Jan. 31, 1967 R. G. BOETTCHER 3,301,034

SHEET METAL DIE FORMING APPARATUS

Filed Feb. 11, 1964 3 Sheets-Sheet 1

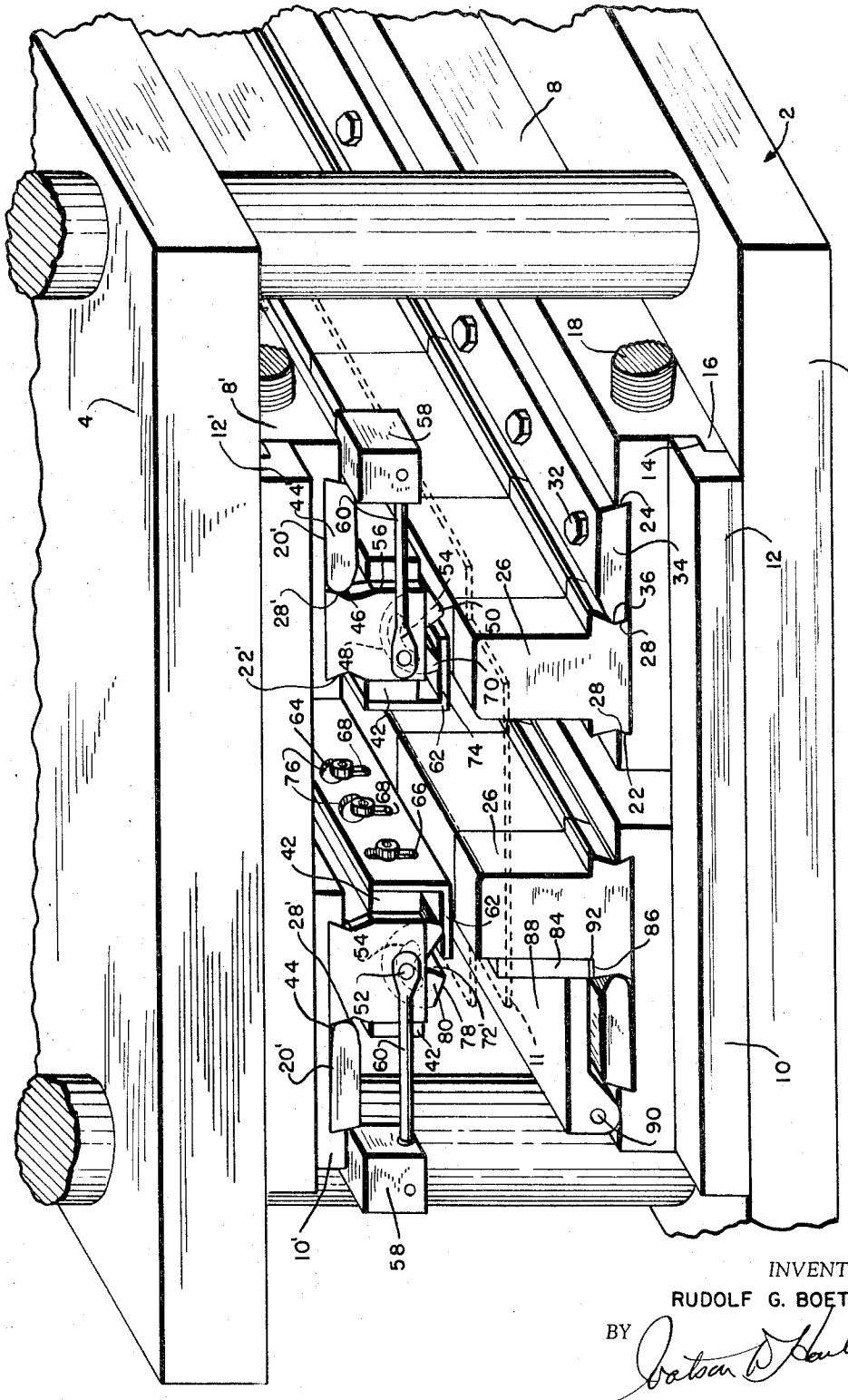

FIG. 1

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SHEET METAL DIE FORMING APPARATUS

