Sept. 3, 1963 M. M. SEELOFF 3,102,502

SCREW OPERATED EXPANDER

Filed Jan. 21, 1959 4 Sheets-Sheet 1

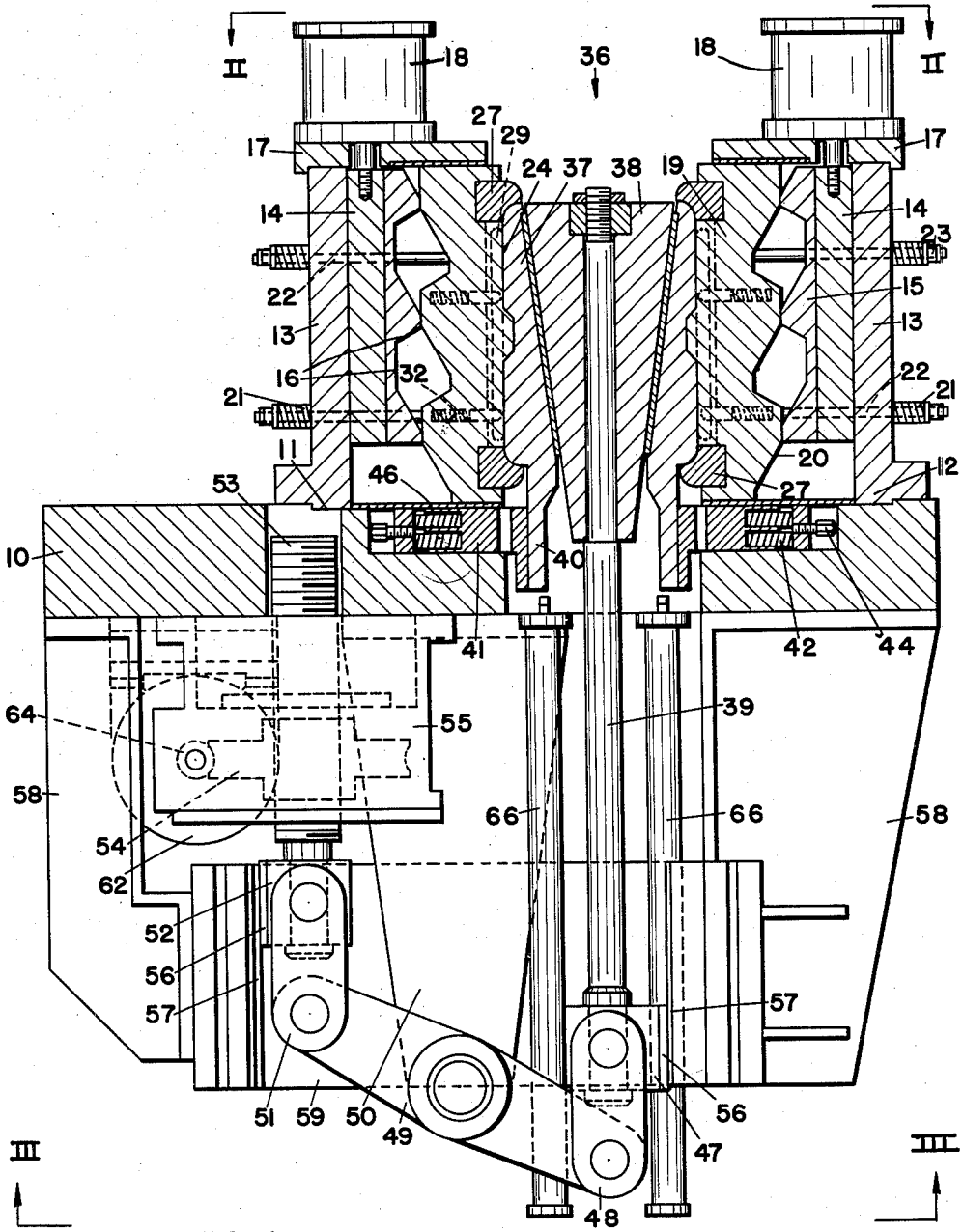


FIG. 1

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SCREW OPERATED EXPANDER

Filed Jan. 21, 1959 4 Sheets-Sheet 2

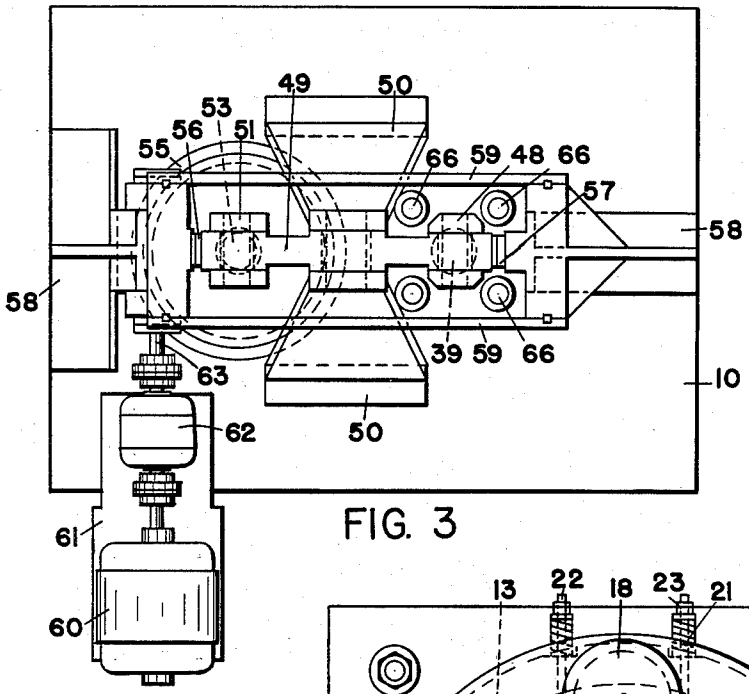


FIG. 3

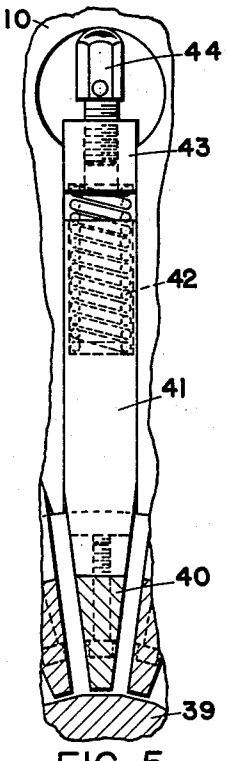


FIG. 5

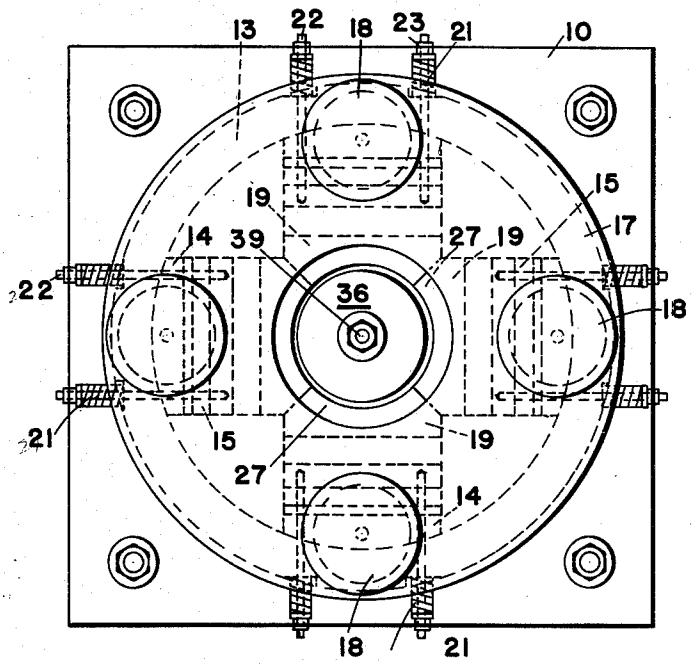


FIG. 2

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SCREW OPERATED EXPANDER

Filed Jan. 21, 1959 4 Sheets-Sheet 3

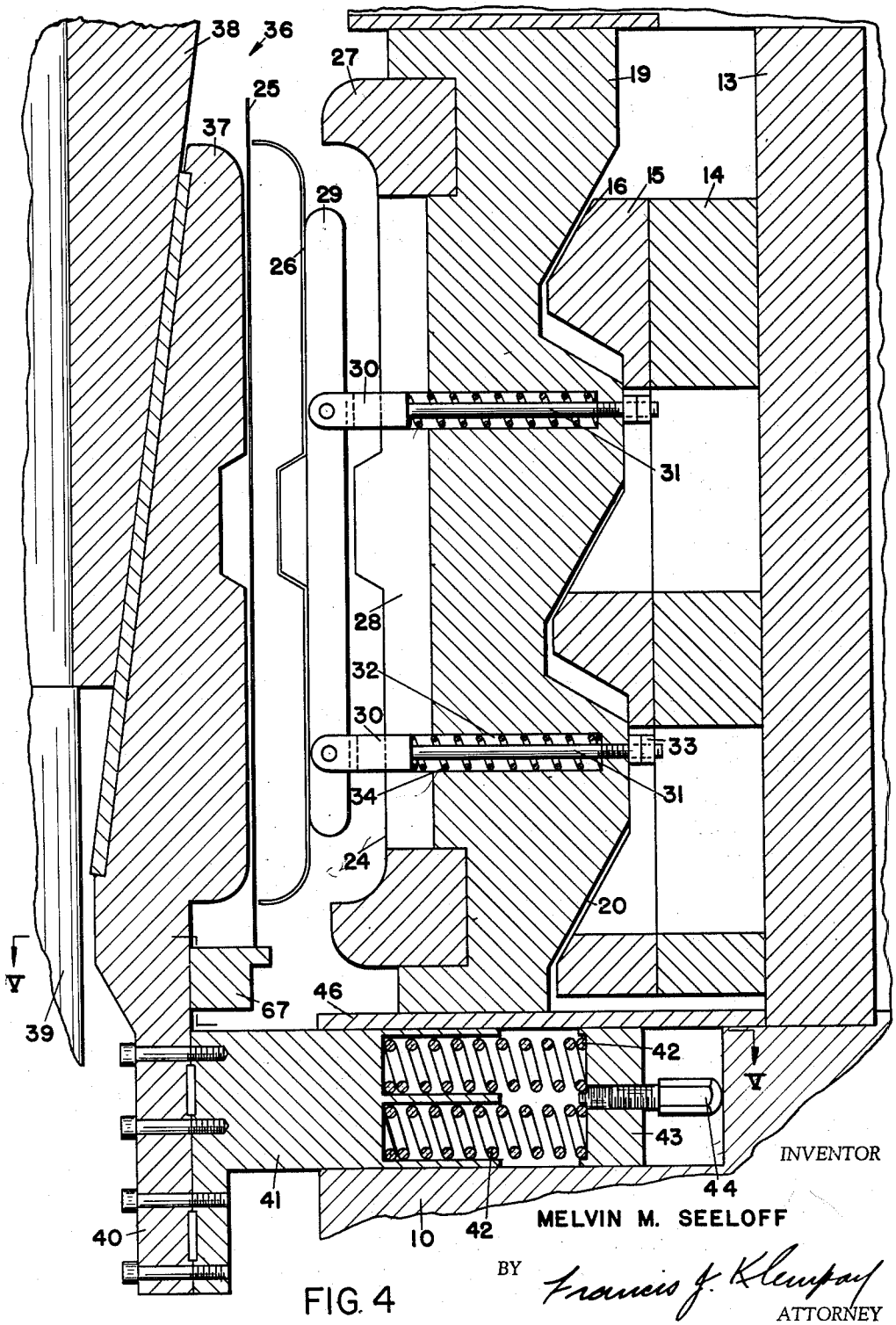


FIG. 4

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SCREW OPERATED EXPANDER

Filed Jan. 21, 1959 4 Sheets-Sheet 4

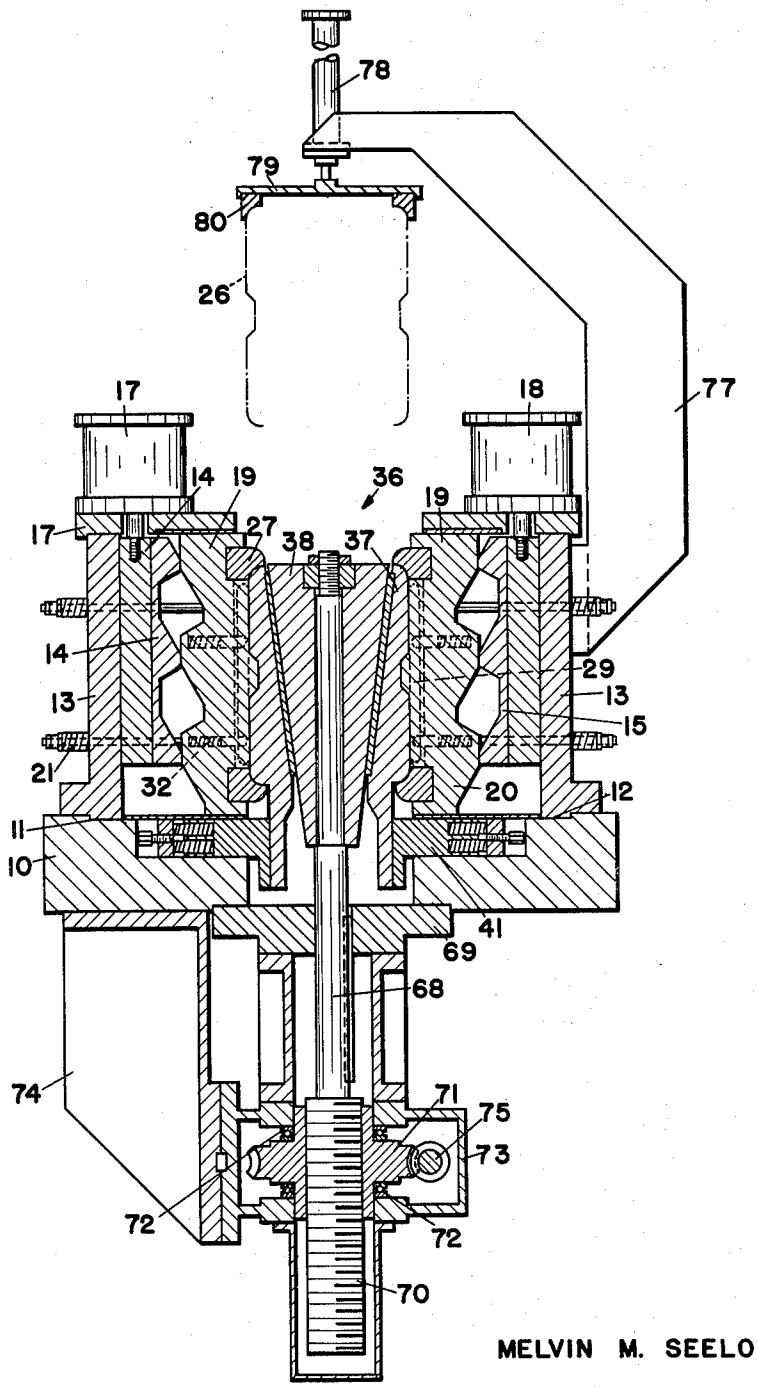


FIG. 6

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United States Patent Office 3,102,502 Patented Sept. 3, 1963

3,102,502

SCREW OPERATED EXPANDER

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Filed Jan. 21, 1959, Ser. No. 788,146
4 Claims. (Cl. 113—48)

The present invention relates generally to the metal forming art and more particularly to the provision of apparatus for forming and/or shaping generally cylindrical sheet metal blanks or shells and other like workpieces. Such apparatus is known in the art as an expander and this terminology will be employed throughout the present specification. However, it should be understood from the outset that the teachings of the present invention are equally applicable to other types of metal forming and/or shaping apparatus as, for example, to shrinkers.

