 24 and die table 21. Stops (not shown) are fastened to the piston rod of cylinder 16 to limit downward movement of punch holder 27. A core rod holder which includes a supporting bar 29 is mounted in slot 28. Supporting bar 29 passes through slot 28 and is supported at its outer ends by rods (not shown) having their upper ends secured to table 21. A core rod 31 passes through inner punch holder 27 along the vertical axis of the press and its lower end threadedly engages supporting bar 29. The upper end of inner punch holder 27 is provided with an upwardly extending inner punch generally designated 32. Inner punch holder 27 passes through the centrally located vertical bore in pressure plate 18 which forms a guide for punch holder 27.

An upwardly extending outer punch generally designated 33 is coaxially mounted about inner punch 32 and is attached at its lower end to the upper side of pressure plate 18.

The upwardly extending piston rod of hydraulic pressure cylinder 12 within block 11 and the depending piston rod of lower reciprocable hydraulic pressure cylinder 17, mounted on the underside of pressure plate 14 are connected by suitable means such as threaded collar 35.

Within base block 11 hydraulic pressure proportionating cylinders 36 and 37 are mounted in side by side relation. The pistons of cylinders 36 and 37 are connected to a lever 38 which pivots about a fulcrum shaft 39 mounted on block 11. Pressure cylinder 16 and proportionating cylinder 36 are interconnected by conduit 40. Pressure cylinder 17 and proportionating cylinder 37 are also interconnected by a similar conduit 41.

Operation of the press shown in Figure 1 will be explained in conjunction with Figures 2a to 2c.

The hydraulic fluid supply to cylinders 12 and 25 is connected to cause such cylinders to withdraw their associated punches from die table 21 such that punch 30 is raised clear of table 21 while punches 32 and 33 are positioned as shown in Figure 2a. With the punches so positioned a charge of powder molding material, such as powder brass, is delivered into the center of die 23. Fluid is then connected to cylinder 25 to advance punch 30

into die 23 to the position shown in Figure 2b. This movement is stopped prior to compaction of the charge of molding material just at the point at which pressure will begin to build up. The stops limiting lower punch downward movement are set such that the relative separation of punch 33 from punch 30, when the latter is at the initial compacting position of Figure 2b, is in the same proportion to the relative separation of punch 32 from punch 30 as these measurements bear to each other in the ultimate positions the punches achieve in molding the desired article.

Full fluid pressure is then applied to cylinder 12 to drive punches 32 and 33 into the die against the molding material. The stops are, of course, positioned to limit sliding movements of the punches into die 23 at the desired ultimate position shown in Figure 2c. As the punches approach this position, however, they do so such that adjacent punches 33 and 32 arrive at their ultimate positions of advance substantially simultaneously and at a substantially constant speed ratio, while exerting throughout their respective strokes substantially equal instantaneous unit molding pressures at any given instant. The powder columns above punches 32 and 33 are thus uniformly compacted to produce an annular stepped article of substantially uniform density. This result is achieved in the following manner.

As fluid pressure is applied to cylinder 12, its associated piston is driven up, thus driving the piston of cylinder 17 upwardly in cylinder 17. The latter movement increases the pressure on the fluid confined in cylinder 17 and hence increases the force applied to platen 14 tending to advance punch 33 into die 23. The same increase in fluid pressure also displaces fluid from cylinder 17 into proportionating cylinder 37 causing its associated piston to extend upwardly and rotate lever 38 to drive the piston associated with proportionating cylinder 36 down into such cylinder. The pressure of the fluid in cylinder 36 is thus increased and fluid is displaced from it into cylinder 16 to drive its associated piston, and punch, 32, upwardly. Fluid pressure is, of course, applied simultaneously to cylinder 25 and cylinder 17, such that all punches reach final compression together.

It is readily apparent that if the fulcrum 39 of lever 38 is adjusted horizontally to take into account the ratio of areas on the upper faces of punches 32 and 33, cylinders 36 and 37 function to move punches 32 and 33 relative to each other as pressure is increased to cause the unit molding pressure exerted by each punch to equal that exerted by the other. Thus, as the punches advance into the die to compact their respective powder columns, they do so with strokes proportionate to the depth of fill of their respective powder columns at initial compaction (Figure 2b). The punches thus arrive simultaneously at the desired final positions shown in Figure 2c.

Although a single outer punch and a single inner punch are illustrated in Figures 1 and 2, any number of punches coaxial and otherwise, can be employed by providing a plurality of cylinders similar to cylinder 16, which cylinders are in similarly proportionated fluid pressure communication with cylinder 17.

