

[54] **METHOD AND APPARATUS FOR POINTING TUBES**

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[51] Int. Cl. **B21d 41/04**

[58] Field of Search.....72/402, 367, 369, 399, 400, 72/410, 452, 468, 469, 470, 472; 18/DIG. 5

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Primary Examiner—Charles W. Lanham

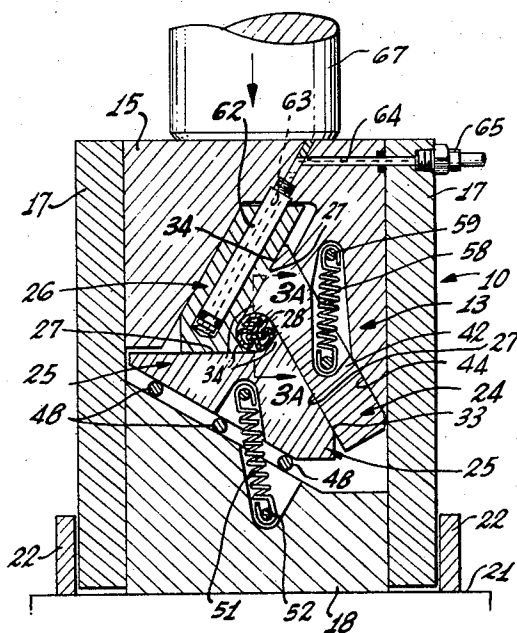
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[57] **ABSTRACT**

Method and apparatus for forming a generally cylindrical point on a tube by first flattening the tube from at least three sides to a polygonal cross section while forming curved sections between the flat sides, and then progressively contracting the tube to bring the curved sections together while buckling the flat sides inwardly into loops that are flattened inside the point. At least three die shoes arranged around a die recess in alternately overlapping relation have flat inner faces with an elongated lip along one side for shaping the curved sections, and also have flat, inclined bevels for shaping the transition zone of the tube during pointing, each bevel having a part-conical lip on one side for the final shaping of the transition zone to a conical shape. One actuating arrangement utilizes a mutual camming action to move all die shoes simultaneously at the same rate to maintain the point on a preselected axis, while a simpler form displaces the axis during pointing.

16 Claims, 27 Drawing Figures



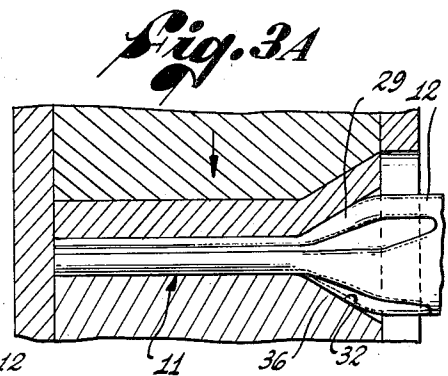
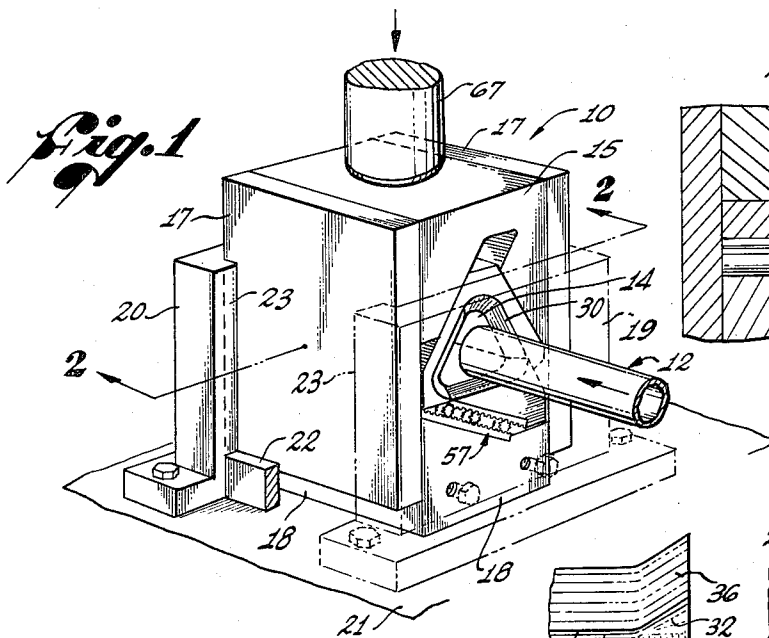