As will be understood by those skilled in the art, an expander may comprise a plurality of segmented outer forming dies and a plurality of segmented inner forming dies which are adapted to cooperate with the outer forming dies in forming and/or shaping generally cylindrical sheet metal blanks or shells. The outer segmented forming dies may be actuated by camming elements to move the same radially between operative and inoperative positions to permit loading and unloading of the expander while the inner forming dies may be expanded radially under the action of a movable wedge into cooperating relation with the outer forming dies. This, in essence, comprises the basic mechanism for an expander and is generally old in the art.

It is one of the primary or main objects of the present invention to provide an improved expander for forming and/or shaping generally cylindrical sheet metal blanks or shells which is of the screw operated type. Expanders of the type heretofore proposed in the art have either used a crank and fly wheel or hydraulic means for moving the wedge to force the inner forming dies radially to form and/or shape the cylindrical sheet metal blanks as evidenced by the prior patents to Grotnes, No. 2,435,306, and Nobles et al., No. 2,638,860, respectively. Although such prior art expanders are widely employed they exhibit certain operating characteristics which are highly undesirable. In the crank and fly wheel operated type of expander the expanding force is not constant while in the hydraulically operated type of expander—in addition to being very expensive due to the large hydraulic pumping unit required—is quite messy and requires almost continuous maintenance. The screw operated expander of the present invention is characterized by a constant expanding force and is much cleaner than hydraulically operated expanders.

