

1PUS copy

REPLACED SHEETS	SG
☒ Description : paged ...2... to paged ...20...	
☒ Claim(s) : paged ...22... to paged ...25...	
☐ Drawing(s) : paged to paged	
☒ Abstract : paged ...4... to paged ...7...	
DATE OF RECEIPT	

-2-

DESCRIPTION

ROTARY APPARATUS

This invention relates to a rotary cutting and forming apparatus for high speed continuous punching, forming or shearing of sheet metal.

BACKGROUND OF THE INVENTION

Conventional sheet metal cutting and forming devices are reciprocating presses. Material to be worked is placed within a press, positioned stationary over a die. The press, usually mechanically operated, is closed, thus forcing a second die into contact with the workpiece. The force exerted on the workpiece by the dies will deform the piece or punch holes in the piece as required. When the operation is complete, the press opens, the workpiece is removed and a new workpiece inserted. Because of the reciprocating motion inherent in such devices, the speed with which they may work is limited. Two solutions have been used. In one system the strip material is moved intermittently, step-wise through the press. In another system a so-called flying shear or die is used with a strip moving continuously. In this system the die is accelerated to the speed of the strip and the press closes, while the die and strip are moving in unison. The die then opens, and returns to its starting position. Typically, the punching, forming or shearing of a continuous material, such as sheet metal, is limited to a line speed of about 250 feet per minute.

This Sheet Has Been Replaced



THIS SHEET HAS BEEN REPLACED

However, a roll forming line without a punching, forming or shearing device could handle strip metal at speeds up to about 1,000 feet per minute.

5 It is evident that the output of an assembly or manufacturing line is only as fast as the slowest element in the line. In theory, a rotary press could be operated at much higher line speeds than a flying shear or die, and thus lead to considerable economies in operation.

10 Existing rotary material-working devices may suffer from various disadvantages. Some may be limited to specific operations such as cutting (see United States Patent Nos. 2,951,410, 3,274,873, 3,438,835, 3,709,077 and 3,828,636); perforating (see United States Patent No. 3,205,744); embossing (see United States Patent Nos. 804,512 and 4,059,000, and United
15 Kingdom Patent Nos. 837,660 and 1,456,530); crimping (see United States Patent Nos. 3,123,905 and 3,367,161); and stretch forming (see United States Patent No. 3,394,573).

20 Such devices are generally designed to perform a specific one of the above operations and may not be able to perform other operations. In particular, they are unable to meet all the requirements for a full range of die forming operations, or for shearing a strip already formed into a complex section.

In such existing rotary machines shearing is feasible on flat, unformed strip. Die forming was achieved by
25 using specially designed dies sometimes formed around an arc, which severely restricted the shape that could be formed. Generally it was not possible to use conventional flat dies as used in conventional reciprocating presses. Dies formed around an arc or radius, such as in U.S. Patent 3,394,573, posed
30 considerable problems. The function of a curved die as it contacts the workpiece is different from that of a flat die. The curved die will commence working the material on one side of the die. As the curved die rotates, deformation of the workpiece will proceed along the workpiece until the operation is complete.
35 This often resulted in distortion. In a flat die as found in conventional die presses, the workpiece is cut or worked

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

simultaneously across the die. In certain applications, such differences between standard and rotary devices may not be desirable.

Another approach to the problem is shown in United States Patent Nos. 1,333,704, 1,581,236 and 3,066,542. In these patents the dies rotate around a circular orbit. In United States Patent No. 1,581,236, the individual dies are guided and controlled by an annular cam track, and cam followers riding in the track. In this arrangement the dies are difficult to control. The cam followers cannot make a perfect fit in the annular track. Some clearance is needed in order that the followers can roll in the track. As a result, the dies are never held securely. When they meet they may fail to register perfectly, and damage may result.

With a view to overcoming these problems, the invention provides for a high speed rotary cutting and forming apparatus which makes use of flat dies and permits the accuracy of conventional die presses.

BRIEF SUMMARY OF THE INVENTION

The invention provides a rotary cutting and forming apparatus for use in association with material forming dies for the forming strip material, [comprising a rotatable upper roll unit and a corresponding rotatable lower roll unit, the units being connected for synchronous rotation, each of said units comprising a rotatable carrier member defining a central axis, and a semi-cylindrical recess, and at least one die support block adapted to be swingably mounted on said corner member, and defining two ends and a surface to which a said die may be affixed, and guide pin means extending from each of the said two ends, said roll units being spaced apart whereby said material may pass therebetween for formation by said dies, path definition means adapted to receive said guide pins and guide said die support blocks during a portion of the rotary cycle whereby a die affixed to said die support member on said upper unit and a die affixed to said die support member on said lower unit may register with each other and cooperate together for the

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

deformation of the material, and retaining means whereby said die support block is retained on said carrier member.)

The advantages of the invention include the following: the device can be operated continuously or
5 intermittently at high speed, thus allowing a manufacturing line, in which the device may be a component, to operate at high line speed. The device is as accurate as conventional, reciprocating die presses. Use of a flat die set allows standard die
10 tool-making procedures to be used. The device may have as much flexibility in its use, for forming holes, indentations and the like in a workpiece, as has a conventional die press.

[Accordingly, it is an objective of the invention to provide a rotary apparatus for cutting or forming strip sheet material at high speed.

15 It is a further objective of the invention to provide such a rotary apparatus incorporating a flat die.

It is a further objective of the invention to provide such a rotary apparatus which may operate with at least the accuracy of conventional die presses.

20 It is a further objective of the invention to provide such a rotary apparatus wherein the die blocks include additional guide means, interengaging between respective die blocks on upper and lower units, and further controlling the position of said die blocks as they close and open relative to
25 said workpiece.

It is a further objective of the invention to provide such a rotary apparatus in which means may be provided for controlled intermittent operation whereby portions of the workpiece may pass through the rotary apparatus without being
30 formed or cut.

The various feature of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and
35 specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

are illustrated and described preferred embodiments of the invention.)

IN THE DRAWINGS

5 Figure 1 is a schematic illustration in perspective of a manufacturing line incorporating a rotary apparatus according to the invention.

Figure 2 is an exploded schematic drawing in perspective of a rotary apparatus according to the invention;

10 Figure 3 is a cross-section along the line 3-3 of Figure 2;

Figure 4 is a detail view in cross-section of a portion of the rotary apparatus of the invention;

15 Figure 5 is a detail view in perspective of a portion of the rotary apparatus according to the invention about to contact the workpiece;

Figure 6 is a view corresponding to Figure 2 but of an alternate embodiment;

20 Figure 7 is a cross-section similar to that of Figure 3, but illustrating the embodiment of Figure 6 in a different position;

Figure 8 represents a cross-sectional view along line 8-8 of Figure 6, illustrating the operation of the embodiment of Figure 6;

25 Figure 9 is an exploded view of a detail of the embodiment of Figure 6;

Figure 10 is a sectional side elevation of an ultimate embodiment;

Figure 11 is a section along the line 11-11 of Figure 10;

30 Figure 12 is a schematic top plan view of an alternate embodiment of the rotary apparatus, for intermittent operation; and,

Figure 13 is a section along the line 13-13 of Figure 12.

35

DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

Referring to Figure 1, there is illustrated a roll 10 of strip sheet material 12 upon which it is desired to perform various forming operations. Material 12 may often be sheet metal. Such operations may typically be performed in a manufacturing line 14. Material 12 is unwound from roll 10 and passed continuously along line 14, in the direction indicated by arrow A. The various forming operations are performed on material 12 as it passes different points along line 14. As material 12 is unwound from roll 10, typical first operations may be die forming operations, performed by a rotary apparatus 20 according to the invention. Apparatus 20 may punch holes, or form complex indentations 22, or both, in material 12 as it passes through apparatus 20. Nip rollers 21, both above and below material 12, guide material 12 through rotary apparatus 20. Subsequent operations may typically include roll-forming operations at station 23. Further operations as desired may be carried out at station 24. The final operation is typically the cutting of material 12 in cutting station 26 into standard lengths 28 convenient for further manufacturing or assembly processes and for storage.

Further nip rollers (not shown) may be used to guide material 12 through stations 23, 24 and 26. Of course, any number of stations 20, 23, 24 and 26 may be used in sequence, as desired.

The above description of a typical manufacturing line is provided herein in order to facilitate the description of the invention. The description of the manufacturing line is not intended to limit the invention in any way. Rather the apparatus according to the invention may be used in any manufacturing line or in any situation requiring high speed, continuous, accurate die forming of strip material.

Referring to Figure 2, there is schematically illustrated a rotary apparatus 20 according to the invention. Motor 30 drives upper roll unit 32 in unison with and, at the same speed, as lower roll unit 34 through transmission 35 and shafts 36. Material 12 passes between and is contacted by upper

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

and lower units 32 and 34. Upper and lower units 32 and 34 may be supported by suitable bearing means 37. In this embodiment, motor 30 and transmission 35 are such as to provide the outer surfaces of upper and lower units 32 and 34 at the point of contact with material 12 with essentially the same speed as material 12, so that there is no slippage or relative motion between the material 12 and either or both of upper unit 32 and lower unit 34.

However in an alternate embodiment described below, relative motion is provided for.

Transmission 35 and bearings 37 may be adjustable to vary the maximum distance between upper and lower units 32 and 34 in order to accommodate sheet material 12 of varying thicknesses or to increase the pressure applied to material 12. Hydraulic pistons 40 may be attached to shafts 36 so that upper unit 32 may be quickly removed from contact with material 12. Such capability allows the apparatus 20 to leave linear portions of material 12 unformed, if desired.

Motor 30, transmission 35, bearings 37 and pistons 40 may all be standard components as are well-known in the machine tooling industry.

Figure 3 illustrates in cross-section upper die unit 32 and lower die unit 34 in position to die form sheet material 12. Upper unit 32 rotates counter-clockwise in the direction indicated by arrow B. Lower unit 34 rotates clockwise in the direction indicated by arrow C. Material 12 moves from left to right in the direction indicated by arrow A.

It will be appreciated that the designations "upper", "lower", "left", "right", "clockwise", and counter-clockwise" are for convenience of description only and are not intended to limit the invention, which will operate equally effectively in any direction or orientation. Similarly, references to an "upper die" located in a certain position and to a corresponding "lower die" in a certain corresponding position are not intended to limit the invention. Two dies operate as a pair and the individual location of each is irrelevant to the invention so long as the pair operates together at the required



location and time.

Upper unit 32 is essentially identical to lower unit 34. Referring to Figures 3 and 4, upper unit 32 includes upper carrier member 41, which defines a longitudinal axis L1 about which upper unit 32 rotates. Member 41 defines at least one (in the illustrated embodiment, there are four) generally semi-circular cylindrical recesses on opening 42, defining central axes (Figure 5) extending longitudinally parallel to the axis L1 of member 41. Member 41 further defines abutments 43 between openings 42. The outer surface of abutments 43 define a notional circular cylindrical surface 44 (shown in cross-section as phantom circle 44). The axes L2 of cylindrical openings 42 may lie on notional surface 44 parallel to axis L1. However in an alternate embodiment described below this is modified.

Referring to Figure 6, upper die support blocks 46 are retained within openings 42 by the semi-circular retaining flanges 47. Each block 46 is semi-cylindrical in shape having a cross-section that is segment-shaped namely, that shape bounded between the perimeter of a circle and a chord of the circle. Thus block 46 defines two surface portions: a semi-cylindrical portion 46a and a planar portion 46b. Semi-cylindrical portion 46a is fitted within opening 42, so that block 46 is freely rotatable within its associated opening 42. A first guide pin means 48 extends from one end of blocks 46 and a second guide pin means 49 extends from the outer end guide blocks 46, and ensure that the planar portions 46b are located in the desired position as described below. On a block 46 pin means 48 and 49 define and lie on different axes for reasons described below.

Upper dies 50 are mounted on planar portions 46b of blocks 46 in any conventional manner. The die surface of a die 50 defines a forming plane P2 (Figure 5). Die 50 is mounted on block 46 so that the plane P2 is essentially parallel to the planar portion 46b of block 46 and so that the plane P2 includes the axis of opening 42, in this embodiment.

Lower unit 34 comprises lower carrier member 52, defining semi-cylindrical openings 54, abutments 55 and



semi-cylindrical surface 56, lower support blocks 58, and flat lower dies 60. Guide pin means 62 and 63 are provided in a fashion offset at opposite ends of the block similar to the equivalent components of upper unit 32. Retaining flanges 47 are also provided.

Each of pins 48, 49, 62 and 63 defines a cam follower means (not shown) at its free end. Pins 48 are guided by cam means such as a cam groove 64 defined in fixed end plate 38, at one end. Pins 49 are guided by cam means such as a cam groove 65 in fixed end plate 39, at the opposite end.

Similarly, on lower unit 34, guide pins 62 and 63 are guided by corresponding cam means; e.g., cam grooves 70 and 72, respectively, in fixed end plates 38 and 39, at opposite ends.

Fixed end plate 38 is divided between grooves 64 and 70 into upper and lower end plates, 38a and 38b respectively. Similarly, end plate 39 is split between grooves 66 and 72 into upper and lower end plates, 39a and 39b. Both end plates 38a and 39a are fixed by suitable means (not shown) relative to the axis L1 of upper unit 32. Such suitable means may, for example, comprise a guide track, preventing the rotation of plates 38a and 39a relative to axis L1, and a bearing means for shaft 36 in plates 38a and 39a.

Similarly, end plates 38b and 39b are fixed relative to the axis L1 of lower unit 34.

The provision of split end plates 38a, 38b, 39a and 39b, fixed as described above, allows the distance between upper unit 32 and lower unit 34 to be varied as desired without interfering with the operation of die forming apparatus 20. As hydraulic cylinders 40 are operated, such distance between units 32 and 34 varies. Upper end plates 38a and 39a move up and down in unison with upper unit 32, yet cam grooves 64 and 65 continue to support pins 48 and 49.

Cam grooves 64 and 65 are shaped and pins 48 and 49 are positioned relative to blocks 46 whereby the forming planes P2 of dies 50 are essentially parallel to material 12 immediately



prior to, during and subsequent to closing. Similarly, cam grooves 70 and 72 are shaped, and pins 62 and 63 are positioned relative to blocks 58 whereby the forming planes P2 of dies 60 are essentially parallel to material 12 immediately prior to, during and subsequent to closing.

Because a block 46 and a block 58 may each be supported by two pins on different axes the blocks are less prone to rock or otherwise move within their fittings than are those found in standard rotary forming devices. Thus, in comparison to previously used rotary devices, the clearances required by the cam follower mechanism do not have as great an effect on the accuracy of the forming operation. In fact, the double cam construction of the invention results in substantially improved forming accuracy, and thus, longer useful die life.

To further ensure accuracy, upper support block 46 may be provided with locating dowels 78 on either side of die 50 (see Figure 5). Lower support block 58 may be provided with corresponding dowel receiving bores 79 on either side of die 60. Dowels 78 and bores 79 are shaped, sized and located on either side of strip material 12 so that they may cooperate and register with each other without interference with material 12. As upper and lower units 32 and 34 rotate, dowels 78 extend toward and are partially inserted into bores 79 prior to contact with material 12. As a die 50 and a die 60 come into contact with material 12, the dowels 78 are fully inserted into the bore 79, thus ensuring that die 50 and die 60 contact material 12 in proper registration with each other. Although accuracy is ensured by the use of dowels 78 and bores 79, such dowels 78 and bores 79 may not always be necessary for the accurate functioning of the device according to the invention. The device as described above has been found to operate with satisfactory accuracy without such dowels and bores.

Referring to Figure 3, in operation, upper and lower units 32 and 34 rotate. Each die 50 rotates through the successive illustrated positions of upper unit 32. Such positions have been labelled in Figure 3 as positions S, U, W, and Y. The



closed position of apparatus 20, which is the position at which material 12 is formed, is defined as position S. Position S is treated as defining the starting point of the rotary cycle. Rotation continues, counter-clockwise as indicated by direction arrow B, through each of the other positions U, W and Y and returns to starting position S. Similarly, each die 60 rotates through the illustrated positions of lower unit 34. The movement of any die 60 is the mirror image of the movement of its corresponding die 50. It will, of course, be appreciated that all dies rotate simultaneously and, at any particular time, are at different positions in the rotary cycle.