Fig. 2

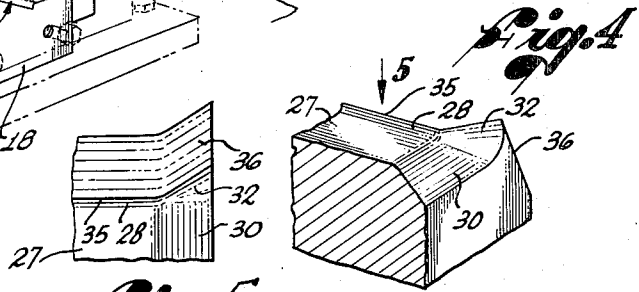
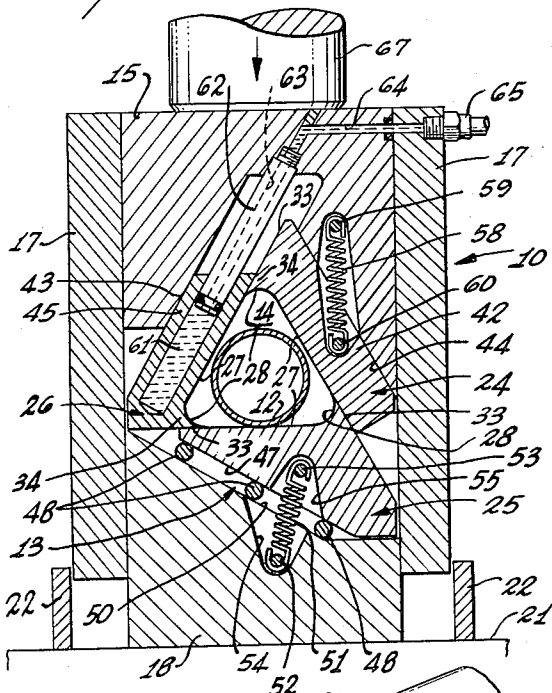
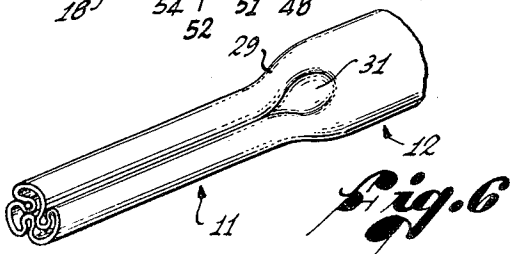
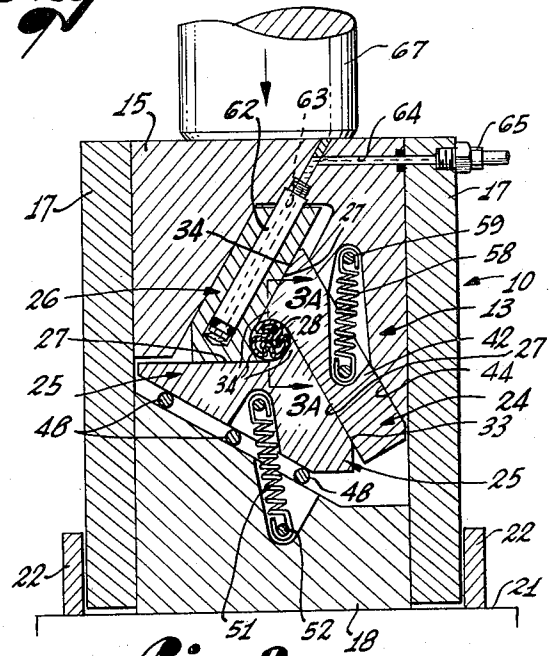
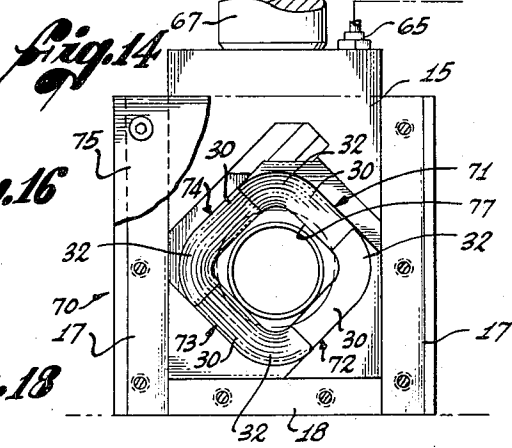
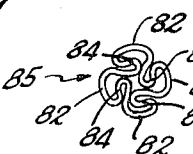
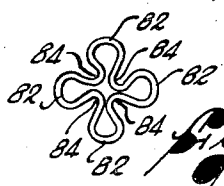
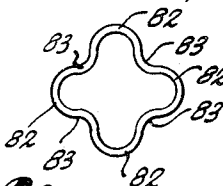
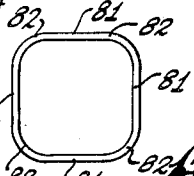
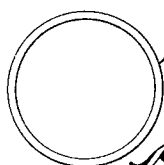
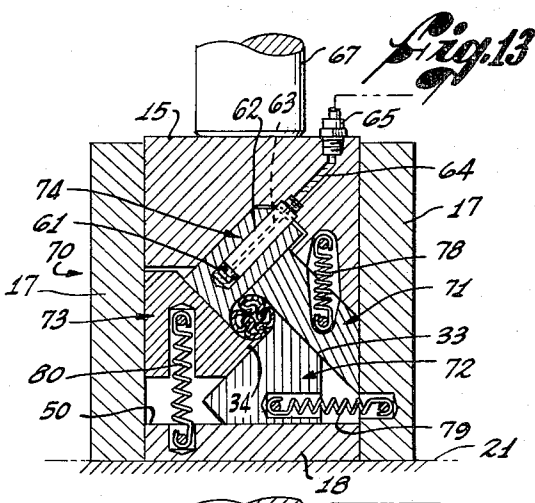
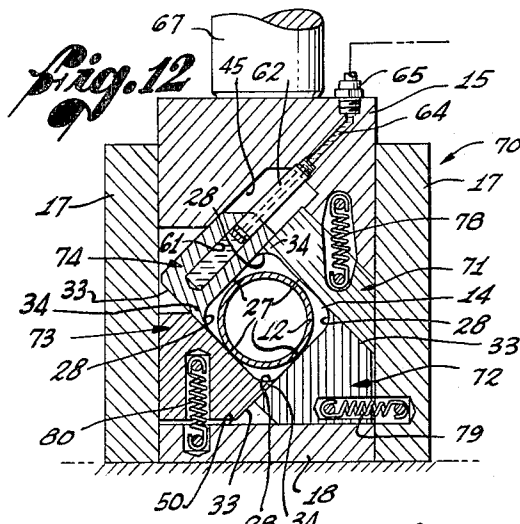
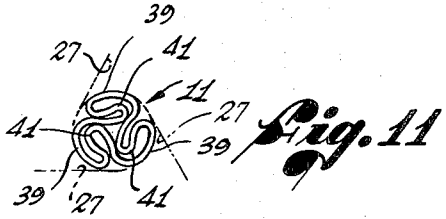
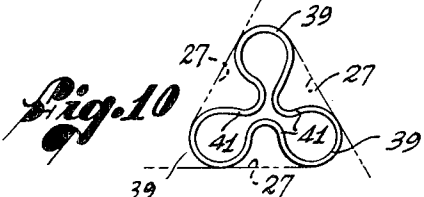
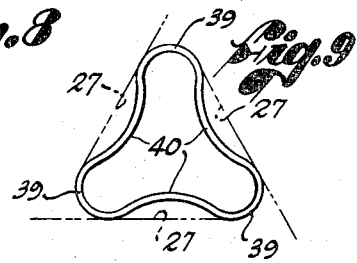
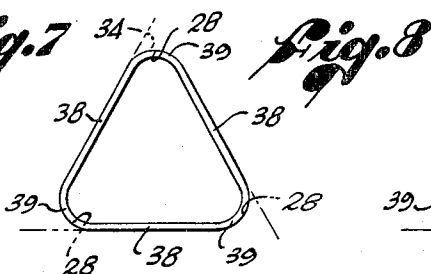
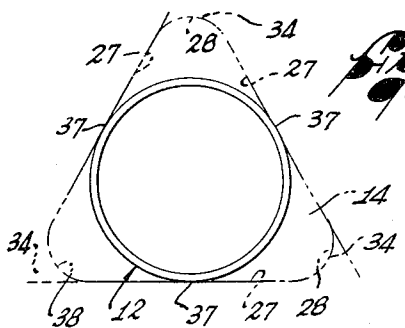