Filed Feb. 11, 1964 3 Sheets-Sheet 2

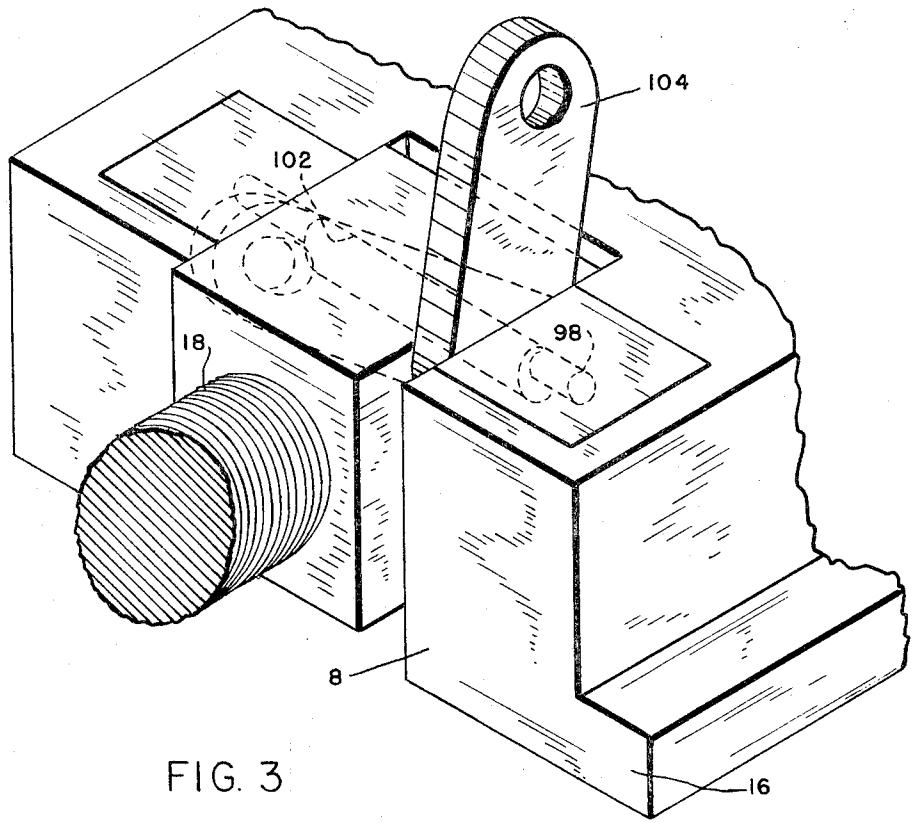

FIG. 3

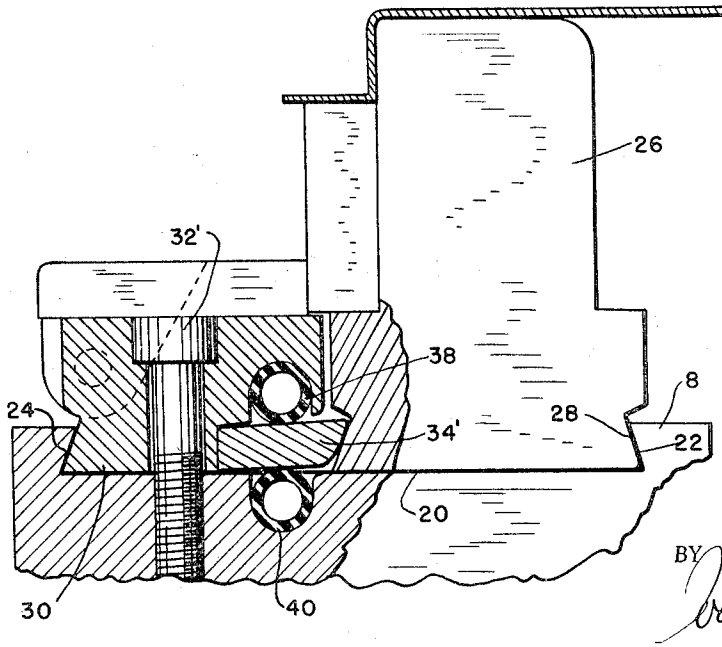

FIG. 2

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Jan. 31, 1967 R. G. BOETTCHER 3,301,034

