June 29, 1954 R. B. SAALFRANK 2,682,080

MACHINE

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Fig. 1,

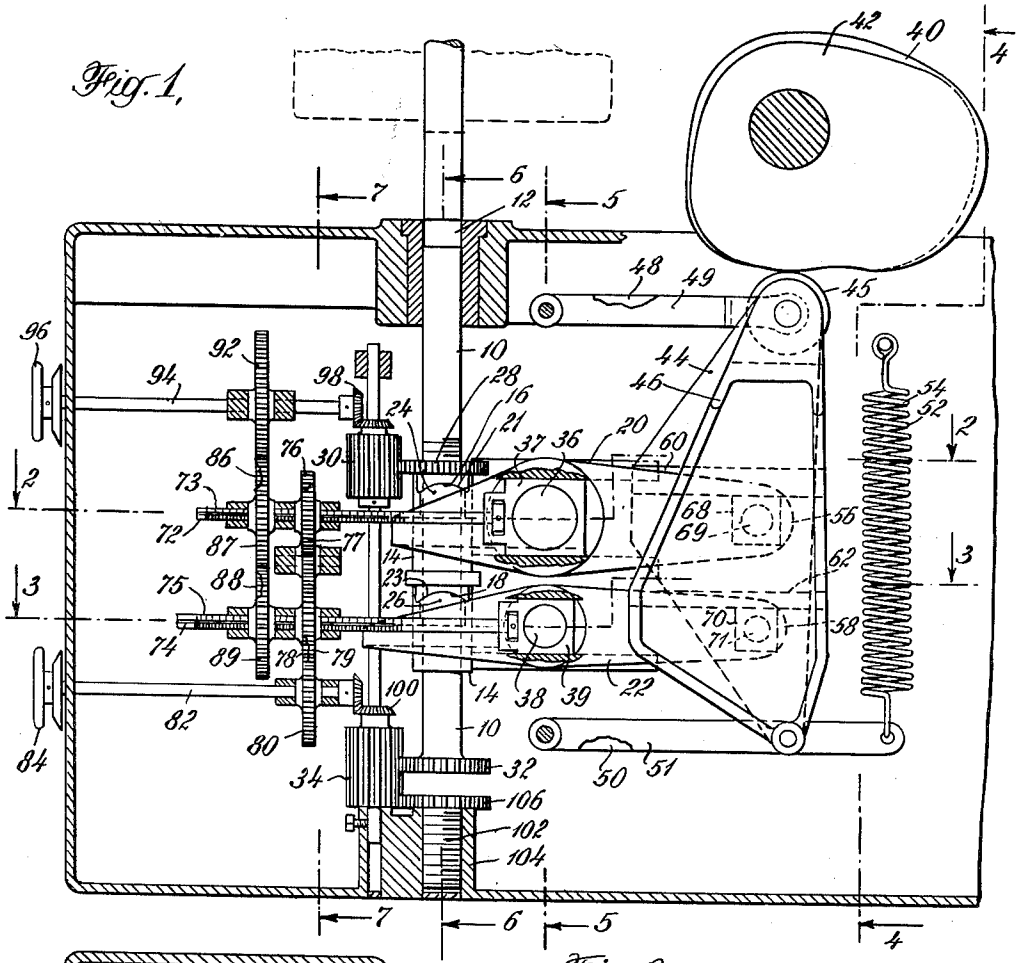
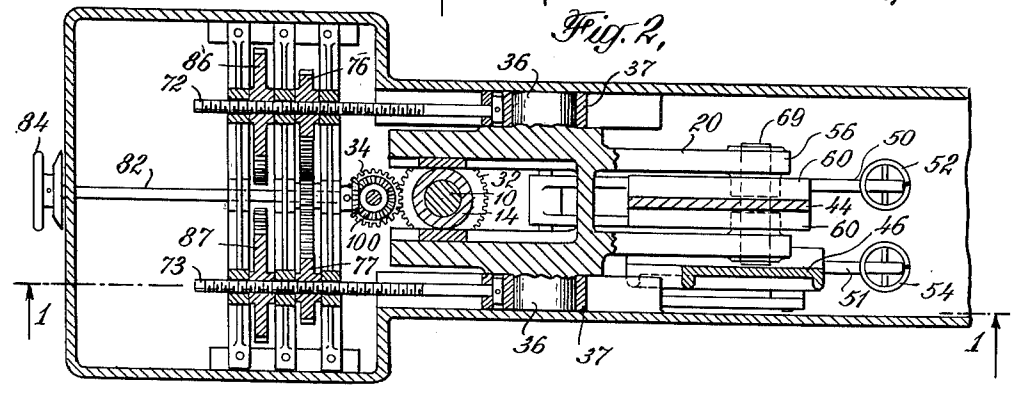