Fig. 5



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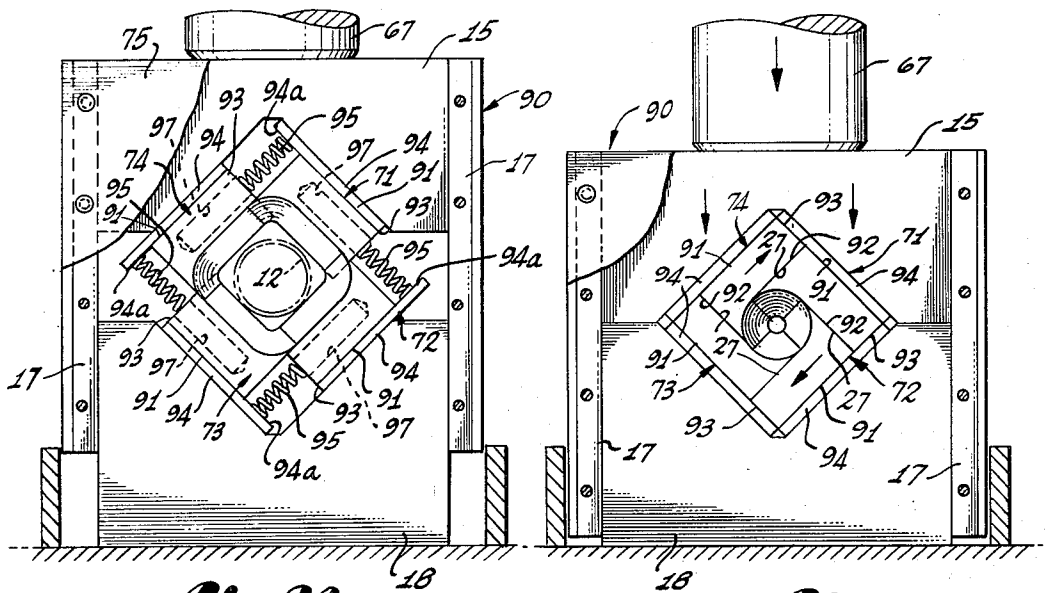


Fig. 20

Fig. 21

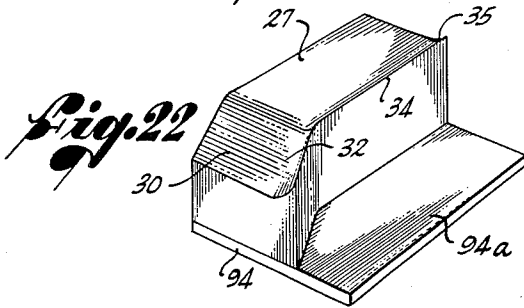


Fig. 22

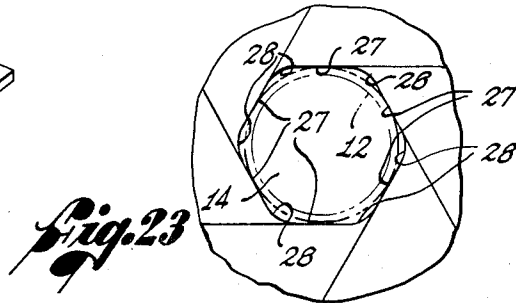


Fig. 23

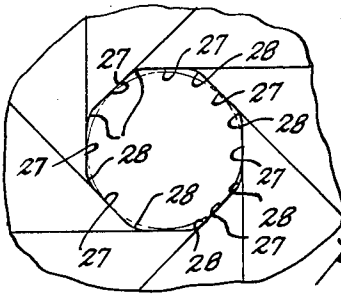


Fig. 25

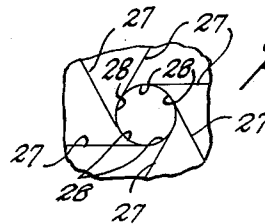


Fig. 24

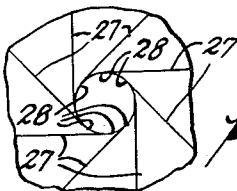


Fig. 26

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METHOD AND APPARATUS FOR POINTING TUBES

BACKGROUND OF THE INVENTION

This invention relates to the forming of reduced-diameter end portions on tubes for use in gripping the tubes during an operation such as drawing through a die. Such reduced-diameter end portions (called "points" although they typically are generally cylindrical or have some other blunt-ended shape) are necessary because the original tubing to be drawn through the die has a larger outside diameter than the diameter of the die, and also to provide a portion of the tube that can be gripped securely to apply the drawing force.

Tube pointing machines of various types are known and have been used by the trade. For example, U.S. Pat. No. 3,292,414 shows an apparatus for swaging points with a plurality of arcuate reciprocating die segments which compress a tube as the arcuate faces of the dies are pressed together around the tube. Rotary swaging also has been used. In another, somewhat similar approach, represented by U.S. Pat. No. 3,073,374, a tube is positioned between two dies having semi-cylindrical, concave faces and is pinched and pleated from opposite sides before the semi-cylindrical dies are closed around the tube.

In still another approach, shown in U.S. Pat. No. 3,068,929, a tube is positioned over an open-sided, part polygonal recess and then forced into the recess by two rams which, when moved toward the open side of the recess, compress the tube into the recess and cooperate therewith to form a regular polygonal cavity in which the tube is collapsed and compacted to the desired shape. A similar result is obtained by the pointer shown in U.S. Pat. No. 3,417,598 in which four dies arranged around the end of a tube are formed with interleaved flat-edged ribs which permit the dies to be moved together to crush the end portion of the tube into a point.

While these and other known pointers are capable of producing usable points on tubes, all of the pointers presently available are subject to one or more deficiencies that have prevented the achievement of optimum results. Specifically, many of the machines produce an excessively high noise level as an incident to the pointing operation, or require rather complicated and difficult-to-maintain machinery. More importantly, despite claims that points can be formed completely in one stroke, it often is necessary to repeat the forming stroke several times in order to obtain a proper point, probably because most of the die systems inherently include gaps into which the metal can be displaced during pointing. At the same time, it is difficult, if at all possible, to obtain uniformity in point diameters while maintaining the points concentric with the tubes.

The configuration of the transition zone between the point and the body of the tube is particularly important from the standpoint of performance of the tube during subsequent drawing operations. If the tube is folded with nonuniform convolutions or distinct creases, particularly in the transition zone, as is common in some of the prior pointers, stress risers are set up and can result in cracks which propagate down the tube during the drawing operations.

Moreover, many tube materials are "notch sensitive," that is, tend to break under stress wherever a notch or groove has been formed during pointing. Thus, any pointer which notches the tube during pointing, particularly in or around the transition zone, produces a likelihood of failure during subsequent operations. Of course, ruggedness, durability and relative simplicity of construction, as well as economy in construction, operation and maintenance, are primary objects of any production machine, and certain of the prior art machines, such as those requiring interleaved ribs, are deficient in these respects.