SHEET METAL DIE FORMING APPARATUS

Filed Feb. 11, 1964 3 Sheets-Sheet 3

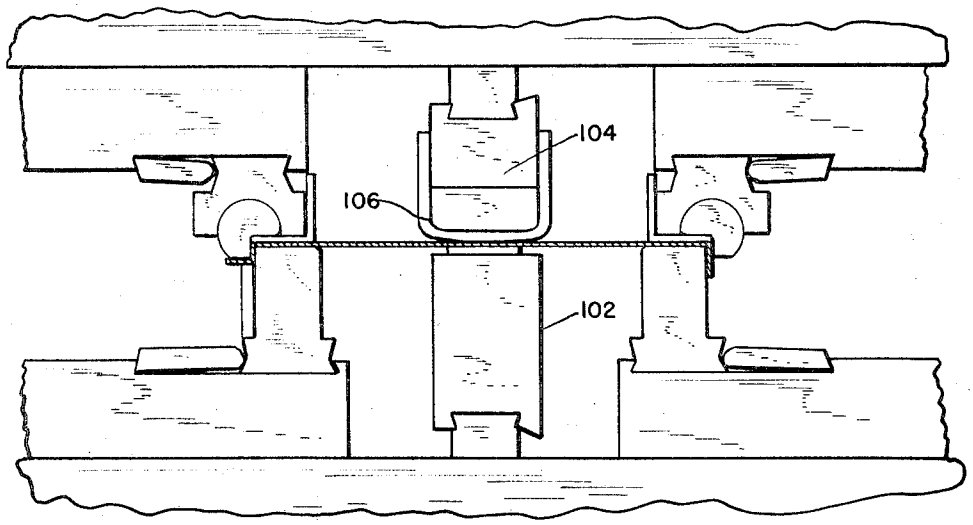

FIG. 5

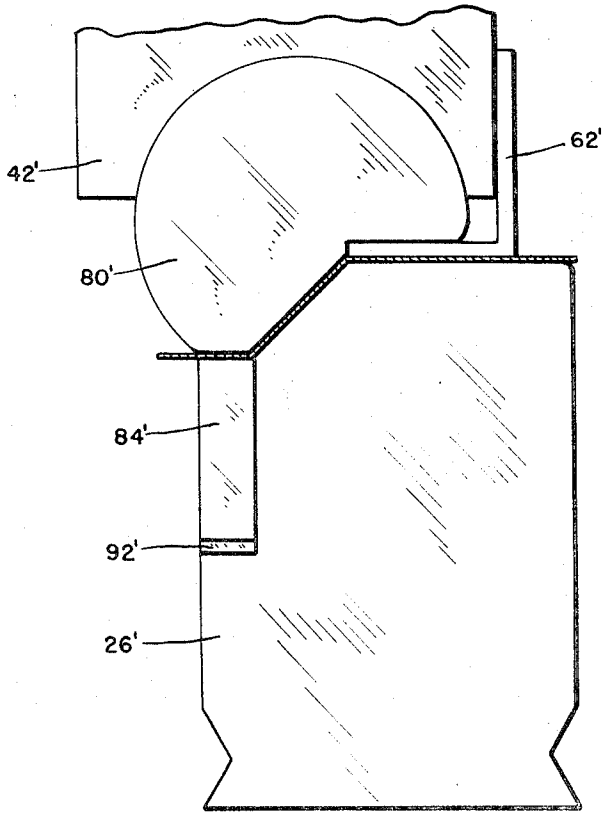

FIG. 4

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United States Patent Office

3,301,034

Patented Jan. 31, 1967

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SHEET METAL DIE FORMING APPARATUS

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12 Claims. (Cl. 72—319)

This invention relates to apparatus for use in die bending flat metal stock, such as sheet metal and the like, and particularly relates to bending flat rectangular sheets into three dimensional shapes at all four edges in two operations on the same dies irrespective of the relative lengths of the edges.

In the manufacture of sheet metal cabinets such as may be found in restaurants, including soda fountains food tables, counters and the like, by way of example and not of limitation, rectangular panels of different lengths and widths are used which must have bends on all four sides within close tolerances for proper mounting and assembly. Conventionally, this requires at least four bending operations on a conventional press-brake and time consuming careful alignment and measurement to insure uniformity between parallel bends made at opposite edges of the panel. When compound bends are required at any or all edges of the panel the bending problems and operations multiply. Moreover, great care must also be exercised to avoid scuffing or scoring of the face side of a finish panel which would mar the appearance of the finished product and the set up time of presses for short runs is prohibitive even for many cabinets limited in design for uniformity of the greatest number of parts.