Fig. 2,



INVENTOR
Royal Bartlett Saalfrank
BY
Pennie Edmonds Morton & Barrows
ATTORNEYS

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Fig. 3,

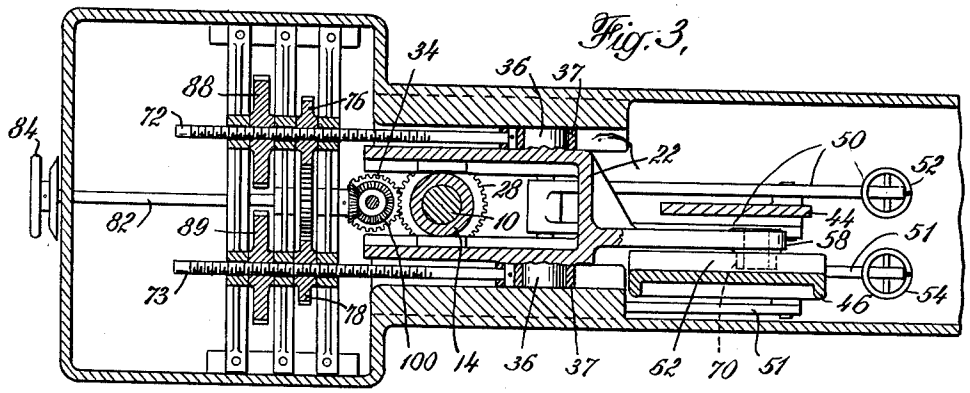


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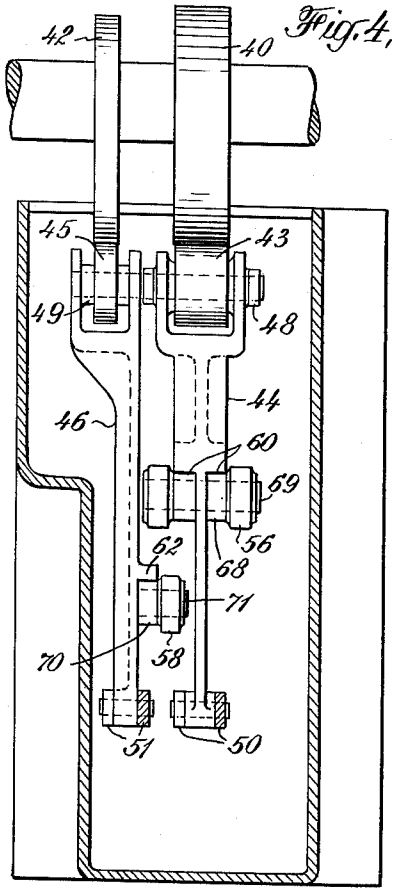
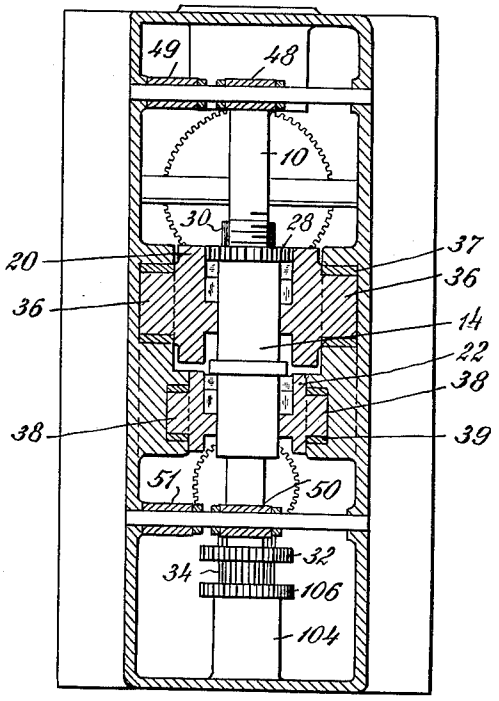


Fig. 5,



INVENTOR
Royal Bartlett Saalfrank
BY
Pennie Edmonds Morton & Barrows
ATTORNEYS

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Fig. 6,

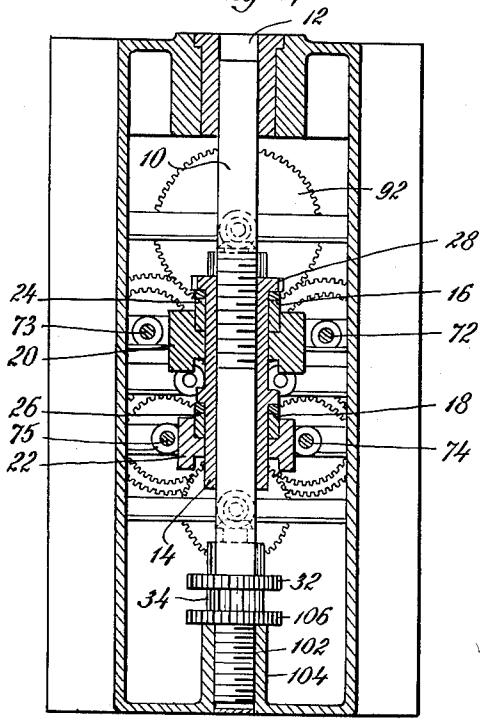


Fig. 7,

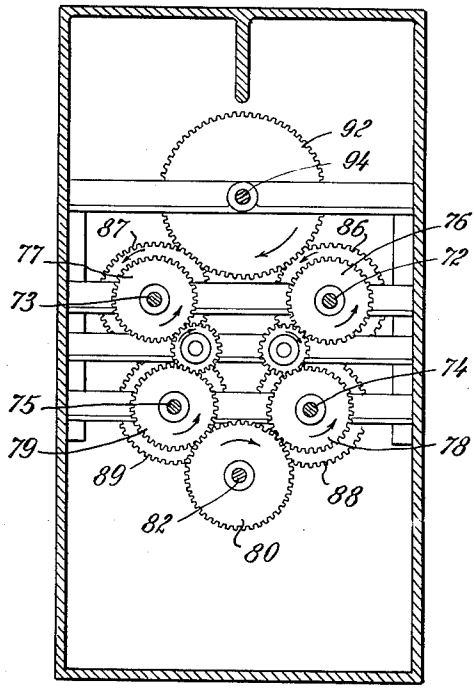


Fig. 8,

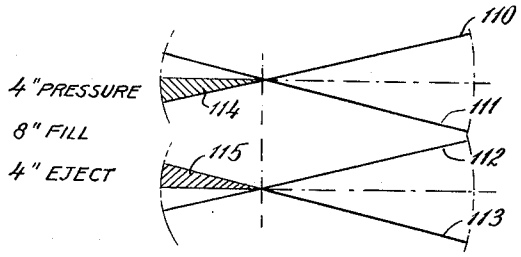


Fig. 9,

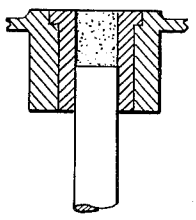


Fig. 10,

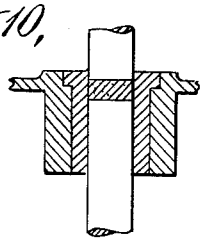
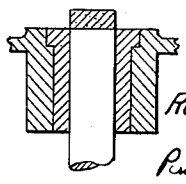