At position S material 12 is formed by die 50 and die 60. As rotation continues to position U, die 50 and die 60 are separated from material 12. Because pins 48, 49, 62 and 63 follow their respective cam grooves 64, 65, 70 or 72, die 50 and die 60 initially remain essentially parallel to each other and to material 12. Abutments 43 and 55 come into contact with material 12. Thus, if there has been any adhesion between material 12 and either die 50 or die 60, material 12 will be pushed away from such dies 50 or 60 and will continue to pass smoothly through rotary apparatus 20.

As rotation continues, the cam followers cause block 46 to rotate through the positions U, W and Y. Following position Y, dies 50 and 60 are brought into essentially parallel position for the forming operation at position S.

In an alternate embodiment, cam grooves defined in the fixed end plates 38 and 39 are not necessary. Instead the cam followers of pins 48, 49, 62 and 63 may be constrained to follow curved ramps during certain pre-determined positions in the rotary cycle. Referring to Figure 6, ramp 80 is affixed to fixed end plate 38a and ramp 82 to fixed end plate 39a. Similarly associated with lower unit 34, ramps 84 and 86 are also affixed to fixed end plates 38b and 39b, respectively. Ramps 80, 82, 84 and 86 define curved surfaces 88, 90, 92 and 94, respectively.

Surfaces 88, 90, 92 and 94 are shaped whereby the forming planes P2 of dies 50 and 60 are essentially parallel to



material 12 and to each other immediately prior to, during and subsequent to closing. During other parts of the rotary cycle, the precise positioning of blocks 46 and 58 relative to members 41 and 52, respectively, are unimportant as long as blocks 46 and 58 may again be brought parallel prior to closing.

Consequently, when the cam followers are not in contact with ramps 80, 82, 84 and 86, blocks 46 and 58 may be biased into a suitable fixed position by an appropriate biasing means. One such possible biasing means is illustrated in Figure 9. Block 46 defines a circumferential channel 96. Member 41 has a post 98, adapted to fit within channel 96 so that block 46 may still orbit within opening 42. Spring 100 is fitted within channel 96 and attached at one end to a wall of channel 96 (or to a post inserted in channel 96) and at the other end to post 98. In such a configuration, spring 100 tends to hold block 46 in the position indicated as J or K in Figure 8 relative to member 41. In this position, pin 48 is extended radially away from axis L1 whereby it may come into contact with its respective ramp 80 at a predetermined position in the rotary cycle.

The operation of this embodiment is best understood by referring to Figures 7 and 8. Figure 7 illustrates upper and lower units 32 and 34 in a position immediately after one pair of dies 50 and 60 have closed and immediately before a second pair of dies 50 and 60 have closed. Figure 8 illustrates one block 46 in member 41 shown at various positions in the rotary cycle. Successive positions are indicated by the labels J, K, H, M, N and O. One ramp 80 and its associated pin 48 are drawn in solid line. The other ramp 82 and its associated pin 49 are shown in phantom.

While only one block 46 is illustrated, it will be appreciated that other blocks 46 attached to member 41 will travel through corresponding positions of the rotary cycle at different times. It will be further appreciated that while only upper unit 32 is illustrated, similar action is occurring in lower unit 34.

Commencing arbitrarily with position J in the rotary

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

cycle, spring 100 holds block 46 so that pin 48 is extended away from the axis L1 of member 41. As rotation occurs block 46 passes through position K to position H. There is no relative motion between block 46 and member 41 from position J to position H. At position H, the forming plane P2 (Figure 5) of die 50 is essentially parallel to material 12.

At position H pin 48 contacts the surface 88 of ramp 80. Also, pin 49 contacts the surface 90 of ramp 82. As rotation continues block 46 now commences to orbit within opening 44. Spring 100 commences to stretch. Pin 48 moves along surface 88. Pin 49 moves along surface 90. Such motion continues to position M. The surfaces 88 and 90 are shaped to ensure that plane P2 remains parallel to material 12.

On lower unit 34 (not shown in Figure 8) a corresponding plane P2 of die 60 is also essentially parallel to material 12 and thus to the plane P2 of die 50.

As rotation continues to position M, relative rotation between block 46 and member 41 continues and spring 100 stretches further. At about position M plane P2 contacts material 12 and, in cooperation with die 60, the material 12 is deformed as required.

After dies 50 and 60 have thus closed, rotation continues. Pins 48 and 49 remain in contact with respective ramps 80 and 82. Plane P2 remains parallel to material 12. Relative rotation between block 46 and member 41 continues and spring 100 stretches further.

At about position N, pin 49 which in this case is the leading pin, is removed from ramp 82.

At about position O, pin 48 which in this case is the trailing pin, reaches the end of ramp 80. Spring 100, which has been urging block 46 to rotate clockwises, may now act to return block 46 to its initial position with respect to member 41, for example, as shown at position J.

Suitable limit means (not shown) allow spring 100 to hold block 46 within opening 42 during rotation from position J to position L. For example, the presence of an abutment means



(not shown) extending into opening 42 from member 41 would allow spring 100 to hold block 46 securely against the abutment. Block 46 would thus be prevented from moving in its opening 42 under the influence of centrifugal force as unit 32 rotates.

Because, in this embodiment, block 46 is pressed into place against the ramps by the rotation of member 41 prior to closing, a solid and accurate punch is possible. Spring 100 operates to keep pins 48 and 49 in contact with their respective ramps 80 and 82, thus further ensuring punching accuracy.

In other embodiments, it may be possible to use a ramp or cam groove on only one side of a die unit in conjunction with such a spring urging a die support block into contact with such ramp or groove. It may also be possible to use a ramp on one side of a die unit and a cam groove on the other side of the same unit. Use of a biasing spring may be avoided in such an embodiment.

It will be appreciated that a die apparatus according to the invention may be used in any situation requiring the use of high speed, accurate cutting or forming. Apart from the standard hole punching or indentation forming operation described above, the apparatus of the invention may, for instance, be used with a shearing die to cut roll formed strip material with a complex, shaped edge.

Several die units may be placed in line for forming complicated holes or shapes. For instance, a first rotary apparatus may punch a hole. A second rotary apparatus may form shapes around the hole. A third rotary apparatus may perform further operations and so on as required. Such operation would be very similar to the operation of existing progressive die presses.

The apparatus of the invention may be used to leave unformed areas at spaced intervals along the strip material. The upper and lower units 32 and 34 are simply separated so that they do not contact material 12 over such intervals.

In accordance with a further embodiment of the invention as shown in Figures 10 and 11, provisions may be made



for still further stabilizing the die support blocks 46 and 58, so that they are forced to adopt precisely parallel planes prior to the engagement of the two dies on the blocks.

5 It will of course be appreciated that if the two die support blocks are not precisely parallel, and parallel with the workpiece, prior to the engagement of the dies on the workpiece, the workpiece will not be formed precisely, and conceivably damage may result to the dies themselves.

10 In the embodiment shown in Figures 1 to 9, the pins 78 and openings 79 will normally provide a sufficient degree of guidance to ensure that the two blocks are precisely parallel to one another before the dies close.

15 However, since some degree of wear is inevitable, it is considered desirable to make provision for a still greater degree of guidance.

Accordingly, as shown in Figures 10 and 11, the upper die block 46 is shown with the die guidance pin 78 received in a bore 102, and being retained therein by any suitable means (not shown).

20 A die block guide channel 104 is machined in either end of the block 46, so as to replace the function of the retaining flanges 47, and is engaged by suitable retaining means (not shown) on carrier member 41.

25 This feature would also be used in the blocks 58 in carrier member 52 in this embodiment.

In order to further assist in guiding and controlling the blocks 46 and 58, a further guide bore 108 is formed in, for example, the upper die block 46, parallel to the bore 102.

30 Bore 108 communicates with a longitudinal channel 110 of generally rectangular shape, extending from side to side of the block 46 transverse to its longitudinal axis.

35 Each of the die blocks 46 and 58 may be provided with two such guidance bores 108, one at each end, and two such channels 110.

An elongated rectangular contact bar 112 is received



in channel 110, and is mounted on a cylindrical guide shaft 114 extending into guide bore 108. A counter-bore 116 is formed in shaft 114, and receives a spring 118 therein. The spring 118 will preferably be a heavy duty compression spring.

5 Any suitable retaining means (not shown) will be provided for retaining the shaft 114 in the bore 108.

The four bars 112 on the upper and lower die members 26 and 58 register with one another in pairs, as the dies are closing, but prior to contact with the workpiece.

10 The heavy duty springs 118 will yield and allow the bars 112 to move inwardly into the channels 110, but will, at the same time, force the faces of the bars 112 firmly into contact with one another along their length.

15 This function will thus ensure that the blocks 46 and 58 are located in parallel spaced-apart planes parallel to the workpiece prior to contact of the dies with the workpiece, thus ensuring accurate repetitive forming of the workpiece, without damage to the dies.

20 It will be appreciated that in the form illustrated both the upper and lower die blocks 46 and 58 are provided with the same guidance bars 112 and shafts 116.

25 The purpose of this is to reduce the distance of travel of each of the guide bars 112, and yet ensure that they meet and contact one another at a point early enough in the closing of the dies, that they can achieve a secure and accurate guidance function before the die is closed.

30 It will, of course, be appreciated however that where dies of a different nature are in use, such that a lesser degree of travel would be acceptable, it may be permissible to provide such guidance bars 112 on only the upper or the lower of the two die blocks. If only one pair of such guidance bars 112 were used then, of course, the guidance bars would simply contact the face of the other block and provide the same guidance function as described above.

35 It will be appreciated, therefor, that while this embodiment of the invention is illustrated as provided on both



upper and lower die blocks and at each end, some degree of guidance function and security will be achieved by providing only one pair of such guidance bars. Conceivably also some limited degree of guidance can be achieved merely by the provision of one
5 of such guidance bars at one end of one block.

The invention is not, therefore, limited to any specific number of such guidance bars.

In accordance with a further embodiment of the invention as illustrated in Figures 12 and 13, provision may be
10 made for intermittent operation of the rotary apparatus.

Intermittent operation may be desirable where it is intended to produce from the strip sheet material, and end product which is cut to a predetermined length. Thus, for example, if it is desired to produce sheet metal strip having a
15 series of formations, along predetermined lengths of the strip, and intermittent discontinuities in the formations, then, as has been described above, one solution would be to simply move one of the roll units away from the other.

Another solution to the problem is, however, to
20 simply stop the upper and lower units momentarily and allow the strip sheet material to pass between them, without being formed or punched, for a predetermined length.

As shown schematically in Figure 12, a typical strip sheet material line for functioning in this way would comprise a
25 rotary cutting or forming apparatus 120, upstream and downstream pinch rolls 122 and 124, and an uncoiler 126. The strip sheet material is indicated as 12, and in this embodiment is shown simply as being formed with generally triangular perforations or openings 12a. A discontinuity indicated generally as 12b is
30 indicated between two of the perforations 12a.

In this embodiment the rotary apparatus 120 is driven by means of a motor 128, driving through a clutch 130. Clutch 130 drives the rotary apparatus 120, and the drive is controlled by means of a brake 132.

35 A line speed indicator 134 may be used if desired, for contacting the strip sheet material 12. However this



information can equally well be obtained in other ways, and it is illustrated here merely for the sake of clarity.

5 A central data processing unit 136 provided with typical controls and displays is connected to the line speed indicator 134, and to the clutch 130 and to the brake 132.

It may also be connected to all of the rolls, and to the motor 128 if desired for capturing further information.

10 Referring now to Figure 13, the rotary apparatus 120 is essentially similar to that described in the preceding description. Accordingly the various features are described in only general terms herein, where they are the same. Thus the rotary apparatus 120 comprises carrier members 138 and 140 having die support blocks 142 and 144, guided and controlled in the manner described above.

15 The central axis of the die blocks 142 and 144 move around a circular path, indicated in phantom as 146.

However, the surface portions 148 and 150 of the carrier members 138 and 140 lie on the perimeter of a circle of a somewhat smaller radius than the circle 146.

20 In this way, when the two carrier members 138 and 140 are in the position illustrated in Figure 13, the surfaces 148 and 150 are out of contact with the workpiece 12.

The workpiece is held in any event between the pinch rolls 122 and 124, and is therefore at all times controlled.

25 By suitably programming the processor 136 to operate the clutch 130 and brake 132 in the correct time sequence, it is possible to stop the upper and lower carrier members 138 and 140 in the position shown in Figure 13, for a predetermined dwell time, sufficient to allow an unformed portion 12b of the
30 workpiece 12 to pass between them.

The processor 136 will then again signal the brake 132 to release and the clutch 130 to re-engage, and rotation of the carrier members 138 and 140 will be resumed.

35 The foregoing is a description of a preferred embodiment of the invention which is given here by way of example only. The invention is not to be taken as limited to any of the



specific features as described, but comprehends all such variations thereof as come within the scope of the appended claims.

5

10

15

20

25

30

35

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

CLAIMSMETHOD OF ROTARY FORMING

1. A method of forming or cutting a workpiece in a rotary apparatus comprising material forming dies (50, 60) for forming strip material (12) comprising a rotatable upper roll unit (32) and a corresponding rotatable lower roll unit (34), said upper and lower roll units (32, 34) being supported by bearing means (37) and being connected for synchronous rotation, each of said units comprising a carrier member (41, 52) defining a central axis, said member having at least one recess (42) extending along said member parallel to the central axis, said recess having bearing surface means of generally semi-circular shape and at least one die support block (46, 58) rotatably received within said recess, said block defining two ends and a platen surface (46) to which at least one of said forming dies (50, 60) may be affixed, said upper and lower units being spaced apart whereby said material may pass therebetween for formation by said dies (50, 60), cam surface means (64, 65, 70, 72) provided on a stationary part in association with each of said rollers and leading and trailing guide members (48, 62, 49, 63) for turning said blocks about their axes which are parallel to the roll axes in said recesses and relative to said roll units so that said dies may be parallel to one another when adjacent to said material and cooperate together for deformation of the material, and characterized by the steps of;

engaging said leading guide members (48, 62) on leading control means (60, 70) prior to engagement of said dies (50, 60) with a workpiece;

engaging said trailing guide members (49, 63) on trailing control means (66, 72) prior to engagement of said dies (50, 60) with a workpiece;

moving said die support members (46, 58) along an arcuate path, while maintaining said leading and trailing

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED



guide members (48, 62, and 49, 63) in engagement with their respective leading and trailing control (64, 70 and 66, 72), and,

bringing said dies (50, 60) into engagement with said workpiece, and thereafter continuing said movement along said arcuate path, to bring said dies out of engagement with said workpiece, while continuing said engagement with said leading and trailing guide members (48, 62, and 49, 63) with their respective said leading and trailing control means (64, 70 and 66, 72).

2. A method of forming or cutting a workpiece as claimed in Claim 1, wherein said carrier members (32, 34) are rotatable about carrier axes, and wherein said leading and trailing control means (64, 70 and 66, 72) extend around 360 degrees, and including the steps of engaging said leading and trailing guide members with their respective leading and trailing control devices throughout the entire rotation of said carrier members.

3. A method of forming or cutting a workpiece as claimed in Claim 1 where said leading and trailing control means (80, 82, 84, 86) define ramp surfaces extending around a predetermined arc less than 360 degrees, and including the steps of engaging said leading and trailing guide members (48, 62 and 49, 63) with their respective leading and trailing control means only over said predetermined arc.

4. A method of forming or cutting a workpiece as claimed in Claim 1 wherein said die support members (46, 58) further include contact bar means (112) reciprocable relative to at least one of said die support members and including the steps of bringing said contact bar means of one of said die support member into engagement with the other of said die support member prior to engagement of said dies with said workpiece, and maintaining said engagement of said contact bar means during engagement of said dies with said workpiece,

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

and subsequently removing said contact bar means from said engagement.]