In the design and manufacture of cabinets wherein the invention has one of its applications by way of example decorative or functional sheet metal panels are utilized for beauty, strength and cleanliness as unitary elements covering large expanses with minimum material and labor. Such panels are usually of uniform height but of various lengths due to the modular type construction and arrangements employed in providing selected lengths of flush fitting cabinets to house in various assembly patterns the many components used in restaurants and the like. Accordingly, although the panels may architecturally be designed to have a common width for manufacturing standardization they have lengths which may vary, for example, in increments of six inches or a foot. Although this should require a minimum of measurement, under the method of construction presently employed the panels must be individually measured whether of the same length or of a proportional length. However uniform widths resorted to for manufacturing economies with expensive conventional processes greatly limits architectural design as well as function factors which multiple panelling within the same height would greatly improve.

My invention, therefore, has for its primary object the provision of die means to enable the user to easily and quickly set up for and perform simple or compound bending operations at all four edges of a square or rectangular sheet of stock in only two steps and hold close tolerances with minimum time and care.

Another object of my invention is to provide novel means for preventing scuffing or scoring of the face side of the flat finish sheet during the bending operations.

A further object of my invention is to provide quickly assembled and dismantled die parts including a quick-release mounting for the dies in a press whereby the dies are easily interchanged with a minimum of set-up time and maximum degree of accuracy.

Another object, therefore, of my invention is to provide improved die elements for various incremental widths as well as lengths to allow rapid change of set-up, without individual measurement of the flat metal stock to form panels of different lengths and widths as desired structurally and architecturally at greatly reduced manufacturing costs and greatly improved production tolerances.

The invention is further characterized by a die operation in which the marginal edges are progressively clamped more tightly as the die progresses with its bending operation with a composite result of maintaining a planar tension on the body of the work piece to assure constancy of dimensions within close tolerances between parallel bends and uniformity of form at the bends.

The invention also contemplates panels which are uniform for production and final results not withstanding initial indexing of the blank may vary to a degree considered to be intolerable under conventional practices.

Further objects and advantages of my invention will become apparent from the following description and drawings in which:

FIG. 1 is a perspective view of the die elements mounted in a press and a blank in place as shown in broken lines ready for initial bending.

FIG. 2 is a cross-sectional view of the retaining mechanism on the lower die element.

FIG. 3 is a partially cutaway perspective view of a mechanism for shifting the die shoes for release of the formed metal.

FIG. 4 is an end view of an alternate construction of the die elements.

FIG. 5 is a cross-sectional view of the die elements similar to FIG. 1 with an additional die element positioned between those shown in FIG. 1.

For a better understanding of the detailed description to follow it may be well to mention that the invention is characterized by a pair of parallel stationary dies initially spaced widely to provide the bends along the opposite short edges or ends of the sheet metal blank in one operation but of a length to make the bend along the long edges of the blank. After the bend is accomplished along the short edges, the space between the dies is narrowed to the distance between the long edges, the bent ends of the blank are dropped over the ends of the dies to snugly register the blanks thereby within close tolerances for the final bend along the long edges whereupon the bend along the long edges is made, the blank released and removed. Each time a bend is made a segmented roller die roll-drives the blank into a bend around the corner of a stationary die with a novel structure in a novel way.

Referring now to FIG. 1 a press is generally shown at **2** having a ram **4** and a bed **6** to which the die elements to be described are mounted and upon which sheet metal blanks are brought to rest for bending. Die shoes **8** and **10** are secured to the face of the bed **6** by die guides **12** at opposite ends of the press to stabilize and prevent endwise movement of the die shoes. The guide **12** is an L-shaped member having a hold down shoulder **14** which cooperates with a lip **16** on die shoes **8** and **10** to allow

lateral adjustment of the shoes to proper working position for the dies in the press. Conventional worm and gear elements **18** can be used to make the lateral adjustment of the shoes and, per se is not considered to be novel although when linked together further assist in reducing set-up time between short runs and serve as micometer adjustments.

Similar die shoes **8'** and **10'** and guides **12'** are mounted to the face of the ram **4** and are also adjustable so as to register with the die elements mounted on the bed.

Each of the die shoes has a die holding groove or keyway **20** having inwardly slanting walls **22** and **24** defining a keyway which are used to lock the die elements in place.

Each of the lower die elements or anvils **26** have parallel outwardly inclined lips **28** which converge to form a key element received in the keyway. One of these lips **28** rests against the solid wall **22** of keyway **22** in a tongue and groove relationship and the other lip is locked in position by a locking member **34** which has a rounded face **36** that engages its lip **28** on die element **26** in a camming clamping relationship. Locking member **34** is bolted directly to the lower die shoe. Tightening of the bolt or bolts **32** cam locks the die to the die shoe.