This invention can also advantageously be incorporated in cam type presses as is illustrated in Figures 3, 4 and 5 wherein like elements to those of Figures 1 and 2a, b and c are provided with the same numbers. Referring to the drawings, the press illustrated comprises a main frame 51 provided with a die table 52 which supports a die 23 having a smooth vertical bore in which the molded article is to be formed. For the formation of a flanged article, such as shown in Figure 2c, the press is provided with a core rod 31, lower inner and outer concentric punches 32 and 33, respectively, and upper punch 30. The die, punches and core rod are similar to those illustrated in Figures 1 and 2a to 2c, inclusive.

Upper punch 30 is carried by a slide 53 mounted for vertical reciprocation between parallel guides 53a and

53b carried by frame 51. Slide 53 is reciprocated by means of a lever 54 mounted to frame 51 at 54a and having the forward end thereof entering between adjustable abutments 53c and 53d carried by slide 53. These abutments may be formed of disc elements provided with stems having threaded connection with slide 53. The rear end of lever 54 is provided with a cam follower 54b which engages an operating cam diagrammatically represented by the circle 54c in Figure 4. Cam 54c is mounted upon and driven by a cam shaft 55 and is provided with a contour suitable for operating the upper plunger in timed relation with the other plungers as will be described hereinafter.

Lower punch 33 is carried by a vertically reciprocable slide mounted between two guides provided on the lower front portion of frame 51. The slide is formed of two side members 61a and 61b joined at the top by a yoke piece 61c which carries the punch 33, and also joined at the lower ends by a bridging portion 61d shown in the dotted lines in Figure 4. This slide is reciprocated on the compression stroke by means of a lever 62 pivoted to frame 51 at 62' and having two arms 62a and 62b extending forwardly from the pivot point and positioned under adjustable abutments 61a' and 61b' carried by slide parts 61a and 61b.

Mounted between slide parts 61a and 61b is a third slide 63 which carries inner tubular punch 32. Mounted in the lower portion of slide 63 is a hydraulic pressure cylinder 63e, the piston rod of which cylinder extends vertically downward from slide 63 and is provided at its exterior end with an adjustable abutment 63a. Slide 63 is moved vertically on the compression stroke by means of a third arm 62c on lever 62 which engages the adjustable abutment 63a on the lower end of the piston rod of cylinder 63e. The rear end of lever 62 is connected through a hydraulic pressure cylinder 64 to a second lever 65 pivoted to frame 51 at 65a and carrying a cam follower 65b which engages an operating cam diagrammatically represented by the circle 65c in Figure 4.

A fourth cam operated lever 66 (the ejection lever) is pivotally supported on the frame 51 at 65a and is provided with three forwardly extending arms, two of which, 66a and 66b, enter openings formed in slide parts 61a and 61b and engage adjustable abutments 61a'' and 61b'' carried by these parts. A third forwardly extending arm 66c on lever 66 enters the opening in slide 63 and engages an adjustable abutment 63b carried by this slide. The rear end of lever 66 is provided with a cam follower 66d which engages an operating cam represented by the circle 66e, Figure 4. The ejection mechanism is substantially that disclosed in U.S. Patent 2,499,980, and since it forms no part of this invention will not be further discussed.

The core-rod 31 mounted within punch 32 extends downwardly through the upper end of slide 63 and into an opening formed within this slide as shown in Figure 3. The lower end of the core-rod is supported in fixed relation with die 23. It can, of course, be mounted for vertical reciprocation by means of a suitable cam-operated lever, if desired.

Referring more particularly to Figure 5, cylinders 63e and 64 are provided with means for proportionate transfer of hydraulic fluid therebetween as, for example, through trunnion mounted hydraulic pressure proportionating cylinders 70 and 71 which operate in substantially the same manner as the proportionating cylinders 36 and 37 illustrated in Figure 1 and described above. Cylinder 64 is connected to cylinder 70 by a suitable conduit 72 for transfer of hydraulic fluid between the cylinders, and cylinders 63e and 71 are connected in like manner by conduit 73. The pistons of proportionating cylinders 70 and 71 are connected by their respective piston rods to a bell crank 74.

Operation of the press is as follows: compression

force is applied to reciprocable cylinder 64 by rotation of cam 65c causing cylinder 64 to move vertically downward. Movement of cylinder 64 is transferred to lever 62 through the piston of cylinder 64, which movement is transferred directly to outer punch 33 carried by yoke 61c on slide parts 61a and 61b through arms 62a and 62b and indirectly to inner punch 32 through cylinder 63e in slide 63 by arm 62c. The total force acting on the piston of cylinder 64 is equal to the sum of the forces acting on the punches by the respective partly compressed powder columns times the ratio of the length of arms 62a, 62b and 62c measured from pivot 62' to substantially their ends to the length of lever 62 measured from pivot 62' to its connection with the piston of cylinder 64. The ratio of the length of the arms of bell crank lever 74 is selected with regard to the mechanical advantage of cylinder 64 over cylinder 63e such that the force acting on the piston of cylinder 63e and, hence, punch 32, will be in the same proportion to the force acting on punch 33 as are the cross-sectional areas of the punches to each other.