Fig. 11,



INVENTOR
Royal Bartlett Saalfrank
BY
Pennie Edmonds Morton & Barrows
ATTORNEYS

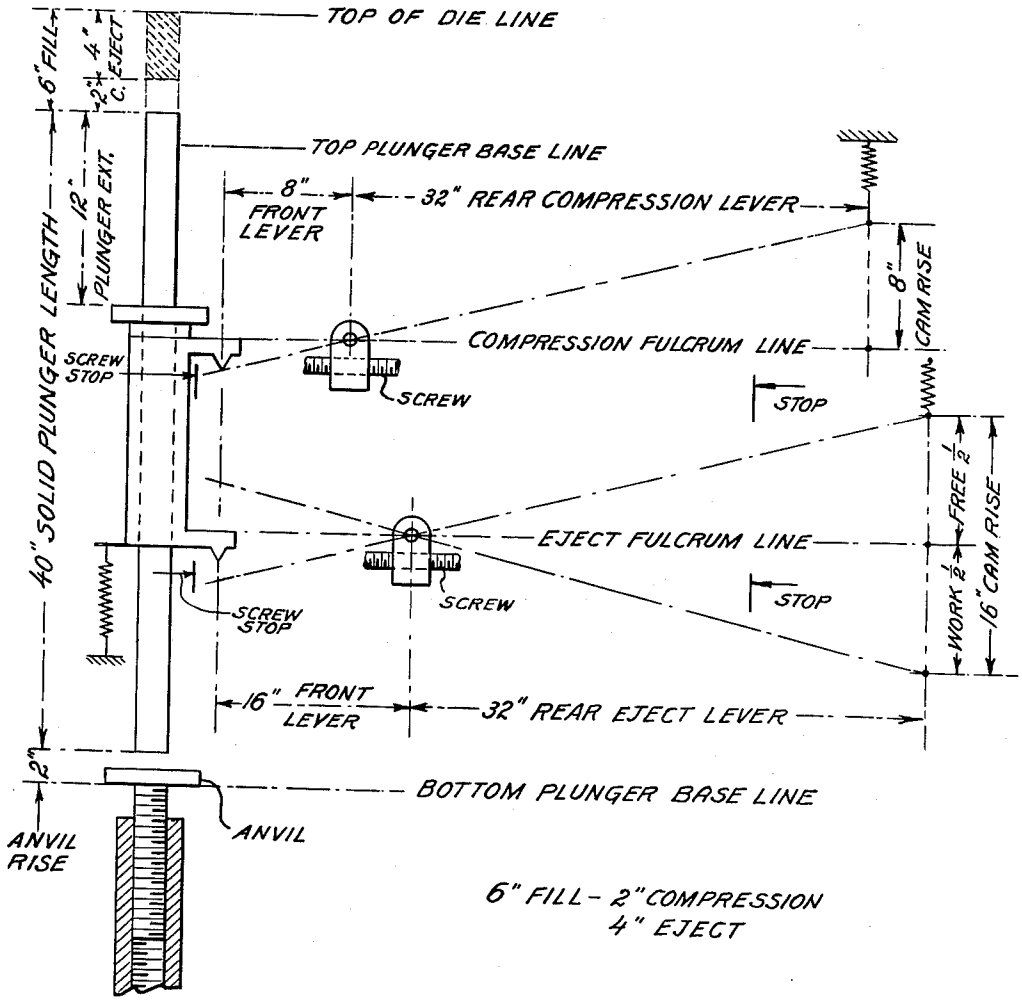
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Fig. 12.

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INVENTOR
Royal Bartlett Saalfrank
BY
Pennie Edmonds Morton Barrows
ATTORNEYS

Patented June 29, 1954

2,682,080

UNITED STATES PATENT OFFICE

2,682,080

MACHINE

Royal Bartlett Saalfrank, Gulfport, Fla., assignor to F. J. Stokes Machine Company, Philadelphia, Pa., a corporation of Pennsylvania

Application May 25, 1949, Serial No. 95,218

10 Claims. (Cl. 18—16)

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This invention relates to improvements in double-acting presses, particularly those used to convert powdered materials by pressure to formed shapes. It is of particular importance as applied to presses for the conversion of powdered metals to formed shapes, i. e., in the field of powder metallurgy.

Double-acting presses are used today for the production of a wide range of articles. For example, in the field of powder metallurgy, they are used to produce contacts from mixtures of such powdered metals as silver, copper, tungsten or the like, to produce motor brushes from mixtures of copper and lead, to produce cores from powdered iron coated with a resin, for the production of porous bearings or the like, as from copper and tin, for the production of special purpose brake linings, articles from such things as carbides and diamond dust with a cobalt or other metallic matrix, permanent magnets and a wide range of metal parts. In presses used in powder metallurgy, pressures required for the compaction of the powder may range from 20 tons per square inch, for relatively porous articles, to as high as 50 tons per square inch or more, and the presses must be of correspondingly rugged and heavy construction.

The most common type of double-acting press operates with the use of one or more plungers or punches urged upwardly through a die by a rocking lever and a corresponding plunger or punch moving downwardly from the top of the die, the compression of the powder to the formed article thus being from both directions. This is important because of the fact that under compression, the powdered metal will not flow in a direction transverse to the direction of applied pressure, and more uniform articles are obtained than if the pressure is applied from one direction only, as by one moving punch or plunger. For the making of flanged articles, or articles having holes through them parallel to the direction of pressing, suitably shaped dies and core rods are commonly used, and for more complex pieces, primary and secondary upper and lower plungers or punches, are commonly used. After the compression is completed, the upper punch is commonly retracted and the lower punch carried further up until it is flush with the top of the die plate, ejecting the formed article and permitting its ready removal, as by the feed shoe which refills the die. It is essential that the lower punch, at the end of the ejection motion be flush with the top of the die, and in every case the stroke of the lower plunger or punch must finally end with this flush relationship between the top of the die and its top.

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In presses of this character, the filling of the die with metal to be compressed is on a volumetric basis, that is, the amount of powdered metal fed to the die is determined entirely by the volume of the die cavity, which depends upon (1) the size of the die opening, including, of course, allowance for any core rods or the like, and (2) the distance which the lower punch moves down. For effective flexibility of operation of a press of this character, therefore, disregarding adjustments of the motion of the upper punch, there are two essential adjustments of the lower punch, namely, the extent to which it moves down to permit filling, and the distance it moves up during the compression stroke when the upper punch is moving down to compress, the compression being followed by the upward motion of the lower punch for the ejection of the formed article, which must always end with the top of the lower punch flush with the top of the die.

Heretofore it has been common practice to adjust the fill, that is, the extent to which the lower punch moves downwardly, by adjustment of an anvil positioned under the lower end of the plunger and an abutment threaded on the plunger and to adjust the relationship of the compression stroke and the ejection stroke by changes in the actuating cam. Both types of adjustment have led to substantial difficulties. First, the fill adjustment, involving the use of an anvil below the lower punch, leads to difficulty because, if a fill less than the maximum is desired, the rocking lever which, actuated by the cam lifts the punch for the compression and ejection operations, is not in contact with the bearing surface against which it presses at the lower portion of the stroke of the lever, and consequently strikes the bearing surface attached to the punch with considerable force when it is in the course of rising to lift the punch (wind cutting). With heavy machinery involving massive parts, this causes noise and strain, and has been a cause of much concern. Secondly, adjustment of the ratio of compressive stroke to ejection stroke has required modification of the cam which actuates the rocking lever, requiring the use of cam inserts or different cams for each adjustment. As the cams are necessarily large, this has been costly, not only from the standpoint of requiring the provision of separate inserts for each ratio of compression to ejection desired in the use of the machine, but also from the standpoint of expense involved in making the changes from one cam contour to another when changes in the articles produced by the press are made.