FIG. 2 shows an alternate method for readily securing the die to the die shoe. A locking assembly **30** is secured to the die shoe by bolt members, **32'**. The locking assembly includes a lock member **34'** positioned between grooves in the locking assembly and the die shoe which contain inflatable high pressure hoses **38** and **40** for air or preferably hydraulic fluids. Inflaton of the upper hose **38** forces locking member **34'** downward. This creates a camming force against the anvil member **26** to secure it in place upon the die shoe **8**. Movement of the die or anvil member for assisting in the release of the work piece is accomplished by inflating the hose **40** while venting the hose **38**. This forces the locking member **34'** upwardly and the die is reset by reversing the hose pressure relationship during the next bending operation which assists in the tensioning and bending relationship with only a couple of thousands of an inch movement required.

The advantage of this method of securement lies in the fact that the releasing movement moves the anvil slightly. If the release is synchronized with the press so as to release when the ram is raised, the slightly loose anvils will greatly facilitate removal of the metal stock which otherwise might tend to bind on the anvils and if returned to its working position as the ram is lowered it provides a work piece tensioning during the initial clamping and bending movements.

Yet another alternative for facilitating removal of the metal stock from the anvils is shown in FIG. 3 where wrist pin **98**, which secures the lead screw **18** to the die shoe **8**, has an eccentric cam **108** and a lever **110**. When the lever **110** is rotated 90° the die shoe **8** is moved horizontally a sufficient amount to release the metal stock by the rotation of the eccentric pin and also functions as mentioned when being returned to its set position simultaneously with the initial work piece bending stages.

The upper die elements **42** have similarly slanted lips **28'** one of which engages a similarly slanted wall **22'** in groove **20'** of the upper die shoe **8'**. Upper die elements **42** are then locked securely to the upper die shoes **8'** and **10'** by locking members **44** which each have a rounded wall **46** engaging slanted lips **28'** in camming relationship.

Locking member **44** is bolted directly to the upper die shoe. Tightening of this bolt (not shown) cams the upper die to the die shoe in locked relationship.

Upper die elements **42** each contain a semi-cylindrically shaped groove or journal **48** which extends through the entire length of the lower face of the die. A cylindrical roll bar **50** having the same diameter as the semi-cylindrical journal **48** is adapted to be secured in the groove by means of eccentric pins **52** at each end of the roll bar. The pins are carried in elongated arcuate slots **54** of end members **56** which are located at each end of the upper die elements. The end members **56** are each likewise secured to the die shoes **8'** and **10'** by means of the locking member **44** which engages a similar slanted wall or lip on end member **56** in maner similar to that described for the upper die element **42**.

Cylindrical roll bar **50**, as illustrated, has a 90° cut-away segment along its axis, so as to form 90° bends in sheet metal stock. Other angles, of course, are possible within the scope of the described invention and compound angles can also be used for the making of compound bends. Several will be described later. As the ram is lowered the roll bar **50** contacts the metal stock at both extremities of the cut-away segment. The unsupported portion of the sheet metal stock yields while the supported portion holds solid. This rotates the roll bar and with this rotary motion the bar wraps the stock around the lower die element as the ram forces the roll bar downwardly.

Preparatory for this movement, the roll bar is biased to a ready position to insure proper initial engagement with the work piece **11** by an air motor **58** mounted at each end of the upper die shoe **8'**. A reciprocating fork member **60** powered by air motor **58** engages the extending end of the eccentric pin **52** to urge roll bar **50** to rotate to its starting position. The extent of the rotation is limited by means of an L-shaped scuff plate member **62** which is attached to and carried by the upper die **42** by means of bolts **64** that extend through elongated slots **66** and **68** on member **62**.

The air motor urges rotation of the roll bar **50** until the working tip **70** of the cutaway segment engages the horizontal portion **74** of plate member **62** to force it downwardly until the upper ends of slot **66** are stopped by bolts **64**. Then as the ram is lowered the scuff plate member **62** contacts the sheet metal work piece **11** and the work piece being supported by the anvil, the scuff plate must yield as the ram proceeds downwardly. This relative movement causes counter rotation of the roll bar against the force of the air motor and the counter rotation forces the unsupported edge of the sheet metal work piece downwardly and bends it around the anvil. These forces reacting between scuff bar movement and the air motor provide a clamping effect between the scuff bar and anvil for the work piece and such can be varied by the applied air pressure.

