

Dec. 14, 1943.

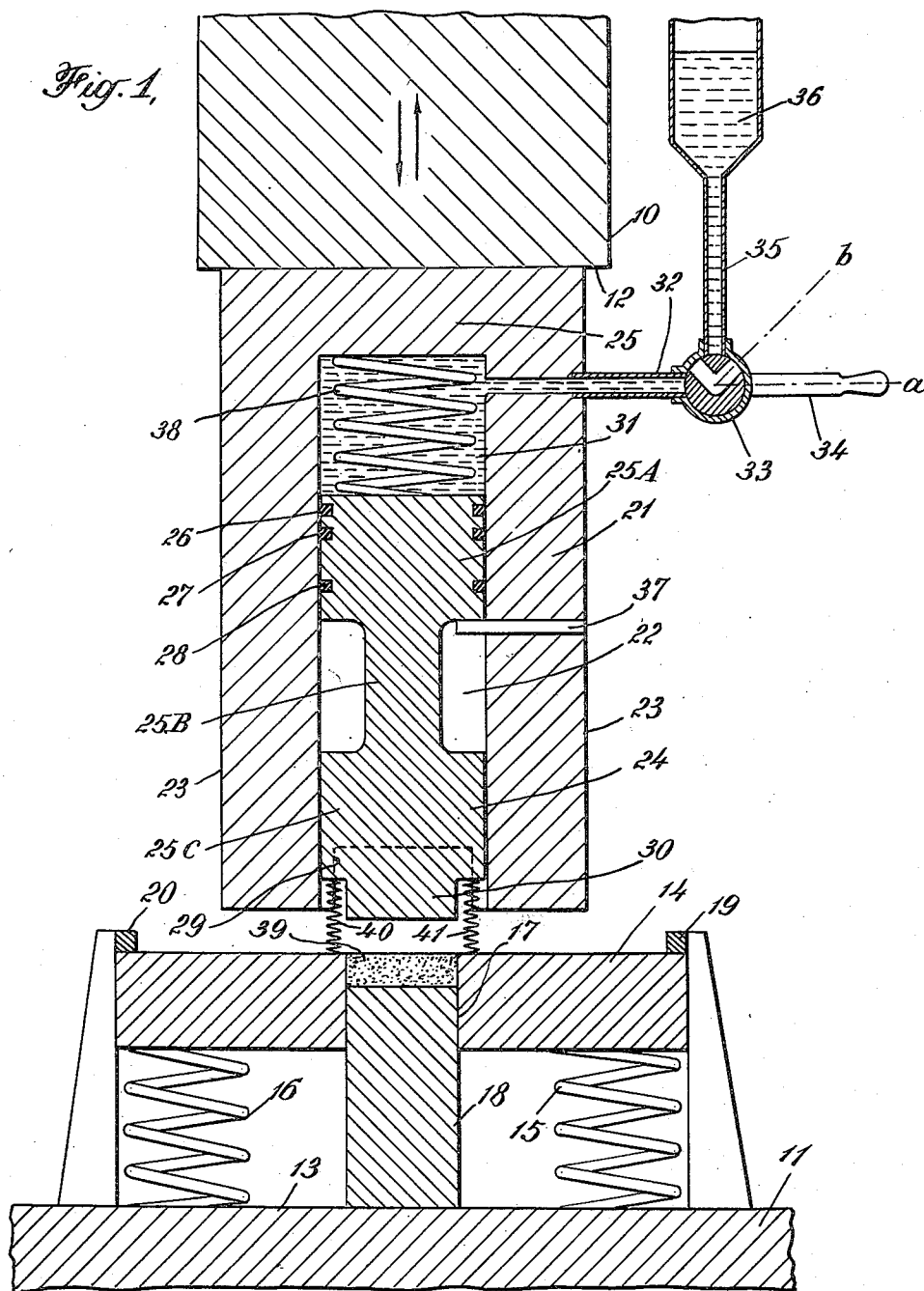
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2,336,982

PRESS

Filed May 14, 1940

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 2.

