

[54] **CONJUGATE CAM ARRANGEMENT
 AND PUNCH PRESS UTILIZING SAME**

[76] Inventor: **Robert F. Sellman**, 9534 North 60th
 Street, Milwaukee, Wis. 53202

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[58] Field of Search..... **72/336, 327, 328,
 72/452**

[56] **References Cited**

UNITED STATES PATENTS

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Primary Examiner—Charles W. Lanham

Assistant Examiner—R. M. Rogers

Attorney—John W. Michael et al.

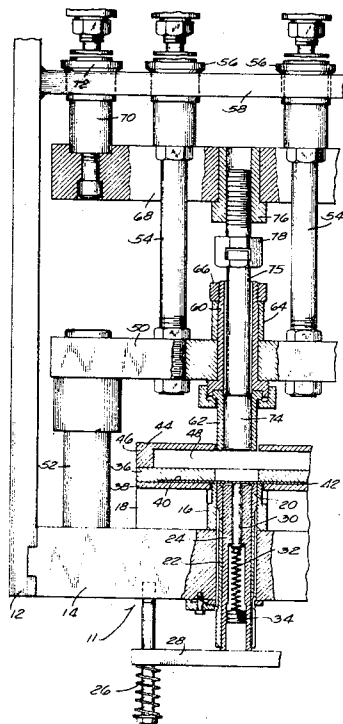
[57] **ABSTRACT**

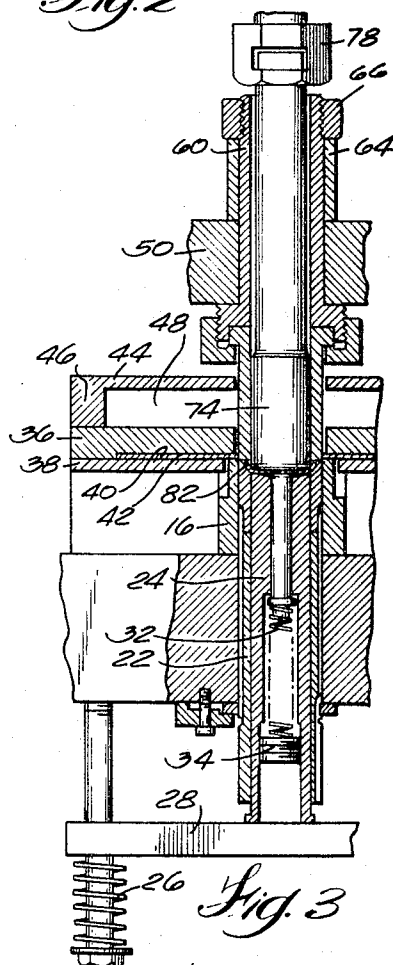
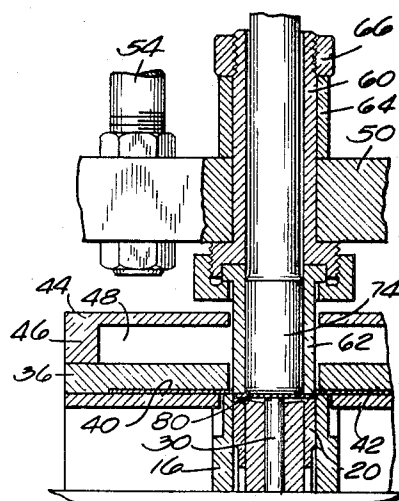
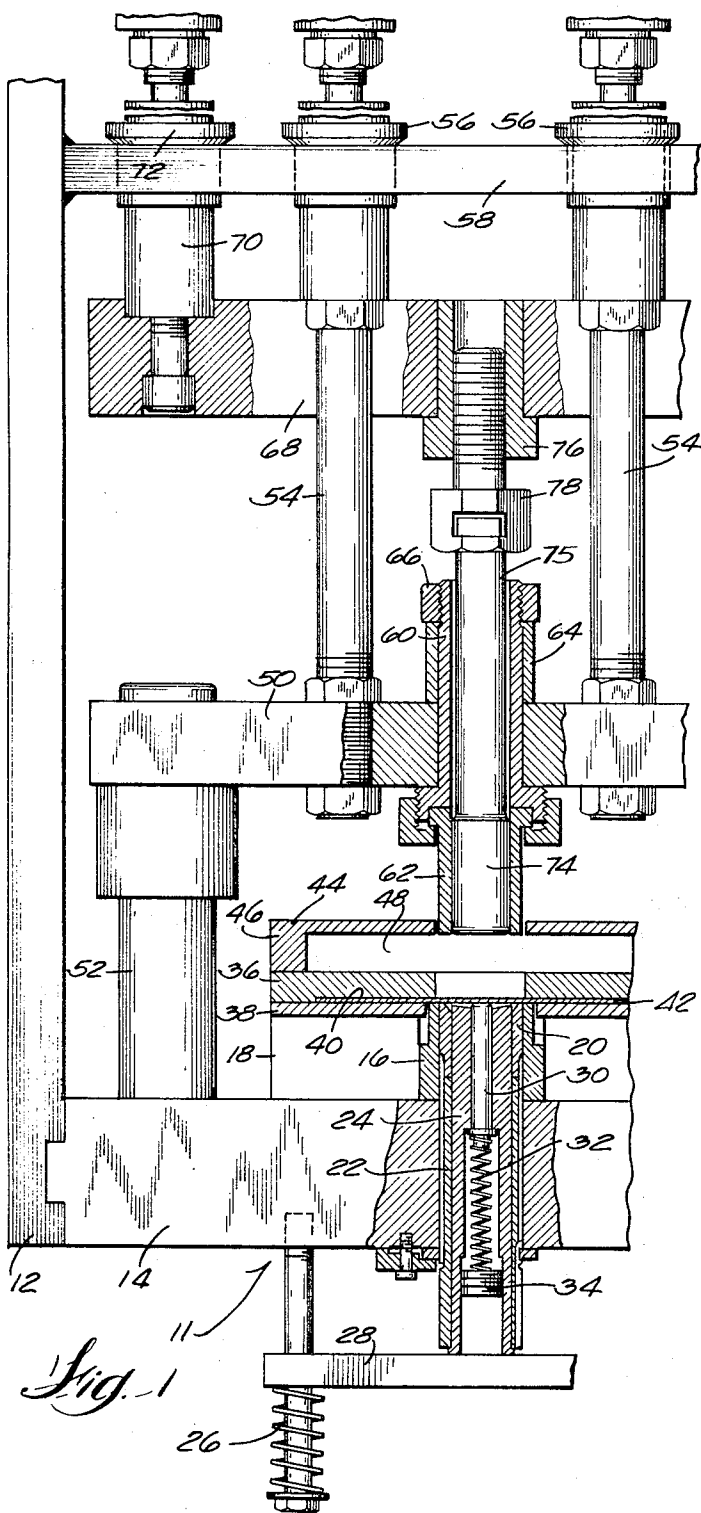
Both the blanking punch and the forming punch (which telescopes inside the blanking punch) are reciprocally driven by separate cam assemblies. Each cam assembly includes an eccentric plate drive cam which cooperates with two plate cam followers to