The working edge of the roll bar engages the scuff bar with any pressure desired and does not mar the surface of the work piece. Moreover this engagement can be lubricated where scuffing of the work piece cannot be. Thus scoring or scuffing of the flat face is substantially eliminated, the engagement between the two bars, the scuff bar and roll bar being somewhat frictionless and lubricated, relative movement will occur here rather than between the scuff bar and work piece.

In addition as the ram is raised the air motor continues to urge the roll bar to rotate to its starting position and this forces the scuff plate downward again. This frees the work piece and prevents the work piece from being lifted with the ram and upper dies thereby preventing the work piece from being indescriminately permitted to fall and cause injury to work piece or labor.

The scuff plate is easily removed for replacement due to the keyhole type slots employed having enlarged holes **76** located at the upper ends of the intermediate slots **68** along the upper die shoes. These enlarged holes have a larger diameter than the heads of bolts **64** thereby necessitating withdrawal of only the two end bolts in slots **66** to remove the scuff plate from die **42'** while the

scuff plate is in its raised position and the air motor is shut down.

The lower die or anvil members 26 are constructed as sectional segments of predetermined lengths as best shown in FIG. 1 so that the length of the anvil can be easily varied by removal or addition of a segment or segments to arrive at the desired length. Each segment of the anvil is secured to the die shoe by locking member 34 as previously described.

In operation the length of anvil segments is selected so as to be exactly the length of the longest bends when rectangular panels are being formed. The work pieces are prenotched at the corners to the bend lines and then placed one by one upon the anvils with the notches serving for registration indices. The notching is done within gross tolerances that are negative as to depth of cut within the thickness of the sheet metal. The die shoes are first spaced to form the bends on the shorter edges within close limits. The ram is then lowered, the roll bars bend the stock about the anvils forming the first two bends within close tolerances and slight overage that may be present on the ends of the long edges is cleared by the dies. The ram is then raised and the stock is lifted off the anvils and removed and stacked ready for the last two bends.

The die shoes are now re-adjusted to the shorter span of the stock. Since the anvil segments were selected to coincide with the longer bends, the short bends just formed will not just slip over the ends of the anvils with the same notches again serving as indices, thus providing both regestrations from the same reference. The final bends are then formed without interfering with the first bends. The panel thus formed has bends on all four sides, each of which is parallel to its counterpart and exactly to a predetermined angle such as 90° on adjacent sides. The scuff plates in addition, insure that the finish face of the panel just formed is free from any scuffing or scoring and ready for polishing without excessive grinding to remove unsightly machining marks conventionally experienced.

Whenever the size of stock or panel is changed the operator re-adjusts the anvil size by again adding or removing segments for the longest bend line and thereafter merely adjusts for spacing between bends. It should be noted here that so long as the upper dies with the roll bars and scuff plates are sized in length for the longest bends desired they need not be changed for any shorter size panels.

Now referring to FIG. 1 and 2 a configuration is shown for making compound bends. As with the previous construction only two operations are required to form such bends on all four sides of a panel. Die elements 26 and 42 are also utilized in this operation with the modifications to be described. Referring first to the upper dies 42, roll bars 50 are replaced by roll bars 80 which each have a flat 78 formed at a right angle to the wall of the cutaway segment's trailing lip 72'. The location of the flat is dependent upon the distance required between the two bends in the stock.

The lower dies 26 are modified in this construction by the addition of a filler block 84 which is placed upon a shoulder 86 of die 26. The filler block is secured to die 26 by a swinging lock bar 88 which is pivotally mounted to the lower die shoe 10 at 90. When not in use, or for interchanging of filler blocks the lock bar can be rotated away from anvil 26. The height of filler block 84 is dependent upon the distance required between the two bends similarly to the location of flats 78. Compensation is also required here for the thickness of the metal stock and shims 92 are, therefore, added to reduce the quantity of sizes needed for the filler blocks.

In operation the first bend is made as previously described but instead of the stock being merely bent downwardly along the side of the anvil 26 it is contacted by filler block 84 and marginally forced into a second bend in conformity with the angle between the side of anvil 26 and the face of filler block 84 by the flat 78 of roll bar 80. As in the previous construction opposite sides are bent simultaneously, requiring therefore only two operations to form the compound bends on all four sides.