The present invention provides improvements in double-acting presses which overcome these two objectionable features of presses as commonly used today and provide convenient adjustment of the fill and adjustment of the relationship of the compression and ejection strokes, while assuring that at the end of the ejection stroke the lower punch is always flush with the top of the die. These adjustments are obtained by simple controls, without requiring the use of cam inserts or changes of cams or cam contours, and without incurring the lost motion of the rocking lever at the bottom of its stroke when the fill is less than the maximum, with consequent shock when the rocking lever picks up the punch in the course of its compression stroke, i. e., without what is known as "wind cutting." Only two adjustments are necessary, when the improvements of the present invention are used, one for adjusting the fill, and the other for adjusting the relationship of the compression and ejection strokes, and such adjustments may be made by means of readily indexed wheels, which on being turned, adjust all of the parts of the mechanism properly.

When the improvements of the present invention are used, two rocking levers are provided to move the lower punch. One lifts the punch for the compression stroke and the other lifts it for the ejection stroke. Means are provided to adjust the positions of the fulcrums of these rocking levers to adjust the fill and the relationship of the compression stroke to the ejection stroke, and to move the bearing surfaces provided on the punch against which the rocking levers operate relative to the punch, so that, regardless of the depth of fill selected, one or the other of the rocking levers bears against one of the bearing surfaces, and regardless of the depth of fill or relationship of compression to ejection strokes, at the end of the ejection stroke the top of the punch always is flush with the top of the die.

The principle upon which the invention depends is that the punch must have a variable extension above the bearing surface on which the rocking lever which supplies the ejection stroke bears, and the length of the variable extension plus the length of the ejection stroke must be a constant, while at the same time, as the length of the compression stroke plus the length of the ejection stroke must be equal to the desired fill, the extension must be lengthened when the fill is made smaller, and shortened when the fill is made greater, and for a given fill must be lengthened when the compression is lengthened and the ejection shortened, and shortened when the compression is shortened and the ejection lengthened. It is the fact that if an adjustment is made in the fill, without changing the ratio of the lengths of the compression and ejection strokes, adjustment of the punch extension above the bearing surfaces equal and opposite to the adjustment of the length of the compression stroke, and, where the fill is not changed but the ratio of the length of the compression and ejection strokes is changed, adjustment of the length of the extension to exactly equal the change in the length of the compression stroke, or, stated differently, it is the fact that adjustment of the length of the extension by an amount which is equal but opposite to, any change in the length of the ejection stroke, and adjustment of the ratio of compression stroke and ejection stroke by equal but opposite changes in each, will always result in (1) the desired fill, (2) the desired ratio of length of compression and ejection strokes, (3) the top of the punch being exactly flush with the top of the die at the end of the ejection stroke, and (4) no lost motion or wind cutting, i. e., at the point where the punch is at the bottom of its movement, for fill, it will be bearing against the compression rocking lever. With cam actuated rocking levers, one for the compression and one for the ejection, these adjustments can be obtained, within all limits of practical operation, without change of the cam contours, by synchronizing adjustment of the positions of the fulcrums of the rocking levers and the length of the extension of the punch above the bearing surfaces, i. e., the position on the punch of the nut or sleeve carrying the bearing surfaces, and with hydraulically actuated rocking levers, without change in the hydraulic actuation.

The invention will be further described in connection with the appended drawings which illustrate one form of a portion of a double-acting press embodying the invention, and its adjustment, but it is to be understood that the invention is not limited thereto.

In the drawings, Fig. 1 is a view in front elevation, partly in section, showing the lower punch of a typical press, together with its actuating mechanism, the upper punch and its actuating mechanism being not illustrated because conventional; Fig. 2 is a sectional view along line 2—2 of Fig. 1; Fig. 3 is a sectional view along line 3—3 of Fig. 1; Fig. 4 is a view in rear elevation; Fig. 5 is a sectional view along line 5—5 of Fig. 1; Fig. 6 is a sectional view along line 6—6 of Fig. 1; Fig. 7 is a sectional view along line 7—7 of Fig. 1; Fig. 8 is a diagrammatic illustration of one setting of the rocking levers; Figs. 9, 10 and 11 show positions of the punch at various stages of a normal operation; and Fig. 12 illustrates diagrammatically an adjustment of the various parts of the apparatus to give a specified fill, compression stroke and ejection stroke.

In the apparatus illustrated in Fig. 1, there is provided a punch or plunger **10**, the upper portion of which fits in the die **12**. As illustrated, the punch has a flat upper surface and is solid, but it is to be understood that in accordance with usual practice, it will have whatever configuration is required for the object to be made. The punch **10** is provided with a sleeve **14** threadedly engaged therewith so that by turning either the punch **10** or the sleeve **14**, the extension of the punch **10** above the top of the sleeve **14** may be adjusted. The sleeve **14** is provided with an upper bearing surface **16** and a lower bearing surface **18** against which the two split rocking levers **20** and **22** bear, suitable rockers **24** and **26** being provided to provide suitable pressure surfaces between the rocking levers and the sleeve. Except that it is provided with two bearing surfaces, one for each of two rocking levers, and with gear teeth **28**, the sleeve is conventional and corresponds to the usual "nut." Gear teeth **28** meshing with the teeth of the elongated gear **30** are provided at the top of the sleeve, and at the bottom of the punch **10** are provided gear teeth **32** meshing with the elongated gear **34**. The purpose of these two elongated gears and the corresponding meshing teeth on the sleeve **14** and the punch **10** will be explained. The rocking levers **20** and **22** are provided with fulcrums **36** and **38** respectively, pivotally mounted in bearings **37** and **39**, in turn

mounted in horizontal slideways which permit horizontal, but prevent vertical, movement. The planes of the working surfaces 21 and 23 of the working arms of the rocking levers 20 and 22 pass through the axes of rotation of the respective levers. The rocking lever 20 and its fulcrum is indicated as of heavier construction than the rocking lever 22 and its fulcrum, because the former is that used for the compression stroke, involving the application of great force to the punch 10, while the latter is used for the ejecting stroke, and the force required to be applied by it is much less. The rocking levers 20 and 22 are actuated by the cams 40 and 42 through the cam followers 43 and 45 and the push rods 44 and 46. Springs 52 and 54 serve to keep the cam followers pressed against the cam surfaces. The motion of the push rods 44 and 46 is constrained by the links 48 through 51 and is therefore substantially vertical, and the pressure exerted as the cams rotate on the ends of the two rocking levers 56 and 58 is downward, with the springs 52 and 54 raising the push rods and cam followers when the cam contours are such that upward motion is to take place. The downward pressure on the ends of the rocking levers 56 and 58 is exerted by the cross bars 60 and 62 rigidly mounted horizontally on the push rods 44 and 46, through the bearings 68 and 70 and axles 69 and 71. These bearings are free to move horizontally with respect to the push rods, sliding along the under surfaces of the cross bars 60 and 62.