5 5. (A method of forming or cutting a workpiece as claimed
in Claim 3 wherein there is an upper carrier member (32), and
a lower carrier member (34), and including upper and lower said
die support members (46, 58) on respective upper and lower
10 carrier members for carrying respective upper and lower dies
(50, 60) for engaging a workpiece simultaneously on opposite
sides, and including the steps of bringing said leading and
trailing guide members (48, 49) of said upper die support
member (46) into engagement with their respective leading and
15 trailing control means (80, 82), and bringing said leading and
trailing guide members of said lower die support member into
engagement with respective leading and trailing control devices
(84, 86) prior to engagement of respective upper and lower said
dies with said workpiece, whereby to maintain said upper and
lower die support members and said upper and lower dies
20 parallel with one another while moving said upper and lower die
support members through respective upper and lower arcs.]

6. A method of forming or cutting a workpiece as claimed
in Claim 1, and further including the steps of passing said
workpiece through a further rotary apparatus having such upper
25 and lower dies supported on upper and lower die support members
in turn swingably carried on upper and lower carrier members,
whereby to perform further forming operations on said
workpiece.

7. A method of forming or cutting a workpiece as claimed
30 in Claim 1 and further including the steps of passing said
workpiece through a plurality of upper and lower roller die
pairs (124), downstream of said rotary apparatus whereby to
form continuous formations in said workpiece.

8. A method of forming or cutting a workpiece as claimed
35 in Claim 1, and further including the steps of

This Sheet Has Been Replaced



* C L M S *

THIS SHEET HAS BEEN
REPLACED

5 subjecting said workpiece to the operation of said upper and lower dies (50, 60) at predetermined regular spaced apart intervals, and momentarily discontinuing such formation, whereby to form discontinuities in said operations at spaced apart intervals therealong.

This Sheet Has Been Replaced



* C L M S *

THIS SHEET HAS BEEN
REPLACED

-1-

ABSTRACT
ROTARY APPARATUS

A rotary cutting and forming apparatus for strip material 12 , having rotatable upper and lower roll units 32,34, the units being connected for synchronous rotation, each of the units having a carrier member 41,52 with at least one recess 42, extending parallel to its central axis, and at least one die support block 46,58; the block being rotatably received within the recess 42, and having two ends, and a surface 46b to which a die may be affixed, leading and trailing control pins 48,62 on the block, extending on parallel spaced apart axes, and leading and trailing cam surfaces 64,70 and 66,72 engaging respective leading and trailing control pins 48,62, to control the position of the blocks during at least part of their rotation.

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

1/10

✓

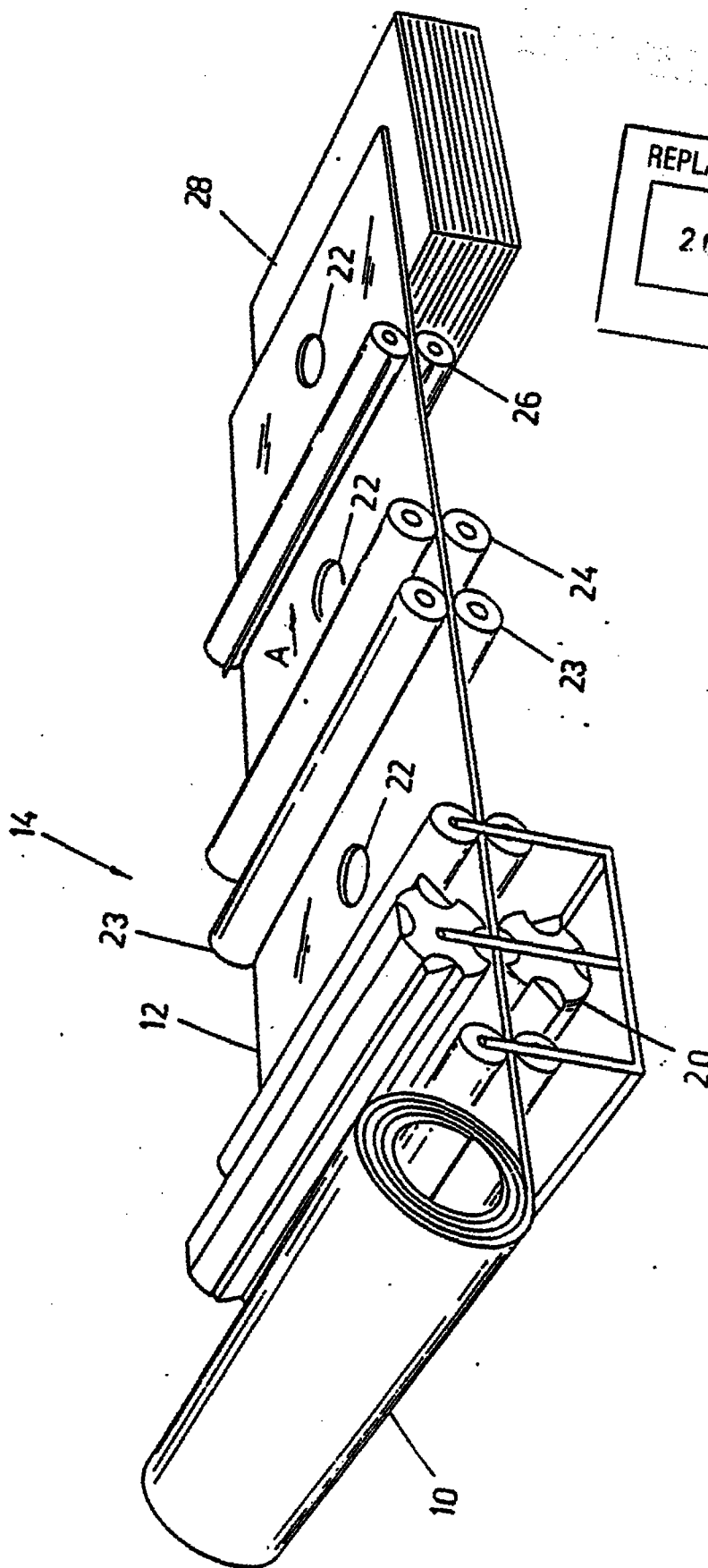
No.

20/3/97

REPLACEMENT SHEET

20 MAR 1997

FIG. 1







20 MAR 1997

4/10

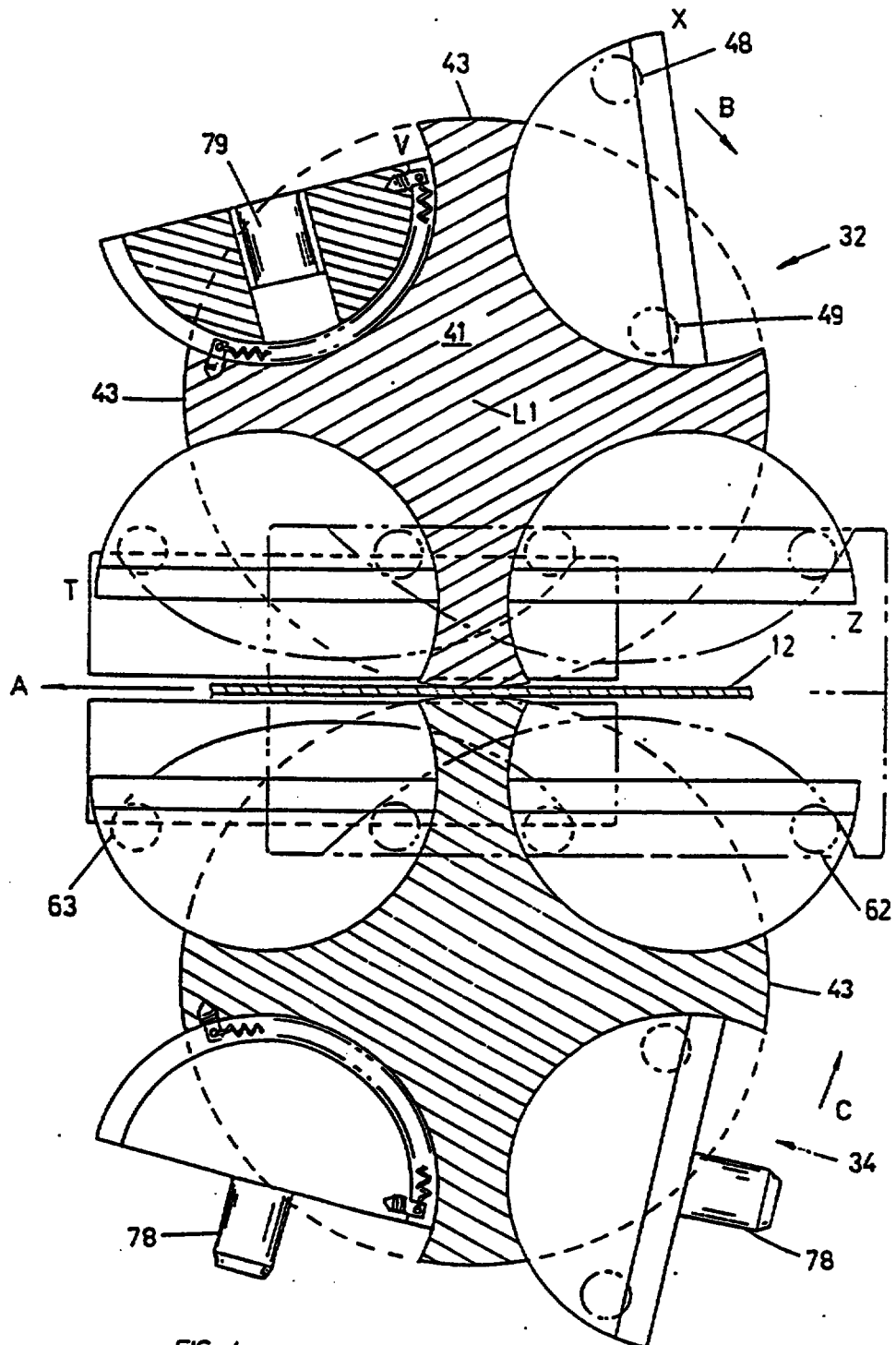


FIG. 4

5/10

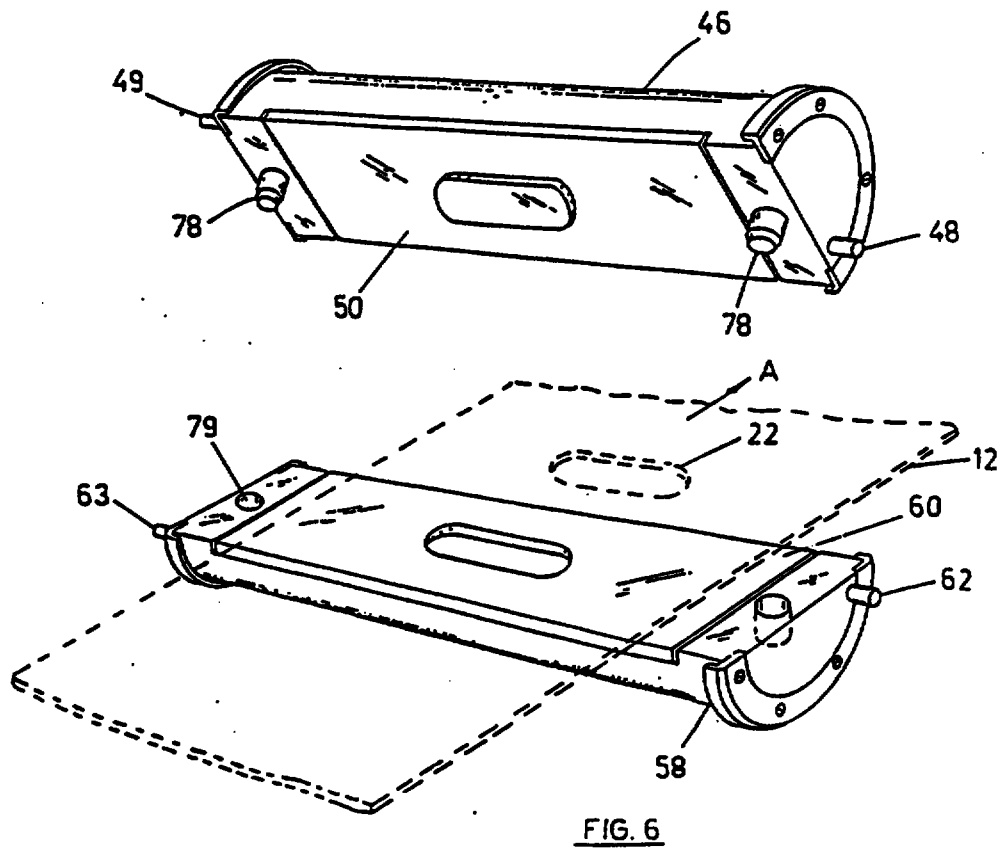
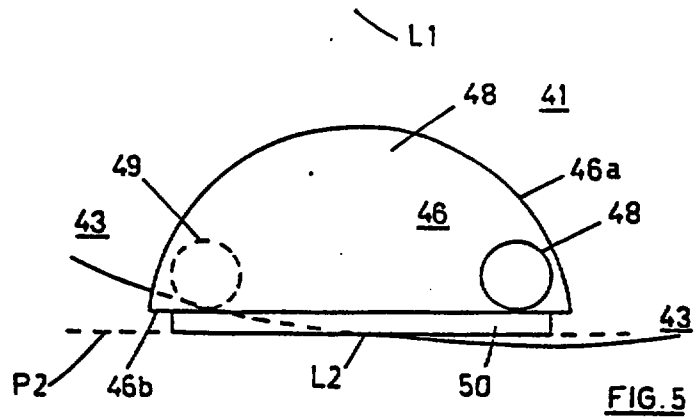