As in the previous construction, the upper die and roll bar need not be changed for different size panels, but only the segmented anvil. If the length between the two bends is to be changed, the filler blocks are removed and replaced by other filler blocks and shims to fit the new size requirement. The upper die roll bars are then replaced by other roll bars which mate to the new configuration. With this interchangeability of elements many sizes and configurations can be made without the high cost and time factor involved in a complete change of upper and lower die elements.

Other bend angles and compound bends can be made according to the teachings of this invention by proper selection of anvil, roll bar, and filler block shapes such as shown in FIG. 4. In most configurations, the end segments of the anvil and filler block members need not be stepped in order to accept the configuration of the initial two bends when the stock is rotated to make the third and fourh bends. However, where a mitered joint is being formed, the end segments may be provided with a corresponding configuration on their ends for that purpose.

FIG. 5 shows an additional functional operation where punching of the face of the panel is accomplished simultaneous with the bending operations.

In this construction punch die elements 102 and 104 are mounted by suitable means to the ram and bed respectively and operate as the dies and anvils close against each other. Conventional strippers 106 preferably are used to prevent a "hang up" of the work piece on the male members particularly when there are quite a few of the die elements 102 and 104 used. It has been found, however, with a numerically limited use of punch die elements, the continuing pressure exerted by the air motors 58 on the roll bars 50 and scuff bars provides sufficient restraint with a punch die having a short stroke to strip the sheet work piece therefrom without work piece displacement.

What is claimed is:

1. In a bending press for bending in two operations all four edges of a substantially rectangular sheet metal work piece notched to the bend lines at its corners to define flange portions bordering a central body portion, said press comprising two pairs of die elements, means for successively spacing said die elements apart two different distances corresponding to different distances between pairs of parallel bend lines that are opposite one another, one die element of each of said pairs of die elements having a length equal to the length of the longer bend line to be made on said work piece, means for receiving said work piece in registered position between said die pairs, spaced their greater distance to initially bend the shorter edges of said work piece, said work piece being received in endwise registration over the ends of the dies when spaced their lesser distance to bend the longer edges of said work piece, one die of each pair comprising a movable element simultaneously engaging said work piece along spaced lines on opposite sides of the bend line of the other die to clamp the body portion of the work piece between the dies while bending the flange portions.

2. In a bending press for bending in two operations all four edges of a substantially rectangular sheet metal work piece notched to the bend lines at the corners to define flange portions bordering a body portion, said press comprising a bend member and a ram member reciprocably mounted for movement with respect to the bed member, two pairs of mating die elements successively spaced apart two different distances equal to the different distances between pairs of parallel bend lines that are opposite one another, one die element of each of said pairs of die ele-

ments being clamped to one of said members and having a length equal to the length of the longer bend line to be made on said work piece, the other of said die members being clamped to the other of said members, said work piece being received between said die pairs when the pairs are spaced their greater distance so as to bend the shorter edges of said work piece first, said work piece being received in endwise registration over the ends of the dies when the pairs are spaced their lesser distance, one die element of each pair comprising a movable element simultaneously engaging said work pieces along spaced lines on opposite sides of the bend line defined by the other die to clamp the body portion of the work piece between the dies while bending the flange portions.

3. In a bending press for bending in two operations all four edges of a substantially rectangular sheet metal work piece notched to the bend lines at its corners to define flange portions bordering a central body portion, said press comprising two pairs of die elements, means for successively spacing said die elements apart two different distances corresponding to different distances between pairs of parallel bend lines that are opposite one another, one die element of each of said pairs of die elements having a length equal to the length of the longer bend line to be made on said work piece, means for receiving said work piece in registered position between said die pairs, spaced their greater distance to initially bend the shorter edges of said work piece, said work piece being received in endwise registration over the ends of the dies when spaced their lesser distance to bend the longer edges of said work piece, one die of each pair comprising a movable element simultaneously engaging said work piece along spaced lines on opposite sides of the bend line of the other die to clamp the body portion of the work piece between the dies while bending the flange portions, said one die element of equal length comprising an anvil die and said one movable die element comprising a roller die, a shoe having a groove formed therein, said roller being journalled in said groove, said roller die having a radial cutaway segment longitudinally the length thereof, biasing means actuating said roller die urging same to rotate in a direction clamping a sheet metal work piece between it and said anvil die, said biasing means including a pneumatc motor for moving said roller die through approximately 45° of revolution to maintain said clamping action during initial reverse movement away from the anvil die, and a scuff bar engaged by said roller die and engaging the sheet metal work piece disposed between it and the anvil die in clamping relationship during bending of the work piece.