Attached to the blocks carrying the bearings in which the fulcrums of the rocking arms are mounted are the rods 72, 73, 74 and 75. Motion of these rods horizontally moves the fulcrums of the two rocking levers correspondingly, and the position of the fulcrums and, therefore, of the rocking levers horizontally, is fixed by the positions of the rods 72 through 75, and it is by the movement of these rods horizontally that adjustment of the positions of the fulcrums of the rocking levers is obtained. It will be noted that because of the substantially vertical motion of the push rods 44 and 46, and the horizontal positioning of the bars 60 and 62, the length of each lever arm from the fulcrum to the point where pressure is applied through the cam action (force arm) remains constant, so the total motion of the applied force end of each of the rocking levers is the same for any position of the levers.

On the other hand, the effective length of the working lever arm of each of the rocking levers depends upon the position of the fulcrums as determined by the adjustment of the rods 72 through 75, because if one pair of these is moved to the left, in the illustration, the working arm of the corresponding lever is shortened, and if moved to the right, lengthened, with a corresponding change in the distance it moves the vertical punch up and down.

The rods 72 and 73, which control the position of the rocking lever 20, threadably engage the gear wheels 76 and 77, which turn in the same direction and in the same amount, because they are part of a gear train so arranged, while the rods 74 and 75 are similarly threadably engaged to the gear wheels 78 and 79 which are part of the same gear train and also turn in the same direction and in the same amount as the wheels 76 and 77. Thus, rotation of these gear wheels by the driving wheel 80, rigidly attached to the shaft 82 provided with a hand wheel 84, causes each of the rods 72, 73, 74 and 75, because of the threaded engagement at the hub of each gear wheel, to move in the same direction and the same distance, causing corresponding movement of the two rocking levers 20 and 22.

The rods 72, 73, 74 and 75 also pass through the hubs of the gear wheels 86, 87, 88 and 89, which are part of another gear train and are intermeshed, but the engagement with these hubs are splined engagements, so that if the wheels turn, the rods 72 through 75 turn with them, but slide back and forth with respect to them. Rotary movement of these wheels, therefore, rotates the rods 72 through 75, and because of their threaded relationship with the hubs of the wheels 76 through 79, causes them to move back or forth with corresponding movement of the rocking levers, none of the wheels being movable except by rotation. The wheels 86 and 87 turn in the same direction and in the same amount, while the wheels 88 and 89 turn in a direction opposite to the direction in which the wheels 86 and 87 turn, but again in the same amount. These wheels are meshed with the gear wheel 92, rigidly fastened to the rod 94, in turn fastened to the hand wheel 96, so that if the hand wheel 96 is turned, the wheels 86 and 87 are turned in one direction and the wheels 88 and 89 in the other direction, with the result that the rods 72 and 73 are moved in one direction and the rods 74 and 75 are moved the same distance but in the opposite direction, so that if the effective working arm of one of the rocking levers is shortened, the length of the other is correspondingly lengthened.

The rod 94, which turns the wheel 92, also, through the pinion 98, turns the wide gear 30 meshed with the gear teeth 28 on the sleeve provided with the bearing surfaces by which the rocking levers move the punch up. When the hand wheel 96 is turned, therefore, moving the rods 72 and 73 in one direction and the rods 74 and 75 in the other direction it will at the same time rotate the sleeve 14 on the punch 10, causing a change in the length of the extension of the punch above the sleeve, and by adjustment of the number of geared teeth in the various parts of the gear train, and the pinion and the gear 30, and the pitch of the threads on the punch 10 engaged by the sleeve 14, the relative motion of the sleeve 14 and the punch 10 is adjusted so that the length of the extension of the punch 10 above the sleeve 14 is changed by an amount which is exactly equal to the change in the length of the compression stroke, that is, the vertical travel of the compression rocking lever at the vertical line of the punch 10 from its lower-most position to the position at which it is horizontal, and at which, as will be explained, through the contours of the actuating cams, the ejection rocking lever lifts the punch 10 away from the compression rocking lever. It will be noted that this adjustment on the turning of the hand wheel 96 changes the length of the extension of the punch 10 above the sleeve 14 by an amount which is equal to and opposite to the amount by which the vertical movement of the ejection rocking lever 22 at the vertical line of the punch from its horizontal position to its upper-most position is changed, so that the net effect of a change in the relative positions of the two rocking levers and the sleeve 14 is to make the total travel of the punch 10, i. e., the fill, the same, while the ratio of the compression to the ejection stroke is changed and the bearing surfaces of the sleeve 14 are always kept against one or the other of the two rocking levers.

During adjustments made by the hand wheel 96 the hand wheel 84 is, of course, kept from rotating so that the gears 76, 77, 78 and 79 do not rotate.

The rod 82 through the pinion 100 rotates the wide gear 34 in turn meshed with the teeth 32 at the bottom of the punch 10. When the wheel 84 is turned, while the hand wheel 96 is restrained from motion, the wheels 76 through 79 are rotated and move the rods 72 through 75 in the same direction and the same amount, correspondingly changing the effective working arms of the two rocking levers the same amount and in the same direction. At the same time, rotation of the gear 34 rotates the punch 10, and as the sleeve 14 is restrained from rotating, changes the length of the extension of the punch 10 above the sleeve. By proper adjustment of the number of gear teeth in the various wheels and gears and taking cognizance of the pitch of the threaded portion of the punch 10, the change in the length of the extension of the punch above the sleeve 14 is made equal and opposite to the change in the length of the compression stroke so that appropriate adjustment of the fill is made, while keeping the bearing surfaces of the sleeve 14 on one or the other of the two rocking levers and insuring that at the end of the ejection stroke the top of the punch is flush with the top of the die 12.

As a matter of precaution, there is provided an anvil 102 below the punch which is threadably positioned in the pedestal 104 and provided at the top with gear teeth 106 meshing with the gear 34. Rotation of the gear 34 moves the upward surface of the anvil up or down, and by making the pitch of the threads of the anvil and the pedestal twice the pitch of the threads on the rod 10, simultaneous rotation of the anvil, and the rod, by rotation of the hand wheel 84, will insure that the position of the anvil is always such as corresponds to the desired fill. This follows from the fact that so far as fill adjustment is concerned, one-half is obtained through changing the length of the extension of the punch 10 above the sleeve 14, and one-half is obtained by change in the bottom position of the punch 10 through adjustment of the position of the fulcrums of the rocking levers, and, therefore, the length of their working strokes at the vertical position of the punch 10 below their horizontal position.