provide a reciprocating stroke to the punches. The two drive cams are symmetrically arranged on a common drive shaft so that the outer ends of the two punches remain substantially flush with each other during the blanking stroke and during dwell at the top of the back stroke. The forming punch drive cam has separate conjugate cam surfaces which selectively engage the cam followers cooperating therewith. One of these cam surfaces includes a lobe which imparts the additional stroke to the forming punch required for forming the completed parts while the blanking punch is in dwell at the bottom of the forward stroke. A slot relief in the backward motion cam follower accommodates the lobe so the forming punch is permitted to dwell at the top of the backstroke.

A ceiling plate, positioned above the dies and having side walls, defines an open-ended passage through which the completed parts are expelled, preferably assisted by a stream of pressurized air introduced into the passage. While in dwell at the top of the backstroke, the outer ends of blanking and forming punches are flush with each other and with the underside of the ceiling plate. Impingement of the completed parts ejected from the die cavities is against the substantially smooth surface provided by the ceiling plate and the bottom ends of the punches thereby minimizing ricocheting of the parts.

13 Claims, 10 Drawing Figures





Inventor
Robert F. Sellman
By Glenn A. Busi
Attorney

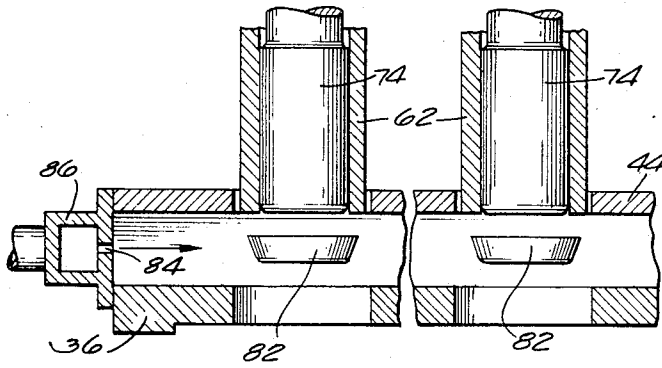


Fig. 4

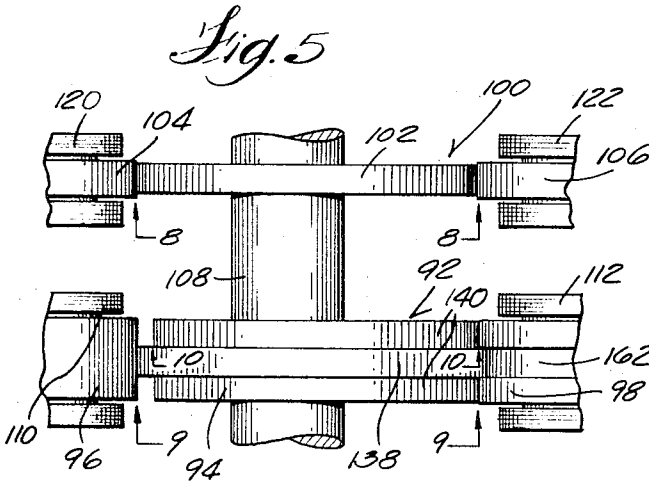


Fig. 5

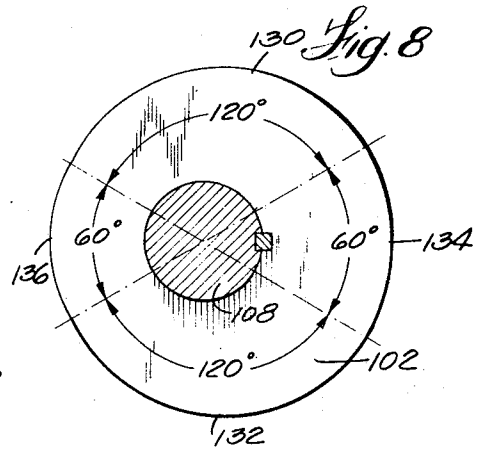


Fig. 8

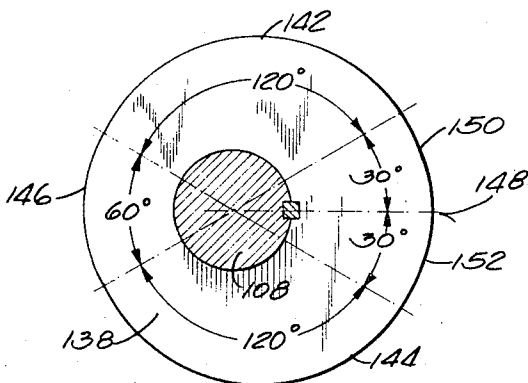


Fig. 9

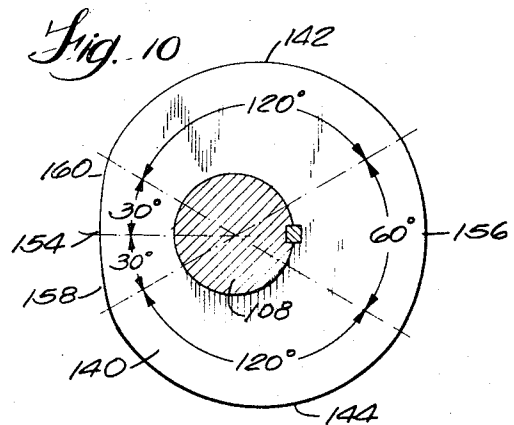


Fig. 10

Inventor
Robert F. Sellman
By Glenn A. Busi
Attorney

Fig. 6

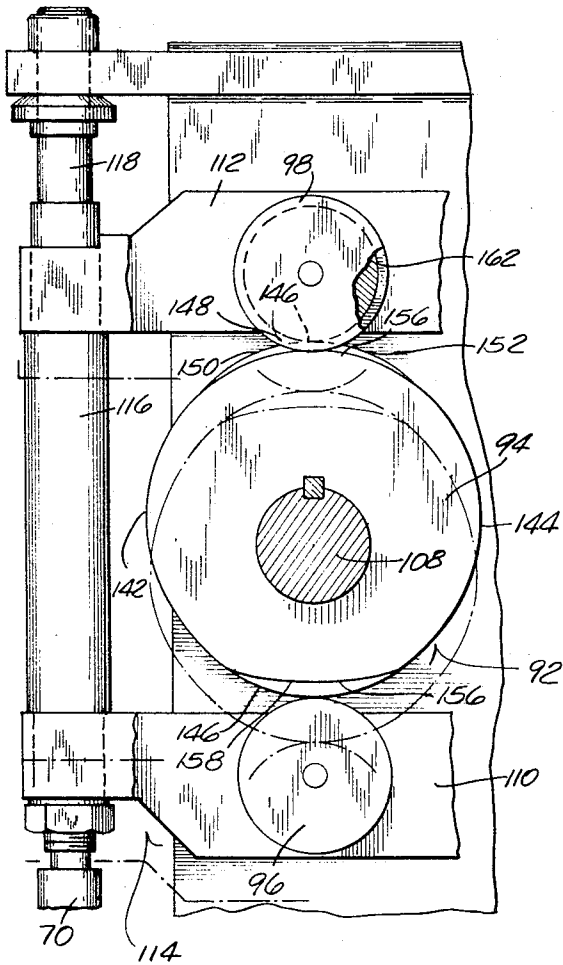
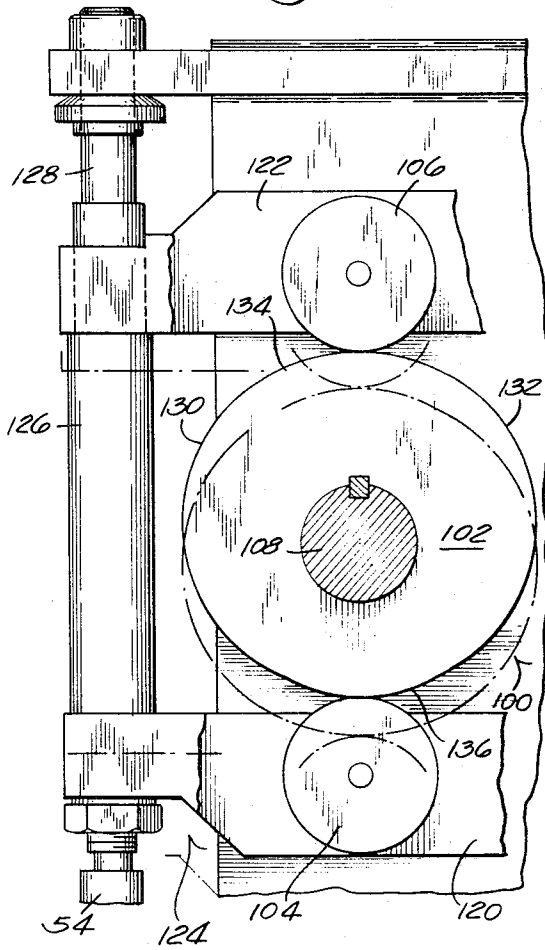


Fig. 7



Inventor
Robert F. Sellman
By Glenn A. Busi
Attorney

CONJUGATE CAM ARRANGEMENT AND PUNCH PRESS UTILIZING SAME

BACKGROUND OF THE INVENTION

This invention relates to a cam drive means for reciprocating mechanism and a punch press utilizing such a means.