It is yet another main object of the invention to provide improved actuating means for expanders of the type above described. In the present embodiments of the invention the wedge is moved by a large screw which in turn is driven by suitable motor means through an appropriate drive connection. This drive connection comprises, in part, an adjustable torque limiting means whereby the movement of the wedge will stop when the expanding and/or shaping force on the cylindrical sheet metal blank or shell equals a predetermined torque applied to the screw by the motor means. In this manner damage to the blanks due to excessive forming and/or shaping forces is entirely precluded. In addition to the above, the torque limiting means is operative to allow the application of a higher torque than the preselected torque required to form and/or shape blanks to unlock the expander and retract the inner dies whereby a formed blank can be removed from the expander. As will be understood, once a blank has been formed and/or shaped and the wedge has stopped moving it takes a much higher torque than the maximum torque required to form the blank to retract the wedge due to the static friction between the various forming dies, the blank and other parts of the expander.

In connection with the above object, it is another object of the invention to provide actuating means for expanders which comprises improved linkage means for transmitting the torque from the motor means and the torque limiting means to the inner forming dies. In one embodiment of the invention this comprises a pair of parallel rods—one of which is movable by the large screw—that are interconnected by a bell crank whereby movement of one of the rods in one direction causes a like movement of the other of the rods in the opposite direction. Thrust plates are provided in such a manner that side thrust on the parallel rods is eliminated. The thrust plates are tied together by tension bars in order that the side thrust forces are contained and limited to a rigid rectangular structure.