SUMMARY OF THE INVENTION

The present invention resides in an improved tube pointer which produces superior and uniform points in a novel manner by positively guiding and controlling the bending of the tube material at all times, both in the zone of the point and in the transition zone, while eliminating gaps in the die apparatus that could result in uncontrolled bending or objectionable displacement of the tube wall. Moreover, the tube pointer of the invention is capable of forming such points in a single and rapid one-stroke operation, is relatively simple, durable and quiet in operation, avoids cracks and objectionable creases in the transition area, and can maintain the point precisely concentric with the tube, thereby avoiding the disadvantages or prior pointers.

To the foregoing ends, the pointer includes a die having at least three die shoes that are arranged around and define an open-ended die recess of generally polygonal cross section and are interfitted to permit the shoes to move inwardly and outwardly, radially of the tube, to contract and expand the recess, the shoes having substantially flat inner working faces which form the tube first into a generally polygonal cross-sectional shape as the shoes move inwardly to contract the recess. The shoes also include means for shaping the tube between the sides of the polygonal cross section into arcuate sections so that continued inward movement of the shoes progressively shortens the sides of the polygonal cross section to buckle and fold the sides inwardly while moving the arcuate sections toward each other, finally squeezing the arcuate sections substantially together into a generally cylindrical point with the buckled portions formed as flattened loops within the point.

Controlled formation of the transition zone of the tube is accomplished by substantially flat bevels on the die shoes which have the same slope away from the working faces as the desired angle of the cone of the transition zone, the bevels also having means thereon for closing conically around the transition zone as the arcuate sections of the point are brought together. The controlled buckling of the point zone and the controlled sinking of the bevels into the tube cooperate to form uniform folds or convolutions in the transition zone with soft creases that flare from the point toward the tube into wide and gently rounded ends at the junction with the tube.

To permit such progressive contraction of die shoes having flat working faces, the shoes are arranged in alternately overlapped relation so that an edge of one shoe slides along the working face of one adjacent shoe, while an edge of the other adjacent shoe slides

along the working face of the first shoe. The illustrative arcuate shaping means for the point comprise fillets overlying the junctions between the working faces and having concave inner surfaces constituting longitudinal sections of a cylinder, and the corresponding means for the transition zone comprise longitudinal sections of a cone overlying the junctions between the bevels.

The concentricity of the point and the tube are maintained in the preferred forms of the invention by moving each die shoe toward the axis of the tube at the same rate, and this is accomplished with a single actuator which shifts one of the die shoes toward the axis at the desired rate while the remaining shoes are cammed inwardly at the same rate in response to the driving force applied by the actuator. Thus, the arcuate sections of the shoes can be maintained concentric with the tube at all stages of the pointing operation.

Other objects and advantages of the invention will become apparent from the accompanying detailed description, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the basic components of a tube pointer embodying the novel features of the present invention, with a length of tubing in position for insertion into the pointer, a representative actuator partially broken away and shown in cross section, and parts of the pointer shown partly in broken lines for clarity;

FIG. 2 is an enlarged fragmentary cross-sectional view of the pointer in FIG. 1, taken substantially along the line 2—2 thereof, after the tube to be pointed has been inserted in the open die;

FIG. 3 is a view similar to FIG. 2 showing the pointer and tube after the die has been closed to form the point;

FIG. 3A is an enlarged fragmentary cross section taken substantially along the lines 3A—3A of FIG. 3;

FIG. 4 is an enlarged fragmentary perspective view of one of the die shoes of the pointer;

FIG. 5 is a fragmentary plan view of the die shoe of FIG. 4;

FIG. 6 is an enlarged fragmentary perspective view of a pointed tube;

FIG. 7 is an enlarged end view of a representative tube with the die shown schematically at the beginning of the pointing operation;

FIG. 8 is a view similar to FIG. 7 showing the first stage of bending of the tube during the initial closing of the die in which the tube is generally polygonal in cross section and the flat sides are connected by arcuate sections;

FIG. 9 is a similar view showing the next stage of bending as the walls of the tube begin to buckle during shortening of the flat sides;

FIG. 10 is a similar view showing the next stage as the buckling continues and loops begin to form;

FIG. 11 is a similar view showing another stage as the loops are flattened and compressed and the arcuate sections are brought together;

FIG. 12 is a cross-sectional view similar to FIG. 2 on a somewhat reduced scale illustrating an alternative form of the pointer having four die shoes, the die being open;

FIG. 13 is a view similar to FIG. 12 with the die closed on a tube;

FIG. 14 is an end view of the pointer in FIG. 12 with a front cover plate thereof partly broken away;

FIGS. 15 to 19 are sequential views similar to FIGS. 7 to 11 illustrating the bending of a tube to a point with the pointer of FIGS. 12 to 14;

FIGS. 20 and 21 are views similar to FIG. 14 illustrating an alternative manner of support and actuation of the die shoes of a four-shoe pointer;

FIG. 22 is a fragmentary perspective view of a die shoe of the type used in the pointer of FIGS. 20 and 21;

FIGS. 23 and 24 are fragmentary views showing the arrangement of die shoes in a pointer having six die shoes, FIG. 23 showing the open position and FIG. 24 showing the closed position; and

FIGS. 25 and 26 are fragmentary views similar to FIGS. 23 and 24 but showing the arrangement of die shoes in a pointer having eight shoes.

DETAILED DESCRIPTION

As shown in the drawings for purposes of illustration, and with specific reference to FIGS. 1—11, the invention is embodied in a tube pointer 10 for forming a reduced diameter end portion or "point" 11 (see FIG. 6) on a tube 12, for subsequent use in gripping the tube and pulling it through a drawing die (not shown) for a conventional purpose such as redrawing of tubing where the diameter is to be reduced, the wall thickness is to be changed, and the like, to obtain the different sizes, shapes and other characteristics required in industry. The point may be inserted through such a die and then gripped in a suitable chuck with which the drawing force is applied.

In general, the pointer 10 includes a pointing die 13 formed by a set of die shoes which are arranged around and define a recess 14 that is open at one end to receive the end of the tube 12 to be pointed. The die set is mounted in a case including a top member 15 above the die shoes, side members 17 depending from opposite edges of the top member, and a bottom member 18 below the shoes. Herein, the case is supported between a pair of spaced front and rear guides 19 and 20 upstanding from and bolted to a suitable base 21, such as a table, and connected by bars 22. Each of the illustrative guides has upright flanges 23 (FIG. 1) which straddle the front and rear edges of the side members 17 and support the latter and the top member 15 for up and down motion, toward and away from the table 21 and the bottom member 18. This up and down motion is used to expand and contract the die recess 14 by moving the die shoes alternately outwardly, away from each other, into the open condition shown in FIGS. 1 and 2, for insertion of a tube 12 in the pointer 10, and then inwardly toward each other into the closed condition (FIG. 3) to compress the portion of the tube within the die recess and form the reduced diameter point 11 thereon. It should be understood, however, that this is only one of various arrangements that may be used to support the die.