A variety of equipment employs cooperative reciprocative mechanisms having sequential strokes. For example, punch presses for forming bottle caps, can ends and similarly shaped pressed metal parts employ such mechanisms; one for punching a blank from the feed stock and another for forming the part. In presses of this type, the forming punch typically telescopes inside the blanking punch. The blanking punch is driven through a stroke sufficient to cooperate with a die and cut out a blank. The forming punch is then extended an additional stroke and cooperates with an appropriately shaped die to draw or from the part. Upon completion of drawing or forming, the punches are retracted (the forming punch being telescoped back into the blanking punch) to a starting position ready for the next cycle. During this retraction, the finished part is ejected.

In many prior art presses of this type, the blanking punch is cam driven and the forming punch is driven by a harmonic crank arrangement. The drive cam for the blanking punch is arranged with a dwell to effectuate a pause at the bottom and top of the stroke. Except for an instantaneous pause at the dead centers at the top and bottom of the stroke, the forming punch is moved continuously by a crank shaft. Consequently, in order to obtain proper timing, the stroke of the forming punch must be substantially greater than that required for the forming operation, i.e., the forming punch is telescoped inside the blanking punch far enough to create a time or motion loss. The resultant lost motion reduces efficiency, accelerates wear and limits production rate. Also, considerable vibration is created at higher production rates because of the inertial effects of the moving elements.

Presses of this type typically include several stations. The completed parts, which generally are ejected in a random manner, can occasionally strike a punch, either the one at the station where formed or at an adjacent station, and ricochet back into a die cavity where they interfere with a subsequent cut, i.e., cause a multiple cut or jamming. The ricocheting action is compounded by the irregularity of the bottom surface of the punch assembly caused by the opening left in the blanking punch when the forming punch has retracted. The parts can also be retained in this opening. The ejection rate capability of these presses limits the number of punching stations which can be used, thereby further limiting the production rate capacity of the press.

SUMMARY OF THE INVENTION

The primary object of this invention is to provide a means for reciprocatively driving separate, cooperative mechanisms through different length strokes in a sequential manner with a minimum of lost motion, a minimum of inertial loads, and a minimum of vibrations.

Another object of this invention is to provide a punch press wherein ricocheting of ejected parts is minimized

and the expulsion rate of the completed parts is increased.

According to this invention, the cooperative mechanisms, such as a blanking punch and a forming punch of a punch press, are reciprocatively driven by separate cam assemblies operatively connected thereto. Each cam assembly includes an eccentric plate drive cam cooperating with two cam followers, a forward motion follower and a backward motion follower, which are positioned a fixed distance apart. The harmonic rise and corresponding harmonic fall portions of the drive cams are symmetrically arranged so the mechanisms are moved back and forth simultaneously as the drive cams are rotated, preferably by a common drive shaft. The blanking punch drive cam has symmetrical dwell portions which permit the blanking punch to dwell for a predetermined time at the end of the forward and backward stroke. The forming punch drive cam has separate cam surfaces which selectively engage the cam followers cooperating therewith during rotation. A first cam surface on the forming punch drive cam includes a lobe which has a total rotational angle corresponding to the dwell portion of the blanking punch drive cam and a dwell portion which is symmetrical with the dwell portions of the blanking punch drive cam. The second cam surface of the forming punch drive cam (which is conjugate with the first cam surface) has a dwell portion which is symmetrical with a dwell portion of the blanking punch drive cam. The term "conjugate" as used herein is intended to mean that the distance from any point on the periphery of the first cam surface on the forming punch drive cam to the diametrically opposed point on the periphery of the second cam surface is constant. The lobe engages a forward motion cam follower (while a flattened conjugate portion of the second cam surface of the second drive cam is in engagement with the backward motion cam follower) to impart an additional stroke to the forming punch while the blanking punch is in dwell. A slot relief provided in backward motion follower through which the lobe passes permits the forming punch to dwell at the end of the back stroke.

The angular symmetry of the acceleration and deceleration portions of both the drive cams, the angular symmetry of the backward stroke dwell portions of both the drive cams and the angular symmetry of the forward stroke dwell portion of the blanking punch drive cam and the lobe on the forming punch drive cam insures proper sequencing of the punches with a significant reduction in lost motion. During the major part of the stroke, the forming punch moves back and forth simultaneously and at the same rate as the blanking punch rather than being driven at a different rate by a harmonic crank conventionally used by prior art devices. The forming punch is moved the relatively short additional stroke required for the forming operation while the blanking punch is in dwell at the end of a forward stroke thereby minimizing lost time. It has been found that with the novel cam arrangement of this arrangement, the blanking stroke for a bottle cap press can be reduced from 1½ inches (typical of prior art devices) to 1¼ inches and the stroke with the forming punch can be reduced from 3 inches (typical of prior art devices) to approximately 1½ inches.