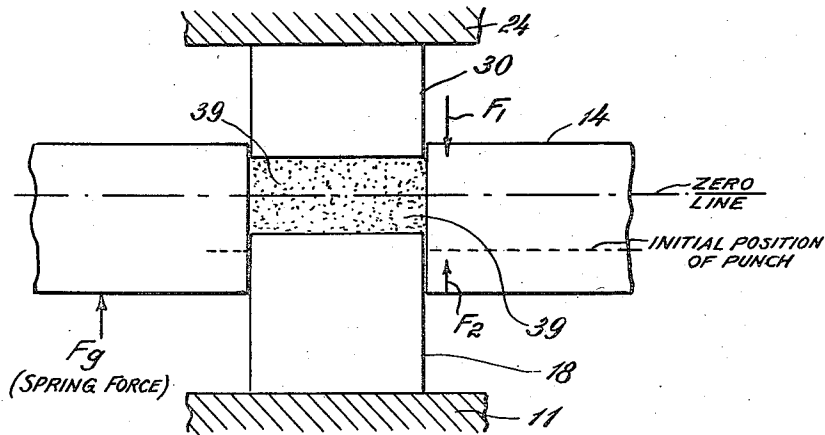


Fig. 3.

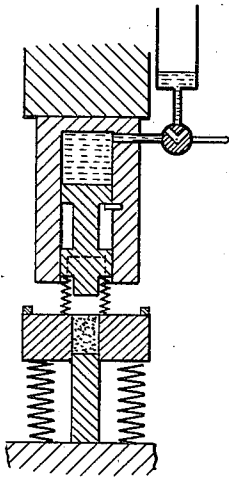


Fig. 4.

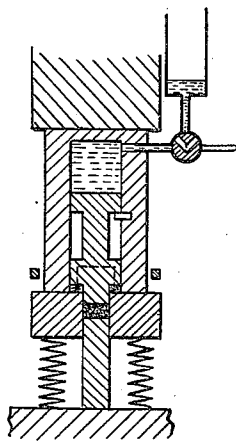


Fig. 5.

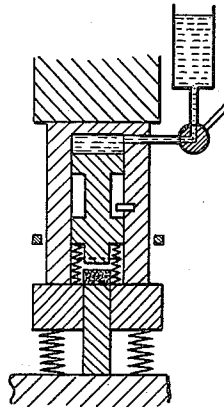
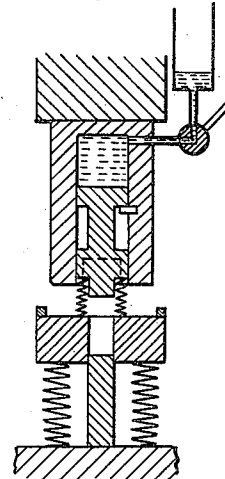


Fig. 6.



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PRESS

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11 Claims. (Cl. 18—16)

This invention relates to presses, especially those employed to shape materials in a die or mold, and is concerned particularly with presses adapted to the compression of metal powders and the like to form a coherent mass of predetermined shape.

Metal powders and other finely-divided substances tend to flow under pressure but do not obey Pascal's law (as do fluids) in that pressure exerted on an enclosed mass of the powder is not transmitted equally to all parts of the mass. Consequently, in powder metallurgy and allied arts that involve compression of an enclosed mass of finely-divided solid particles, the resulting coherent mass frequently exhibits lack of uniformity in density, strength or other physical properties and may exhibit zones or planes of weakness.

I have developed a press of novel construction in which the aforementioned difficulties due to lack of uniformity in transmission of pressure throughout a mass of solid particles are largely overcome, with the result that coherent masses formed in the press have improved physical properties and are less likely to contain flaws or other zones or planes of weakness. My invention contemplates the combination in a press of a "floating" die plate having a bore therethrough, a first plunger slidably fitted in one end of the bore, spring means fastening the die plate to a base (and adapted to permit "floating," i. e., restricted movement of the die plate back and forth in the direction that the plungers are moved) and a second plunger adapted to be slid into the other end of the bore. The floating die plate and the two plungers enclose a die cavity defined by the walls of the bore and the end surfaces of the two plungers which fit slidably thereinto. In this space, the material undergoing treatment, say a mass of metal powders, is compressed as the two plungers are forced toward each other, and pressure upon the material being compressed tends to be equalized automatically because the spring-held die plate has relative freedom of movement with respect to the plungers and the mass between them, force to bring about such movement being transmitted to the die plate as a result of friction developed between the die plate and the mass and plungers.

The cross section of the bore may be of any desired shape. The ends of the plungers that fit into the bore may also be of any desired shape, provided, however, that they are formed as to permit removal of the compressed mass from the apparatus.