In accordance with the primary aspect of the present invention, at least three die shoes 24, 25 and 26 are arranged around the die recess 14 and have inner working faces 27 that initially define the recess with a generally polygonal cross section, and are fitted

together to permit the shoes to be moved simultaneously inwardly, toward each other, to bend the tube initially to the polygonal cross section and then to contract the cross section progressively as such movement continues. In addition, the die shoes have curved surfaces 28 shaping the portions of the tube between the sides of the polygonal cross section into curved sections, which are squeezed progressively toward each other as the die shoes are closed. Accordingly, the continued shortening of the sides, accompanying the squeezing of the curved sections toward each other, causes the portions of the tube between the curved sections to buckle inwardly in a controlled and predictable manner, forming loops which are flattened and compressed within the point as the curved sections are brought together to form the periphery of the point.

In its broader aspects, the invention also contemplates the control of the formation of the transition zone 29 of the tube 12 in a novel manner where the outside diameter increases from that of the point 11 to that of the body of the tube. For this purpose, each die shoe 24, 25, 26 has a bevel 30 that is inclined outwardly and forwardly from the front of the working face 27 at a selected angle relative to the axis of the tube. These bevels sink progressively into the tube from all sides as the point is formed, and insure that the folds or convolutions (indicated generally at 31 in FIG. 6) in the transition zone are formed uniformly and without objectionable creases or notches. Finally, curved surfaces 32 between the bevels close conically around the transition zone as the curved surfaces 28 close around the remainder of the point.

In the illustrative embodiment shown in FIGS. 1-5, each die shoe 24-26 is shown as having the flat working face 27 disposed in a plane parallel to the axis of the tube 12, the three working faces being identical and cooperating to define the recess 14 with the general cross-sectional shape of an equilateral triangle, as shown most clearly in FIG. 2. The three shoes are arranged in alternately overlapping relation, each having one side edge portion 33 which abuts slidably against an extension of the working face of an adjacent shoe on one side, while the corresponding side edge portion 33 of the other shoe abuts slidably against an extension of the working face of the first shoe. Thus, all three shoes can be moved simultaneously inwardly toward the tube axis in mutually sliding, gap-free relation.

Each side edge portion 33 of a shoe that overlaps the working face 27 of the adjacent shoe herein is formed with an inwardly projecting, longitudinal lip 34 having an arcuate inner side of concave curvature constituting the curved surface 28 for shaping the curved sections of the tube, this surface preferably being concentric with the tube and tangent to the working face 27 of the shoe on which it is formed, and also tangent to the working face 27 of the shoe against which the lip slides. Ideally, the arcuate surface might terminate in a knife edge at 35, but for the practical purpose of minimizing the likelihood of breakage, this edge preferably is blunted.

As shown most clearly in FIGS. 3A and 4, the bevels are simply flat surfaces disposed at suitable forwardly and outwardly inclined angles with the axis of the tube, for example, five to forty degrees, depending upon the desired angle of the transition zone. On one side of

each bevel is a flared lip 36 constituting an extension of the associated lip 34 and having a concave inner side which preferably is a section of a cone and constitutes the surface 32 for shaping the tube in the transition zone. The free edge of this lip preferably is blunted for durability and is in the same plane as the edge of the lip 34.

The actuator of the pointer 10, which may take various forms, moves all of the die shoes simultaneously inwardly relative to each other toward the axis of the tube 12 (which may be either stationary or movable) thereby to close the die 13. During such closing movement, the overlapping side edge portions 33 slide along the working faces 27 of the adjacent shoes while the working faces themselves remain parallel to the tube axis. Thus, the working faces first are pressed against the sides of the tube (three sides as in FIG. 7) in tangent relation therewith along three longitudinal lines 37, and then begin to flatten the sides of the tube progressively toward the triangular condition shown in FIG. 8. Such flattening is accompanied by initial sinking of the three bevels 30 into the tube in angularly spaced relation around the portion of the tube within the flared end portion of the die recess 14 that is defined by the bevels.

As closing of the die 13 continues, the tube 12 is formed to the shape shown in FIG. 8 with three flat sides 38, and the longitudinal portions of the tube between these flat sides are shaped into arcuate sections 39 which nest firmly against the inner surfaces 28 of the lips 34. After the die reaches the condition shown in FIG. 8, further inward motion of the shoes squeezes the arcuate sections 39 radially inwardly and progressively shortens the exposed portions of the working faces. The flat sides 38 of the tube, being confined and backed against outward bulging, begin to buckle inwardly, as shown at 40 in FIG. 9, and to form loops as shown at 41 in FIG. 10.

Apparently because there is effective tangential travel of the working faces 27 as the die 13 is closed, the loops 41 thus formed are not directed exactly toward the axis of the tube, as might be expected. Instead, as illustrated in FIG. 10, each loop is offset slightly from center so that continued crushing of the tube results in flattening of the loops in an offset, pinwheel fashion as shown in FIG. 11, thus producing a general symmetry or uniformity in the cross-sectional configuration of the point. Closing of the die can be terminated at any selected stage after the generally cylindrical point 11 has been formed, and, of course, can be continued beyond the condition shown in FIG. 11 if a denser point is desired. In fact, with sufficient actuating pressure and appropriately formed die shoes, the point can be crushed to an essentially solid rod and even extended in length.

The loops 41 shown in FIG. 10 extend forwardly beyond the working faces 27 and along the bevels 30, while the arcuate sections 39 extend forwardly and flare outwardly along the concave surfaces 32 constituting sections of a cone. Thus, each transition convolution 31 (FIG. 6) is formed between two arcuate sections of the tube that are controlled by the conical surfaces, and it has been found that a rounded crease forms at the bottom of the convolution and spreads progressively as the convolution flares, being broadly

rounded short of the larger end of the transition zone 29. As closing of the die is completed, the part-conical surfaces 32 come together into the desired full-conical shape to form the transition zone to that shape. The closed, conical condition is shown most clearly in FIG. 3A, and also in FIG. 21 with regard to a four-shoe form of the pointer, hereinafter described in detail.