It is thus evident that the press in Figures 3-5 also functions in exactly the manner described with respect to Figures 2a-2c for the press shown in Figure 1 to achieve "proportional pressing" in which punches 32 and 33 are advanced into the die with stroke lengths proportional to the configuration of the desired article while at all times exerting equal instantaneous unit molding pressures.

It is evident that conversion of a particular press to form articles having different structural configurations can be accomplished by changing the punches where required, by resetting the stops and by repositioning the fulcrum 39 of lever 38 or the fulcrum of bellcrank lever 74. A lever having an adjustable fulcrum is desirable in many instances to accomplish the last. Figure 6 shows such a lever in which the reference numbers 80 and 81 represent proportionating cylinders, such as those illustrated in Figure 1 and designated by the reference numbers 36 and 37 and those designated by the numbers 70 and 71 in Figure 5.

In the device shown in Figure 6 piston rods 82 and 83, respectively carried by pistons 84 and 85 located respectively in cylinders 80 and 81, are pivotally engaged at their outer ends with a lever 86. Intermediate at its ends lever 86 is pivotally mounted receiving a pin 87 supported on a base 88. Base 88 is suitably mounted for horizontal sliding movement in a frame 89, which can form a portion of the base of the press or which can be positioned entirely apart from the press. Within frame 89 there is located a worm drive 90 which meshes with a cog 91 affixed to base 88 of fulcrum pin 87. The pivotal connection of piston rod 82 and of piston rod 83 to the opposite ends of lever 86 includes respectively pins 92 and 93 affixed on the ends of rods 82 and 83 and which are slidably received in elongated slots 94 and 95 located in the ends of lever 86. Thus when it is desired to change the proportionate forces driving punches 32 and 33 in order to accommodate different relative stroke lengths of the punches, or different relative punch areas, rotation of worm 90 can be employed to shift the fulcrum point of lever 86 against which the proportionating cylinders 80 and 81 operate.

While the preceding specific description has been confined to the employment of control hydraulic cylinders and of proportionating cylinders to balance the forces applied by the punches by the control cylinders to maintain the unit molding pressures exerted by each punch identical, it will be evident, particularly in the case of larger tonnage presses where hydraulic control pressures would be high, that the same results can be achieved and proportional pressing accomplished if the press is provided with a device which will sense the unit molding pressure exerted by each punch at any instant (a linear function of the force applied to the punch) and a device for controlling application of force to each punch which

7

is operably responsive to the sensing devices to correct any deviation in unit molding pressures exerted by the various punches and thus hold the unit molding pressures exerted by each punch at the same value at any given instant.

I claim:

1. A proportional pressing control device for a molding press having multiple adjacent punches which includes means sensitive to the unit molding pressure exerted by each said adjacent punch, and drive means for each said adjacent punch including means controlling the movement of each said punch operably responsive to the associated pressure sensitive means to maintain the unit molding pressure instantaneously exerted by each said punch substantially equal to the unit molding pressure exerted by each other said punch.

2. A proportional pressing control device for a molding press having multiple adjacent punches which includes means operably connected to reciprocate each said punch, including a separate hydraulic pressure motor positioned to transmit force to each said punch, and hydraulic fluid transfer means communicating with each of said motor sensitive to the hydraulic pressure developed therein and operable to transfer hydraulic fluid to and from each said motor to maintain the hydraulic pressure in each said motor in a predetermined constant proportion to the hydraulic pressure in each other said motor.

3. A proportional pressing control device for a molding press having a first punch and a second punch, said punches being reciprocable adjacent each other, which

8

includes means for reciprocating said punches including a first hydraulic cylinder positioned to transmit force to said first punch and a second hydraulic cylinder positioned to transmit force to said second punch, and hydraulic fluid transfer means communicating with each said cylinder sensitive to the hydraulic pressure therein operable to transfer hydraulic fluid from and to said first cylinder and to and from said second cylinder to maintain the hydraulic pressure in said first cylinder in a predetermined constant proportion to the hydraulic pressure in said second cylinder, whereby said punches exert substantially equal instantaneous unit molding pressures.

4. A control device according to claim 3 in which said second cylinder is positioned to transmit force to said first punch in series with said first cylinder.

5. A control device according to claim 3 in which said hydraulic fluid transfer means comprises a third hydraulic cylinder in open communication with said first cylinder, a fourth hydraulic cylinder in open communication with said second cylinder, and pivoted lever means mechanically linking said third and fourth cylinders to react against each other about a fulcrum.

References Cited in the file of this patent

UNITED STATES PATENTS

2,556,951 Weidner ----- June 12, 1951

FOREIGN PATENTS

497,996 Canada ----- Dec. 1, 1953