According to another aspect of this invention, the punch press is provided with a ceiling plate spaced above the die cavities. The ceiling plate has side walls

and defines an open-ended passage through which the completed parts are expelled, preferably assisted by a stream of pressurized gas introduced into the passage. The ceiling plate is arranged to minimize the axial travel of the parts ejected from the dies thereby minimizing wedging in the passage. The semi-closed passage increases the effectiveness of the gas stream expelling the parts and thereby increases the expulsion rate capability of the press. The longitudinal axes of the punches and the dies are preferably arranged at an angle 90° to the vertical in order to obtain maximum benefit of gravity and further increase the expulsion rate. With this increased expulsion rate capability, it has been found the number of rows of punching stations can be increased from two (typically used in prior art devices) to four.

As discussed above, the novel cam arrangement of this invention permits the outer ends of the blanking and forming punches to be flush with each other while in dwell with the end of the backstroke. The ceiling plate is arranged so that the bottom ends of the punches are substantially flush with underside thereof while in dwell. Impingement of the ejected parts in against the substantially smooth surface provided by the ceiling plate and the outer ends of the punches and not against adjacent punch station or a blanking punch having an opening left by the retracted forming punch as is the case in prior art devices. Hence, ricocheting problems associated therewith are minimized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary, side elevation view, partially sectioned, of a punching station of a press embodying this invention showing the position of the blanking and forming punches at the top and backstroke.

FIG. 2 is a fragmentary view of the punching station shown in FIG. 1 showing the position of the blanking and forming punches at the end of the blanking stroke.

FIG. 3 is a fragmentary view of the punching station shown in FIG. 1 showing the position of the blanking and forming punches at the end of the forming stroke.

FIG. 4 is a fragmentary, cross-sectional view of adjacent punching stations showing completed bottle caps ejected into the expulsion passage.

FIG. 5 is a fragmentary, plan view of the cam assemblies which drive the blanking and forming punches.

FIG. 6 is a fragmentary, side elevational view, partially sectioned, of the forming punch cam assembly.

FIG. 7 is a fragmentary, side elevation view of the blanking punch cam assembly.

FIG. 8 is a side elevation view of the blanking punch drive cam taken along the plane designated 8—8 in FIG. 5.

FIG. 9 is a side elevation view of the form punch drive cam taken along the plane designated 9—9 in FIG. 5 with cam 94 removed.

FIG. 10 is a side elevation view of the forming punch drive cam taken along the plane designated 10—10 in FIG. 5 with cam 138 removed.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The punch press of this invention includes a plurality of punching stations 11 arranged in staggered rows. A single station is illustrated and will be described for the sake of brevity. As shown in FIGS. 1-3, the press includes a pair of side frame members 12 (one shown)

and a cross member 14. Each punching station 11 includes a blanking die 16 carried by a die nest 18, and a corrugated crown die 20 carried by die holder 22. Ejector 24, slidably mounted within die holder 22, is urged to the normal position shown in FIG. 1 by spring 26 bearing against spring pad 28 which holds ejectors from several punching stations. Shedder pin 30, slidably mounted within ejector 24, is urged to the normal position shown in FIG. 1 by spring 32 which is held by retainer nut 34.

Stripper plate 36 positioned over die cover 38 includes a slot 40 through which sheet metal feed stock 42 is fed. Ceiling plate 44, having depending side walls 46 (one shown), covers stripper plate 36 and defines a passage 48 through which the completed bottle cap is expelled from the press as described hereinafter.

A blanking ram 50, slidably mounted to leader pins 52 supported by cross member 14, is reciprocally actuated by drive rods 54 as described hereinafter. Drive rods 54 are slidably mounted within bushings 56 provided in guide member 58 which is connected to side member 12. Blanking punch holder 60, carrying blanking punch 62, is connected to blanking ram 50 by spacer 64 and retainer nut 66.

A forming ram 68 is reciprocally actuated by drive rods 70 (one shown) as described hereinafter. Drive rods 70 are slidably mounted within bushings 72 (one shown) provided in guide member 58. A forming punch 74, slidably mounted within blanking punch 62, is carried by a forming punch holder 74 which is connected to forming ram 68 by split retainer 76 and adjustment nut 78.

In FIG. 1, the above-described components of the press are shown in their starting position with feed stock 42 in place ready for the formation of a bottle cap. The blanking and forming rams are actuated through drive rods 54 and 70, respectively, by a cam arrangement described hereinafter. During operation of the press, blanking ram 50 and forming ram 68 are initially advanced simultaneously through a stroke sufficient for blanking punch 50 to engage feed stock 42 and, in cooperation with blanking die 16, punch out a bottle cap blank 80 from the feed stock as shown in FIG. 2. Blanking ram 50 dwells in that position and forming ram 68 is advanced an additional stroke sufficient for forming punch 74 to deform blank 80 into corrugated crown die 20 and draw a crowned bottle cap 82 as shown in FIG. 3.

Upon completion of forming, the forming punch is first telescoped inside the blanking punch and then both punches are retracted simultaneously to the starting position. The punches dwell at the starting position where their surfaces are substantially flush with the underside of ceiling plate 44 as shown in FIG. 1. As the punches are retracted, shedder pin 30 and ejector 24, which were depressed by the punches, are urged back to their normal position by their respective springs and bottle caps 82 are ejected from the die cavities into passage 48 as shown in FIG. 4. Pressurized air flowing through orifice 84 from manifold 86 attached to one end of ceiling plate 44 assists the expulsion of the bottle cap out the opposite open end of the ceiling plate (not shown).