FIG. 7

20 MAR 1997

7/10

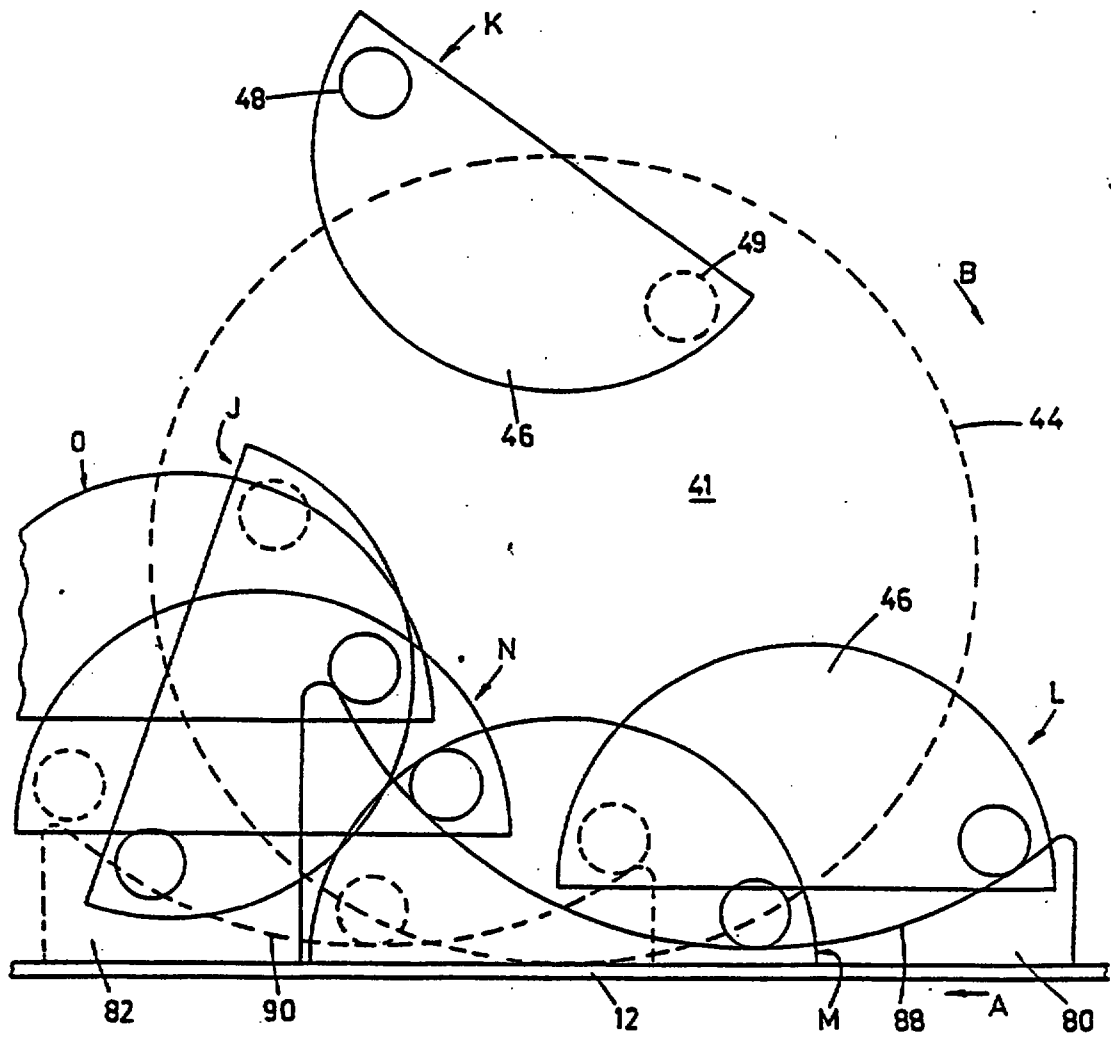


FIG. 8

20 MAR 1997

8/10

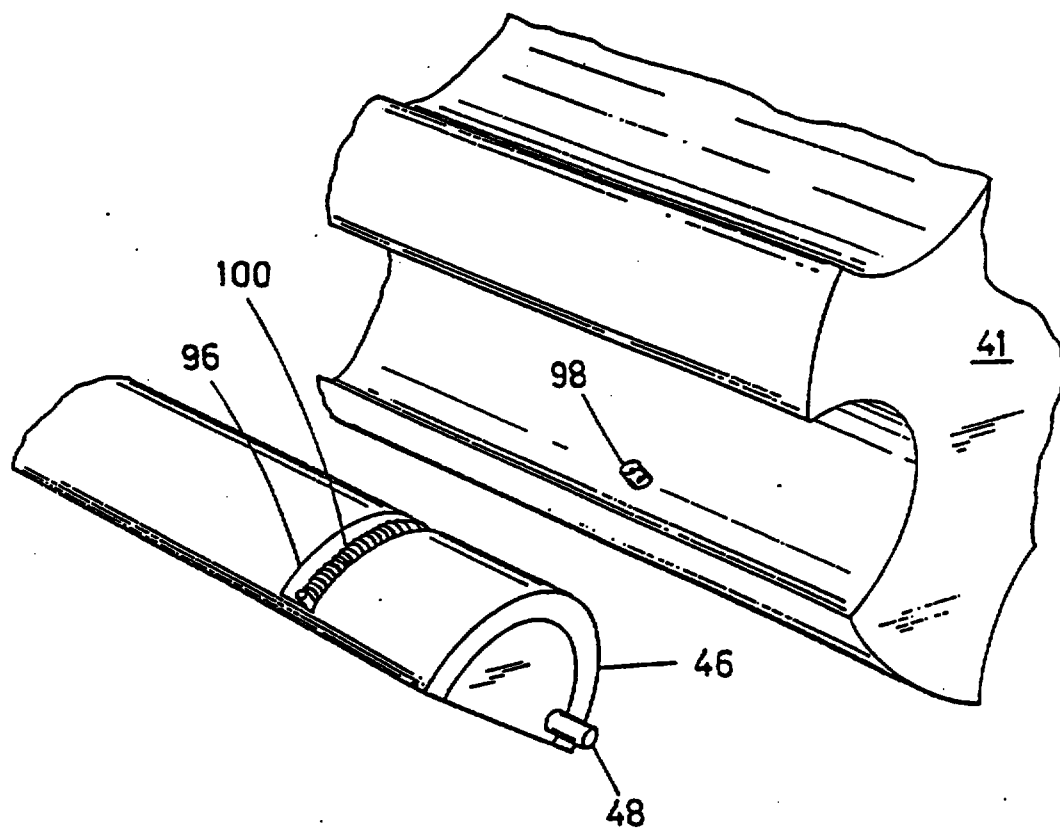


FIG. 9

20 MAR 1997

9/10

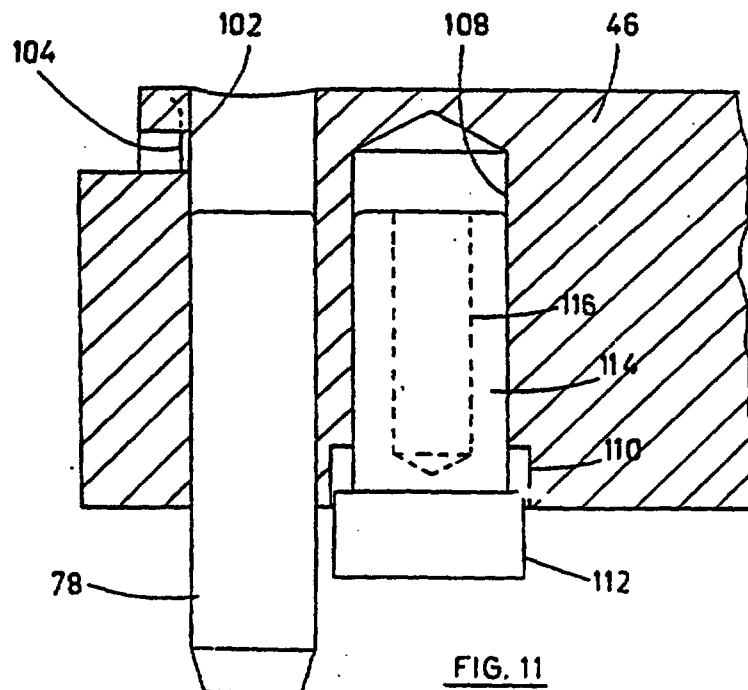
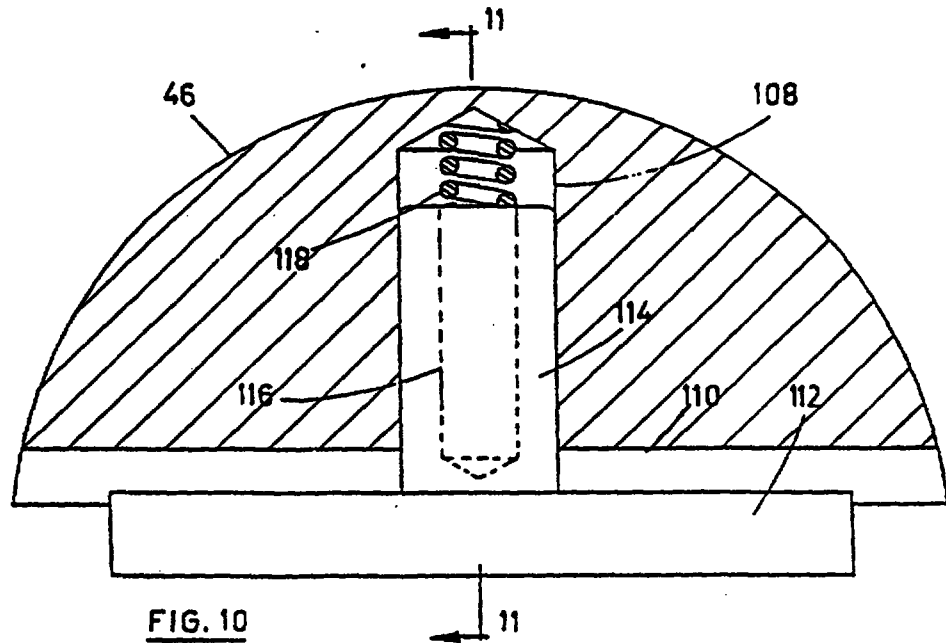


FIG. 12

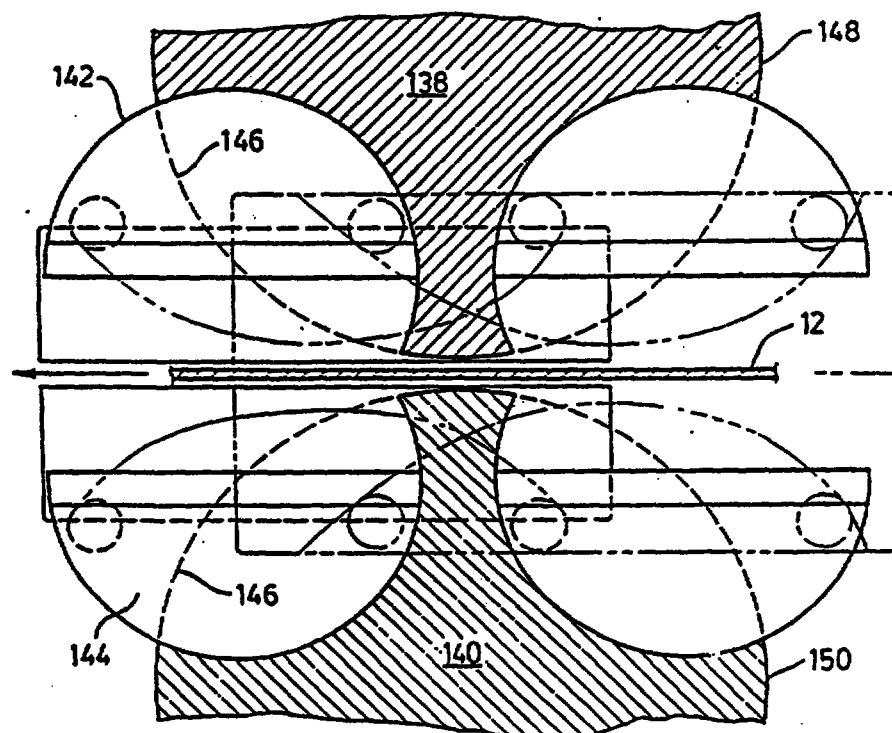


FIG. 13

REPLACED SHEETS		SG
☒	Description : paged 1 to paged 19	
☒	Claim(s) : paged 20 to paged 22	
☐	Drawing(s) : paged to paged	
☒	Abstract : paged 23 to paged	
DATE OF RECEIPT		

1

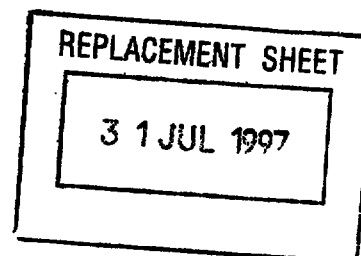
REPLACEMENT SHEETS		SG
☒	Description : paged 1 to paged 19	
☒	Claim(s) : paged 20 to paged 22	
☒	Drawing(s) : paged to paged	
☒	Abstract : paged 23 to paged	
		31/7/97

METHOD OF ROTARY FORMING

This invention relates to a rotary cutting and forming apparatus for high speed continuous punching, forming or shearing of sheet metal.

BACKGROUND OF THE INVENTION

Conventional sheet metal cutting and forming devices are reciprocating presses. Material to be worked is placed within a press, positioned stationary over a die. The press, usually mechanically operated, is closed, thus forcing a second die into contact with the workpiece. The force exerted on the workpiece by the dies will deform the piece or punch holes in the piece as required. When the operation is complete the press opens, the workpiece is removed and a new workpiece inserted. Because of the reciprocating motion inherent in such devices, the speed with which they may work is limited. Two solutions have been used. In one system the strip material is moved intermittently, step-wise through the press. In another system a so-called flying shear or die is used with a strip moving continuously. In this system the die is accelerated to the speed of the strip and the press closes, while the die and strip are moving in unison. The die then opens, and returns to its starting position. Typically, the punching, forming or shearing of a continuous material, such as sheet metal, is limited to a line speed of about 250 feet per minute.



This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

31 JUL 1997

However, a roll forming line without a punching, forming or shearing device could handle strip metal at speeds up to about 1,000 feet per minute.

It is evident that the output of an assembly or manufacturing line is only as fast as the slowest element in the line. In theory, a rotary press could be operated at much higher line speeds than a flying shear or die, and thus lead to considerable economies in operation.

Existing rotary material-working devices may suffer from various disadvantages. Some may be limited to specific operations such as cutting (see United States Patent Nos. 2,951,410, 3,274,873, 3,438,835, 3,709,077 and 3,828,636); perforating (see United States Patent No. 3,205,744); embossing (see United States Patent Nos. 804,512 and 4,059,000, and United Kingdom Patent Nos. 837,660 and 1,456,530); crimping (see United States Patent Nos. 3,123,905 and 3,367,161); and stretch forming (see United States Patent No. 3,394,573).

Such devices are generally designed to perform a specific one of the above operations and may not be able to perform other operations. In particular, they are unable to meet all the requirements for a full range of die forming operations, or for shearing a strip already formed into a complex section.

In such existing rotary machines shearing is feasible on flat, unformed strip. Die forming was achieved by using specially designed dies sometimes formed around an arc, which severely restricted the shape that could be formed. Generally it was not possible to use conventional flat dies as used in conventional reciprocating presses. Dies formed around an arc or radius, such as in U.S. Patent 3,394,573, posed considerable problems. The function of a curved die as it contacts the workpiece is different from that of a flat die. The curved die will commence working the material on one side of the die. As the curved die rotates, deformation of the workpiece will proceed along the workpiece until the operation is complete. This often resulted in distortion. In a flat die as found in conventional die presses, the workpiece is cut or worked

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

This Sheet Has Been Replaced



REPLACEMENT SHEET

3 1 JUL 1997

3

simultaneously across the die. In certain applications, such differences between standard and rotary devices may not be desirable.

Another approach to the problem is shown in United States Patent Nos 1 333 704, 1 581 236 and 3 066 542. In these patents the dies rotate around a circular orbit.

In United States Patent No 1 581 236, the individual dies are guided and controlled by an annular cam track, and cam followers riding in the track. In this arrangement the dies are oscillated or rocked, and are difficult to control. The cam followers cannot make a perfect fit in the annular track. Some clearance is needed in order that the followers can roll in the track. As a result, the dies are never held securely. When they meet they may fail to register perfectly, and damage may result.

With a view to overcoming these problems, the invention provides for a high speed rotary cutting and forming apparatus which makes use of flat dies and permits the accuracy of conventional die presses.

According to the invention apparatus for rotary cutting and forming comprises rotary cutting and forming apparatus comprising material forming dies for forming strip material comprising a rotatable upper roll unit and a corresponding rotatable lower roll unit, said units being connected for synchronous rotation, each of said units comprising a carrier member defining a central axis, said member having at least one recess extending along said member parallel to the central axis, said recess having bearing surface means of generally semi-circular shape and at least one die support block rotatably received within said recess, said block defining two ends and a platen surface to which at least one of said forming dies may be affixed, said upper and lower units being spaced apart whereby said material may pass therebetween for formation by said dies cam surface means provided on a stationary part in association with each of said rollers and means effective between said cam

THIS SHEET HAS BEEN
REPLACED

REPLACEMENT SHEET

31 JUL 1997

surface means at each said die support block for turning said blocks about their axes which are parallel to the roll axes in said recesses and relative to said roll units so that the said dies may be parallel to one another when adjacent to said material and cooperate together for deformation of the material characterised in that said means effective between the cam surface means and each die support block comprise leading and trailing control pin means extending from said block eccentrically of the axis of said block and respectively forwardly and rearwardly of said axis when the block is in the position adjacent said material, each of said control pins being associated with and engaging a corresponding and different one of the cam surface means (pin engaging cam pin engaging cam pin engaging cam and pin engaging cam whereby the said blocks are caused to rotate about their axes relative to the roll units as the latter rotate about their axes.

The advantages of the invention include the following: the device can be operated continuously or intermittently at high speed, thus allowing a manufacturing line, in which the device may be a component, to operate at high line speed. The device is as accurate as conventional, reciprocating die presses. use of a flat die set allows standard die tool-making procedures to be used. The device may have as much flexibility in its use, for forming holes, indentations and the like in a workpiece, as has a conventional die press.

Reference should be had to the accompanying drawings and descriptive matter in which there

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

3 1 JUL 1997

are illustrated and described preferred embodiments of the invention.