A further important object of the present invention is to provide an expander embodying improved means for breaking the formed and/or shaped blanks from the outer forming dies. One of the problems associated with apparatus of this general character is that the formed and/or shaped blanks tend to hang up and stick to portions of the forming dies. In the present invention there is provided for each one of the segmented outer forming dies a resiliently and yieldably mounted breaking and centering bar. The bars are received in recesses within the outer forming die segments during forming operation but upon radial retraction of the outer forming dies and contraction of the inner forming dies are operative to break the blank from the forming dies and center the same in the machine for subsequent removal.

Yet another object of the invention is to provide an expander for forming and/or shaping generally cylindrical sheet metal blanks which comprises improved means for mounting the inner forming dies and for biasing the same into engagement with the movable wedge. Each of the inner forming dies is carried adjacent its lower end below the blank engaging surfaces thereof by a spring biased slide in such a manner that the inner forming dies are always forced into pressure engagement with the wedge without interfering with the operation of the expander in any manner.

In addition to the above, it is an object of the invention to provide an expander for forming and/or shaping generally cylindrical sheet metal blanks which embodies improved means for removing the formed and/or shaped blanks from the expander. In one embodiment of the invention this means comprises a vertically movable ring magnet mounted over the dies while in another embodiment this means comprises ejection cylinders mounted on the underside of the apparatus which are adapted to push the formed blanks from the expander.

Another, and particularly important, object of the present invention is to provide an expander of the type above described in which all of the forming dies and other associated apparatus are easily and readily accessible for inspection, maintenance and/or effecting major alterations. In practically all of the prior art expanders it has been necessary to remove all of the outer forming dies piece by piece before the inner dies are accessible for inspection, maintenance and/or alteration. This is a time consuming and laborious operation as is readily apparent and substantially limits the utilization of such machines. The expander of the present invention, however, is so constructed that all of the outer forming dies—including the camming elements, guides, operating slide fluid cylinders, etc.—can be removed from the ex-

pander as a complete integral unit to expose the inner forming dies and the apparatus associated therewith. In this manner inspection, maintenance and/or alterations may be completed in a minimum of time.

Still another object of the invention is to provide an expander which is ideally suited for inclusion in an automatic process line. By providing an expander wherein the formed blanks are easily and quickly ejected and wherein inspection, maintenance and/or alterations can be effected in a minimum of time the apparatus is adapted for such an installation. In addition, the expander of the present invention is readily adaptable to automatic control as will be apparent to those skilled in the control art.

A further object of the invention is to provide apparatus of the character above set forth which embodies improved features of construction and is inexpensive to manufacture and assemble.

The above, as well as other objects and advantages of the invention, will become more readily apparent upon consideration of the following specification and accompanying drawing wherein there are disclosed certain preferred embodiments constructed in accordance with the teachings of the present invention.

In the drawing:

FIGURE 1 is a side elevational view, partially in section, showing a screw operated expander constructed in accordance with the teachings of the present invention;

FIGURE 2 is a top plan view of the screw operated expander as seen from the lines II—II of FIGURE 1;

FIGURE 3 is an underside plan view of the apparatus of FIGURE 1 taken along the lines III—III;

FIGURE 4 is an enlarged fragmentary sectional view showing specifically the construction and cooperation of the forming dies and other apparatus associated therewith employed in the screw operated expander of FIGURE 1;

FIGURE 5 is a fragmentary sectional view taken along the section line V—V of FIGURE 4 depicting the means employed for resiliently and yieldably mounting the inner forming dies; and

FIGURE 6 is a side sectional view of a second embodiment of a screw operated expander constructed in accordance with the teachings of the present invention.

Referring now to the drawing, and initially to FIGURES 1–5 thereof wherein is shown one preferred embodiment of a screw operated expander constructed in accordance with the teachings of the present invention, the reference numeral **10** designates a thick rectangular supporting base plate that serves as a supporting base for the various component parts of the expander. The upper surface of the base plate **10** has an annular groove **11** therein which receives the rabbeted end **12** of a generally cylindrical and vertically extending housing **13**. The housing **13** contains the various forming dies that are adapted to form and/or shape generally cylindrical sheet metal blanks or shells as will be hereinafter more fully explained.

Mounted for vertical sliding movement at spaced points about the inner circumference of the housing **13** are a plurality of operating slides **14**. As shown in FIGURE 2 of the drawing, each of the operating slides has a rounded outer surface which nests with the inner circumferential surface of the housing **13** and a generally flat inner surface that mounts a generally elongated vertically extending camming element **15**. There are thus provided a plurality of circumferentially spaced camming elements **15**, each of which has a camming surface **16** of the shape shown in the various views of the drawing. The upper end of the housing **13** is partially closed by an annular cover plate **17** that serves as a support for a plurality of operating slide fluid cylinders **18** whose piston rods are connected to the operating slides **14**. Thus, upon proper actuation of the operating slide fluid cylinders **18** of the operating slides **14** and the camming elements **15** carried thereby are adapted to be moved

to vertically shift the position of the various camming surfaces **16**.

Positioned inwardly of the camming elements **15** are a plurality of segmented outer forming dies **19** that have properly shaped camming surfaces **20** on the rear surfaces thereof. The outer forming dies **19** are biased into engagement with the camming surfaces **16** of the camming elements **15** by a plurality of compression coil springs **21** that encircle the outer ends of pull rods **22** and extend between the outer surface of the generally cylindrical housing **13** and nuts **23** which are threaded on the outer ends of the pull rods **22**. The pull rods extend through the housing and elongated apertures, not particularly shown, in the operating slides and the camming elements and have their ends attached to the outer forming dies **19**. In this manner of construction the outer camming surfaces **20** of the outer forming dies **19** are always biased into engagement with the camming surfaces **16** of the camming elements **15** without interfering with the vertical movement of the operating slides **14** and the camming elements **15**. It will be noted that four of the pull rods **22** and the compression coil springs **21** are provided at vertically spaced points for each of the outer forming dies **19**.