Ceiling plate 44 is spaced above stripper plate 36 so there is sufficient clearance for completed bottle caps to be expelled through passage 48 but the travel of the bottle caps parallel to the ejector axis is minimized, i.e.,

is less than the width of the bottle caps; in this instance the diameter. This prevents the caps from being wedged between ceiling plate and the stripper plate. Since the bottom ends of the blanking and forming punches remain substantially flush with each other and with the underside of the ceiling plate while in dwell, impingement of the ejected bottle caps is against the substantially smooth surface provided thereby and ricocheting is minimized, i.e., the ejected cap cannot catch on any exposed corners and bounce back into die 20. The enclosed passage provided by ceiling plate 44 and side walls 46 enables a more efficient utilization of the pressurized air stream. Hence, the expulsion rate of the bottle caps from the press is increased significantly.

Preferably, the longitudinal axes of the punching stations are arranged at 90° to the vertical (rather than 45° as generally is the case in prior art devices) with the open end of the ceiling plate positioned down to obtain maximum benefit of gravitational forces to assist expulsion of the bottle cap. When so positioned, the press can be operated without the use of pressurized air where the expulsion rate of the completed bottle caps is not particularly critical.

The reciprocative motion of forming ram 68 and blanking ram 50 described above is provided by the cam arrangements shown in FIGS. 5-7. The forming ram cam assembly 92 includes a drive cam 94, a forward motion cam follower 96 and a backward motion cam follower 98. The blanking ram cam assembly 100 includes a drive cam 102, a forward cam follower 104 and a backward motion cam follower 106. As shown in FIG. 5, drive cams 94 and 102 are mounted on a common cam shaft 108 journaled in a fixed frame (not shown). Cam shaft 108 is driven by a conventional means, such as an electric motor-driven gear on pulley and belt arrangement (not shown).

As shown in FIG. 6, cam followers 96, 98 are rotatably mounted to vertical arms 110, 112, respectively, of yoke assembly 114. Sleeve 116, connected between arms 110 and 112 to maintain the centers of cam followers 96, 98 a fixed distance apart, is slidably mounted on guide rod 118 so that yoke assembly 114 is free to move back and forth as drive cam 94 is rotated. Drive rods 70, connected at one end to forming ram 68, are connected at the other end to yoke assembly 114.

As shown in FIG. 7, cam followers 104, 106 are rotatably mounted to vertical arms 120, 122, respectively, of yoke assembly 124. Sleeve 126, connected between vertical arms 120, 122 to maintain the centers of cam followers 104, 106 a fixed distance apart, is slidably mounted on guide rod 128 so that yoke assembly 124 is free to move back and forth as drive cam 102 is rotated. Drive rods 54, connected at one end to blanking ram 50, are connected at the other end to yoke assembly 124.

As shown in FIGS. 7 and 8 blanking ram drive cam 102 is arranged with a 120° harmonic rise 130 (arranged to provide the desired stroke of the blanking punch, e.g., 1.25 inches), a corresponding 120° harmonic fall 132, and two 60° dwell sections; one for the bottom of the blanking punch stroke, designated 134, and the other for the top of the blanking punch stroke, designated 136.

As shown in FIG. 5, forming ram drive cam 94 has three separate cam surfaces, a center cam surface 138 and two outer cam surfaces 140, 140. These separate

cam surfaces can be made as an integral part; however, they are preferably machined from separate parts and assembled together as shown in FIG. 5. Outer surface 140, 140 are identically shaped, so only one is illustrated in FIG. 10. As shown in FIGS. 9 and 10 all the cam surfaces of forming ram drive cam have a 120° harmonic rise 142, and a corresponding 120° harmonic fall 144. This rise and fall is symmetrical with the 120° harmonic rise and the 120° fall, respectively, of cam 102, so that cam 94 simultaneously moves the forming punch through the same stroke as the blanking punch. Cam surface 138 includes a 60° dwell section 146 and a 60° lobe 148. Lobe 148 is arranged with a 30° harmonic rise 150 (arranged to provide the desired additional stroke of the forming punch, e.g., 0.25 inch) and a corresponding 30° harmonic fall 152. Cam surfaces 140 include a 60° dwell section 156 and a 60° conjugate section 154. Conjugate section 154 is diametrically opposed and is conjugate with lobe 148 of cam surface 138. A 30° segment 158 of conjugate section 154 is conjugate with the 30° harmonic rise 150 of lobe 148 and the other 30° segment 160 is conjugate with the 30° harmonic fall 152 of lobe 148. Backward motion cam follower 98 has a cut out or slot relief 162 so that neither lobe 148 nor dwell section 146 of cam surface 138 engages cam follower 98 during rotation of cam 94.

Drive cams 94 and 102 are simultaneously rotated counter-clockwise by cam shaft 108. As shown in FIGS. 6 and 7, drive cams 94 and 102 are at a position corresponding to dead center of the backstroke of the blanking and forming punches. During the first 30° of rotation, cam followers 104 and 106 of blanking ram assembly 100 are engaged by dwell sections 136 and 134 of blanking drive cam 102, respectively, and there is no movement of yoke 124. At the same time, cam follower 96 of forming ram assembly 92 is engaged by dwell section 146 of cam surface 138 and cam follower 98 is engaged by dwell section 156 of cam surfaces 140 and there is no movement of yoke 114. Lobe 148 is in relief and does not engage cam follower 98.