IN THE DRAWINGS

Figure 1 is a schematic illustration in perspective of a manufacturing line incorporating a rotary apparatus according to the invention.

Figure 2 is an exploded schematic drawing in perspective of a rotary apparatus according to the invention;

Figure 3 is a cross-section along the line 3-3 of Figure 2:

Figure 4 is a detail view in cross-section of a portion of the rotary apparatus of the invention;

Figure 5 is a detail view in perspective of a portion of the rotary apparatus according to the invention about to contact the workpiece;

Figure 6 is an exploded perspective view showing the apparatus performing a punching operation;

Figure 7 is a view similar to that of Figure 2, but illustrating a second embodiment;

Figure 8 is a diagrammatic view showing the upper die unit only, and illustrating successive positions of one (only) die block, in the Fig 7 embodiment:

Figure 9 is an exploded view of a detail of the embodiment of Figure 7;

Figure 10 is a sectional side elevation of a further embodiment:

Figure 11 is a section along the line 11-11 of Figure 10;

Figure 12 is a schematic top plan view of an alternate embodiment of the rotary apparatus, for intermittent operation; and

Figure 13 is a section along the line 13-13 of Figure 12.

DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

31 JUL 1997

Referring to Figure 1, there is illustrated a roll 10 of strip sheet material 12 upon which it is desired to perform various forming operations. Material 12 may often be sheet metal. Such operations may typically be performed in a manufacturing line 14. Material 12 is unwound from roll 10 and passed continuously along line 14, in the direction indicated by arrow A. The various forming operations are performed on material 12 as it passes different points along line 14. As material 12 is unwound from roll 10, typical first operations may be die forming operations, performed by a rotary apparatus 20 according to the invention. Apparatus 20 may punch holes, or form complex indentations 22, or both, in material 12 as it passes through apparatus 20. Nip rollers 21, both above and below material 12, guide material 12 through rotary apparatus 20. Subsequent operations may typically include roll-forming operations at station 23. Further operations as desired may be carried out at station 24. The final operation is typically the cutting of material 12 in cutting station 26 into standard lengths 28 convenient for further manufacturing or assembly processes and for storage.

Further nip rollers (not shown) may be used to guide material 12 through stations 23, 24 and 26. Of course, any number of stations 20, 23, 24 and 26 may be used in sequence, as desired.

The above description of a typical manufacturing line is provided herein in order to facilitate the description of the invention. The description of the manufacturing line is not intended to limit the invention in any way. Rather the apparatus according to the invention may be used in any manufacturing line or in any situation requiring high speed, continuous, accurate die forming of strip material.

Referring to Figure 2, there is schematically illustrated a rotary apparatus 20 according to the invention. Motor 30 drives upper roll unit 32 in unison with and, at the same speed, as lower roll unit 34 through transmission 35 and shafts 36. Material 12 passes between and is contacted by upper

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

REPLACEMENT SHEET

3 1 JUL 1997

7

and lower units 32 and 34. Upper and lower units 32 and 34 may be supported by suitable bearing means 37. In this embodiment, motor 30 and transmission 35 are such as to provide the outer surfaces of upper and lower units 32 and 34 at the point of contact with material 12 with essentially the same speed as material 12, so that there is no slippage or relative motion between the material 12 and either or both of upper unit 32 and lower unit 34.

However in an alternate embodiment described below, relative motion is provided for.

Transmission 35 and bearings 37 may be adjustable to vary the maximum distance between upper and lower units 32 and 34 in order to accommodate sheet material 12 of varying thicknesses or to increase the pressure applied to material 12. Hydraulic pistons 40 may be attached to shafts 36 so that upper unit 32 may be quickly removed from contact with material 12. Such capability allows the apparatus 20 to leave linear portions of material 12 unformed, if desired.

Motor 30, transmission 35, bearings 37 and pistons 40 may all be standard components as are well-known in the machine tooling industry.

Figure 3 illustrates in cross-section upper die unit 32 and lower die unit 34 in position to die form sheet material 12. Upper unit 32 rotates counter-clockwise in the direction indicated by arrow B. Lower unit 34 rotates clockwise in the direction indicated by arrow C. Material 12 moves from left to right in the direction indicated by arrow A.

It will be appreciated that the designations "upper", "lower", "left", "right", "clockwise", and "counter-clockwise" are for convenience of description only and are not intended to limit the invention, which will operate equally effectively in any direction or orientation. Similarly, references to an "upper die" located in a certain position and to a corresponding "lower die" in a certain corresponding position are not intended to limit the invention. Two dies operate as a pair and the individual location of each is irrelevant to the invention so long as the pair operates together at the required

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

31 JUL 1997

location and time

Upper unit 32 is essentially identical to lower unit 34. Referring to Figures 3 and 4, upper unit 32 includes upper carrier member 41, which defines a longitudinal axis L1 about which upper unit 32 rotates. Member 41 defines at least one (in the illustrated embodiment, there are four) generally semi-circular cylindrical recesses on opening 42, defining central axes (Figure 5) extending longitudinally parallel to the axis L1 of member 41. Member 41 further defines abutments 43 between openings 42. The outer surface of abutments 43 define a notional circular cylindrical surface 44 (shown in cross-section as phantom circle 44). The axes L2 of cylindrical openings 42 may lie on notional surface 44 parallel to axis L1. However in an alternate embodiment described below this is modified.

Referring to Figures 5 and 6, upper die support blocks 46 are retained within openings 42 by the semi-circular retaining flanges 47. Each block 46 is semi-cylindrical in shape having a cross-section that is segment-shaped namely, that shape bounded between the perimeter of a circle and a chord of the circle. Thus block 46 defines two surface portions: a semi-cylindrical portion 46a and a planar portion 46b. Semi-cylindrical portion 46a is fitted within opening 42, so that block 46 is freely rotatable within its associated opening 42. A first guide pin means 48 extends from one end of blocks 46 and a second guide pin means 49 extends from the outer end guide blocks 46, and ensure that the planar portions 46b are located in the desired position as described below. On a block 46 pin means 48 and 49 define and lie on different axes for reasons described below.

Upper dies 50 are mounted on planar portions 46b of blocks 46 in any conventional manner. The die surface of a die 50 defines a forming plane P2 (Figure 5). Die 50 is mounted on block 46 so that the plane P2 is essentially parallel to the planar portion 46b of block 46 and so that the plane P2 includes the axis of opening 42, in this embodiment.

Lower unit 34 comprises lower carrier member 52, defining semi-cylindrical openings 54, abutments 55 and



31 JUL 1997

semi-cylindrical surface 56, lower support blocks 58, and flat lower dies 60. Guide pin means 62 and 63 are provided in a fashion offset at opposite ends of the block similar to the equivalent components of upper unit 32. Retaining flanges 47 are also provided.

Each of pins 48, 49, 62 and 63 defines a cam follower means (not shown) at its free end. Pins 48 are guided by cam means such as a cam groove 64 defined in fixed end plate 38, at one end. Pins 49 are guided by cam means such as a cam groove 65 in fixed end plate 39, at the opposite end.

Similarly, on lower unit 34, guide pins 62 and 63 are guided by corresponding cam means; e.g., cam grooves 70 and 72, respectively, in fixed end plates 38 and 39, at opposite ends.

Fixed end plate 38 is divided between grooves 64 and 70 into upper and lower end plates, 38a and 38b respectively. Similarly, end plate 39 is split between grooves 66 and 72 into upper and lower end plates, 39a and 39b. Both end plates 38a and 39a are fixed by suitable means (not shown) relative to the axis L1 of upper unit 32. Such suitable means may, for example, comprise a guide track, preventing the rotation of plates 38a and 39a relative to axis L1, and a bearing means for shaft 36 in plates 38a and 39a.

Similarly, end plates 38b and 39b are fixed relative to the axis L1 of lower unit 34.

The provision of split end plates 38a, 38b, 39a and 39b, fixed as described above, allows the distance between upper unit 32 and lower unit 34 to be varied as desired without interfering with the operation of die forming apparatus 20. As hydraulic cylinders 40 are operated, such distance between units 32 and 34 varies. Upper end plates 38a and 39a move up and down in unison with upper unit 32, yet cam grooves 64 and 65 continue to support pins 48 and 49.

Cam grooves 64 and 65 are shaped and pins 48 and 49 are positioned relative to blocks 46 whereby the forming planes P2 of dies 50 are essentially parallel to material 12 immediately



31 JUL 1997

prior to, during and subsequent to closing. Similarly, cam grooves 70 and 72 are shaped, and pins 62 and 63 are positioned relative to blocks 58 whereby the forming planes P2 of dies 60 are essentially parallel to material 12 immediately prior to, during and subsequent to closing.

Because a block 46 and a block 58 may each be supported by two pins on different axes the blocks are less prone to rock or otherwise move within their fittings than are those found in standard rotary forming devices. Thus, in comparison to previously used rotary devices, the clearances required by the cam follower mechanism do not have as great an effect on the accuracy of the forming operation. In fact, the double cam construction of the invention results in substantially improved forming accuracy, and thus, longer useful die life.

To further ensure accuracy, upper support block 46 may be provided with locating dowels 78 on either side of die 50 (see Figure 6). Lower support block 58 may be provided with corresponding dowel receiving bores 79 on either side of die 60. Dowels 78 and bores 79 are shaped, sized and located on either side of strip material 12 so that they may cooperate and register with each other without interference with material 12. As upper and lower units 32 and 34 rotate, dowels 78 extend toward and are partially inserted into bores 79 prior to contact with material 12. As a die 50 and a die 60 come into contact with material 12 the dowels 78 are fully inserted into the bore 79, thus ensuring that die 50 and die 60 contact material 12 in proper registration with each other. Although accuracy is ensured by the use of dowels 78 and bores 79, such dowels 78 and bores 79 may not always be necessary for the accurate functioning of the device according to the invention. The device as described above has been found to operate with satisfactory accuracy without such dowels and bores.

Referring to Figure 3, in operation, upper and lower units 32 and 34 rotate. Each die 50 rotates through the successive illustrated positions of upper unit 32. Such positions have been labelled in Figure 3 as positions S, U, W, and Y. The

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

31 JUL 1997

closed position of apparatus 20, which is the position at which material 12 is formed, is defined as position S. Position S is treated as defining the starting point of the rotary cycle. Rotation continues, counter-clockwise as indicated by direction arrow B, through each of the other positions U, W and Y and returns to starting position S. Similarly, each die 60 rotates through the illustrated positions of lower unit 34. The movement of any die 60 is the mirror image of the movement of its corresponding die 50. It will, of course, be appreciated that all dies rotate simultaneously and, at any particular time, are at different positions in the rotary cycle.

At position S material 12 is formed by die 50 and die 60. As rotation continues to position U, die 50 and die 60 are separated from material 12. Because pins 48, 49, 62 and 63 follow their respective cam grooves 64, 65, 70 or 72, die 50 and die 60 initially remain essentially parallel to each other and to material 12. Abutments 43 and 55 come into contact with material 12. Thus, if there has been any adhesion between material 12 and either die 50 or die 60, material 12 will be pushed away from such dies 50 or 60 and will continue to pass smoothly through rotary apparatus 20.

As rotation continues, the cam followers cause block 46 to rotate through the positions U, W and Y. Following position Y, dies 50 and 60 are brought into essentially parallel position for the forming operation at position S.

In an alternate embodiment, cam grooves defined in the fixed end plates 38 and 39 are not necessary. Instead the cam followers of pins 48, 49, 62 and 63 may be constrained to follow curved ramps during certain pre-determined positions in the rotary cycle. Referring to Figure 7, ramp 80 is affixed to fixed end plate 38a and ramp 82 to fixed end plate 39a. Similarly associated with lower unit 34, ramps 84 and 86 are also affixed to fixed end plates 38b and 39b, respectively. Ramps 80, 82, 84 and 86 define curved surfaces 88, 90, 92 and 94, respectively.

Surfaces 88, 90, 92 and 94 are shaped whereby the forming planes P2 of dies 50 and 60 are essentially parallel to

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

31 JUL 1997

material 12 and to each other immediately prior to, during and subsequent to closing. During other parts of the rotary cycle, the precise positioning of blocks 46 and 58 relative to members 41 and 52, respectively, are unimportant as long as blocks 46 and 58 may again be brought parallel prior to closing.

Consequently, when the cam followers are not in contact with ramps 80, 82, 84 and 86, blocks 46 and 58 may be biased into a suitable fixed position by an appropriate biasing means. One such possible biasing means is illustrated in Figure 9. Block 46 defines a circumferential channel 96. Member 41 has a post 98, adapted to fit within channel 96 so that block 46 may still orbit within opening 42. Spring 100 is fitted within channel 96 and attached at one end to a wall of channel 96 (or to a post inserted in channel 96) and at the other end to post 98. In such a configuration, spring 100 tends to hold block 46 in the position indicated as J or K in Figure 8 relative to member 41. In this position, pin 48 is extended radially away from axis L1 whereby it may come into contact with its respective ramp 80 at a predetermined position in the rotary cycle.

The operation of this embodiment is best understood by referring to Figures 7 and 8. Figure 7 illustrates upper and lower units 32 and 34 in a position immediately after one pair of dies 50 and 60 have closed and immediately before a second pair of dies 50 and 60 have closed. Figure 8 illustrates one block 46 in member 41 shown at various positions in the rotary cycle. Successive positions are indicated by the labels J, K, H, M, N and O. One ramp 80 and its associated pin 48 are drawn in solid line. The other ramp 82 and its associated pin 49 are shown in phantom.

While only one block 46 is illustrated, it will be appreciated that other blocks 46 attached to member 41 will travel through corresponding positions of the rotary cycle at different times. It will be further appreciated that while only upper unit 32 is illustrated, similar action is occurring in lower unit 34.

Commencing arbitrarily with position J in the rotary

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

31 JUL 1997

cycle, spring 100 holds block 46 so that pin 48 is extended away from the axis L1 of member 41. As rotation occurs block 46 passes through position K to position H. There is no relative motion between block 46 and member 41 from position J to position H. At position H, the forming plane P2 (Figure 5) of die 50 is essentially parallel to material 12.

At position H pin 48 contacts the surface 88 of ramp 80. Also, pin 49 contacts the surface 90 of ramp 82. As rotation continues block 46 now commences to orbit within opening 44. Spring 100 commences to stretch. Pin 48 moves along surface 88. Pin 49 moves along surface 90. Such motion continues to position M. The surfaces 88 and 90 are shaped to ensure that plane P2 remains parallel to material 12.

On lower unit 34 (not shown in Figure 8) a corresponding plane P2 of die 60 is also essentially parallel to material 12 and thus to the plane P2 of die 50.

As rotation continues to position M, relative rotation between block 46 and member 41 continues and spring 100 stretches further. At about position M plane P2 contacts material 12 and, in cooperation with die 60, the material 12 is deformed as required.

After dies 50 and 60 have thus closed, rotation continues. Pins 48 and 49 remain in contact with respective ramps 80 and 82. Plane P2 remains parallel to material 12. Relative rotation between block 46 and member 41 continues and spring 100 stretches further.

At about position N, pin 49 which in this case is the leading pin, is removed from ramp 82.

At about position O, pin 48 which in this case is the trailing pin, reaches the end of ramp 80. Spring 100, which has been urging block 46 to rotate clockwises, may now act to return block 46 to its initial position with respect to member 41, for example, as shown at position J.

Suitable limit means (not shown) allow spring 100 to hold block 46 within opening 42 during rotation from position J to position L. For example, the presence of an abutment means



31 JUL 1997

(not shown) extending into opening 42 from member 41 would allow spring 100 to hold block 46 securely against the abutment. Block 46 would thus be prevented from moving in its opening 42 under the influence of centrifugal force as unit 32 rotates.

Because, in this embodiment, block 46 is pressed into place against the ramps by the rotation of member 41 prior to closing, a solid and accurate punch is possible. Spring 100 operates to keep pins 48 and 49 in contact with their respective ramps 80 and 82, thus further ensuring punching accuracy.

In other embodiments, it may be possible to use a ramp or cam groove on only one side of a die unit in conjunction with such a spring urging a die support block into contact with such ramp or groove. It may also be possible to use a ramp on one side of a die unit and a cam groove on the other side of the same unit. Use of a biasing spring may be avoided in such an embodiment.