4. In a metal forming apparatus having an anvil die and a roller die, said roller die comprising a shoe having a groove formed therein, roller die journalled in said groove, said roller die having a radial cutaway segment longitudinally the length thereof, and biasing means actuating said roller die urging same to rotate in a direction clamping a sheet metal work piece between it and said anvil die.

5. The combination called for in claim 4 in which said biasing means includes a pneumatc motor for moving said roller die through approximately 45° of revolution to maintain said clamping action during its initial reverse movement away from the anvil die.

6. The combination called for in claim 4 in which said anvil die includes a fluid pressure responsive means for moving said anvil die away from the roller die in a direction transverse to the line of their working movements upon initial reverse movement of the roller die away from the anvil die.

7. The combination called for in claim 4 including a scuff bar engaged by said roller die and engaging the sheet metal work piece disposed between it and the anvil die in clamping relationship during bending of the work piece.

8. In a bending press for bending in two operations all four edges of a substantially rectangular sheet metal work piece notched to the bend lines at the corners to define flange portions bordering a body portion, said press comprising a bend member and a ram member reciprocably mounted for movement with respect to the bend member, two pairs of mating die elements successively spaced apart two different distances equal to the different distances between pairs of parallel bend lines that are opposite one another, one die element of each of said pairs of die elements being clamped to one of said members and having a length equal to the length of the longer bend line to be made on said work piece, the other of said die members being clamped to the other of said members, said work piece being received between said die pairs when the pairs are spaced their greater distance so as to bend the shorter edges of said work piece first, said work piece being received in endwise registration over the ends of the dies when the pairs are spaced their lesser distance, one die element of each pair comprising a movable element simultaneously engaging said work pieces along spaced lines on opposite sides of the bend line defined by the other die to clamp the body portion of the work piece between the dies while bending the flange portions, said first mentioned die element comprising an anvil die including a fluid pressure responsive means for moving said anvil die away from the roller die in a direction transverse to the line of their working movements upon initial reverse movement of the roller die away from the anvil die.

9. The combination called for in claim 2 in which the first mentioned one die element comprises incremental segments compositely providing said length, means for clamping including retaining lips for retention on said one of said members, and releasable means contacting said retaining lips for removal of said die element segments.

10. The process of forming flanges on all edges of a rectangular panel of sheet metal having pairs of edges of different length comprising notching the corners of the sheet metal the depth of the flanges to the bend lines, bending the two short edges opposite each other simultaneously with parallel pairs of mating dies of a length equalling the length of the longer bend lines and spaced from each other a distance equal to the distance between the shorter bend lines, respacing the dies to a distance equal to the distance between the long bend lines and rotating the sheet 90° to rest over the ends of said dies in a position registered by the ends of the dies, and simultaneously bending the two long edges, said bending in both instances including clamping the sheet between the bending mating dies upon contact with the work piece by a force during die advance that varies directly with the bending effort of the mating die upon the work piece, and continuing to clamp the panel of sheet metal between the mating dies as the dies move with respect to each other during their reverse movement.

11. The combination called for in claim 10 including moving the dies laterally relative to each other in a direction parallel to the plane of said panel to release the bent parts laterally during said continuing clamping relationship.

12. The process of forming flanges on a rectangular panel of sheet metal having pairs of edges of different length comprising notching the corners of the sheet metal to the bend lines to the depth of the flanges, bending the two parallel shorter edges opposite each other simultaneously with parallel pairs of mating dies equalling the length of the longer bend lines and spaced from each other a distance equal to the distance between the shorter edge bend lines, respacing the dies to a distance equal to the distance between the long bend lines and rotating the sheet 90° to register over the ends of said dies and simultaneously bending the two long edges, said bending in both instances including defining one bend line for the work piece with one of the mating dies engaging the panel, contacting the panel with the other one of the mating dies

along spaced parallel lines disposed on opposite sides of said one bend line, clamping the panel between the mating dies along one of the spaced parallel lines while bending downwardly the panel portion engaged by the other one of the mating dies along the other one of said spaced parallel lines varying the clamping force on said panel during die advance directly with the bending effort of the die upon the work piece, and continuing to clamp the panel of sheet metal with the dies as the dies move with respect to each other during their reverse movement.

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