From 30° to 150° of rotation, cam follower 104 is engaged by 120° harmonic rise 130 of blanking drive cam 102 and cam follower 106 is engaged by 120° harmonic fall 132 of blanking drive cam 102. Yoke 124 is advanced to the position shown in dashed lines in FIG. 7, and therefore the blanking punch is advanced (moved downwardly as viewed in the drawings) through a stroke of 1.25 inches and, in cooperation with blanking die 16, cuts out blank 80 from feedstock 42. At the same time, cam follower 96 is engaged by the 120° harmonic rise 142 of cam surfaces 138 and 140 and cam follower 98 is engaged by the 120° harmonic fall 144 of cam surfaces 138 and 140. Yoke 114, and therefore the forming punch, is advanced (moved downwardly as viewed in the drawing) through a stroke of 1.25 inches. Hence, the blanking and forming punches are simultaneously advanced 1.25 inches during this phase of the rotation of the drive cams.

From 150° to 180° of rotation, cam followers 104 and 106 are engaged by dwell portions 134 and 136 of drive cam 102, respectively, and yoke 124, and therefore the blanking punch, does not move. At the same time, cam follower 96 is engaged by the 30° harmonic rise of lobe 148 on cam surface 138 and follower 98 is engaged by the 30° conjugate segment 158 of cam surfaces 140. Dwell section 146 of cam surface 138 is in relief and does not engage cam follower 98. Yoke 114 is ad-

vanced to the position shown in dashed lines in FIG. 6, and therefore the forming punch, is advanced a distance corresponding to the 30° harmonic rise, e.g., 0.25 inch. Hence, during this phase of the rotation of the drive cams, the blanking punch is in dwell and the forming punch deforms blank 80 into corrugated die 20 to form bottle cap 82.

From 180° to 210° of rotation, cam follower 104 and 106 continue to be engaged by dwell portions 134 and 136 of blanking drive cam 102, respectively, and the blanking punch remains in dwell. At the same time, cam follower 96 is engaged by the 30° harmonic fall 152 of lobe 148 and cam follower 98 is in engagement with 30° conjugate segment 160 of cam surface 140. Dwell section 146 of cam surface 138 remains in relief. Yoke 114, and therefore forming punch 74, is retracted a distance corresponding to 30° harmonic fall of lobe 140, i.e., 0.25 inch. At the end of this phase of rotation, the blanking punch has been telescoped back inside the forming punch and the outer ends of both punches are substantially flush with each other.

From 210° to 330° rotation, cam followers 104 and 106 are engaged by 120° harmonic fall 132 and 120° harmonic rise 130 of blanking drive cam 102, respectively, and blanking punch 62 is retracted 1.25 inches. Simultaneously, cam followers 96 and 98 are respectively in engagement with the 120° fall 144 and the 120° harmonic rise 142 of cam surfaces 138 and 140 and forming punch 74 is retracted 1.25 inches. At the end of this return stroke, the outer ends of both the blanking punch and the forming punch are substantially flush with the underside of the ceiling plate.

From 330° to 360° of rotation, and during the first 30° of the next cycle, cam followers 104 and 106 are engaged by dwell portions 136 and 134, respectively, and the blanking punch remains in dwell. Simultaneously, cam follower 96 is engaged by dwell section 146 of cam surface 138 and cam follower 98 is engaged by dwell section 156 of cam surfaces 140 and the forming punch remains in dwell. During this dwell period, the blanking and forming punches, along with the ceiling plate, provide a substantially smooth surface against which formed bottle caps 82 can impinge.

Although the cam arrangement has been described in conjunction with a punch press, it should be appreciated that it can be used to actuate any mechanism where sequential, reciprocative motion with different length strokes is desired.

As will be readily apparent to those skilled in the art upon reading the above description of this invention, various modifications can be made without departing from the scope and spirit thereof.

I claim:

1. A punch press comprising
 - a blanking punch;
 - a forming punch telescopically mounted inside said blanking punch;
 - a first drive cam;
 - a second drive cam having first and second cam surfaces; means for simultaneously rotating said drive cam;
 - a first pair of forward and backward motion cam followers which engage said first drive cam, are spaced a fixed distance apart at diametrically opposed positions with respect to said first drive cam, and are operatively connected to said blanking punch;

said first drive cam having corresponding harmonic rise and fall portions and dwell portions so that the rotation of said first drive cam, in cooperation with said first cam followers, reciprocatively moves said blanking punch through a forward blanking stroke and a corresponding backward stroke with a dwell period between each forward and backward stroke; a second pair of forward and backward motion cam followers which selectively engage said first and second cam surfaces of said second drive cam, are spaced a fixed distance apart at diametrically opposed positions with respect to said second drive cam, and are operatively connected to said forming punch;

said first and second cam surfaces including corresponding harmonic rise and fall portions so that the rotation of said second drive cam, in cooperation with said second cam followers, reciprocatively moves said forming punch through a primary forward stroke and a corresponding backward stroke; and

said first cam surface also including a lobe between the harmonic rise and fall portions thereof which engages said second forward motion cam follower and said second cam surface also including a portion which is conjugate with said lobe and engages said second backward motion cam follower so that, during rotation of said second drive cam said forming punch is moved reciprocatively through a secondary forward forming stroke and a corresponding backward stroke while said blanking punch is in dwell at the end of its forward stroke.