In the preferred form of press structure of my invention, compression of material to form a desired shape and subsequent ejection of the shape from the die take place during a single unidirectional stroke of the apparatus. This desirable action is permitted by the fact that one of the plungers acts as, or is attached to, a piston in another member (i. e., a cylinder) to which the moving force is supplied until adequate compression of the mass has taken place, the piston and member being held in fixed relationship until this has occurred, and then the two are released from each other. The member continues in its stroke toward the die plate and abuts upon it, whereupon the die plate is moved relative to the plungers and the compressed mass with the result that the latter is ejected. These and other features of my invention will be more thoroughly understood in the light of the following detailed description, taken in conjunction with the accompanying drawings in which:

Fig. 1 is a fragmentary sectional elevation through a portion of a press constructed in accordance with my invention;

Fig. 2 is a diagram illustrating the forces acting upon a mass being compressed in the die of the press of Fig. 1; and

Figs. 3, 4, 5 and 6 are diagrams illustrating the cycle of operation of the press of Fig. 1.

Referring now to Fig. 1, the apparatus comprises a press having a head 10 and a table 11 which are adapted to be forced toward each other. Ordinarily, the table of the press will remain stationary and the head of the press will be movable toward and away from the table by conventional means (not shown) and the invention will be described as though this were the case, it being understood that the head may be stationary while the table is moved or that both table and head may move toward and away from each other. The lower face 12 of the head is a plane surface perpendicular to the direction of movement of the head and substantially parallel to the upper plane surface 13 of the table.

The particular embodiment of my invention herein illustrated is adapted to be installed in any conventional press (such as that just described) which is adapted to impose pressure on an object inserted between a table and a head or equivalent members that are movable toward each other. Thus, the apparatus of Fig. 1 is a detachable unit provided with a floating die plate 14 mounted on heavy springs 15, 16 that

rest on the table and are ordinarily under some degree of compression. The die plate has a bore or aperture 17 of uniform and suitably shaped cross section. In the present instance, the bore is circular and vertically disposed. A punch 18 of cylindrical form is mounted rigidly in a vertical position on the table midway between the springs. The punch is fitted slidably into the bore of the die plate. The punch constitutes one of the plungers referred to hereinbefore.

The springs are maintainer in a compressed condition when the floating die plate is at its uppermost position by means of a pair of stops 19, 20 disposed above the die plate at its outer edges and fixed to the table of the press or otherwise maintained in a stationary position.

Disposed coaxially with the head of the press and the punch, with its upper face abutting and fastened to the head, is a cylinder 21 having a central bore 22 with a heavy side wall 23. A piston 24 is slidably mounted in the bore 22 which is closed at the top by the end portion 25 of the cylinder. The upper portion 25A of the piston is oil-tight and is made so by packing rings 26, 27, 28 disposed in annular grooves in the piston. A mid portion 25B of the piston is of smaller cross section. The lower portion 25C of the piston corresponds in diameter to the bore of the cylinder and on its underface carries a small punch 30 of the same cross section as the bore of the die plate and adapted to fit therewith. The punch 30 is the second of the two plungers referred to hereinbefore and projects below the bottom of the cylinder, being of smaller cross section than the piston.

An ejection slot 29 cuts transversely (horizontally) through the lower end of the cylinder, exposing the upper punch 30 at its sides.

A pair of light springs 40, 41 are disposed between the piston and the die plate and are adapted to push the piston upward and free the compact or coherent mass during the ejection thereof.

A chamber 31 in the cylinder above the piston (i. e., the upper portion of the bore 22) is filled with oil or other suitable incompressible liquid which enters the chamber in a conduit 32 through the side of the cylinder. This conduit is connected to a plug cock 33 or other quick operating valve provided with an operating lever 34. The other side of the cock is connected through a conduit 35 to an oil reservoir 36 that is disposed substantially above the chamber in the cylinder so as to maintain a substantial head thereon.

A stop 37 projects into the bore of the cylinder and is adapted to abut against the lower edge of the upper portion of the piston as it moves downward. A relatively light spring 38 may be disposed in the oil-filled chamber and is adapted to hold the piston against the stop when the apparatus is at rest. This spring is not essential and may be omitted when a sufficient head of liquid is available to force the piston downward to engage the stop.

In operation of the above-described apparatus, a suitable amount of powder is introduced into a die cavity 39, the bottom of which is formed by the lower punch and the sides of which are formed by the walls of the bore in the die plate. The material, say copper powder, is levelled off at the top of the die plate, with a scraper or the like. The press is then set in operation from the position shown in Fig. 3 so that the head of the press moves toward the table, while the valve 33 is in the "a" position, i. e., closed, with the piston

resting on the stop and locked in this position because of the incompressibility of the oil in the sealed chamber. As the press head approaches the plate, the small punch 30 enters the die cavity and starts compressing the powder therein (see Fig. 4). Assuming that the metal powder or other powder material to be compacted in the die cavity is not such as to obey Pascal's law, and assuming further that this material exerts friction upon the walls of the die cavity (which will normally be the case) thereby effectively resisting the punch 30, the springs 15-16 tend to be compressed because the head of the press is still approaching the table. As the springs are compressed, the die plate is pushed down over the lower punch and the material in the die cavity is compressed from the lower side. However, friction of the compact, i. e., the metal powder, against the die walls also tends to resist the motion causing the compression from the lower side and when this value of friction increases to the actual value of the frictional force of the upper punch and compact minus the combined force of the springs, the forces tending to compress the compact from above and below are balanced and the force system is in equilibrium. As compression is continued the two pistons move into the die cavity simultaneously.