The preferred manner of actuation of the pointer 10 is the cam arrangement illustrated in FIGS. 2 and 3 wherein it will be seen that the upper die shoes 24 and 26 are arranged generally in the shape of an inverted "V" with inclined, upwardly facing outer sides 42 and 43 parallel to the working faces 27 of the shoes and nested against similarly inclined, downwardly facing surfaces 44 and 45 on the underside of the top member 15 of the case. The third die shoe 25 is generally triangular in shape and has an outer side 47 that is inclined upwardly and to the left, and the overlapped side edge 33 is inclined downwardly and to the right beyond the overlapping portion of the working face 27 of the shoe 24. Rollers 48 are disposed between the inclined outer side 47 and an inclined, parallel upper surface 50 of the bottom member 18, thus supporting the lower die shoe 25 for movement upwardly and to the left along the inclined surface 50 of the bottom member.

A coiled extension spring 51 is stretched between two pins 52 and 53 respectively mounted in a recess 54 in the bottom member 18 and a recess 55 in the lower die shoe 25, thus urging the shoe downwardly toward the position shown in FIG. 2 and holding it firmly against the rollers 48, which may be maintained in spaced parallel relation by rack-and-pinion mechanisms 57 at their ends, as shown in FIG. 1. A similar spring 58 for holding the upper right die shoe 24 against the surface 44 is stretched between pins 59 and 60 on the top member 15 and the shoe, although it will be seen that this shoe does not move relative to the upper member during actuation of the pointer. The spring merely holds the die shoe firmly in place against the surface 44 and forms a releasable connection facilitating changing of the die.

The die shoe 26 may be similarly spring positioned, but preferably is controlled by a hydraulic cylinder formed by a blind bore 61 which parallels the inclined surface 45 of the top member and telescopingly receives the lower end portion of a plunger 62 that is formed with a longitudinal through passage 63. This passage communicates at its lower end with the bore 61 and at its upper end with a conduit 64 for receiving fluid under pressure from an external source (not shown) through a fitting 65. This cylinder forms, in effect, a hydraulic spring which returns the shoe 26 and the top member 15 to the positions shown in FIG. 2 to open the die 13 after each pointing operation.

With the foregoing arrangement, the parts are disposed in the positions shown in FIG. 2 prior to each pointing operation, and a tube 12 may be inserted in the open die recess 14 in the manner shown, with sufficient clearance around the tube to permit easy insertion. If desired, a tube guide (not shown) may be mounted on, or in front of, the front guide 19 to position the tube for the pointing operation.

With the tube properly positioned, a ram 67 abutting against the top member 15 is actuated to force the top member and the side plates 17 downwardly relative to

the bottom member 18, thus forcing the right upper die shoe 24 downwardly along the right side of the lower die shoe 25. As the right shoe slides along the lower shoe, the abutting inclined surfaces 33 and 27 of the shoes cooperate to cam the lower shoe to the left, and the upwardly inclined surface 50 of the bottom member 18 simultaneously guides the lower shoe upwardly and inwardly at a rate determined by the slope of the surface 50. At the same time, this upward motion of the lower shoe is transferred to the lower edge 33 of the left shoe 26 through the overlapped sides of the two shoes, and is combined with the downward motion of the top member 15 to produce an inward (to the right) motion of the left die shoe at a rate determined by the slope of the inclined surface 45 and the rate of movement of the left shoe along this surface.

Accordingly, with properly correlated slopes on the various cam surfaces, the three die shoes 24-26 are moved simultaneously and at the same rate toward the axis of the tube 12. Termination of this closing movement can be controlled in various ways, for example, by one or more limit switches (not shown) actuated in response to movement of the die shoes to selected positions, the limit switches preferably being adjustably positioned for selective variation of the point of termination. The same switching arrangement that terminates the closing stroke also can automatically initiate the following opening stroke.

During opening of the die recess 14, the three shoes 24-26 move reversely along the paths followed during closing, the right shoe 24 being raised as the top member 15 is raised by the hydraulic cylinder 61, 62, thereby permitting the lower shoe 25 to be returned along the surface 50 by the spring 51 and the left shoe 26 to be lowered along the surface. An additional switching arrangement can be provided to terminate the opening stroke as the die shoes return to the position in FIG. 2. The details of such switching arrangements, including manual or timed automatic actuation, are well known in the art and therefore are not described in detail herein.

FIRST ALTERNATIVE EMBODIMENT (FIGS. 12-19)

It has been stated that at least three die shoes are believed to be necessary in order to define a gap-free die recess capable of being closed around a tube in accordance with the present invention. It should be emphasized, however, that the invention is not limited to the use of three die shoes, and that, in fact, different circumstances may make the use of four or more shoes advantageous.

Since each die shoe produces one fold or convolution in the tube in, and adjacent to, the point, changes in the number of shoes will result in different numbers and angular spacings of the convolutions. With tubes having walls with a relatively high thickness-to-diameter ratio, it is relatively difficult to buckle and fold the tube wall, so the use of a lesser number of shoes will form the folds farther apart, angularly, around the tube and insure that the wall sections will buckle inwardly from the polygonal stage rather than feeding peripherally around the inner surfaces of the die. For tubes having walls with a relatively low thickness-to-diameter ratio, a greater number of die shoes are used

to provide better control of the relatively easy-to-fold tube walls.

In the pointer 70 shown in FIGS. 12-14, in which some corresponding, generally similar parts are indicated by corresponding reference numbers it will be seen that four die shoes 71-74 are arranged around and define the die recess 14, which thus is generally square in cross section when the die is open. As before, these die shoes have flat inner working faces 27 in planes parallel to the axis of the tube 12, are arranged in alternately overlapped relation permitting closing movement of the die shoes in the square or rectangular form, and have lips 34 with curved inner surfaces 28 preferably constituting longitudinal sections of a cylinder.

In addition, as shown in FIG. 14, each die shoe 71-74 has a bevel 30 from the forward end of the working face 27 to the front side of the shoe, and each bevel merges smoothly with a part conical surface 32 for shaping the transition zone 29 of the tube as the die is closed, forming the full conical surface around the tube as can be seen in the similar form shown in FIG. 21.

The four die shoes 71-74 of FIGS. 12-14 are mounted and actuated in substantially the same way as the three shoes in FIGS. 1-5, being mounted in a case including a fixed bottom member 18, two upstanding side plates 17 which in this instance are fastened to the side edges of the bottom member, and a top member 15 which is movable vertically between the side plates. A ram 67 engages the top member to apply the force necessary to push the top member down and close the die around the tube 12, and a front plate 75 is bolted to the bottom member and the side plates to close the front of the case except for an aperture 77 (FIG. 14) formed therein to admit the tube into the die recess 14.