The cam contours of the two actuating cams are such that, assuming the punch to be at the bottom of its stroke with the die just filled with powder, the compression rocking lever, the upper one in the apparatus illustrated, leads the other so that the rotation of the cam shaft causes the compression rocking lever to raise the sleeve 14 and the punch 10 and accomplish the desired compression. The upper punch which has not been illustrated will, of course, be actuated in one of the usual ways to simultaneously or otherwise compress from the top. When the two rocking levers are in a horizontal position, the cam driving the ejection rocking lever, the lower one, catches up to and starts to go ahead of the cam driving the compression rocking lever, so that for the remaining part of the upward motion of the two rocking levers, the ejection rocking lever is ahead and carries the sleeve 14 and the plunger 10 up for the ejection action. The cams may be designed to provide a dwell at the end of the compression stroke and before the ejection stroke begins, and, as pointed out above, may be constructed so that, for a short distance after compression is finished and ejection is to begin, the two levers move together, so that the compression lever helps the ejection lever to break any adhesion of the article to the die. Such variations are matters of conventional cam design. When the ejection is completed, and ordinarily a dwell will be provided to hold the punch 10 flush with the top of the die for a short interval to permit removal of the formed article, and the working arms of the two rocking levers go down, the cam actuating the compression rocking lever again passes the other so the sleeve 14 essentially rests on the compression rocking lever at the end of its downward motion. The punch 10 may be downwardly urged by a spring to keep it bearing against one or the other of the rocking levers at all times, and while the anvil 102 is not necessary, it is a convenient way of assuring that the fill is exactly correct. It will be noted that the two rocking levers remain substantially parallel, except for the leads provided to permit one or the other to carry the load in raising the punch, and for this reason, they can, within practical limits, operate on bearing surfaces which are not adjustable with respect to each other.

It has been previously pointed out that by the adjustments of the position of the sleeve on the punch, and the fulcrums of the two levers, it is possible to provide, within the working limits of the press, any desired fill, and any desired ratio and compression stroke to ejection stroke by adjustment by the two hand wheels. This is true within the practical limits of operation of a press of this type, because of the fact that in practice the length of the ejection stroke is at least as long as, and ordinarily longer than, the length of the compression stroke. This follows from the fact that compression of powdered metals and the like is of the order of three to one, that is, the volume of the fill is about three times as great as the volume of the finished product. Assuming that half of the compression is the result of the downward motion of the upper punch and half the upward motion of the lower punch it follows that for any practical operation, the ejection stroke will exceed the compression stroke in length by an amount roughly equivalent to the vertical thickness of the formed article.

The significance of this with respect to machines in which the actuating force is cam driven, as in the machine being described, is that while theoretically it would be possible to have any fill and any ratio of compression stroke to ejection stroke, practically the limit imposed where the compression stroke is greater than the ejection stroke is that resulting from the amount which the cam which drives the ejection rocking lever can be cut back over those portions of its contour which correspond to the portions of the motion of the ejection rocking lever where the working arm is below the horizontal. Thus, if the compression stroke is longer than the ejection stroke, the punch at the lower-most part of the stroke, that is, for fill, is carried by the compression rocking lever, and because of the fixed relationship between the bearing surfaces upon which the respective levers operate, the ejection lever must, in the vertical line of the punch, be at least as far below the horizontal as is the compression lever at the same line. Because both levers have fixed force arms, it follows that the cam driving the ejection rocking lever must be cut back at this point a distance sufficient to ac-

commodate this amount of motion, and practically the amount which it can be cut back within the limits of satisfactory cam design impose the limit on the extent to which the compression stroke can be made longer than the ejection stroke.

For example, assume that the fill desired is 6'', the compression 4'', the ejection 2'', and the fixed force arms of the two rocking levers are 32'', with the vertical motion of the compression push rod from its top position to the horizontal position of the lever 8'', and the ejection push rod 8'' from the horizontal to its lower-most position. It follows that the length of the working arm of the compression lever must be 16'' so that it moves 4'' from its lower-most point to the horizontal, and of the ejection rocking lever 8'' so it will move 2'' from the horizontal to its highest point. To permit the sleeve to be carried by the compression rocking lever at the lower-most position of the punch means that at the vertical line of the punch, the ejection lever must move down at least 4'', corresponding to a rise of the corresponding push rod of about 16'', and the cam for the ejection rocking lever would have to be cut back accordingly. Further disproportion between the compression and the ejection stroke in this direction would impose even greater requirements on the extent of the cam cutback, so that for any substantial accommodation in this direction extremely large cams would be required. As pointed out, however, this is as a practical matter of relatively little importance because of the fact that the ejection stroke is as long as or longer than the compression stroke, but the cams can be readily constructed in such a way as to permit the compression stroke to be longer than the ejection stroke within some limits.

The corresponding problem does not arise on the upward stroke, that is, the fact that the ejection stroke is longer than the compression stroke is not important, because all that happens is that the ejection rocking lever lifts the punch away from the compression lever, and after ejection and when the punch is going down for fill, redeposits it on the compression lever at whatever point in the operation is selected by design of the cam contours. The only thing that is required here is that the design of the levers and the sleeve be such as to permit the ejection lever to lift the sleeve and the punch it carries away from the compression lever; and the greater the disproportion between the ejection stroke and the compression stroke, where the former is longer, the wider apart must be the bearing surfaces between which the respective levers operate.

The construction of the gear trains which fix the positions of the fulcrums of the two rocking levers through the rods **72** through **75** is best illustrated in Fig. 7, which shows the relationship of the wheels **76**, **77**, **78** and **79**, driven by the wheel **80**, all in the same direction and the same amount, thereby causing simultaneous movement of the two fulcrums in the same direction and the same amount through the operation of the threaded portion of the rods **72** through **75**; and the relationship of wheels **86**, **87**, **88** and **89** driven by the wheel **92**, the first two being driven in one direction and the other two in the opposite direction whereby, because of the splined relationship of the rods **72** through **75** to the hubs of the wheels, one fulcrum is caused to move in one direction and the other the same distance in the opposite direction.