The contours of the camming surfaces **16** of the camming elements **15** and the camming surfaces **20** of the outer forming dies **19** are such that the outer forming dies are adapted to move radially upon vertical movement of the camming elements **15** between operative and inoperative positions. When the camming elements are disposed as shown in FIGURE 1 the outer forming dies are disposed to form a contiguous and cylindrical outer die having a shape conforming to the desired outer peripheral shape of a formed blank or shell. However, when the camming elements are moved downwardly to the position shown in FIGURE 4 of the drawing the outer forming dies are retracted radially outwardly under the force of the coil springs **21** to allow loading and unloading of the expander.

As mentioned above, each of the outer forming dies **19** has a die surface **24** thereon which corresponds to the desired shape of a finished metal blank. In general, a cylindrical metal blank **25** is positioned in the expander and properly formed by the various forming dies to provide a finished sheet metal blank or shell **26**. The inwardly curving upper and lower edges of the finished blank or shell **26** are formed by a vertically spaced pair of segmented annular forming dies **27** that are attached at vertically spaced points to the inner surfaces of the outer forming dies **19**. Although the finished blank or shell **26** is representative of the type of forming and/or shaping operations for which the expander of the present invention is ideally suited, it should be clearly understood that the expander is adapted to form an almost unlimited number of differently shaped finished blanks upon selection of outer forming dies having die surfaces properly contoured to conform to the shape desired.

Each of the outer forming dies is provided with a recess **28** in the outer die surface thereof as is clearly shown in FIGURE 4 of the drawing. Adapted to be received within each of the recesses **28** is an elongated and vertically extending breaking and centering bar **29** which is pivotally attached by clevises **30** to a pair of vertically spaced rods **31**. The rods **31** extend through suitable enlarged apertures **32** in the outer forming die **19** and are provided with stop nuts **33** adjacent their outer ends which are adapted to bear against the outer camming surface **20** of the outer forming die **19**. Encircling the rods **31** and extending between the clevises **30** and the shoulders defined by the enlarged apertures **32** are compression coil springs **34** which tend to force the breaking and centering bar outwardly of the outer forming die to the position shown in FIGURE 4. It will be observed that outward movement of the breaking and centering bar **29** is limited by the stop nuts **33**.

A breaking and centering bar 29 is provided for each of the outer forming dies 19 and the arrangement is such that when the outer dies are in their innermost positions and the inner forming dies are expanded into cooperation therewith to form and/or shape a cylindrical sheet metal blank the breaking and centering bars are retracted within the recesses 28 whereby the same do not interfere in any manner with the forming and/or shaping of the blank. However, when the inner forming dies are contracted and the outer forming dies 19 are retracted the breaking and centering bars 29 move inwardly from the recesses 28 beyond the faces of the outer forming dies to engage the formed blank at circumferentially spaced points. The breaking and centering bars 29 break the finished blank from the forming dies and center the same with respect to the expander inwardly of the retracted outer forming dies. In this manner any sticking or hanging up of the finished blank on the various forming dies is effectively precluded and the finished blank is centered for easy removal in a manner to be hereinafter more fully explained.

Positioned centrally within the generally cylindrical and vertically extending housing 13 and inwardly of the outer forming dies 19 is an expanding mandrel assembly which is generally designated by the reference numeral 36. The expanding mandrel assembly 36 comprises a plurality of inner forming dies 37 which are biased into engagement with a properly shaped downwardly tapering wedge 38. The wedge is apertured throughout its length to receive the upper shouldered end portion of an elongated wedge pull rod 39 which extends downwardly through an enlarged aperture provided in the thick rectangular supporting base plate 10. In general, the arrangement is such that upon vertical movement of the wedge pull rod 39 the wedge 38 is caused to move vertically relative to the inner forming dies 37 thereby causing the same to expand outwardly into cooperation with the outer forming dies 19 or to contract inwardly to allow loading and unloading of the expander.

As shown in the various views of the drawing, there are provided a plurality of the inner forming dies 37 which are segmented and shaped to cooperate with the outer forming dies 19 in forming the finished blank. When the inner forming dies are expanded outwardly they define an inner die surface corresponding to the desired inner peripheral surface of the finished blank as is readily apparent.

Each of the inner forming dies 37 is provided with a downwardly depending end portion 40 which projects below the lower ends of the outer forming dies 19. Bolted to these depending end portions 40 are the feet portions of generally L-shaped slides 41. The slides 41 are slidably received within recesses provided in the top surface of the supporting base plate 10 and these recesses extend radially outwardly from the enlarged aperture therein. Each of the L-shaped slides has a pair of cylindrical recesses in the leg portion thereof for receiving a pair of compression coil springs 42. The upper ends of the compression coil springs bear against the lower surface of a stop block 43 which is radially adjustable by means of a headed adjusting screw 44 to control the force exerted by the compression coil springs. The arrangement is such that each of the segmented inner forming dies is positively biased at all times into engagement with the tapering surfaces of the tapering wedge 38 whereby the inner forming dies will move inwardly and outwardly in response to vertical movements of the tapering wedge 38. One of the important advantages of this arrangement is that the inner forming dies 37 are biased into engagement with the tapering wedge at a point below the confines of the actual die surfaces of the inner and outer forming dies whereby the means for biasing the inner forming dies does not interfere in any manner with the normal operation of the expander.

As intimated above, almost an unlimited number of shapes of finished blanks can be obtained by the use of the screw operated expander of the present invention upon proper selection of the inner and outer forming dies. In addition to cylindrical finished blanks, the expander can be employed to form and/or shape rectangular and other multi-sided finished blanks. Further, the blanks could be punched or cut upon the inclusion of proper blanking or cutting dies as will be apparent to those skilled in the art. In this respect, the number of segmented outer forming dies, camming elements, operating slides, inner forming dies, L-shaped slides, etc., as well as the cross sectional shape of the tapering wedge 38, can be chosen as is best adapted for the finished blank to the formed. In the illustrated embodiment of the invention there are shown four outer forming dies and a large number of inner forming dies but the number thereof could be increased or decreased by the duplication or elimination of parts.