The forces working upon the compact formed of the metal powder in the die cavity are illustrated in Fig. 2. Referring to this figure, it may be assumed that the "zero line" passing horizontally through the compact does not move, the material above and below this line being compressed toward the center of the compact. This result is obtained if the distances travelled by the respective punches 18 and 30 are equal. In such an operation and neglecting minor forces, such as that of gravity and of the small springs 40, 41

$$F_1 = F_2 + F_g$$

Where F_1 equals the friction force exerted by the punch 30 and about half of the powder mass in the die against the die wall:

F_2 equals the like frictional force of the punch 18 and the lower half of the powder against the die walls and F_g equals the increment of force required to compress the spring system at a given instant. This force is not constant but varies as $F_g = KX$, where K is the spring constant of the system and X is the distance the spring is compressed.

It should be observed that F_1 , F_2 and F_g all vary in absolute value during the stroke of the press but their variations are relative so that the equality indicated above holds true throughout the period of compression.

When the powder in the mold cavity has become sufficiently compressed, i. e., when the compressive force exerted thereon has reached a predetermined value necessary to bring about the required degree of compactness or density, the valve 33 is opened, i. e., thrown to position b, thus relieving the pressure within the oil cavity and permitting the piston to move upward relative to the cylinder, as the latter impelled by the press head continues to move downward toward the table and abut thereon. In this situation, the press is not required to exert great pressure on the compact, but substantially only that required to overcome friction of the compact against the die walls plus the force exerted by the spring supporting the die plate and the spring 38 in the oil chamber. Hence, the punch 18 moves relative to the die plate and tends to

eject the compressed mass from the die cavity (see Fig. 5). In other words, the head of the press continues to move downward with the result that the cylinder abuts upon the die plate and presses the die plate downwardly against the springs until its upper surface is below the compact. Meanwhile, the springs 40, 41 push the punch 30 away from the compact and free it therefrom. In this way, the compact is ejected clear of the die surface and may then be withdrawn laterally from the press through the slot 29.

The head of the press is then returned upward to the position occupied at the beginning of the cycle with the valve to the oil chamber open so that the piston drops and seats against the stop (see Fig. 6).

To summarize the cycle of operation of the press as illustrated by Figs. 3 to 6, inclusive, the first portion of the cycle is one in which a powder mass is compressed in the die cavity between the two punches, which due to the floating die plate tend to move equally with respect to the powder mass being compressed and thus tend to equalize pressures applied throughout the mass.

In the second stage of the operation, the head continues its downward motion and the cylinder pushes the floating die plate out of the way, so that the compact can be removed laterally from the apparatus through the ejection slot.

The third stage of the operation is the return of the press head to its original position with the valve to the oil chamber in the cylinder opened, so that the apparatus assumes its original position and is ready to be employed again in the cycle.

It should be noted that the small springs 40, 41 may be fixed either to the piston or to the die plate, so that they are compressed as the upper punch enters the die plate. These springs should be so designed that the force required to compress them is sufficient to force the piston upwardly with respect to the cylinder when the valve 33 to the oil chamber is open. In other words, the force exerted by these springs should be sufficient to overcome the head of oil in the apparatus plus compressive force exerted by the spring 38, if such a spring is employed.

The use of the springs 40, 41 or equivalent device to free the punch 30 from the compact during the ejection step is recommended, since it facilitates the lateral withdrawal of the compact. In case the compact is concave or convex on its upper or lower surfaces the springs are necessary in order that ejection can occur. However, when the compact has plane upper and lower surfaces, the springs or their mechanical equivalent are not necessary because the compact may be pushed laterally from between the two punches (which exert but slight compressive force on the compact when the valve to the oil chamber is open).

It will be understood that the apparatus of my invention need not be detachable and may be built into a press. However, in order that the press may be employed for a variety of operations the detachable form illustrated is particularly desirable.