It will be noted that adjustment by the wheel **84** changes the length of the effective working arm of each of the rocking levers by the same amount and in the same direction, and with the synchronized change in the length of the extension of the punch **10** above the sleeve **14**, changes the fill without changing the ratio of the compression stroke to the ejection stroke. Adjustment by the hand wheel **96** on the other hand changes the effective working arm of one rocking lever by the same amount as it changes the effective working arm of the other but in the opposite direction, and with the synchronized change in the length of the extension of the punch **10** above the sleeve **14**, changes the ratio of the compression stroke to the ejection stroke without changing the fill. Both of these adjustments are made without changing the cam contours and without changing the vertical motion of the push rods **44** and **46**, and without changing the vertical motion of the force ends of the rocking levers in character or amount. It is thus apparent that by these adjustments, and within the limits of motion of the rocking levers imposed by the cam design, two simple hand wheel adjustments permit the obtaining of any desired fill and any desired ratio of compression stroke to ejection stroke while assuring that at the end of the ejection stroke the top of the punch is flush with the top of the die, and that one or the other of the rocking levers always bears against a bearing surface of the sleeve **14**, so that wind cutting is eliminated and the noise and the strain heretofore incident to adjustment of fill or the like is avoided.

Fig. 8 illustrates a way in which the effective motions of the rocking levers may be portrayed. The limits of motion are shown by the lines **110**, **111**, **112** and **113**, the working part of the motions by the shaded areas—for compression, area **114**, for ejection, area **115**. Figs. 9, 10 and 11 illustrate the die, punches and material treated, conventionally, Fig. 9 showing the die, lower punch and loose fill, Fig. 10 the die, upper and lower punches and formed article after compression, and Fig. 11 the die, lower punch and formed article at the end of the ejection stroke.

In Fig. 12 is shown one setting of a machine having specified characteristics. In this machine it is assumed that the force arm of each of the rocking levers is 32'', that the total working vertical motion of each push rod is 8'', that the working arms of the two rocking levers have a maximum usable length of 32'', and the maximum motion of the punch, that is, maximum fill, is 8''. It is also assumed that the extension of the plunger **10** above the sleeve for this operation is 12'' and the sleeve is positioned accordingly. For operation with an 8'' fill, 4'' compression and 4'' ejection, the two fulcrums, therefore, would be positioned so that the working arm of each rocking lever is 16'' long, so that, from the bottom of the punch stroke the compression rocking lever would raise the punch 4'', at which time it would be horizontal, the ejection rocking lever would pass it, and the ejection rocking lever would then raise the punch the remaining 4''. This is a convenient starting point for illustrating the way in which the adjustments of this invention are made.

Assuming that it is desired to change to an operation in which the fill is 6'', the compression 2'' and the ejection 4'', the following adjustments are made:

To adjust the fill, the wheel **84** is turned, turning the wheels **76** through **79**, moving the rods **72** through **75** to the left, and moving the fulcrums of the two rocking levers to the left a distance of 4''. This reduces the working arms of the two rocking levers to 12'', and the effective length of their strokes at the vertical position of the punch to a 6'' total, the desired fill. However, it will be noted that if the position of the sleeve **14** with respect to the punch **10** is left unchanged, and the machine were operated with this setting, the top of the punch **10** would be 1'' below the top of the die at the top of the ejection stroke. This, however, is taken care of by the rotation of the gear **34** and the punch **10** which, because of its threaded relationship with the sleeve **14**, moves 1'' with respect to the sleeve increasing the length of the extension from 12 to 13''. This time, if the machine is operated, it will operate with a compression stroke of 3'' and an ejection stroke of 3'' and a fill of 6''. The anvil will also have been raised 2'' by the action of the gear **34**, so that it will be properly positioned.

To obtain the desired setting of a 2'' compression and a 4'' ejection, the wheel **96** is turned while the wheel **84** is restrained. This in turn rotates the wheels **86** and **87** in one direction and the wheels **88** and **89** an equal amount in the other direction, thereby moving the rods **72** and **73** one way and the rods **74** and **75** in the other way an equal amount, and is carried out to move the rods **72** and **73** 4'' to the left, and the rods **74** and **75** 4'' to the right, giving the compression rocking lever a working arm of 8'' and the ejection rocking lever a working arm of 16''. If the machine were now operated without changing the length of the punch extension above the sleeve, it would have a 2'' compression, and a 4'' ejection but the punch would extend 1'' above the top of the die at the end of the ejection operation. This result is not obtained, however, because the gear **30** turns at the same time that the wheels **86** and **87** do, and, as the punch **10** is restrained from rotating moves relative to the punch **10**, so that the length of the extension is reduced 1'' to 12''. Because in this second adjustment the fill is not changed, no adjustment of the position of the anvil is required.

The final position of the machine for the postulated operation, with the various dimensions illustrated, appears in Fig. 12.

The following table illustrates the flexibility of adjustment of presses embodying the invention and the fact that every adjustment of fill and ratio of compression to ejection stroke is readily and accurately obtained merely by adjustment of the two hand wheels. The limitations with respect to settings in which the compression stroke is longer than the ejection stroke imposed by the limitations of cam design, have been ignored. It is assumed that the machine is of such dimensions that the force arm of each rocking lever is 32'', mamimum fill 8'', length of the extension of the punch above the slide 12'' when the fill is 8'' and compression equals ejection, and that the zero value for each adjustment corresponds to this setting. The values selected do not necessarily and in many cases do not reflect values which will be used in actual practice, where fill, compression stroke and ejection stroke will be fixed in accordance with well known practice. What is illustrated is the flexibility of the adjustments, that is, the capacity to provide any desired fill, compression stroke and ejection stroke by two convenient adjusting wheels, without the disadvantages heretofore encountered in making changes in the operation of a press of this character.

Tabulated are (*a*) various depths of fill, (*b*) lengths of compression stroke, (*c*) lengths of ejection stroke, (*d*) adjustments of lengths of the rocking arm of the compression rocking lever (plus where lengthened, minus where shortened), (*e*) adjustment of lengths of ejection rocking lever working arm (plus where lengthened, minus where shortened), (*f*) length of punch extension, (*g*) adjustment of length of punch extension by turning punch by gear 34 (plus or zero in all cases because starting point is maximum fill), (*h*) adjustment of punch extension by turning slide by gear 30 (plus where lengthened, minus where shortened), and (*i*) the anvil adjustment (zero or plus in all cases because starting point is maximum fill).