In this instance, the upper right die shoe 71 is detachably connected to the top member 15 by a spring 78 and remains stationary during actuation of the pointer 70, as did the shoe 24 in the first form, and the lower right shoe 72 is slidable horizontally across the top surface 50 of the bottom member in response to the camming action of the downwardly and rightwardly inclined working face 27 of the upper right shoe 71 on the abutting inclined side 33 of the lower right shoe. A spring 79, stretched between the shoe and the adjacent side plate 17, yields during closing of the die and then returns the shoe to the right when the closing force is relieved.

The lower left shoe 73 slides vertically along the left side plate 17 in response to the camming action of the inclined face 27 of the lower right shoe 72 on the abutting inclined side 33 of the lower left shoe, and is urged yieldably toward the bottom member 18 by a spring 80. The upper left shoe 74, as before, is guided along an upwardly and rightwardly inclined wall 45 of the top member 15, and also is cammed inwardly and upwardly by the inclined face 27 of the lower left shoe 73, this face abutting against the inclined edge 33 of the upper left shoe. A blind bore 61 is formed in the upper left block and telescopingly receives a plunger 62, thus forming a hydraulic cylinder which opens the die set in the same manner as in the first form.

As shown in FIGS. 15-19, the bending of the tube wall follows the same sequence as in FIGS. 7-11, the only significant difference being the formation of a

generally rectangular initial cross section with four sides 81 (FIG. 16) joined by four arcuate sections 82. This is followed by the buckling of the four sides at 83 (FIG. 17), the formation of loops 84 (FIG. 18) which are slightly offset from center, and the collapse of the loops into the generally cylindrical point 85 (FIG. 19). From this collapsed condition, the point may be further compressed to a smaller diameter and greater density, as desired. Of course, the formation of the transition zone of the tube follows the same procedure as before, with the addition of one fold or convolution.

SECOND ALTERNATIVE EMBODIMENT (FIGS. 20-22)

The pointer 90 shown in FIGS. 20 and 21 is similar to the first alternative embodiment in that it has four die blocks 71-74 (corresponding reference numbers being used in both of these forms, where applicable), but in this case the closing of the die results in displacement of the axis of the die recess 14 and the tube point, downwardly in parallel from the original position. Thus, this pointer is suited for use under circumstances which permit the tube to be moved during the pointing operation so as to follow the movement of the point and remain at least generally coaxial therewith.

As will be seen most clearly in FIG. 21, the configuration and arrangement of the four die shoes 71-74 are virtually the same as in FIGS. 12-14. The shoes may be identical in shape, however, with outer sides 91 parallel to the working faces 27 and with opposite end surfaces 92 and 93 in planes that are perpendicular to the inner and outer surfaces. Actuating plates 94 are fastened, as by bolting, to the outer sides 91 with one projecting end portion 94a of each plate overhanging the end surface 93 of an adjacent shoe, in spaced parallel relation therewith when the die is open (FIG. 20). Coiled compression springs 95 are disposed between these overhanging portions and the adjacent end surfaces to urge the die shoes toward the open positions. Herein, the springs are held in place by bores 97 which extend into the shoes so that the springs are compressed between the actuating plates and the ends of the bores. Thus, the springs urge the plates 94 away from the ends of the shoes, and thereby urge the die shoes toward the open condition shown in FIG. 20.

The two lower shoes 72 and 73 are nested in a V-shaped groove or notch in the bottom member 18 with the associated actuating plates 94 resting against the walls of the notch, and the two upper shoes 71 and 74 are similarly nested in an inverted V-shaped notch in the underside of the top member 15. In this instance, the side plates 17 are fastened to the top member and extend downwardly along, and slide against, the sides of the bottom member.

As the top member 15 is forced downwardly by the ram 67, the two upper die shoes 71 and 74 are forced downwardly toward and against the tube 12, the upper right shoe 71 moving substantially straight down and camming the lower right shoe 72 downwardly to the left, deeper into the lower notch. As this happens, the lower left shoe 73 remains substantially stationary and the upper left shoe 74 is cammed upwardly to the right and deeper into the upper notch.

Accordingly, the die is closed as before, but the axis of the die recess moves progressively lower during such

closing, from the level shown in FIG. 20 to the level in FIG. 21, the springs 95 being compressed between the die shoes and the actuating plates as an incident to the closing. Subsequently, as the ram 67 is retracted, the springs return the die shoes to the open condition of FIG. 20. The actuating plates 94 prevent a combined rotation effect of the die shoes that could be present if the springs were to bear against the surfaces of the notches in the top and bottom members.

ADDITIONAL ALTERNATIVE EMBODIMENTS (FIGS. 23-26)

The schematic views in FIGS. 23-26 are included to illustrate die arrangements for larger numbers of die shoes, six in FIGS. 23 and 24 and eight in FIGS. 25 and 26. It will be seen that the initially exposed portions of the working faces 27 become progressively shorter, in proportion, as the number of die shoes is increased, thus forming initial folds of shorter angular extent, and the arcs of the arcuate surfaces 28 are similarly changed as the final cylinder is divided into a larger number of longitudinal sections that are distributed around the die as parts of the die shoes.

From the foregoing, it will be seen that the present invention provides a novel apparatus for forming reduced diameter portions or "points" on tubes, and uses a similarly novel method of reducing the diameter to a substantially similar point. In each embodiment illustrated and described, the alternately overlapping die shoes are movable in gap-free relation from an open position in which the flat inner working faces of the shoes define a die recess of regular polygonal shape with curved surfaces between the flat sides, thus forming the tube to the same polygonal shape with curved longitudinal sections as an incident to the initial closing movement of the die shoes.

Moreover, continued closing movement in each case progressively shortens the flat sides while squeezing the curved sections toward each other, causing the flat sides to buckle inwardly and form loops that may be flattened in a relatively uniform manner within the point.

The result is a die apparatus and pointing method which produce improved points in a highly effective manner, with a relatively simple die structure of competitive initial cost and relatively rugged and durable construction, and with a smooth and continuous stroke that normally is effective to form the point in a simple, rapid and quiet operation. Accordingly, the present invention avoids disadvantages that have been inherent in prior pointers, while forming a controlled point without notches, creases or other irregularities that could interfere with proper performance in a later operation.