The floating die plate and the two plungers or punches may be employed in a structure which is not provided with the cylinder 21 which furthers ejection on the same stroke as compression. However, convenience of operation will ordinarily dictate that the floating die plate be

employed in conjunction with the upper portion of the mechanism of Fig. 1.

I claim:

1. In a press structure the combination which comprises a die plate having a bore therethrough, a first plunger slidably fitted in one end of the bore, a second plunger adapted to be slid into the other end of the bore, a base, spring means disposed between the die plate and the base to permit restricted movement of the die plate back and forth in the direction that the second plunger is moved, a piston attached at its end to the second plunger, a cylinder having an open end within which said piston is mounted slidably, the axis of the cylinder being substantially parallel to that of the plungers and the cylinder being movable along said axis to engage the die plate, means for forcing the open end of the cylinder toward the first plunger and against the die plate, and means operable alternately to lock the second piston in fixed relationship with the cylinder and to release the second piston to permit relative movement between it and the cylinder.

2. Apparatus in accordance with claim 1 provided with stops bearing upon the die plate and adapted to maintain the spring means in compression.

3. Apparatus in accordance with claim 1 in which the cylinder has a closed end remote from the second plunger, and the locking means comprises a reservoir for an incompressible liquid, with a conduit extending from the reservoir to the closed end of the cylinder and with a valve in said conduit.

4. Apparatus according to claim 1 in which the end of the cylinder opposite the second plunger is closed to form a chamber, one end of which is formed by the head of the piston, and the locking means comprises a reservoir for an incompressible liquid, a conduit communicating from the reservoir to the chamber, a valve in said conduit, the apparatus also being provided with a compression spring in the chamber, and a stop adapted to prevent said compression spring from pushing the piston beyond a fixed point in the cylinder.

5. Apparatus according to claim 1 in which the cylinder is provided with an ejection slot adjacent the end of the piston to which the second plunger is attached.

6. In a press structure the combination which comprises a die plate having a bore therethrough, a base, spring means disposed between the die plate and the base to permit restricted movement of the die plate back and forth in the direction of the bore, a first plunger slidably in one end of the bore, a second plunger slidably in the other end of the bore, a cylinder in which the first plunger is slidably mounted, means for locking the cylinder and the first plunger together and subsequently releasing them to permit relative movement therebetween, and means for moving the cylinder and first plunger toward the second plunger and engaging the cylinder with the die plate.

7. In a press structure the combination which comprises a die plate having a bore therethrough, a base, spring means disposed between the die plate and the base to permit restricted movement of the die plate back and forth in the direction of the bore, a first plunger slidably into one end of the bore, a second plunger slidably into the other end of the bore, a cylinder having an open end and a closed end, the first plunger

er being slidably mounted in the open end, a conduit for introducing an incompressible liquid into the closed end of the cylinder, a valve in said conduit, means for closing the valve to confine the liquid within the cylinder and means for moving the cylinder and the first plunger toward the second plunger and engaging the cylinder and the die plate.

8. In a press structure the combination which comprises a die plate having a bore therethrough, a base, spring means disposed between the die plate and the base to permit restricted movement of the die plate back and forth in the direction of the bore, a first plunger slidable in one end of the bore, a second plunger slidable in the other end of the bore, a cylinder having an open end and a closed end, the first plunger being slidably mounted in the open end, a conduit, means for forcing an incompressible liquid through the conduit into the closed end of the cylinder, a valve in the conduit, means for closing the valve to confine the liquid within the cylinder and means for forcing the cylinder toward the second plunger and engaging the die plate and the cylinder.

9. In a press structure the combination which comprises a die plate having a bore therethrough, a first plunger slidable in one end of the bore,

a second plunger slidable in the other end of the bore, a base, spring means disposed between the base and the die plate to permit restricted movement of the die plate back and forth in the direction of the bore, a cylinder having an open end adjacent the die plate and closed at the other end, a piston mounted slidably in the cylinder and having one of the plungers attached thereto, a liquid reservoir, an incompressible liquid in said reservoir, a conduit extending from the reservoir to the closed end of the cylinder, a body of incompressible liquid in the closed end of the cylinder, a valve in the conduit for controlling the flow of liquid between the reservoir and the closed end of the cylinder and for holding the liquid in the closed end of the cylinder when closed, means for operating the valve, and means for engaging the cylinder with the die plate.

10. Apparatus according to claim 9 in which the oil reservoir is mounted above the closed end of the cylinder and imposes a hydrostatic head thereon when the valve is opened.

11. Apparatus according to claim 9 provided with at least one spring disposed between the die plate and the plunger that is mounted on the end of the piston.

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