Table

	1	2	3	4	5	6	7	8	9	10	11	12	13
a. Fill	8	8	6	6	6	5	4	4	3	3	2	1	8
b. Compression stroke	4	6	3	5	1	3	2	1	2	1	1	.75	1
c. Ejection stroke	4	2	3	1	5	2	2	3	1	2	1	.25	7
d. Adjustment Comp. R. L.	0	+8	−4	+4	−12	−4	−8	−12	−8	−12	−12	−13	−12
e. Adjustment Eject. R. L.	0	−8	−4	−12	+4	−8	−8	−4	−12	−8	−12	−15	+12
f. Length punch extension	12	14	13	15	11	14	14	13	15	14	15	15.75	9
g. Adjustment by gear 34	0	0	+1	+1	+1	+1.5	+2	+2	+2.5	+2.5	+3	+3.5	0
h. Adjustment by gear 30	0	+2	0	+2	−2	+.5	0	−1	+.5	−.5	0	+.25	−3
i. Anvil adjustment	0	0	+2	+2	+2	+3	+4	+4	+5	+5	+6	+7	0

Illustrations 2, 4, and 12 in the table are not practical, or are dubiously practical, because in these cases the compression stroke so exceeds the ejection stroke that the force end of the ejection rod must rise very substantially to avoid having the sleeve rest on the ejection lever instead of the compression lever at the bottom of the strok of the rocking arms. For illustrations 2 and 12 the rise of the cam push rod would have to be such that the force end of the force arm of the ejection rocking lever rises 19.2'' above the horizontal, and for illustration 4 the rise would have to be 25''. These may exceed the limits of practical cam design. For illustration 6, the rise would have to be 12'' and for illustration 9, 14.3''. These are within the limits of cam design. The rises in each case are determined on an assumption of circular motion of the force end of the ejection rod and lever rather than vertical motion, as, in the design of the cams, they must be. It should be noted that the vertical motion of the compression lever push rod from its uppermost point to the horizontal position of the lever will be about 7.76'', and of the other push rod from the horizontal position of the lever to its lower-most point the same.

The double-acting press, certain portions of which have been described in detail in connection with the appended drawing, is one in which the lower punch is solid. It is to be understood that a cored cylindrical punch with a cooperating core rod may be used instead, without any change in the application of the principle of the inven-

tion and further that in addition to a primary punch, the press may be provided with a secondary punch in accordance with customary practice where the nature of the articles being formed are such as to require both a primary and a secondary punch, with the secondary punch actuated by a cam driven rocking lever, driven by the same cam shaft, or by the same cams as drive the primary punch using multiple cross bars on the push rods.

The synchronous automatic adjustment of the positions of the rocking lever fulcrums and the sleeve on the plunger is very advantageous in providing rapid, accurate and simple adjustments in fill and ratio of compression to ejection stroke while eliminating wind-cutting and changes in the actuating mechanisms, i. e., cams or hydraulic devices. However, substantial improvement over presently existing double-acting presses can be obtained without realizing the full advantages made possible by the present invention. Thus, in stead of providing for the synchronous adjustment of the position of the sleeve on the plunger and the positions of the rocking lever fulcrums, provision may be made for separate adjustment of the position of the sleeve on the plunger. For example, the positions of the rocking lever fulcrums may be adjusted as described, and, after that adjustment, the position of the sleeve on the plunger adjusted manually or in other ways, as by bringing the ejection lever up to its maximum height and then adjusting the position of the sleeve on the plunger so that the top of the punch is flush with the top of the die. Adjustment of the anvil can then be accomplished by bringing the plunger to its lower-most position and manually or otherwise moving the anvil to the corresponding position. While a machine constructed for operation in this manner represents a substantial improvement over the machines heretofore proposed or used, in that it permits elimination of wind-cutting and requirements for changes in cam contours or hydraulic actuation, it does require a delicate adjustment of the position of the sleeve on the plunger and so is less advantageous than the machine having the fully automatic synchronized adjustments.

I claim:

1. In a double-acting press having a lower and an upper punch, the combination for adjusting the motion of the lower punch which includes means for changing the length of the compression stroke and the length of the ejection stroke simultaneously by the same amount and in the same direction whereby fill is adjusted, and means for changing the length of the compression stroke and the ejection stroke simultaneously by the same amount but in opposite directions, whereby the ratio of the two strokes is adjusted.

2. The combination as in claim 1 in which the lower punch is provided with an adjustable sleeve with two bearing surfaces a fixed distance apart, a first and a second rocking lever bearing against said bearing surfaces, said rocking levers being adapted to oscillate above and below the horizontal lines through their respective fulcrums, the first such lever leading the second when the working arms are below the horizontal and the second leading the first when the rocking arms are above the horizontal during upward motion.

3. The combination as in claim 2 in which the rocking levers have fixed force arms and in which the means for adjusting the lengths of the strokes are means for moving the fulcrums of the rocking levers horizontally.

4. The combination as in claim 3 including means to adjust the position of the sleeve on the punch and hence the distance between the top of the punch and the surface against which the second rocking lever bears by an amount proportional and opposite to any change in the length of the working arm of said second rocking lever.

5. The combination as in claim 4 in which the means for moving the fulcrums of the rocking levers and the means for adjusting the position of the sleeve on the punch include intermeshing gears.

6. In a double-acting press, a lower punch provided with a sleeve carrying two bearing surfaces a fixed distance apart, each adapted to bear against the working arm of a rocking lever, actuating cams, two rocking levers actuated by said cams with force arms of fixed length and with horizontally movable fulcrums, one adapted to lift the punch for the first part of its upward motion for the compression stroke and the other to lift the punch for the second part of its upward motion for the ejection stroke, means to move both fulcrums horizontally in the same direction and the same distance, and means to move the fulcrums horizontally in opposite directions but the same distances, and means to adjust the distance from one of the bearing surfaces of the sleeve to the top of the punch by an amount equal and opposite to the change in length of the ejection stroke of the punch, the contours of the actuating cams being such that the rocking arm of the compression rocking lever leads the other during the portion of the movement of the levers from their lower-most positions to the horizontal position and the working arm of the ejection rocking levers leads the other during the portion of the movement from the horizontal position to the upper-most position.

7. In a double-acting press having a lower punch which has a compression stroke and an ejection stroke, means for adjusting the compression stroke and means actuated thereby for adjusting the ejection stroke to level the punch at the top of the die at the end of the ejection cycle.

8. In a double-acting press having a lower punch which has a compression stroke and an ejection stroke, means for adjusting the length of the compression stroke and the ejection stroke and means actuated thereby to level the punch at the top of the die at the end of the ejection stroke.

9. In a double-acting press having a lower punch which strokes during the compression cycle, means which provide for adjustment of said compression stroke and means actuated thereby for compensating the ejection stroke to level the punch at the top of the die at the end of the ejection cycle.

10. In a double-acting press having a lower punch which strokes during the compression cycle, means which simultaneously adjust said stroke and compensate the ejection stroke to level the punch at the top of the die at the end of the ejection cycle and means for adjusting the length of the compression stroke and the ejection stroke whereby wind cutting of the actuating means for the punch is eliminated.

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