2. The punch press according to claim 1 wherein said first cam surface of said second drive cam has a dwell portion diametrically opposed to said lobe and said second cam surface of said second drive cam has a dwell portion diametrically opposed to said conjugate portion so that said forming punch dwells for a predetermined time period at the end of its primary backstroke.

3. The punch press according to claim 2 wherein said second cam surface includes separate, identically-shaped surfaces located on opposite sides of said first cam surface and said second backward motion cam follower includes a relief section adapted to receive said lobe and said dwell portion of said first cam surface so that said lobe and said dwell portion of said first cam surface do not engage said second backward motion cam follower during the rotation of said second drive cam.

4. The punch press according to claim 2 wherein said harmonic rise and fall portions of said second drive cam are angularly symmetrical with the harmonic rise and fall portions of said first drive cam about the axes of rotation of said drive cams; said dwell portions on said first and second cam surfaces of said second drive cam are angularly symmetrical with the dwell portions of said first drive cam about the axes of rotation of said drive cams; and said lobe on said first cam surface of said second drive cam is angularly symmetrical with said dwell portion of said first drive cam about the axes of rotation of said drive cams.

5. The punch press according to claim 4 wherein said first and second drive cams and said first and second cam followers are arranged so that the rate of movement of and the length of the primary forward and backward

strokes of said said forming punch is the same as the forward and backward strokes of said blanking punch.

6. In a punch press comprising a plurality of punching stations, each of which includes a blanking punch, a forming punch telescopically mounted inside the blanking punch, a blanking die, a forming die, means for reciprocally moving said blanking and forming punches so they cooperate with the dies to sequentially blank and form a part from a sheet feed stock and means for ejecting the completed part from the dies, wherein the improvement comprises

a first drive cam;

a second drive cam having first and second cam surfaces;

means for simultaneously rotating said drive cams;

a first pair of forward and backward motion cam followers which engage said first drive cam, are spaced a fixed distance apart at diametrically opposed positions with respect to said first drive cam, and are operatively connected to said blanking punch;

said first drive cam including corresponding harmonic rise and fall portions and dwell portions so that the rotation of said first drive cam, in cooperation with said first cam followers, reciprocally moves said blanking punch through a forward blanking stroke and a corresponding backward stroke with a dwell period between each forward and backward stroke;

a second pair of forward and backward motion cam followers which selectively engage said first and second cam surfaces of said second drive cam, are spaced a fixed distance apart at diametrically opposed positions with respect to said second drive cam, and are operatively connected to said forming punch;

said first and second cam surfaces including corresponding harmonic rise and fall portions so that the rotation of said second drive cam, in cooperation with said second cam followers, reciprocally moves said forming punch through a primary forward stroke and a corresponding backward stroke;

said first cam surface also including a lobe between the harmonic rise and fall portion thereof which engages said second forward motion cam follower and a dwell portion diametrically opposed to said lobe;

said second cam surface also including a portion which is conjugate with said lobe and engages said backward motion cam follower and further including a dwell portion diametrically opposed to said conjugate portion so, that during rotation of said second drive cam, said forming punch is reciprocally moved through a secondary forward forming stroke and a corresponding backstroke while said blanking punch is in dwell at the end of its forward stroke and said forming punch dwells for a predetermined time period at the end of its primary backward stroke;

said first and second drive cams being arranged so the blanking and forming ends of said punches are maintained substantially flush with each other

while said drive cams are in dwell at the end of the backward stroke of said blanking punch and the primary backward stroke of said forming punch; a ceiling plate positioned over the dies of said punching stations and spaced from said dies, the side of said ceiling plate closest to said dies being flat and substantially flush with the blanking and forming ends of said punches when they are in dwell at the end of the backward stroke so that any impingement by the completed parts upon ejection is against the substantially smooth surface provided by said ceiling plate and said punches.

7. The punch press according to claim 6 including side walls and an end wall depending from said ceiling plate to define an open-ended passageway above said dies into which said completed parts are ejected from said dies and through which said parts are expelled from the press.

8. The punch press according to claim 6 wherein said spacing of the ceiling plate from said dies is less than the smallest width of the completed part so as to prevent the parts from becoming lodged in said passageway.

9. The punch press according to claim 6 including means for introducing a pressurized stream of gas into said passageway to assist the expulsion of said articles from the press through said passageway.

10. The punch press according to claim 7 wherein the longitudinal axis of said punches is at about 90° to the vertical.

11. The punch press according to claim 6 wherein said second cam surface includes separate, identically-shaped surfaces located on opposite sides of said first cam surface and said second backward motion cam follower includes a relief section adapted to receive said lobe and said dwell portion of said first cam surface so that said lobe and said dwell portion of said first cam surface do not engage said second backward motion cam follower during the rotation of said second drive cam.

12. The punch press according to claim 11 wherein said harmonic rise and fall portions of said second drive cam are angularly symmetrical with the harmonic rise and fall portions of said first drive cam about the axes of rotation of said drive cams; said dwell portions on said first and second cam surfaces of said second drive cam are angularly symmetrical with dwell portions of said first drive cam about the axes of rotation of said drive cams; and said lobe on said first cam surface of said second drive cam is angularly symmetrical with said dwell portion of said first drive cam about the axes of rotation of said drive cams.

13. The punch press according to claim 12 wherein said first and second drive cams and said first and second cam followers are arranged so that the rate of movement of and the length of the primary forward and backward strokes of said said forming punch is the same as the forward and backward strokes of said blanking punch.

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