I claim:

1. A tube pointer having, in combination:
a case;

a die mounted in said case and comprising at least three die shoes arranged in alternately overlapped relation around, and defining, an open-ended recess for receiving one end portion of a tube to be pointed;

each of said die shoes having a flat inner working face forming one side of said recess, a side surface in sliding relation with an extension of the working

face of a first adjacent die shoe, and an extension of its working face in sliding relation with the side surface of a second adjacent die shoe whereby said shoes are movable simultaneously inwardly from an open position toward a closed position and then back outwardly toward said open position to contract and expand said recess;

a bevel on each of said shoes inclined outwardly from the working face thereof toward said open end; an elongated first lip extending along the side of each working face adjacent the side surface thereof that slides along the working face of an adjacent block, each of said lips having a curved inner surface generally tangent to both of the adjacent working faces and curved about the axis of a tube centered in said recess;

and a second lip constituting an extension of said first lip on each of said shoes along one side of the bevel thereon, each of said second lips having an inner surface of generally conical curvature flaring toward said open end and generally tangent to both of the adjacent bevels, whereby said die shoes are movable progressively inwardly from said open position to contract said recess about a tube, bend the tube first to a flattened, generally polygonal cross section with curved sections between the flattened wall portions, progressively contract the tube polygonally to cause the flattened wall portions to buckle inwardly, and finally bring the curved sections together to a substantially cylindrical point while shaping the tube conically between said second lips.

2. A tube pointer as defined in claim 1 further including means for moving all of said die shoes simultaneously inwardly at the same rate and maintaining the point on a preselected axis as it is formed.

3. A tube pointer as defined in claim 2 in which said moving means includes actuating means for shifting at least one of said shoes inwardly at a selected rate, and camming means responsive to movement of said actuating means and said one shoe to move the remaining shoes simultaneously inwardly at said rate.

4. A tube pointer as defined in claim 3 in which said camming means include said extensions of said working faces in sliding and camming engagement with said side surfaces.

5. A tube pointer as defined in claim 1 in which said die has three die shoes arranged around said recess with said working faces forming an equilateral triangle.

6. A tube pointer as defined in claim 1 in which said die has four die shoes arranged around said recess with said working faces forming a square.

7. A tube pointer as defined in claim 1 in which said die has more than four die shoes.

8. A tube pointer as defined in claim 1 in which said curved inner surfaces are longitudinal sections of a cylinder and move together to form a cylinder in said closed position.

9. Apparatus for forming a reduced diameter portion on a tube, said apparatus having, in combination:

at least three die shoes arranged around and defining an open-ended recess of generally polygonal cross section for receiving the portion of the tube to be reduced in diameter;

each of said shoes having a substantially flat inner working face forming one side of said recess, and said shoes being fitted together for in and out movement in gap-free relation to contract and expand said recess in generally polygonal cross-sectional shape;

means on said shoes for changing the shape of said recess from generally polygonal to generally cylindrical shape as the shoes are moved inwardly to a selected closed position, whereby the tube first is flattened to said generally polygonal shape and then is formed to said generally cylindrical shape; and

means on said shoes for controlling the transition zone of the tube between said reduced diameter portion and the remainder of the tube, and including an extension of each working face projecting outwardly at one end of said recess and inclined away from the tube to sink progressively into the transition zone at a selected angle as the recess is contracted in said polygonal cross-sectional shape, and means on said extensions for closing around said transition zone in a tapered form of generally circular cross section as the shape of said recess is changed from polygonal to cylindrical shape.

10. Apparatus as defined in claim 9 in which said shape-changing means comprise a curved inner surface on each of said shoes curving concavely between the working face of the shoe on which it is formed and the working face of the adjacent shoe, whereby said generally polygonal cross section has flat sides joined by curved sections, said curved sections being moved together to said generally cylindrical shape as said shoes are moved to said closed position.

11. Apparatus as defined in claim 10 in which each of said extensions is a bevel that is inclined outwardly from one end of the working face thereon toward the open end of said recess, and said means for closing around the transition zone comprises a second concavely curved inner surface on each of said shoes between one side of the bevel thereof and the bevel of the adjacent shoe, said second curved surface being an extension of the first curved surface and generally in the shape of a longitudinal section of a cone.

12. Apparatus for forming a reduced-size portion on a tube, said apparatus having, in combination:

at least three die shoes arranged in alternately overlapped relation around, and defining, a recess for receiving the portion of the tube to be reduced in size;

each of said shoes having an inner working face forming one side of said recess, a side surface in sliding relation with an extension of the working face of a first adjacent die shoe, and an extension of its working face in sliding relation with the side surface of a second adjacent die shoe whereby said shoes are movable inwardly from an open position toward a closed position and then back outwardly to contract and expand said recess in polygonal form;

and means for moving said die shoes simultaneously inwardly at the same rate while a portion of a tube is disposed in said recess, thereby flattening the tube to the shape of said recess and then progressively reducing the size of the tube while maintain-

ing the tube and the reduced-size portion coaxial, said moving means comprising an actuating member engaging at least one of said die shoes and operable to shift said one shoe inwardly at a selected rate, and camming means responsive to movement of said actuating member and said one shoe for shifting all of said shoes inwardly at the same rate as said one shoe thereby to maintain said reduced size portion constantly positioned on a substantially stationary longitudinal axis.

13. Apparatus as defined in claim 12 in which each of said shoes has a concavely curved, inwardly facing surface extending along the side of its working face which slides along the working face of an adjacent shoe, thereby to form curved sections in the tube between said working faces and squeeze said curved sections toward each other as the shoes are moved inwardly, and further including a bevel on each shoe inclined outwardly from one end of the working face thereon toward one end of said recess, and a second concavely curved inner surface on each of said shoes between one side of the bevel thereof and the bevel of the adjacent shoe, said second curved surface being an extension of the first curved surface and generally in the shape of a longitudinal section of a cone.

14. The method of forming a reduced size diameter on one end portion of a tube, said method including the steps of:

flattening said one end portion from at least three sides thereof to form the tube into a generally polygonal cross section while shaping the tube between the sides of said polygonal cross section into curved sections;

sinking the tube inwardly in controlled tapered fashion from at least three sides in the zone between said one end portion and the remainder of the tube;

squeezing said one end portion to shorten said sides and cause them to buckle inwardly between said curved sections while moving said curved sections toward each other;

squeezing said zone toward a tapered form of generally circular cross section;

and continuing such squeezing and buckling at least until said curved sections are brought substantially together into a reduced diameter portion and said zone is brought into a tapered form of substantially circular cross section.

15. Apparatus as defined in claim 12 including a case having inside guiding surfaces constituting part of said camming means, said actuating member forming one movable side of said case and having a V-shaped notch on its inner side forming two of said guiding surfaces, each of said die shoes having an outer side movable along one of said guiding surfaces, and two of said outer surfaces being slidably engaged by said guiding surfaces of said actuating member during inward movement thereof, the overlapped surfaces of said shoes cooperating with said outer sides and said guiding surfaces to cam all of said shoes inwardly at the same rate as said actuating member moves inwardly.

16. Apparatus as defined in claim 12 further including means for shifting all of said shoes simultaneously outwardly from said closed position as said actuating member moves outwardly.