It will be appreciated that a die apparatus according to the invention may be used in any situation requiring the use of high speed, accurate cutting or forming. Apart from the standard hole punching or indentation forming operation described above, the apparatus of the invention may, for instance, be used with a shearing die to cut roll formed strip material with a complex, shaped edge.

Several die units may be placed in line for forming complicated holes or shapes. For instance, a first rotary apparatus may punch a hole. A second rotary apparatus may form shapes around the hole. A third rotary apparatus may perform further operations and so on as required. Such operation would be very similar to the operation of existing progressive die presses.

The apparatus of the invention may be used to leave unformed areas at spaced intervals along the strip material. The upper and lower units 32 and 34 are simply separated so that they do not contact material 12 over such intervals.

In accordance with a further embodiment of the invention as shown in Figures 10 and 11, provisions may be made



31 JUL 1997

for still further stabilizing the die support blocks 46 and 58, so that they are forced to adopt precisely parallel planes prior to the engagement of the two dies on the blocks.

It will of course be appreciated that if the two die support blocks are not precisely parallel, and parallel with the workpiece, prior to the engagement of the dies on the workpiece, the workpiece will not be formed precisely, and conceivably damage may result to the dies themselves.

In the embodiment shown in Figures 1 to 6, the pins 78 and openings 79 will normally provide a sufficient degree of guidance to ensure that the two blocks are precisely parallel to one another before the dies close.

However, since some degree of wear is inevitable, it is considered desirable to make provision for a still greater degree of guidance.

Accordingly, as shown in Figures 10 and 11, the upper die block 46 is shown with the die guidance pin 78 received in a bore 102, and being retained therein by any suitable means (not shown).

A die block guide channel 104 is machined in either end of the block 46, so as to replace the function of the retaining flanges 47, and is engaged by suitable retaining means (not shown) on carrier member 41.

This feature would also be used in the blocks 58 in carrier member 52 in this embodiment.

In order to further assist in guiding and controlling the blocks 46 and 58, a further guide bore 108 is formed in, for example, the upper die block 46, parallel to the bore 102.

Bore 108 communicates with a longitudinal channel 110 of generally rectangular shape, extending from side to side of the block 46 transverse to its longitudinal axis.

Each of the die blocks 46 and 58 may be provided with two such guidance bores 108, one at each end, and two such channels 110.

An elongated rectangular contact bar 112 is received

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

31 JUL 1997

in channel 110, and is mounted on a cylindrical guide shaft 114 extending into guide bore 108. A counter-bore 116 is formed in shaft 114, and receives a spring 118 therein. The spring 118 will preferably be a heavy duty compression spring.

Any suitable retaining means (not shown) will be provided for retaining the shaft 114 in the bore 108.

The four bars 112 on the upper and lower die members 26 and 58 register with one another in pairs, as the dies are closing, but prior to contact with the workpiece.

The heavy duty springs 118 will yield and allow the bars 112 to move inwardly into the channels 110, but will, at the same time, force the faces of the bars 112 firmly into contact with one another along their length.

This function will thus ensure that the blocks 46 and 58 are located in parallel spaced-apart planes parallel to the workpiece prior to contact of the dies with the workpiece, thus ensuring accurate repetitive forming of the workpiece, without damage to the dies.

It will be appreciated that in the form illustrated both the upper and lower die blocks 46 and 58 are provided with the same guidance bars 112 and shafts 116.

The purpose of this is to reduce the distance of travel of each of the guide bars 112, and yet ensure that they meet and contact one another at a point early enough in the closing of the dies, that they can achieve a secure and accurate guidance function before the die is closed.

It will, of course, be appreciated however that where dies of a different nature are in use, such that a lesser degree of travel would be acceptable, it may be permissible to provide such guidance bars 112 on only the upper or the lower of the two die blocks. If only one pair of such guidance bars 112 were used then, of course, the guidance bars would simply contact the face of the other block and provide the same guidance function as described above.

It will be appreciated, therefore, that while this embodiment of the invention is illustrated as provided on both

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

31 JUL 1997

upper and lower die blocks and at each end, some degree of guidance function and security will be achieved by providing only one pair of such guidance bars. Conceivably also some limited degree of guidance can be achieved merely by the provision of one of such guidance bars at one end of one block.

The invention is not, therefore, limited to any specific number of such guidance bars.

In accordance with a further embodiment of the invention as illustrated in Figures 12 and 13, provision may be made for intermittent operation of the rotary apparatus.

Intermittent operation may be desirable where it is intended to produce from the strip sheet material, an end product which is cut to a predetermined length. Thus, for example, if it is desired to produce sheet metal strip having a series of formations, along predetermined lengths of the strip, and intermittent discontinuities in the formations, then, as has been described above, one solution would be to simply move one of the roll units away from the other.

Another solution to the problem is, however, to simply stop the upper and lower units momentarily and allow the strip sheet material to pass between them, without being formed or punched, for a predetermined length.

As shown schematically in Figure 12, a typical strip sheet material line for functioning in this way would comprise a rotary cutting or forming apparatus 120, upstream and downstream pinch rolls 122 and 124, and an uncoiler 126. The strip sheet material is indicated as 12, and in this embodiment is shown simply as being formed with generally triangular perforations or openings 12a. A discontinuity indicated generally as 12b is indicated between two of the perforations 12a.

In this embodiment the rotary apparatus 120 is driven by means of a motor 128, driving through a clutch 130. Clutch 130 drives the rotary apparatus 120, and the drive is controlled by means of a brake 132.

A line speed indicator 134 may be used if desired, for contacting the strip sheet material 12. However this



31 JUL 1997

information can equally well be obtained in other ways, and it is illustrated here merely for the sake of clarity.

A central data processing unit 136 provided with typical controls and displays is connected to the line speed indicator 134, and to the clutch 130 and to the brake 132.

It may also be connected to all of the rolls, and to the motor 128 if desired for capturing further information.

Referring now to Figure 13, the rotary apparatus 120 is essentially similar to that described in the preceding description. Accordingly the various features are described in only general terms herein, where they are the same. Thus the rotary apparatus 120 comprises carrier members 138 and 140 having die support blocks 142 and 144, guided and controlled in the manner described above.

The central axis of the die blocks 142 and 144 move around a circular path, indicated in phantom as 146.

However, the surface portions 148 and 150 of the carrier members 138 and 140 lie on the perimeter of a circle of a somewhat smaller radius than the circle 146.

In this way, when the two carrier members 138 and 140 are in the position illustrated in Figure 13, the surfaces 148 and 150 are out of contact with the workpiece 12.

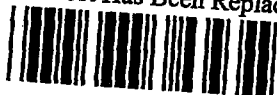
The workpiece is held in any event between the pinch rolls 122 and 124, and is therefore at all times controlled.

By suitably programming the processor 136 to operate the clutch 130 and brake 132 in the correct time sequence, it is possible to stop the upper and lower carrier members 138 and 140 in the position shown in Figure 13, for a predetermined dwell time, sufficient to allow an unformed portion 12b of the workpiece 12 to pass between them.

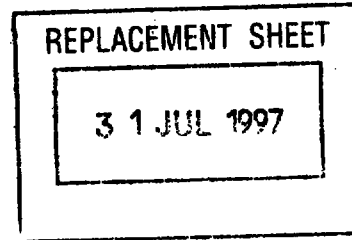
The processor 136 will then again signal the brake 132 to release and the clutch 130 to re-engage, and rotation of the carrier members 138 and 140 will be resumed.

The foregoing is a description of a preferred embodiment of the invention which is given here by way of example only. The invention is not to be taken as limited to any of the

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED



specific features as described, but comprehends all such variations thereof within the scope of the appended claims.

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

3 1 JUL 1997

CLAIMS

1. A method of forming or cutting a workpiece in a rotary apparatus, in which upper and lower dies 50, 60 are supported on upper and lower die support members 46, 58, which are in turn swingably supported on upper and lower carrier members 32, 34, in which each die support member is provided with leading and trailing guide members 48, 62, and 49, 63, and comprising the steps of;

engaging said leading guide members 48, 62 on leading control means 64, 70, prior to engagement of said dies 50, 60 with a workpiece;

engaging said trailing guide members 49, 63 on trailing control means 66, 72 prior to engagement of said dies 50, 60 with a workpiece;

moving said die support members 46, 58 along an arcuate path, while maintaining said leading and trailing guide members 48, 62, and 49, 63 in engagement with their respective leading and trailing control 64, 70 and 66, 72, and,

bringing said dies 50, 60 into engagement with said workpiece, and thereafter continuing said movement along said arcuate path, to bring said dies out of engagement with said workpiece, while continuing said engagement of said leading and trailing guide members 48, 62 and 49, 63 with their respective said leading and trailing control means 64, 70 and 66, 72.

2. A method of forming or cutting a workpiece as claimed in Claim 1, wherein said carrier members 32, 34 are rotatable about carrier axes, and wherein said leading and trailing control means 64, 70 and 66, 72 extend around 360 degrees, and including the steps of engaging said leading and trailing guide members with their respective leading and trailing control devices throughout the entire rotation of said carrier members.

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

3 1 JUL 1997

3. A method of forming or cutting a workpiece as claimed in Claim 1 wherein said leading and trailing control means 80, 82, 84, 86 define ramp surfaces extending around a predetermined arc less than 360 degrees, and including the steps of engaging said leading and trailing guide members 48, 62, and 49, 63 with their respective leading and trailing control means only over said predetermined arc.

4. A method of forming or cutting a workpiece as claimed in Claim 1 wherein said die support members 46, 58 further include contact bar means 112 reciprocable relative to at least one of said die support members and including the steps of bringing said contact bar means of one of said die support member into engagement with the other of said die support member prior to engagement of said dies with said workpiece, and maintaining said engagement of said contact bar means during engagement of said dies with said workpiece, and subsequently removing said contact bar means from said engagement.

5. A method of forming or cutting a workpiece as claimed in Claim 3 wherein there is an upper carrier member 32, and a lower carrier member 34, and including upper and lower said die support members 46, 58 on respective upper and lower carrier members for carrying respective upper and lower dies 50, 60 for engaging a workpiece simultaneously on opposite sides, and including the steps of bringing said leading and trailing guide members 48, 49 of said upper die support member 46 into engagement with their respective leading and trailing control means 80, 82, and bringing said leading and trailing guide members of said lower die support member into engagement with respective leading and trailing control devices 84, 86, prior to engagement of respective upper and lower said dies with said workpiece, whereby to maintain said upper and lower die support members and said upper and lower dies parallel with one another while moving said upper and lower die support members through respective

This Sheet Has Been Replaced

THIS SHEET HAS BEEN
REPLACED

REPLACEMENT SHEET

31 JUL 1997

upper and lower arcs.

6. A method of forming or cutting a workpiece as claimed in Claim 1, and further including the steps of passing said workpiece through a further rotary apparatus having such upper and lower dies supported on upper and lower die support members in turn swingably carried on upper and lower carrier members, whereby to perform further forming operations on said workpiece.

7. A method of forming or cutting a workpiece as claimed in Claim 1 and further including the steps of passing said workpiece through a plurality of upper and lower roller die pairs 124, downstream of said rotary apparatus whereby to form continuous formations in said workpiece.

8. A method of forming or cutting a workpiece as claimed in Claim 1, and further including the steps of subjecting said workpiece to the operation of said upper and lower dies 50, 60 at predetermined regular spaced apart intervals, and momentarily discontinuing such formation, whereby to form discontinuities in said operations at spaced apart intervals there along.



This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

REPLACEMENT SHEET

31 JUL 1997

ABSTRACTROTARY APPARATUS

A rotary cutting and forming apparatus for strip material 12, having rotatable upper and lower roll units 32,34, the units being connected for synchronous rotation, each of the units having a carrier member 41,52 with at least one recess 42, extending parallel to its central axis, and at least one die support block 46,58; the block being rotatably received within the recess 42, and having two ends, and a surface 46b to which a die may be affixed, leading and trailing control pins 48,62 on the block, extending on parallel spaced apart axes, and leading and trailing cam surfaces 64,70 and 66,72 engaging respective leading and trailing control pins 48,62, to control the position of the blocks during at least part of their rotation.

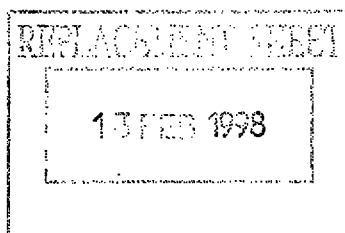
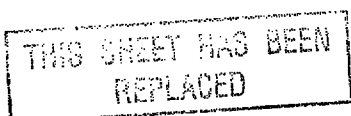
This Sheet Has Been ReplacedTHIS SHEET HAS BEEN
REPLACED

METHOD OF ROTARY FORMING

ABSTRACT

A rotary cutting and forming apparatus for strip material 12, having rotatable upper and lower roll units 32,34, the units being connected for synchronous rotation, each of the units having a carrier member 41,52 with at least one recess 42, extending parallel to its central axis, and at least one die support block 46,58; the block being rotatably received within the recess 42, and having two ends, and a surface 46b to which a die may be affixed, leading and trailing control pins 48,62 on the block, extending on parallel spaced apart axes, and leading and trailing cam surfaces 64,70 and 66,72 engaging respective leading and trailing control pins 48,62, to control the position of the blocks during at least part of their rotation.

Figure 1



This Sheet Has Been Replaced



- 1 -

REPLACEMENT SHEET

23 AUG 1999

METHOD OF ROTARY FORMING

This invention relates to a rotary cutting and forming apparatus for high speed for high speed continuous punching, forming or shearing of sheet metal, according to the preamble of claim 1 as for example know from US-A-1 581 236.

BACKGROUND OF THE INVENTION

Conventional sheet metal cutting and forming devices are reciprocating presses. Material to be worked is placed within a press, positioned stationary over a die. The press, usually mechanically operated, is closed, thus forcing a second die into contact with the workpiece. The force exerted on the workpiece by the dies will deform the piece or punch holes in the piece as required. When the operation is complete, the press opens, the workpiece is removed and a new workpiece inserted. Because of the reciprocating motion inherent in such devices, the speed with which they may work is limited. Two solutions have been used. In one system the strip material is moved intermittently, step-wise through the press. In another system a so-called flying shear or die is used with a strip moving continuously. In this system the die is accelerated to the speed of the strip and the press closes, while the die and strip are moving in unison. The die then opens, and returns to its starting position. Typically, the punching, forming or shearing of a continuous material, such as sheet metal, is limited to a line speed of about 250 feet per minute.

REPLACEMENT SHEETS	
☒ Description :	paged 1. to paged 18.
☒ Claim(s) :	paged 19. to paged 21.
☐ Drawing(s) :	paged to paged
☒ Abstract :	paged 22. to paged
DATE OF RECEIPT ... 23/6/99 ...	

23 AUG 1999

- 2 -

However, a roll forming line without a punching, forming or shearing device could handle strip metal at speeds up to about 1,000 feet per minute.

5 It is evident that the output of an assembly or manufacturing line is only as fast as the slowest element in the line. In theory, a rotary press could be operated at much higher line speeds than a flying shear or die, and thus lead to considerable economies in operation.

10 Existing rotary material-working devices may suffer from various disadvantages. Some may be limited to specific operations such as cutting (see United States Patent Nos. 2,951,410, 3,274,873, 3,438,835, 3,709,077 and 3,828,636); perforating (see United States Patent No. 3,205,744); embossing (see United States Patent Nos. 804,512 and 4,059,000, and United
15 Kingdom Patent Nos. 837,660 and 1,456,530); crimping (see United States Patent Nos. 3,123,905 and 3,367,161); and stretch forming (see United States Patent No. 3,394,573).

Such devices are generally designed to perform a specific one of the above operations and may not be able to
20 perform other operations. In particular, they are unable to meet all the requirements for a full range of die forming operations, or for shearing a strip already formed into a complex section.