One of the most important aspects of the present invention is that the expander is designed in such a manner that inspection, maintenance and/or alteration thereof is easily and quickly afforded. It will be noted that the operating slide fluid cylinders 18, the operating slides 14 and the outer forming dies 19 are all attached to and carried by the generally cylindrical and vertically extending housing 13. When the housing 13 is removed from the supporting base plate 10 the entire expanding mandrel assembly 36 will be exposed and can easily be worked upon. The outer forming dies 19 and the apparatus associated therewith are removed as an integral unit without the necessity of removing these parts on a piece by piece basis which has characterized prior art equipment of a comparable nature. When the housing 13 is removed not only are the inner and outer forming dies immediately exposed and accessible but also the L-shaped slides are readily accessible upon removal of an annular cover plate 46 as is clearly shown in FIGURE 1 of the drawing. In removing the housing 13 the outer forming dies 19 are moved to their retracted or outermost position while the inner forming dies 37 are contracted by moving the tapering wedge 38 upwardly to its highest position. The housing 13 can then be easily removed and the overall advantage is that all operating parts of the expander can be exposed for inspection, maintenance and/or alteration in a minimum of time and with a minimum of effort. This greatly increases the overall efficiency of the expander and allows the same to be used in continuous process lines where down time of any one machine is of primary importance.

As should now be readily apparent, the inner forming dies 37 are adapted to be expanded into cooperation with the outer forming dies 19 or contracted to allow loading and unloading of the expander upon vertical movement of the tapering wedge 38. For moving the tapering wedge 38 there is attached to the lower headed end of the elongated and large diametered wedge pull rod 39 a pivot block 47 which pivotally mounts a pair of downwardly extending links 48. The other ends of the spaced and parallel links 48 are attached to one arm of a large lever 49 which, as shown in FIGURES 1 and 3 of the drawing, is pivotally mounted between a pair of brackets 50 that extend downwardly from the bottom face of the thick rectangular supporting base plate 10. The other arm of the lever 49 pivotally mounts a pair of links 51 which are in turn pivotally connected to a large pivot block 52 mounted on and carried by the lower headed end of a large diametered threaded drive rod 53. The large diameter threaded drive rod is threadably received within an annular gear 54 which is journaled by suitable means, not specifically shown, in a suitable housing 55 attached to the bottom of the supporting base plate 10. The linkage above described is such that upon rotation of the annular gear 54 the threaded drive rod 53 will be caused to move vertically in one direction and the large diametered wedge pull rod 39, which is disposed in par-

allel relation with respect to the threaded drive rod **53**, will be caused to move a corresponding distance in the opposite direction. In order to properly form a cylindrical sheet metal blank **25** into a finished blank **26** considerable force must be applied to the wedge pull rod **39** and it will be noted that all components of the linkage means, including the links **48** and **51**, pivot blocks **47** and **52** and lever **49**, as well as the threaded drive rod **53**, annular gear **54** and the wedge pull rod **39**, are of sufficient size and capacity to efficiently and effectively transmit this force.

Each of the pivot blocks **47** and **52** mounts a wear plate **56** that is adapted to have sliding contact with a vertically extending thrust plate **57**. The thrust plates **57** are mounted from suitable depending brackets **58** attached to the bottom of the supporting base plate **10** and are tied together by spaced parallel tension bars **59**. The thrust plates **57** and the tension bars **59** form, in essence, a very rigid rectangular structure. The thrust plates not only insure parallel movement of the wedge pull rod **39** and the threaded drive rod **53** but also absorb any side thrust or pull on the wedge pull rod or threaded drive rod due to the arc the arms of the lever swing through when the lever is pivoted about its central pivot point between the brackets **50**. All such side thrust is taken by the thrust plates **57** and the tension bars **59** whereby this force is limited to these members and effectively isolated from all other component parts of the expander. In this respect, the thrust plates and tension bars make the side thrust self contained.

For driving the threaded drive rod **53** there is provided an electric drive motor **60** which is mounted on a suitable base **61** that is attached to the bottom of the supporting base plate **10** and whose output shaft is coupled with the input shaft of a torque limiting device **62**. The output shaft of the torque limiting device is connected to a shaft **63** which mounts a worm gear **64** that meshes with the annular gear **54**. Thus, upon proper energization of the electric motor **60** and the torque limiting device **62** the worm gear **64** will be caused to rotate to turn the annular gear **54** to move the threaded drive rod **53**.

The torque limiting device **62** is particularly important in accomplishing the objects of the present invention and, in essence, forms a means for adjustably limiting the torque applied to the threaded drive rod **53** and consequently the force applied to the tapering wedge **39**. While the expanding mandrel assembly **36** is forming a generally cylindrical sheet metal blank the threaded drive rod **53**, the interconnecting linkage, the wedge pull rod **39**, the tapering wedge **38** and the inner forming dies **37** will all be moving until the inner forming dies set the sheet metal blank in its final desired shape as determined by the extended outer forming dies **19**. At this instant of time a certain and predetermined torque on the threaded drive rod **53** is required for properly setting any given desired shape of the blank and when this torque is obtained all movement of the various components should stop with the tapering wedge **38**, inner forming dies **37**, the formed blank and the outer forming dies **19** locked solidly together. In order to remove the formed blank the tapering wedge must be retracted to contract the inner forming dies and the torque required on the threaded drive rod to unlock the various components for this purpose will be much higher than the torque required to set any given shape of metal blank due to the standing or static friction of the forming dies, cylindrical sheet metal blank and the tapering wedge.

To meet the above described operating conditions the torque limiting device **62** is interposed between the drive motor **60** and the threaded drive rod **53**. This device, in the first instance, allows only a predetermined maximum torque to be applied to the threaded drive rod to set the cylindrical blank to the desired shape. In this manner damage to the cylindrical blank or the expander due to excessive expanding forces on the forming dies is completely and effectively mitigated. The torque supplied by the torque limiting device in the first instance is adjustable however, whereby a value of torque best suited for any shaped cylindrical blank being formed is obtainable. In the second instance this device allows the application of a much higher torque to the threaded drive rod **53** than that required to set the cylindrical blank to overcome the static friction and allow contraction of the inner forming dies.