In such existing rotary machines shearing is feasible on flat, unformed strip. Die forming was achieved by
25 using specially designed dies sometimes formed around an arc, which severely restricted the shape that could be formed. Generally it was not possible to use conventional flat dies as used in conventional reciprocating presses. Dies formed around an arc or radius, such as in U.S. Patent 3,394,573, posed
30 considerable problems. The function of a curved die as it contacts the workpiece is different from that of a flat die. The curved die will commence working the material on one side of the die. As the curved die rotates, deformation of the workpiece will proceed along the workpiece until the operation is complete.
35 This often resulted in distortion. In a flat die as found in conventional die presses, the workpiece is cut or worked

23 AUG 1999

- 3 -

simultaneously across the die. In certain applications, such differences between standard and rotary devices may not be desirable.

Another approach to the problem is shown in United States Patent Nos 1 333 704, 1 581 236 and 3 066 542. In these patents the dies rotate around a circular orbit.

In United States Patent No 1 581 236, the individual dies are guided and controlled by an annular cam track, and cam followers riding in the track. In this arrangement the dies are oscillated or rocked, and are difficult to control. The cam followers cannot make a perfect fit in the annular track. Some clearance is needed in order that the followers can roll in the track. As a result, the dies are never held securely. When they meet they may fail to register perfectly, and damage may result.

With a view to overcoming these problems, the invention provides for a high speed rotary cutting and forming apparatus which makes use of flat dies and permits the accuracy of conventional die presses.

According to the invention we provide a method of forming or cutting a workpiece in a rotary cutting and forming apparatus forming strip material (12) for use in association with material forming dies (50, 60) and having a rotatable upper roll unit (32) and a corresponding rotatable lower roll unit (34), said units being connected for synchronous rotation, each of said units comprising a carrier member (41, 52) defining a central axis, said member having at least one recess (42) extending along said member parallel to the central axis, said recess having bearing surface means of generally semi-circular shape, and at least one die support block (46, 58) rotatably received within said recess, said block defining two ends and a platen surface (46) to which at least one of said forming dies (50, 60) may be affixed; control pin means (48, 49, 62, 63) extending from a portion of a said end along an axis; said upper and lower and lower roll units being spaced apart whereby said material may pass therebetween for formation by said dies

23 AUG 1999

- 4 -

(50,60); cam surface means (64, 65, 70, 72) positioned to engage said pin means, and having a predetermined cam profile to support said die support blocks during a portion of the rotary cycle whereby said forming dies affixed to said blocks on said upper and lower units may register with each other and cooperate together for the deformation of the material; and bearing means (37) for supporting said units,

and characterized by both leading control pin means (48, 62) and trailing control pin means (49, 63) being provided on each block, said leading control pin means extending from a leading portion of a said end of a first axis and said trailing control means extending from the trailing portion of a said end on a second axis, and in that said cam surface means comprise leading cam surface means positioned to engage said leading control pin means and trailing cam surface means positioned to engage said trailing control pin means and to avoid said leading control pin means; the method including rotating said units thereby causing said die support blocks (46, 58) to rotate about their axes relative to said roll units as the latter rotate about their axes, and causing said die blocks (46, 58) to remain in parallel planes just before closure, during closure and just after closure, each die block being supported by two pins on different axes.

The advantages of the invention include the following: the device can be operated continuously or intermittently at high speed, thus allowing a manufacturing line, in which the device may be a component, to operate at high line speed. The device is as accurate as conventional, reciprocating die presses. use of a flat die set allows standard die tool-making procedures to be used. The device may have as much flexibility in its use, for forming holes, indentations and the like in a workpiece, as has a conventional die press.

Reference should be had to the accompanying drawings and descriptive matter in which there

23 AUG 1999

- 5 -

are illustrated and described preferred embodiments of the invention.

IN THE DRAWINGS

Figure 1 is a schematic illustration in perspective of a manufacturing line incorporating a rotary apparatus according to the invention.

Figure 2 is an exploded schematic drawing in perspective of a rotary apparatus according to the invention;

Figure 3 is a cross-section along the line 3-3 of Figure 2:

Figure 4 is a detail view in cross-section of a portion of the rotary apparatus of the invention;

Figure 5 is a detail view in perspective of a portion of the rotary apparatus according to the invention about to contact the workpiece;

Figure 6 is an exploded perspective view showing the apparatus performing a punching operation;

Figure 7 is a view similar to that of Figure 2, but illustrating a second embodiment;

Figure 8 is a diagrammatic view showing the upper die unit only, and illustrating successive positions of one (only) die block, in the Fig 7 embodiment:

Figure 9 is an exploded view of a detail of the embodiment of Figure 7;

Figure 10 is a sectional side elevation of a further embodiment:

Figure 11 is a section along the line 11-11 of Figure 10;

Figure 12 is a schematic top plan view of an alternate embodiment of the rotary apparatus, for intermittent operation; and

Figure 13 is a section along the line 13-13 of Figure 12.

DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

23 AUG 1999

- 6 -

Referring to Figure 1, there is illustrated a roll 10 of strip sheet material 12 upon which it is desired to perform various forming operations. Material 12 may often be sheet metal. Such operations may typically be performed in a manufacturing line 14. Material 12 is unwound from roll 10 and passed continuously along line 14, in the direction indicated by arrow A. The various forming operations are performed on material 12 as it passes different points along line 14. As material 12 is unwound from roll 10, typical first operations may be die forming operations, performed by a rotary apparatus 20 according to the invention. Apparatus 20 may punch holes, or form complex indentations 22, or both, in material 12 as it passes through apparatus 20. Nip rollers 21, both above and below material 12, guide material 12 through rotary apparatus 20. Subsequent operations may typically include roll-forming operations at station 23. Further operations as desired may be carried out at station 24. The final operation is typically the cutting of material 12 in cutting station 26 into standard lengths 28 convenient for further manufacturing or assembly processes and for storage.

Further nip rollers (not shown) may be used to guide material 12 through stations 23, 24 and 26. Of course, any number of stations 20, 23, 24 and 26 may be used in sequence, as desired.

The above description of a typical manufacturing line is provided herein in order to facilitate the description of the invention. The description of the manufacturing line is not intended to limit the invention in any way. Rather the apparatus according to the invention may be used in any manufacturing line or in any situation requiring high speed, continuous, accurate die forming of strip material.

Referring to Figure 2, there is schematically illustrated a rotary apparatus 20 according to the invention. Motor 30 drives upper roll unit 32 in unison with and, at the same speed, as lower roll unit 34 through transmission 35 and shafts 36. Material 12 passes between and is contacted by upper

23 AUG 1999

- 7 -

and lower units 32 and 34. Upper and lower units 32 and 34 may be supported by suitable bearing means 37. In this embodiment, motor 30 and transmission 35 are such as to provide the outer surfaces of upper and lower units 32 and 34 at the point of contact with material 12 with essentially the same speed as material 12, so that there is no slippage or relative motion between the material 12 and either or both of upper unit 32 and lower unit 34.

However in an alternate embodiment described below, relative motion is provided for.

Transmission 35 and bearings 37 may be adjustable to vary the maximum distance between upper and lower units 32 and 34 in order to accommodate sheet material 12 of varying thicknesses or to increase the pressure applied to material 12. Hydraulic pistons 40 may be attached to shafts 36 so that upper unit 32 may be quickly removed from contact with material 12. Such capability allows the apparatus 20 to leave linear portions of material 12 unformed, if desired.

Motor 30, transmission 35, bearings 37 and pistons 40 may all be standard components as are well-known in the machine tooling industry.

Figure 3 illustrates in cross-section upper die unit 32 and lower die unit 34 in position to die form sheet material 12. Upper unit 32 rotates counter-clockwise in the direction indicated by arrow B. Lower unit 34 rotates clockwise in the direction indicated by arrow C. Material 12 moves from left to right in the direction indicated by arrow A.

It will be appreciated that the designations "upper", "lower", "left", "right", "clockwise", and "counter-clockwise" are for convenience of description only and are not intended to limit the invention, which will operate equally effectively in any direction or orientation. Similarly, references to an "upper die" located in a certain position and to a corresponding "lower die" in a certain corresponding position are not intended to limit the invention. Two dies operate as a pair and the individual location of each is irrelevant to the invention so long as the pair operates together at the required

23 AUG 1999

- 8 -

location and time

Upper unit 32 is essentially identical to lower unit 34. Referring to Figures 3 and 4, upper unit 32 includes upper carrier member 41, which defines a longitudinal axis L1 about which upper unit 32 rotates. Member 41 defines at least one (in the illustrated embodiment, there are four) generally semi-circular cylindrical recesses on opening 42, defining central axes (Figure 5) extending longitudinally parallel to the axis L1 of member 41. Member 41 further defines abutments 43 between openings 42. The outer surface of abutments 43 define a notional circular cylindrical surface 44 (shown in cross-section as phantom circle 44). The axes L2 of cylindrical openings 42 may lie on notional surface 44 parallel to axis L1. However in an alternate embodiment described below this is modified.

Referring to Figures 5 and 6, upper die support blocks 46 are retained within openings 42 by the semi-circular retaining flanges 47. Each block 46 is semi-cylindrical in shape having a cross-section that is segment-shaped namely, that shape bounded between the perimeter of a circle and a chord of the circle. Thus block 46 defines two surface portions: a semi-cylindrical portion 46a and a planar portion 46b. Semi-cylindrical portion 46a is fitted within opening 42, so that block 46 is freely rotatable within its associated opening 42. A first guide pin means 48 extends from one end of blocks 46 and a second guide pin means 49 extends from the outer end guide blocks 46, and ensure that the planar portions 46b are located in the desired position as described below. On a block 46 pin means 48 and 49 define and lie on different axes for reasons described below.

Upper dies 50 are mounted on planar portions 46b of blocks 46 in any conventional manner. The die surface of a die 50 defines a forming plane P2 (Figure 5). Die 50 is mounted on block 46 so that the plane P2 is essentially parallel to the planar portion 46b of block 46 and so that the plane P2 includes the axis of opening 42, in this embodiment.

Lower unit 34 comprises lower carrier member 52, defining semi-cylindrical openings 54, abutments 55 and

23 AUG 1999

- 9 -

semi-cylindrical surface 56, lower support blocks 58, and flat lower dies 60. Guide pin means 62 and 63 are provided in a fashion offset at opposite ends of the block similar to the equivalent components of upper unit 32. Retaining flanges 47 are also provided.

Each of pins 48, 49, 62 and 63 defines a cam follower means (not shown) at its free end. Pins 48 are guided by cam means such as a cam groove 64 defined in fixed end plate 38, at one end. Pins 49 are guided by cam means such as a cam groove 65 in fixed end plate 39, at the opposite end.

Similarly, on lower unit 34, guide pins 62 and 63 are guided by corresponding cam means; e.g., cam grooves 70 and 72, respectively, in fixed end plates 38 and 39, at opposite ends.

Fixed end plate 38 is divided between grooves 64 and 70 into upper and lower end plates, 38a and 38b respectively. Similarly, end plate 39 is split between grooves 66 and 72 into upper and lower end plates, 39a and 39b. Both end plates 38a and 39a are fixed by suitable means (not shown) relative to the axis L1 of upper unit 32. Such suitable means may, for example, comprise a guide track, preventing the rotation of plates 38a and 39a relative to axis L1, and a bearing means for shaft 36 in plates 38a and 39a.

Similarly, end plates 38b and 39b are fixed relative to the axis L1 of lower unit 34.

The provision of split end plates 38a, 38b, 39a and 39b, fixed as described above, allows the distance between upper unit 32 and lower unit 34 to be varied as desired without interfering with the operation of die forming apparatus 20. As hydraulic cylinders 40 are operated, such distance between units 32 and 34 varies. Upper end plates 38a and 39a move up and down in unison with upper unit 32, yet cam grooves 64 and 65 continue to support pins 48 and 49.

Cam grooves 64 and 65 are shaped and pins 48 and 49 are positioned relative to blocks 46 whereby the forming planes P2 of dies 50 are essentially parallel to material 12 immediately

23 AUG 1999

- 10 -

prior to, during and subsequent to closing. Similarly, cam grooves 70 and 72 are shaped, and pins 62 and 63 are positioned relative to blocks 58 whereby the forming planes P2 of dies 60 are essentially parallel to material 12 immediately prior to, during and subsequent to closing.

Because a block 46 and a block 58 may each be supported by two pins on different axes the blocks are less prone to rock or otherwise move within their fittings than are those found in standard rotary forming devices. Thus, in comparison to previously used rotary devices, the clearances required by the cam follower mechanism do not have as great an effect on the accuracy of the forming operation. In fact, the double cam construction of the invention results in substantially improved forming accuracy, and thus, longer useful die life.

To further ensure accuracy, upper support block 46 may be provided with locating dowels 78 on either side of die 50 (see Figure 6). Lower support block 58 may be provided with corresponding dowel receiving bores 79 on either side of die 60. Dowels 78 and bores 79 are shaped, sized and located on either side of strip material 12 so that they may cooperate and register with each other without interference with material 12. As upper and lower units 32 and 34 rotate, dowels 78 extend toward and are partially inserted into bores 79 prior to contact with material 12. As a die 50 and a die 60 come into contact with material 12 the dowels 78 are fully inserted into the bore 79, thus ensuring that die 50 and die 60 contact material 12 in proper registration with each other. Although accuracy is ensured by the use of dowels 78 and bores 79, such dowels 78 and bores 79 may not always be necessary for the accurate functioning of the device according to the invention. The device as described above has been found to operate with satisfactory accuracy without such dowels and bores.

Referring to Figure 3, in operation, upper and lower units 32 and 34 rotate. Each die 50 rotates through the successive illustrated positions of upper unit 32. Such positions have been labelled in Figure 3 as positions S, U, W, and Y. The

23 AUG 1999

- 11 -

closed position of apparatus 20, which is the ~~position at which~~ material 12 is formed, is defined as position S. Position S is treated as defining the starting point of the rotary cycle. Rotation continues, counter-clockwise as indicated by direction arrow B, through each of the other positions U, W and Y and returns to starting position S. Similarly, each die 60 rotates through the illustrated positions of lower unit 34. The movement of any die 60 is the mirror image of the movement of its corresponding die 50. It will, of course, be appreciated that all dies rotate simultaneously and, at any particular time, are at different positions in the rotary cycle.

At position S material 12 is formed by die 50 and die 60. As rotation continues to position U, die 50 and die 60 are separated from material 12. Because pins 48, 49, 62 and 63 follow their respective cam grooves 64, 65, 70 or 72, die 50 and die 60 initially remain essentially parallel to each other and to material 12. Abutments 43 and 55 come into contact with material 12. Thus, if there has been any adhesion between material 12 and either die 50 or die 60, material 12 will be pushed away from such dies 50 or 60 and will continue to pass smoothly through rotary apparatus 20.

As rotation continues, the cam followers cause block 46 to rotate through the positions U, W and Y. Following position Y, dies 50 and 60 are brought into essentially parallel position for the forming operation at position S.

In an alternate embodiment, cam grooves defined in the fixed end plates 38 and 39 are not necessary. Instead the cam followers of pins 48, 49, 62 and 63 may be constrained to follow curved ramps during certain pre-determined positions in the rotary cycle. Referring to Figure 7, ramp 80 is affixed to fixed end plate 38a and ramp 82 to fixed end plate 39a. Similarly associated with lower unit 34, ramps 84 and 86 are also affixed to fixed end plates 38b and 39b, respectively. Ramps 80, 82, 84 and 86 define curved surfaces 88, 90, 92 and 94, respectively.

Surfaces 88, 90, 92 and 94 are shaped whereby the forming planes P2 of dies 50 and 60 are essentially parallel to

23 AUG 1999

- 12 -

material 12 and to each other immediately prior to, during and subsequent to closing. During other parts of the rotary cycle, the precise positioning of blocks 46 and 58 relative to members 41 and 52, respectively, are unimportant as long as blocks 46 and 58 may again be brought parallel prior to closing.