The torque limiting device **62** may be of any well known type providing the same operates in accordance with the above description. In the illustrated embodiment of the invention the torque limiting device **62** is shown to be a magnetic particle clutch. In such a clutch the gap between the driving and driven members thereof contains finely divided ferromagnetic particles. Until the stator coil is energized the magnetic particles within the gap have insignificant frictional bonding and torque transmission is essentially zero with the clutch operating at full slip. However, when the stator coil is energized a magnetic particle bond is produced which is proportional to the energizing current in the stator coil. Thus, to control the amount of torque delivered by the magnetic particle clutch it is only necessary to regulate the stator coil energizing current and when used in connection with an expander the above described operating characteristics can be obtained with the use of a highly simplified control circuit as will be understood by those skilled in the control art. The magnetic particle clutch, other than used in connection with the expander, does not form a part of the present invention. For those desiring a more detailed disclosure of a typical magnetic particle clutch reference is made to Bulletin No. 6000–A and Supplement No. 1 thereto which are published by Vickers Inc., 1815 Locust Street, St. Louis 3, Missouri. Obviously, the magnetic particle clutch is not the only torque limiting means which may be employed since similar results could be obtained by pneumatic, hydraulic or mechanical means. Accordingly, the present invention, in its broader aspects, is not limited to any particular torque applying means or device.

It is, of course, necessary to provide means for removing the formed cylindrical blanks from the expander and in the present instance this is accomplished by a plurality of ejection fluid cylinders **66** which are mounted on the bottom of the supporting base plate **10** and whose piston rods project through suitable apertures therein. After the finished cylindrical blank is freed from the inner and outer forming dies and centered with respect to the expander by the breaking and centering bars **29** the ejection fluid cylinders **66** are energized in such a manner that the finished cylindrical blank is raised upwardly above the housing **13** and the same is removed. At least a portion of the inner forming dies **37** are provided with radially projecting lugs **67** (see FIGURE 4) which define positioning stops for properly positioning an unformed blank vertically with respect to the inner and outer forming dies.

Considering now the overall operation of the above described embodiment of a screw operated expander, it will be assumed that initially that the operating slides and camming elements are in there lowered positions whereby the outer forming dies are in their outwardly retracted or inoperative positions. It will also be assumed that the tapering wedge is in its most extended highest vertical position whereby the inner forming dies are completely contracted. At this time the expander is open and a generally cylindrical blank can be positioned within the expander with the lower end resting on the positioning stops **67**. To initiate an expanding operation the operating slide fluid cylinders are actuated to raise the camming elements to move the outer forming dies to their innermost or operative positions. Then the motor **60** is energized to drive the threaded drive rod in a direction to cause the tapering wedge to move downwardly through linkage hereinbefore described. As the tapering wedge moves downwardly the inner forming dies will expand radially into

contact with the cylindrical blank and outer forming dies. When a predetermined forming force is exerted on the blank under the control of the torque limiting device 62 all movement will stop and the blank will be properly formed. To remove the formed blank from the expander the motor 60 is reversely actuated and the torque limiting device 62 controlled to apply a predetermined torque to the threaded drive rod 53 to unlock the forming dies and the blank in accordance with the principles above set forth. As the tapering wedge moves upwardly the inner forming dies move inwardly under the action of the compression coil springs 42 and slides 41 to their contracted positions. At the same time the operating slide cylinders shift the camming elements downwardly whereby the outer forming dies are moved radially outwardly toward their retracted or inoperative positions. While the inner forming dies are contracting and the outer forming dies are retracting the breaking and centering bars 29 move toward their extended positions and in so doing break the formed blank from the inner and outer dies and center the same with respect to the expander. When the forming dies are completely contracted and retracted and the blank is properly centered the ejection cylinders 66 are actuated in unison to lift the formed blank from the expander and the same is then removed.

It will be noted that at this time all of the forming dies are retracted whereby the expander is completely open and is ready to receive a cylindrical blank preparatory to another expanding operation. In this manner the expander of the present invention is adapted for continuous cyclic operation and is ideally suited for inclusion in an automatic process line. The expander can be employed with automatic handling equipment for feeding and loading the cylindrical blanks and conveying the formed blanks if so desired. In this particular embodiment of the invention such equipment is easily integrated with the expander since the same is completely open and accessible from the top thereof. The expander is particularly well adapted for use with automatic control instrumentalities whereby the same operates automatically in a repetitive cycle to form and/or shape the cylindrical blanks.

The expander of the present invention is screw operated and this is advantageous in that the expanding force on the inner forming dies is constant at all times and that the expander is clean and of a rugged nature well adapted for heavy mill-type duty. As explained above, crank and fly wheel operated expanders have a definite limitation in that the expanding force is not constant and hydraulically operated expanders are messy and require almost continuous maintenance. The use of the screw drive for the expanding mandrel allows the expander of the present invention to be employed in certain installations where prior art expanders could not be advantageously employed.

In FIGURE 6 of the drawing there is shown a side sectional view of a second preferred embodiment of a screw operated expander constructed in accordance with the teachings of the present invention. This embodiment employs many of the basic concepts and constructional features of the expander above described and to avoid unnecessary repetition in the specification component parts which are the same for both embodiments have been designated by like reference numerals. In general, this embodiment of the screw operated expander differs from the embodiment shown in FIGURES 1–5 in the driving means for the tapering wedge 38 which contracts or expands the inner forming dies and the means employed for removing a formed and/or shaped blank from the expander.

The tapering wedge 38 of this embodiment is apertured throughout its length to receive the shouldered end portion of an elongated wedge pull rod 68 which extends downwardly through the enlarged aperture in the supporting base plate 10. Mounted on the lower side of the supporting base plate is an annular cover cap 69 which guides the wedge pull rod 68 for and limits the same to vertical movement. The lower end of the wedge pull rod is threaded at 70 and this threaded end portion is received within an internally threaded annular gear 71. The annular gear 71 is journaled by pairs of spaced bearing assemblies 72 in a housing 73 that is mounted in depending relation from the annular cover cap 69 and from the bottom surface of the supporting base plate 10 by a bracket 74. Meshing with the annular gear 71 is a worm gear 75 which is driven by an electric motor through a torque limiting device, not shown, in exactly the same manner and for exactly the same purposes as the worm gear 64 is driven by the motor 60 and the torque limiting device 62. When the annular gear is rotated in one direction the threaded wedge pull rod 68 will move upwardly whereby the inner forming dies may contract and when rotated in the other direction the wedge pull rod will move downwardly to cause the inner forming dies to expand to form and/or shape a cylindrical blank.

By threading the end of the wedge pull rod and driving this member directly the drive means for raising and lowering the tapering wedge is much simpler since all of the linkage mechanism—including the links 43 and 51, pivot blocks 47 and 52 and bell crank 49, as well as the threaded drive rod 53, thrust plates 57 and tension bars 59—are eliminated. However, it will be noted that the housing 73 containing the annular gear 74 and the worm gear 75 prevents the mounting of the ejection cylinders 66 on the bottom surface of the supporting base plate 10 and consequently some other means must be employed for removing the formed blanks from the expander.

This is accomplished in the present instance by attaching a generally C-shaped arm 77 on the housing 13 whose upper end extends over and above the center of the various forming dies. Mounted on the upper end of the C-shaped arm 77 is a long stroke blank removal fluid cylinder 78 whose piston rod carried a generally rectangular plate 79. Attached to the lower side of the plate 79 is a ring magnet 80 which, as shown in the drawing, has a cross sectional shape that corresponds to the top edge of a formed blank. Upon actuation of the blank removal fluid cylinder 78 the magnet is lowered into the center of the expander until it engages the top edge of the formed blank. The blank is attracted, and attached to the ring magnet by magnetic force and the blank removal fluid cylinder is reversely actuated to lift the formed blank from the expander. This operation, of course, takes place after a blank has been formed and the inner forming dies contracted and the outer forming dies retracted.

The operation of this embodiment of the invention is in exact accordance with the operation of the first described embodiment with the exception of the driving means for the wedge and the formed blank removing means whose operation and functioning are set forth above. Each of the embodiments is characterized by advantages which may make the same preferable in any given installation. In the first embodiment the expander is completely clear from the top and this may be important where the same is employed with automatic handling equipment. In the second embodiment the drive means for the expanding mandrel assembly is highly simplified and may be utilized where complete access from the top is not required. In all other aspects the embodiments of the invention are similar.

It should thus be apparent that I have accomplished the objects initially set forth. Although there has been shown and described two preferred embodiments of the invention, it should be understood that many changes may be made therein without departing from the clear teachings of the invention. Accordingly, reference should be had to the following appended claims in determining the true scope and intent of the present invention.

I claim:

1. Apparatus for forming a cylindrical metallic shape

comprising an outer die set having a plurality of segmental die units for engaging the outer surface of the workpiece, power means to move said segmental die units radially inward and outward toward and away from each other to permit entry and removal of the workpiece, an expanding die concentrically within said outer die set, each of said die units having on its inner or working face a vertically disposed slot, a vertically disposed bar mounted on each of said units for radial movement into and out of the slot, and means to resiliently urge said bars to predetermined radially inward positions with respect to said units whereby upon completion of a forming cycle and during outward retraction of said units said bars will clamp the formed workpiece and retain the same concentrically within said units but free and clear thereof for easy removal from the apparatus in a vertical sliding movement.

2. Apparatus for forming a cylindrical metallic shape comprising a horizontally disposed plate-like base having an aperture therein, a cylindrical housing mounted on said base concentric about said aperture and mounting on its inner periphery a plurality of circumferentially disposed but vertically extending and vertically movable slides, segmental outer forming dies positioned radially inward of said slides and being connected to said housing by means which bias said dies into continuous engagement with said slides, cam means on the radially outward faces of said dies for cooperating with complementary cam means on the radially inward faces of said slides whereby upon sliding movement of said slides in one vertical direction said dies will be moved inwardly and upon movement of said slides in the opposite vertical direction said dies will be retracted radially outward by said biasing means, an internal expanding die assembly positioned radially within said first mentioned dies and having an actuating rod depending downwardly through said aperture, means to move said rod vertically comprising a screw, a nut on said screw held against axial movement, rotative power means, and an adjustable torque limiting drive interconnecting said power means and said nut.

3. Apparatus for forming a cylindrical metallic shape comprising a horizontally disposed plate-like base having an aperture therein, a cylindrical housing mounted on said base concentric about said aperture and mounting on its inner periphery a plurality of circumferentially disposed but vertically extending and vertically movable slides, segmental outer forming dies positioned radially inward of said slides and being connected to said housing by means which bias said dies into continuous engagement with said slides, cam means on the radially outward faces of said dies for co-operating with complementary cam means on the radially inward faces of said slides whereby upon sliding movement of said slides in one vertical direction said dies will be moved inwardly and upon movement of said slides in the opposite vertical direction said dies will be retracted radially outward by said biasing means, an internal expanding die assembly positioned radially within said first mentioned dies and having an actuating rod depending downwardly through said aperture, power means supported wholly on said housing and connected to said slides to vertically move the same, the arrangement being such that upon removal of said housing from said base said internal expanding die assembly is fully exposed for change or repair, each of said segmental dies being formed with a vertically disposed slot in its radially inward or working face, a bar for each of the slots and adapted to lie within the same, carriers for said bars mounted on said segmental dies and operative to support said bars for radially inward horizontal movement, and means on said segmental dies to resiliently urge said bars to predetermined radial positions inwardly of said segmental dies, the arrangement being such that upon completion of a forming operation and the subsequent retraction of said segmental dies said bars will clamp and retain the completed workpiece concentrically within said segmental dies but free and clear thereof for easy sliding movement vertically out of the apparatus.

4. Apparatus for forming a cylindrical metallic shape comprising a horizontally disposed plate-like base having an aperture therein, an expanding segmental inner die supported above said plate and having a vertically disposed and vertically movable actuating rod extending down through said aperture, an outer segmental and expandable die assembly mounted on said base concentric about said inner die and operative with said inner die to form and size a cylindrical workpiece, means to position a formed workpiece concentrically between said dies when the inner die is contracted and the outer die is expanded, the arrangement being such that upon completion of a forming and sizing operation and the subsequent contraction of said inner die and expansion of said outer die assembly the workpiece may remain concentrically free and clear of both said inner die and said outer die assembly, a vertically disposed and vertically movable member supported below said base in widely offset relation to said actuating rod, power means to raise and lower said member, a lever pivotally mounted intermediate its ends for rocking movement about an axis fixed with respect to said base, means pivotally connecting one end of said lever to said member, means pivotally connecting the other end of said lever to the lower end of said actuating rod, and a plurality of vertically elongated and vertically movable plungers circumferentially surrounding said actuating rod and normally positioned below said base but operative when moved upwardly to raise the formed and sized workpiece when the same is free and clear of the inner and outer dies as above stated to thereby eject the completed workpiece vertically upward out of the apparatus.

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