Consequently, when the cam followers are not in contact with ramps 80, 82, 84 and 86, blocks 46 and 58 may be biased into a suitable fixed position by an appropriate biasing means. One such possible biasing means is illustrated in Figure 9. Block 46 defines a circumferential channel 96. Member 41 has a post 98, adapted to fit within channel 96 so that block 46 may still orbit within opening 42. Spring 100 is fitted within channel 96 and attached at one end to a wall of channel 96 (or to a post inserted in channel 96) and at the other end to post 98. In such a configuration, spring 100 tends to hold block 46 in the position indicated as J or K in Figure 8 relative to member 41. In this position, pin 48 is extended radially away from axis L1 whereby it may come into contact with its respective ramp 80 at a predetermined position in the rotary cycle.

The operation of this embodiment is best understood by referring to Figures 7 and 8. Figure 7 illustrates upper and lower units 32 and 34 in a position immediately after one pair of dies 50 and 60 have closed and immediately before a second pair of dies 50 and 60 have closed. Figure 8 illustrates one block 46 in member 41 shown at various positions in the rotary cycle. Successive positions are indicated by the labels J, K, H, M, N and O. One ramp 80 and its associated pin 48 are drawn in solid line. The other ramp 82 and its associated pin 49 are shown in phantom.

While only one block 46 is illustrated, it will be appreciated that other blocks 46 attached to member 41 will travel through corresponding positions of the rotary cycle at different times. It will be further appreciated that while only upper unit 32 is illustrated, similar action is occurring in lower unit 34.

Commencing arbitrarily with position J in the rotary

23 AUG 1999

- 13 -

cycle, spring 100 holds block 46 so that pin 48 is extended away from the axis L1 of member 41. As rotation occurs block 46 passes through position K to position H. There is no relative motion between block 46 and member 41 from position J to position H. At position H, the forming plane P2 (Figure 5) of die 50 is essentially parallel to material 12.

At position H pin 48 contacts the surface 88 of ramp 80. Also, pin 49 contacts the surface 90 of ramp 82. As rotation continues block 46 now commences to orbit within opening 44. Spring 100 commences to stretch. Pin 48 moves along surface 88. Pin 49 moves along surface 90. Such motion continues to position M. The surfaces 88 and 90 are shaped to ensure that plane P2 remains parallel to material 12.

On lower unit 34 (not shown in Figure 8) a corresponding plane P2 of die 60 is also essentially parallel to material 12 and thus to the plane P2 of die 50.

As rotation continues to position M, relative rotation between block 46 and member 41 continues and spring 100 stretches further. At about position M plane P2 contacts material 12 and, in cooperation with die 60, the material 12 is deformed as required.

After dies 50 and 60 have thus closed, rotation continues. Pins 48 and 49 remain in contact with respective ramps 80 and 82. Plane P2 remains parallel to material 12. Relative rotation between block 46 and member 41 continues and spring 100 stretches further.

At about position N, pin 49 which in this case is the leading pin, is removed from ramp 82.

At about position O, pin 48 which in this case is the trailing pin, reaches the end of ramp 80. Spring 100, which has been urging block 46 to rotate clockwises, may now act to return block 46 to its initial position with respect to member 41, for example, as shown at position J.

Suitable limit means (not shown) allow spring 100 to hold block 46 within opening 42 during rotation from position J to position L. For example, the presence of an abutment means

23 AUG 1999

- 14 -

(not shown) extending into opening 42 from member 41 would allow spring 100 to hold block 46 securely against the abutment. Block 46 would thus be prevented from moving in its opening 42 under the influence of centrifugal force as unit 32 rotates.

Because, in this embodiment, block 46 is pressed into place against the ramps by the rotation of member 41 prior to closing, a solid and accurate punch is possible. Spring 100 operates to keep pins 48 and 49 in contact with their respective ramps 80 and 82, thus further ensuring punching accuracy.

In other embodiments, it may be possible to use a ramp or cam groove on only one side of a die unit in conjunction with such a spring urging a die support block into contact with such ramp or groove. It may also be possible to use a ramp on one side of a die unit and a cam groove on the other side of the same unit. Use of a biasing spring may be avoided in such an embodiment.

It will be appreciated that a die apparatus according to the invention may be used in any situation requiring the use of high speed, accurate cutting or forming. Apart from the standard hole punching or indentation forming operation described above, the apparatus of the invention may, for instance, be used with a shearing die to cut roll formed strip material with a complex, shaped edge.

Several die units may be placed in line for forming complicated holes or shapes. For instance, a first rotary apparatus may punch a hole. A second rotary apparatus may form shapes around the hole. A third rotary apparatus may perform further operations and so on as required. Such operation would be very similar to the operation of existing progressive die presses.

The apparatus of the invention may be used to leave unformed areas at spaced intervals along the strip material. The upper and lower units 32 and 34 are simply separated so that they do not contact material 12 over such intervals.

In accordance with a further embodiment of the invention as shown in Figures 10 and 11, provisions may be made

23 AUG 1999

- 15 -

for still further stabilizing the die support blocks 46 and 58, so that they are forced to adopt precisely parallel planes prior to the engagement of the two dies on the blocks.

5 It will of course be appreciated that if the two die support blocks are not precisely parallel, and parallel with the workpiece, prior to the engagement of the dies on the workpiece, the workpiece will not be formed precisely, and conceivably damage may result to the dies themselves.

10 In the embodiment shown in Figures 1 to 6, the pins 78 and openings 79 will normally provide a sufficient degree of guidance to ensure that the two blocks are precisely parallel to one another before the dies close.

15 However, since some degree of wear is inevitable, it is considered desirable to make provision for a still greater degree of guidance.

Accordingly, as shown in Figures 10 and 11, the upper die block 46 is shown with the die guidance pin 78 received in a bore 102, and being retained therein by any suitable means (not shown).

20 A die block guide channel 104 is machined in either end of the block 46, so as to replace the function of the retaining flanges 47, and is engaged by suitable retaining means (not shown) on carrier member 41.

25 This feature would also be used in the blocks 58 in carrier member 52 in this embodiment.

In order to further assist in guiding and controlling the blocks 46 and 58, a further guide bore 108 is formed in, for example, the upper die block 46, parallel to the bore 102.

30 Bore 108 communicates with a longitudinal channel 110 of generally rectangular shape, extending from side to side of the block 46 transverse to its longitudinal axis.

Each of the die blocks 46 and 58 may be provided with two such guidance bores 108, one at each end, and two such channels 110.

35 An elongated rectangular contact bar 112 is received

23 AUG 1999

- 16 -

in channel 110, and is mounted on a cylindrical guide shaft 114 extending into guide bore 108. A counter-bore 116 is formed in shaft 114, and receives a spring 118 therein. The spring 118 will preferably be a heavy duty compression spring.

5 Any suitable retaining means (not shown) will be provided for retaining the shaft 114 in the bore 108.

The four bars 112 on the upper and lower die members 26 and 58 register with one another in pairs, as the dies are closing, but prior to contact with the workpiece.

10 The heavy duty springs 118 will yield and allow the bars 112 to move inwardly into the channels 110, but will, at the same time, force the faces of the bars 112 firmly into contact with one another along their length.

15 This function will thus ensure that the blocks 46 and 58 are located in parallel spaced-apart planes parallel to the workpiece prior to contact of the dies with the workpiece, thus ensuring accurate repetitive forming of the workpiece, without damage to the dies.

20 It will be appreciated that in the form illustrated both the upper and lower die blocks 46 and 58 are provided with the same guidance bars 112 and shafts 116.

25 The purpose of this is to reduce the distance of travel of each of the guide bars 112, and yet ensure that they meet and contact one another at a point early enough in the closing of the dies, that they can achieve a secure and accurate guidance function before the die is closed.

30 It will, of course, be appreciated however that where dies of a different nature are in use, such that a lesser degree of travel would be acceptable, it may be permissible to provide such guidance bars 112 on only the upper or the lower of the two die blocks. If only one pair of such guidance bars 112 were used then, of course, the guidance bars would simply contact the face of the other block and provide the same guidance function as described above.

35 It will be appreciated, therefore, that while this embodiment of the invention is illustrated as provided on both

23 AUG 1999

- 17 -

upper and lower die blocks and at each end, some degree of guidance function and security will be achieved by providing only one pair of such guidance bars. Conceivably also some limited degree of guidance can be achieved merely by the provision of one of such guidance bars at one end of one block.

The invention is not, therefore, limited to any specific number of such guidance bars.

In accordance with a further embodiment of the invention as illustrated in Figures 12 and 13, provision may be made for intermittent operation of the rotary apparatus.

Intermittent operation may be desirable where it is intended to produce from the strip sheet material, an end product which is cut to a predetermined length. Thus, for example, if it is desired to produce sheet metal strip having a series of formations, along predetermined lengths of the strip, and intermittent discontinuities in the formations, then, as has been described above, one solution would be to simply move one of the roll units away from the other.

Another solution to the problem is, however, to simply stop the upper and lower units momentarily and allow the strip sheet material to pass between them, without being formed or punched, for a predetermined length.

As shown schematically in Figure 12, a typical strip sheet material line for functioning in this way would comprise a rotary cutting or forming apparatus 120, upstream and downstream pinch rolls 122 and 124, and an uncoiler 126. The strip sheet material is indicated as 12, and in this embodiment is shown simply as being formed with generally triangular perforations or openings 12a. A discontinuity indicated generally as 12b is indicated between two of the perforations 12a.

In this embodiment the rotary apparatus 120 is driven by means of a motor 128, driving through a clutch 130. Clutch 130 drives the rotary apparatus 120, and the drive is controlled by means of a brake 132.

A line speed indicator 134 may be used if desired, for contacting the strip sheet material 12. However this

23 AUG 1999

- 18 -

information can equally well be obtained in other ways, and it is illustrated here merely for the sake of clarity.

5 A central data processing unit 136 provided with typical controls and displays is connected to the line speed indicator 134, and to the clutch 130 and to the brake 132.

It may also be connected to all of the rolls, and to the motor 128 if desired for capturing further information.

10 Referring now to Figure 13, the rotary apparatus 120 is essentially similar to that described in the preceding description. Accordingly the various features are described in only general terms herein, where they are the same. Thus the rotary apparatus 120 comprises carrier members 138 and 140 having die support blocks 142 and 144, guided and controlled in the manner described above.

15 The central axis of the die blocks 142 and 144 move around a circular path, indicated in phantom as 146.

However, the surface portions 148 and 150 of the carrier members 138 and 140 lie on the perimeter of a circle of a somewhat smaller radius than the circle 146.

20 In this way, when the two carrier members 138 and 140 are in the position illustrated in Figure 13, the surfaces 148 and 150 are out of contact with the workpiece 12.

The workpiece is held in any event between the pinch rolls 122 and 124, and is therefore at all times controlled.

25 By suitably programming the processor 136 to operate the clutch 130 and brake 132 in the correct time sequence, it is possible to stop the upper and lower carrier members 138 and 140 in the position shown in Figure 13, for a predetermined dwell time, sufficient to allow an unformed portion 12b of the
30 workpiece 12 to pass between them.

The processor 136 will then again signal the brake 132 to release and the clutch 130 to re-engage, and rotation of the carrier members 138 and 140 will be resumed.

23 AUG 1999

CLAIMS

A method of forming or cutting a workpiece in a rotary cutting and forming apparatus for forming strip material (12) for use in association with material forming dies (50,60) and having a rotatable upper roll unit (32) and a corresponding rotatable lower roll unit (34), said units being connected for synchronous rotation, each of said units comprising a carrier member (41,52) defining a central axis, said member having at least one recess (42) extending along said member parallel to the central axis, said recess having bearing surface means of generally semi-circular shape, and at least one die support block (46,58) rotatably received within said recess, said block defining two ends and a platen surface (46) to which at least one of said forming dies (50, 60) may be affixed; control pin means (48, 49, 62, 63) extending from a portion of a said end along an axis; said upper and lower and lower roll units being spaced apart whereby said material may pass therebetween for formation by said dies (50,60); cam surface means (64,65,70,72) positioned to engage said pin means, and having a predetermined cam profile; whereby to support said die support blocks during a portion of the rotary cycle whereby said forming dies affixed to said blocks on said upper and lower units may register with each other and cooperate together for the deformation of the material; and bearing means (37) for supporting said units,

And characterized by both leading control pin means (48, 62) and trailing control pin means (49,63) being provided on each block, said leading control pin means extending from a leading portion of a said end of a first axis and said trailing control means extending from the trailing portion of said end on a second axis, and in that said cam surface means comprise leading cam surface means positioned to engage said leading control pin means and trailing cam surface means positioned to engage said trailing control pin means and to avoid said leading control pin means; the method includes rotating said units thereby causing said die support blocks (46,58) to rotate about their axes relative to said roll units as the latter rotate about their axes, and causing said die blocks (46,58) to remain in parallel planes just before closure, during closure and just after closure, each die block being supported by two pins on different axes.

2. A method of forming or cutting a workpiece as claimed in Claim 1, wherein said carrier members (32, 34) are rotatable about carrier axes, and wherein said leading and trailing control means (64, 70 and 66, 72) extend around 360 degrees, and including the steps of engaging said leading and trailing guide members with their respective leading and trailing control devices throughout the entire rotation of said carrier members.



* C L M S *

23 AUG 1999

- 20 -

3. A method of forming or cutting a workpiece as claimed in Claim 1 wherein said leading and trailing control means (80, 82, 84, 86) define ramp surfaces extending around a predetermined arc less than 360 degrees, and including the steps of engaging said leading and trailing guide members (48, 62, and 49, 63) with their respective leading and trailing control means only over said predetermined arc.

4. A method of forming or cutting a workpiece as claimed in Claim 1 wherein said die support members (46, 58) further include contact bar means (112) reciprocable relative to at least one of said die support members and including the steps of bringing said contact bar means of one of said die support member into engagement with the other of said die support member prior to engagement of said dies with said workpiece, and maintaining said engagement of said contact bar means during engagement of said dies with said workpiece, and subsequently removing said contact bar means from said engagement.

5. A method of forming or cutting a workpiece as claimed in Claim 3 wherein there is an upper carrier member (32) and a lower carrier member (34) and including upper and lower said die support members (46, 58) on respective upper and lower carrier members for carrying respective upper and lower dies (50, 60) for engaging a workpiece simultaneously on opposite sides, and including the steps of bringing said leading and trailing control means (48, 49) of said upper die support member (46) into engagement with their respective leading and trailing control means (80, 82) and bringing said leading and trailing guide members of said lower die support member into engagement with respective leading and trailing control devices (84, 86), prior to engagement of respective upper and lower said dies with said workpiece, whereby to maintain said upper and lower die support members and said upper and lower dies parallel with one another while moving said upper and lower die support members through respective



REPLACEMENT SHEET

23 AUG 1999

- 21 -

upper and lower arcs.

6. A method of forming or cutting a workpiece as claimed in Claim 1, and further including the steps of passing said workpiece through a further rotary apparatus having such upper and lower dies supported on upper and lower die support members in turn swingably carried on upper and lower carrier members, whereby to perform further forming operations on said workpiece.

7. A method of forming or cutting a workpiece as claimed in Claim 1 and further including the steps of passing said workpiece through a plurality of upper and lower roller die pairs (24) downstream of said rotary apparatus whereby to form continuous formations in said workpiece.

8. A method of forming or cutting a workpiece as claimed in Claim 1, and further including the steps of subjecting said workpiece to the operation of said upper and lower dies (50, 60) at predetermined regular spaced apart intervals, and momentarily discontinuing such formation, whereby to form discontinuities in said operations at spaced apart intervals therealong.



REPLACEMENT SHEET

23 AUG 1999

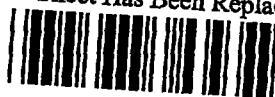
- 22 -

ABSTRACT

ROTARY APPARATUS

5 A rotary cutting and forming apparatus for strip
material 12 , having rotatable upper and lower roll units 32,34,
the units being connected for synchronous rotation, each of the
units having a carrier member 41,52 with at least one recess 42,
extending parallel to its central axis, and at least one die
support block 46,58, the block being rotatably received within
the recess 42, and having two ends, and a surface 46b to which a
10 die may be affixed, leading and trailing control pins 48,62 on
the block, extending on parallel spaced apart axes, and leading
and trailing cam surfaces 64,70 and 66,72 engaging respective
leading and trailing control pins 48,62, to control the position
of the blocks during at least part of their rotation.

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED