Nov. 17, 1970 J. W. HINSHAW 3,540,259

SEGMENTED DIE HOLDER FOR DRAWING APPARATUS

Filed Aug. 20, 1968 3 Sheets-Sheet 1

FIG. 1.

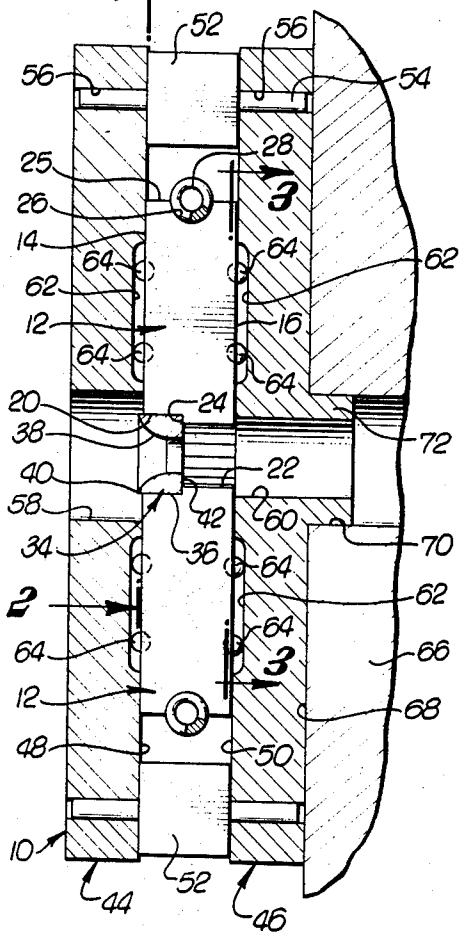


FIG. 2.

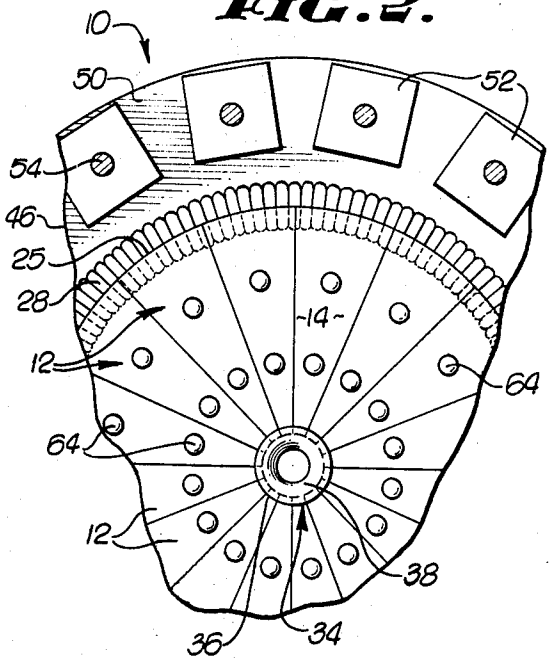


FIG. 3.

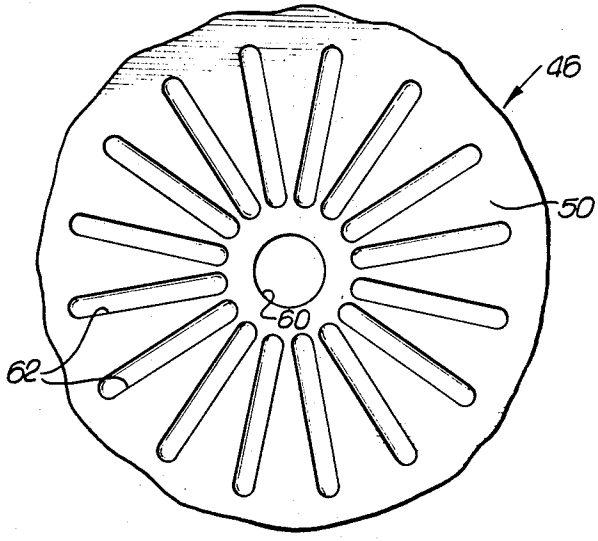
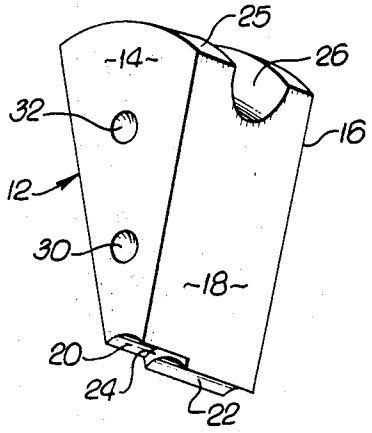


FIG. 4.



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Nov. 17, 1970 J. W. HINSHAW 3,540,259

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Filed Aug. 20, 1968 3 Sheets-Sheet 2

FIG. 5.

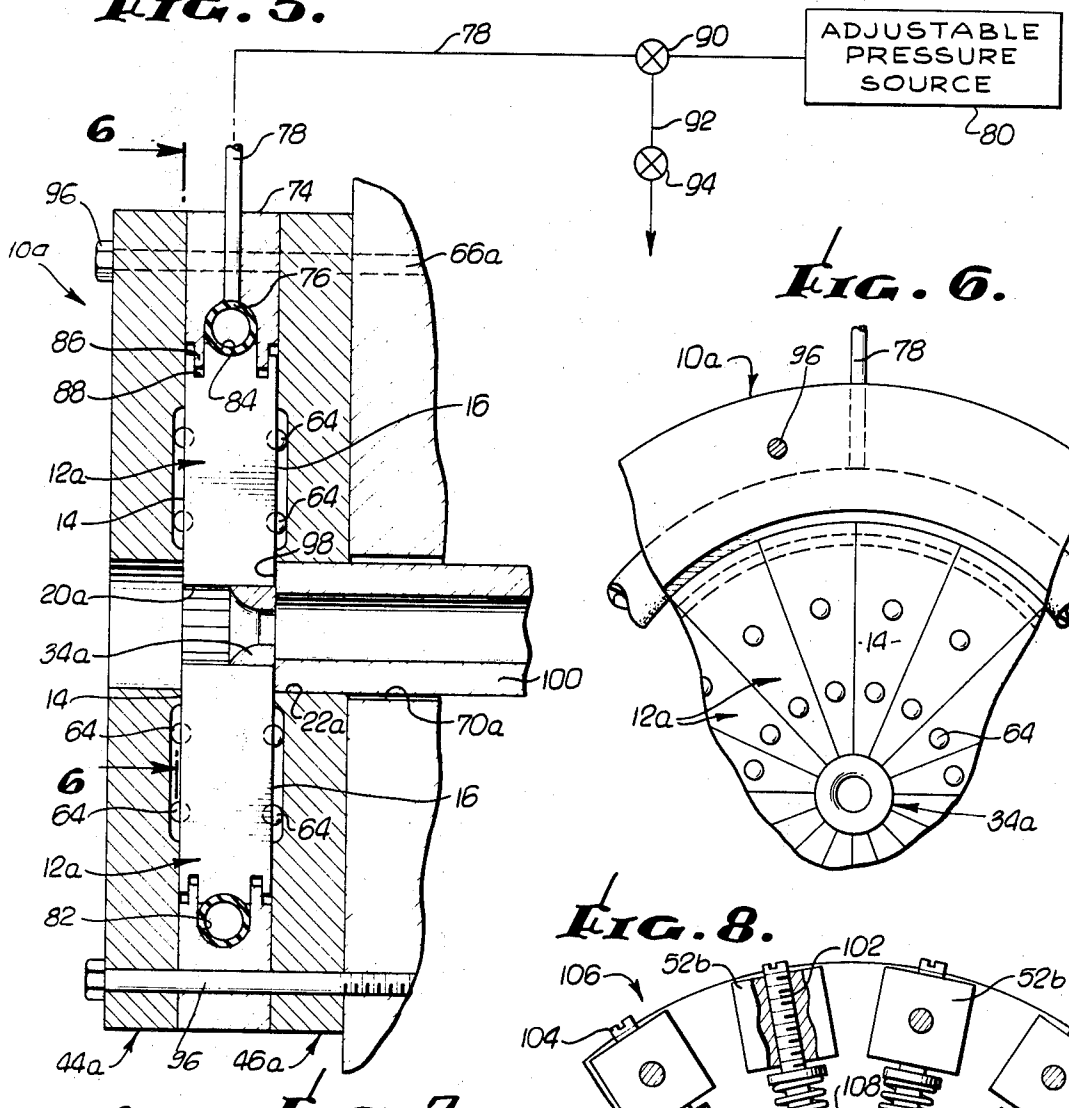


FIG. 6.

FIG. 7.

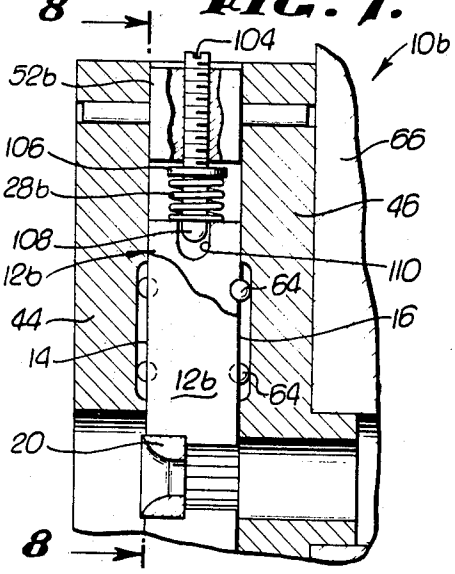
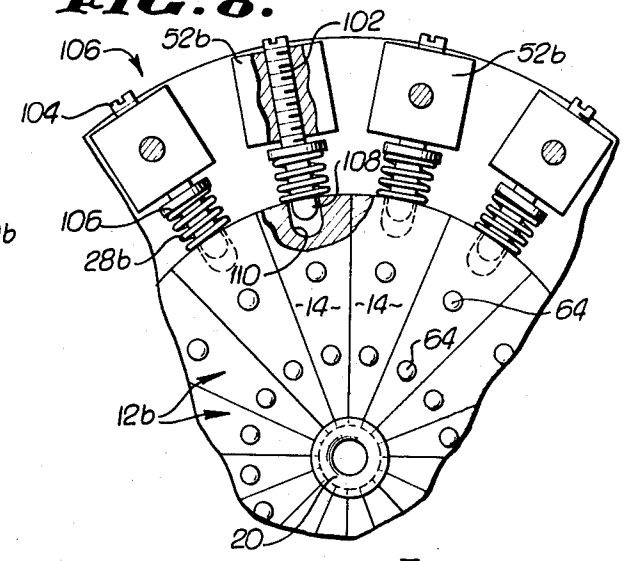


FIG. 8.



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Nov. 17, 1970 J. W. HINSHAW 3,540,259

SEGMENTED DIE HOLDER FOR DRAWING APPARATUS

Filed Aug. 20, 1968 3 Sheets-Sheet 3

FIG. 9.

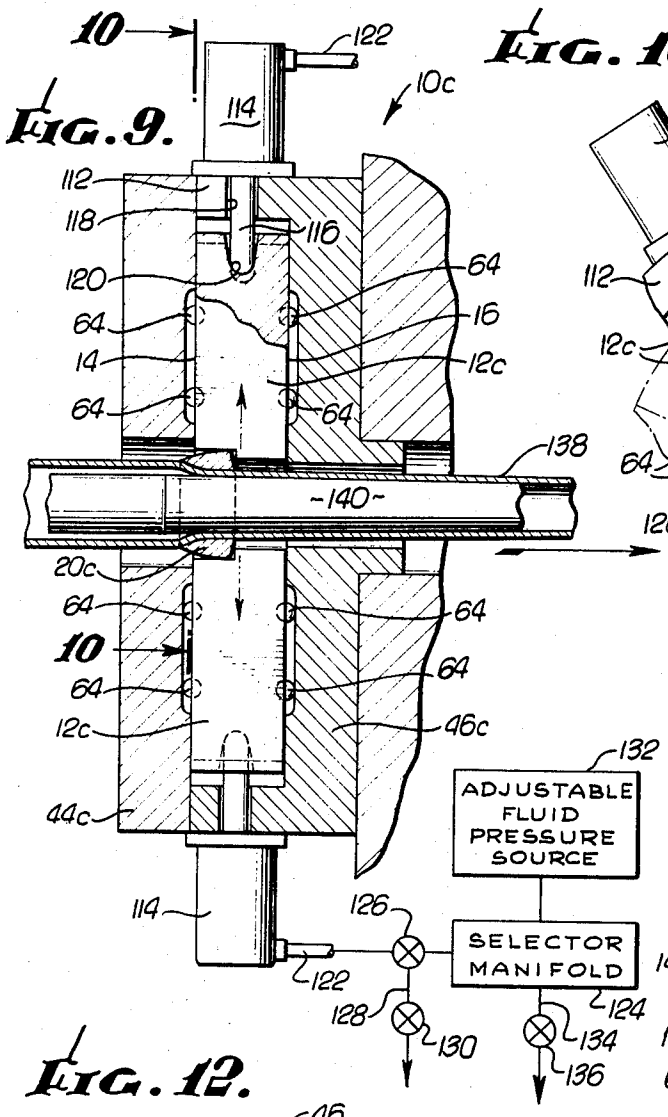


FIG. 10.

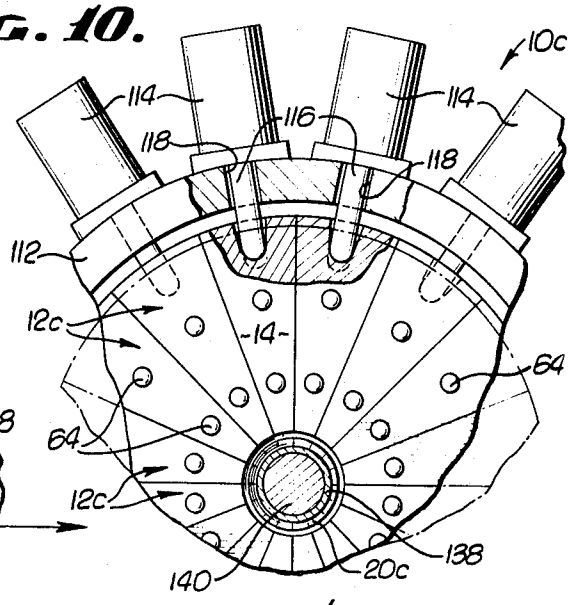


FIG. 11.

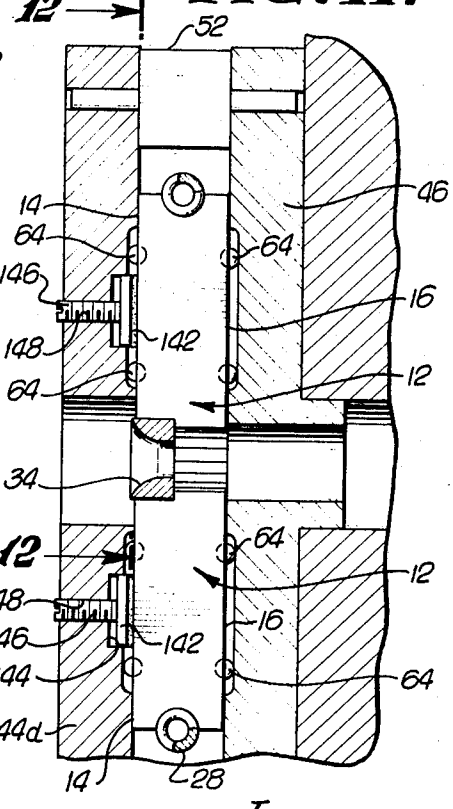
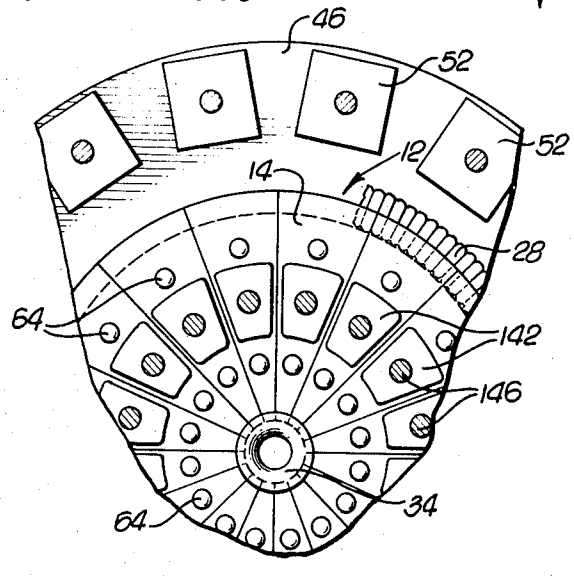


FIG. 12.



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United States Patent Office 3,540,259 Patented Nov. 17, 1970

3,540,259

SEGMENTED DIE HOLDER FOR DRAWING APPARATUS

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Filed Aug. 20, 1968, Ser. No. 753,988
Int. Cl. B21c 3/12
U.S. Cl. 72—465 18 Claims

ABSTRACT OF THE DISCLOSURE

A segmented die holder comprising a symmetrical annular array of three or more holder segments which support a drawing die ring of solid material coaxially therein. The segments are supported and guided for either collective or selective radial expansion and contraction between a pair of parallel plate surfaces arranged normal to the drawing axis, and serve to provide control of the effective working strength of the die ring relative to the workpiece, to reduce the amount of die ring material required, to reduce friction between die ring and seat, and to maintain proper die ring alignment.

BACKGROUND OF THE INVENTION

Tube drawing, including such phases thereof as tube sinking, tube wall sizing, and tube tapering, is generally accomplished on a drawbench by drawing the tubing through a die ring of solid metal. In some types of tube drawing, as for example in tube tapering, this die ring must be variable as to its internal diameter, being either expansible or contractable, or both.

Such tube drawing involves the application of relatively large axial forces on the die ring, and accordingly a die seat must be provided on the drawbench which is capable of holding the die ring in alignment with the tubing and also capable of supporting the die ring against such axial forces. Typically, in the prior art such die ring seats were in the form of a rigid, heavy ring or plate for backing up the die, the ring or plate being apertured for passage of the tube therethrough after the tube passed through the die. Frequently such prior art solid, apertured die holders were counterbored at the forward face thereof for seating of the die in a fixed position relative to the die holder.

A problem encountered in the use of such solid die holders is that it was difficult to accurately align the die with the workpiece so as to assure uniform deformation of the workpiece during the drawing operation. Any misalignment occurring between the die ring and the die holder, or between the die holder and the drawbench, results in imperfect centering of the die relative to the workpiece, with a consequent likelihood of improper deformation of the workpiece. With such prior art solid die seats, once the drawing operation is commenced and substantial axial forces are applied between the die ring and die holder, the friction between the die ring and holder precludes any substantial self-centering action, so that an off-center condition will usually remain during the entire drawing operation. Normally such drawing operations are accomplished on a horizontal drawbench, whereby the force of gravity on the die ring or die holder, or both, tends to establish an off-center initial condition.

The foregoing problems become much more severe, and additional problems arise, where the die ring is variable in size, as for example where the die ring is employed to draw a cylindrical tube into a tapered configuration over a tapered mandrel. In this case, the die ring must usually expand, or must sometimes contract, and such expansion or contraction is opposed and retarded by varying amounts of frictional force between the die ring and the die holder seat, which results in an unpredictable amount of confining force of the die on the workpiece, and a further tendency toward misalignment between the die and the workpiece.

A major problem in the use of a variable die ring of solid material is in maintaining the strength of the die relative to the workpiece throughout the changing configurations required. The die must remain sufficiently strong to deform the workpiece, as required, but it must on the other hand be sufficiently weak to be deformed by the workpiece when a change in die configuration is required. The resistance of the die and of the workpiece to deformation will vary a great deal during the operation, yet the relative strengths must be maintained within certain ranges required to perform the specified deformations.

The operator has very little control over the strength and physical properties of the workpiece, as these are generally determined by the type of material in the workpiece, its past metallurgical history, and the shape to be achieved. Similarly, the operator has very little control over the strength and physical properties of the die during the deformation process. The operator can exercise a certain amount of control through the selection of die material and the preparation of the die; however, once the die begins to deform, the properties of the die are changed by cold working and a number of variables enter the picture which the operator cannot control. The conventional die holder in no way assists the operator to control the constricting force of the die as the physical properties of the die and workpiece, and hence the relative strengths thereof, vary during the drawing operation.

Another problem in connection with conventional support means for variable tube drawing dies is that such support means did not, except for the uncertain forces of friction discussed above, assist the die ring in its constrictive force on the tube being drawn. The result was that an undesirably large mass of die material frequently had to be employed to provide the required amount of constricting force for the particular tube drawing job. This resulted in undesirably large costs for the die material and for reforming the die material into a new die where possible, and resulted in increased effects of work hardening and consequent changes in the physical properties of the die material during the drawing operation.

A still further problem in connection with prior art drawing die supports is that they did not provide for the selective increase or decrease of radially inwardly directed supporting forces at different points around the periphery of the die, and accordingly permitted only minimum variations from round of the cross-sectional tube shapes that could be drawn thereby.

One prior art attempt to solve some of the foregoing problems is disclosed in my U.S. Pat. No. 3,327,513, issued June 27, 1967, for Method and Apparatus for Working Metal, wherein a die holder for a variable tube drawing die is shown which consists of a pair of semicircular holder segments within which the variable die is seated, the segments being biased toward each other by means of a spring loop disposed thereabout, and the segments being backed up by a solid end plate. While such two-segment die holder was expansible, it nevertheless failed to solve most of the foregoing problems because friction of these two segments against the solid backup plate prevented free expansion thereof, the expansion when it did occur was not uniform, the two segments sometimes opening up only at one side, and in general opening in an irregular manner, and the semicircular ID of the two-segment holder allowing expansion and contraction thereof only normal

to the plane of separation of the two semicircular segments, but not in the direction of such plane of separation.

SUMMARY OF THE INVENTION

In view of these and other problems in the art, it is an object of the present invention to provide a holder for supporting a solid die ring employed for drawing tubing or other elongated members, the holder comprising a symmetrical annular array of generally wedge-shaped segments supporting the die ring coaxially therein, the segments being supported and guided for either collective or selective radial expansion and contraction so as to hold the die ring in correct axial alignment and back up the ring in the radial direction, while at the same time adjusting to variations in the diameter of the die ring.

Another object of the invention is to provide a segmented die holder of the character described which includes biasing means peripherally arranged about the annular array of die holder segments for collectively biasing the segments radially inwardly against the die ring so so as to provide a self-centering action whereby the die ring will at all times be firmly held in the holder segments during an entire drawing operation, while at the same time the die ring is allowed to automatically seek and adjust to a centered or axially aligned position with respect to the workpiece and drawbench.

Another object of the invention is to provide a segmented die holder of the character described which includes adjustable means for applying radially inwardly directed constricting force to the wedge-shaped die holder segmentes which supplements the constricting force of the die ring itself against the workpiece, thereby allowing the use of die rings containing a much smaller mass of metal than otherwise required, and providing the operator with a wide latitude of control over the overall effective constricting force of the die against the workpiece, allowing the operator to maintain the required effective strength of the die during an entire drawing operation despite changes which occur in the physical properties of both the die and the workpiece because of cold working and other factors.

Another object of the invention is to provide a segmented die holder of the character described which includes means for individually adjusting the radially inwardly directed constricting forces of the holder segments against the die ring, whereby by selectively increasing or decreasing the radially inwardly directed supporting forces at different points around the periphery of the die ring a wide variety of cross-sectional tube shapes can be drawn.

A still further object of the invention is to provide a segmented die holder of the character described which, by being expansible or contractable according to expansion and contraction of the die ring supported therein, greatly reduces or substantially eliminates the heretofore generally unpredictable and variable frictional forces between the die ring and die holder seat, thereby permitting more accurate alignment between the die and the workpiece, and more accurate operator control over the overall constricting force of the die against the workpieec.

Further objects and advantages of this invention will appear during the course of the following part of this specification, wherein the details of construction and mode of operation of several preferred embodiments are described with reference to the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial sectional view illustrating a first form of segmented die holder according to the present invention, with a solid die ring supported therein.

FIG. 2 is a fragmentary transverse section taken on the line **2—2** in FIG. 1.

FIG. 3 is a fragmentary transverse section taken on the line **3—3** in FIG. 1.

FIG. 4 is an enlarged perspective view illustrating one of the die holder segments employed in the form of the invention shown in FIGS. 1 to 3.

FIG. 5 is an axial sectional view illustrating a second form of segmented die holder according to the invention, with pressure control means therefor diagrammatically illustrated.

FIG. 6 is a fragmentary transverse section taken on the line **6—6** in FIG. 5.

FIG. 7 is a fragmentary axial section, partly in elevation, illustrating a third form of segmented die holder according to the invention.

FIG. 8 is a fragmentary transverse section taken on the line **8—8** in FIG. 7.

FIG. 9 is an axial section, partly in elevation, illustrating a fourth form of segmented die holder according to the invention, with pressure control means therefor illustrated diagrammatically, the die and die holder being illustrated in FIG. 9 in partially expanded positions during the drawing of a tapered tube.

FIG. 10 is a fragmentary transverse section taken on the line **10—10** in FIG. 9.

FIG. 11 is a fragmentary axial section illustrating a fifth form of segmented die holder according to the invention.

FIGURE 12 is a fragmentary transverse section taken on the line **12—12** in FIGURE 11.

DETAILED DESCRIPTION

Referring to the drawings, and at first to FIGS. 1 to 4 thereof, these figures illustrate a first form of die holder according to the invention, which is generally designated **10**. The die holder **10** includes a symmetrical annular array of generally wedge-shaped holder segments **12**. At least three of the wedge-shaped segments **12** are employed, and preferably a larger number, since the greater the number of segments **12** that are employed the smaller the spacing between adjacent segments and the more complete the confining action of the segments on the die ring as the die ring expands. The die holder **10** shown in FIGS. 1 to 4 includes sixteen of the wedge-shaped segments **12**, which has been found to be an adequate number of segments for most purposes.

Each of the wedge-shaped segments **12** has generally flat, substantially parallel front and rear surfaces **14** and **16**, respectively, and a pair of flat side surfaces **18** which are substantially normal to the front and rear surfaces **14** and **16**, the side surfaces **18** being located in planes which intersect at an included angle equal to 360° divided by the number of segments. Thus, the angle between the side surfaces **18** for each segment where the minimum number of three segments is employed equals 360° divided by 3, or 120°. If sixteen of the segments **12** are employed as shown in the drawings, the included angle between side surfaces **18** will be 360° divided by 16 or 22½°.

With the segments **12** in their fully constricted or closed relationship as illustrated in FIGS. 1 and 2, wherein adjacent side surfaces **18** of the segments are flush against each other, the segments **12** collectively define a generally continuous, closed annular inner surface of stepped configuration having forward and rearward cylindrical surface portions **20** and **22** separated by a forwardly facing annular shoulder **24** which serves as the die seat.

When the die segments **12** are thus in their constricted or closed relationship as shown in FIGS. 1 and 2, their outer or larger ends collectively define a generally cylindrical, continuous annular outer surface **25**, the surface **25** having an annular groove centrally located therein which is of generally semicircular cross-section. A spring loop **28** is circumferentially engaged about the segments **12** and is seated in the annular groove **26**, spring loop **28** comprising a spiral or helical type spring which is closed to a generally torus-shaped configuration.

Spring loop **28** is a tension spring which applies a constricting or closing force collectively against all of the segments **12**.

Each of the segments **12** has a pair of generally hemispherical, radially spaced ball recesses **30** and **32** located in each of the sides **14** and **16** thereof. The ball recesses **30** and **32** are preferably substantially centered relative to a plane which bisects the angle included between the planes of the two side surfaces **18** of each segment **12**.

FIGS. 1 and 2 illustrate a die ring of solid material supported coaxially within the annular array of die segments **12**. The die ring **34** as illustrated in FIGS. 1 and 2 is in its initial, unexpanded condition, and in such condition its outer cylindrical surface **36** has a diameter which is substantially equal to the closed diameter of the forward inner surface portion **20** collectively defined by the holder segments **12**. Die ring **34** also includes a curved, forwardly flaring inner working surface **38** extending from leading edge **40** to a generally flat annular rear surface **42** which seats against the die segment shoulder **24** adjacent the outer cylindrical surface **36** of the die.

The die segments **12** are supported for individual and collective radial shifting movement thereof between front and rear support plates **44** and **46**, respectively, which have spaced, opposed, parallel plate surfaces **48** and **50** between which the segments **12** are located. The support plate surfaces **48** and **50** are spaced apart slightly more than the thickness of the segments **12** between their front and rear surfaces **14** and **16**, respectively, by means of a series of spacer blocks **52** interposed between the plates **44** and **46** in regularly spaced arrangements about the periphery of the die holder **10** radially outwardly of the segments **12** and spring loops **28**. Each of the spacer blocks **52** has pins **54** projecting outwardly therefrom which extend into holes **56** in support plates **44** and **46**, whereby the plates **44** and **46** and the spacer blocks **52** are maintained in proper alignment. Suitable fastener means (not shown in FIGS. 1 to 4) may be employed to secure the support plates **44** and **46**, spacer blocks **52** and die holder segments **12** in axially stacked relationship as illustrated in FIG. 1.

The support plates **44** and **46** have respective apertures **58** and **60** extending axially therethrough, the apertures **58** and **60** being substantially larger in diameter than the initial ID of the die ring **34** so as to allow the unobstructed passage therethrough of a tube or other elongated member that is being drawn through the die ring **34**. In a typical tube drawing operation, as for example in tube sinking, a tube will be drawn from left to right as viewed in FIG. 1 through the die **34**, and as the tube passes through the die **34** it will be reduced substantially in diameter. Accordingly, the diameter of aperture **58** in the front plate **44** is somewhat larger than the diameter of aperture **60** in the rear plate **46**.

The support plates **44** and **46** each have an annular array of regularly spaced, radially directed ball-receiving grooves in their respective opposed surfaces **48** and **50**. The number of these radial grooves **62** in each of the plate surfaces **48** and **50** is equal to the number of wedge-shaped die holder segments **12**. Thus, for example, if there are three of the die holder segments **12**, there will likewise be three of the regularly spaced, radially directed grooves **62** in each of the plate surfaces **48** and **50**. Similarly, as illustrated in FIGS. 1 to 4 of the drawings, where there are sixteen of the segments **12**, then there will likewise be sixteen of the regularly spaced, radially directed grooves **62** in each of the plate surfaces **48** and **50**. The support plates **44** and **46** are rotationally oriented so that each of the grooves **62** in one plate will be aligned with a corresponding groove **62** in the other plate; i.e., such corresponding grooves will lie in a common plane extending through the axis of the holder.

A ball bearing **64** is seated in each of the ball recesses **30** and **32** in each die segment **12**, and these ball bearings **64** ride in the radial grooves **62** in the plate surfaces **44** and **46** as best illustrated in FIG. 1. Thus, each of the wedge-shaped segments **12** is supported for freely floating radial shifting movement on four ball bearings **64** as best shown in FIG. 1. By this means the die ring **34** is allowed to automatically seek and maintain correct alignment with the workpiece so that it will apply substantially uniform constrictive force to the workpiece about its annulus, and a predetermined amount of constrictive force is added to the constrictive force of the die ring **34** itself by the force of spring loop **28** applied to the die ring **34** through the wedge-shaped segments **12**. If the die ring **34** is intended to vary in diameter during the drawing operation, as for example where a tube is being drawn against a tapered mandrel, then the holder segments **12** will shift radially outwardly to accommodate such enlargement of the die ring **34**, and such radial outward shifting of the segments **12** will not be opposed by any substantial friction, but only by the constraining force of the spring loop **28**. Similarly, since the segments **12** expand outwardly with the die ring **34**, there will be no substantial opposing friction from engagement of the die ring **34** against the seat shoulder **24** in the segments. Accordingly, there are no substantial variable or undeterminable frictional forces opposing the expansion of the die ring **34**, and all of the forces are predictable.

In normal tube drawing operations the OD of the die ring **34** will not expand more than about 50% from its initial, minimum size as illustrated in FIG. 1, and that amount of expansion will result in separation between the side surfaces **18** of the segments **12** which is barely perceptible, and accordingly the OD of the die ring **34** remains substantially fully confined within the inner surface portion **20** of the segments **12** and substantially fully supported by the shoulder **24** against axial displacement.

The freely floating support arrangement for the wedge-shaped segments **12** allows the segments **12** to shift radially outwardly different relative amounts to accommodate variations from round of the cross-sectional shape of the tube or other elongated structure being drawn. For example, where a tube is drawn over a mandrel having a cross-section that is oblong, hexagonal, square or of other out-of-round configuration, the die ring **34** will be permitted to follow such odd cross-sectional configuration while nevertheless being fully peripherally supported by the inner ends of the segments **12**, since the segments are allowed to freely shift radially relative to each other to accommodate such odd configurations.

The combination of support plates **44** and **46**, ball bearing supported holder segments **12**, spacer blocks **52** and die ring **34** is normally supported on a drawbench in a suitable support body or block **66** having a forwardly facing surface **68** against which the rear support plate **46** seats, and having an axial passage **70** therethough into which the tubular projection or boss **72** on the rear support plate **46** seats.

While ball bearings **64** have been shown and described as being seated in ball recesses in the segments **12** and arranged to ride in grooves **62** in the plate surfaces, it is to be understood that alternatively the balls may be seated in similar recesses in the plate surfaces so as to ride in similar radially oriented grooves in the flat front and rear surfaces of the die segments. While it is preferred to utilize ball bearing guide means to control the radial orientation of the segments **12** while allowing them to shift in the radial direction, it is to be understood that alternatively other guide means may be employed for the same purpose, as for example tongue-and-groove means engageable between the holder segments and holder plates or pin-and-groove means engageable between the holder segments and plates. Additionally, although it is preferred to have such guide means engageable between both the front and rear surfaces **14** and **16** of each segment and the

respective support plates **44** and **46** so as to obtain optimum stability of the segments **12**, nevertheless if desired the ball bearing or other guide means may be provided so as to be operatively engageable between only one surface **14** or **16** of each segment **12** and the corresponding support plate **44** or **46** without departing from the invention.

Referring now to FIGS. 5 and 6 of the drawings, a second form **10***a* of the invention is shown in these figures wherein the annular array of wedge-shaped segments **12***a* is peripherally encased within an annular housing **74** which serves the function of the spacer blocks **52** shown in FIGS. 1 and 2, separating the support plates sufficiently for freedom of radial shifting movement of the segments **12***a*, and which aditionally serves to house a flexible inner tube **76** composed of neoprene or other suitable elastomeric material which is coupled through a suitable conduit **78** to an adjustable fluid pressure source **80** diagrammatically shown in FIG. 5. The adjustable pressure source **80** may furnish any suitable pressurizing fluid, either liquid or gas, i.e., either hydraulic or pneumatic, according to the requirements of any particular drawing operation. Thus, where relatively low pressure is all that is required, a pneumatic pressure source will be suitable; while a hydraulic fluid pressure source will be required if high pressures are desired.

The housing **74** defines an inwardly facing annular groove **82** of rounded cross-section within which the radially outwardly facing half of the inner tube **76** seats; while the radially inwardly facing part of inner tube **76** seats in an opposed, radially outwardly facing annular channel **84** of rounded cross-section. In order to keep the inner tube **76** fully enclosed within the housing **74** despite radial contraction and expansion of the annular array of wedge-shaped segments **12** corresponding to pressure changes within the inner tube **76**, the housing **74** is provided with a pair of parallel, radially inwardly directed annular ribs **86** which extend into a pair of complementary grooves **88** in the outer ends of the segments **12***a*. The complementary housing ribs **86** and segment grooves **88** are of sufficient depth to remain interengaged over the entire range of radial shifting movement of the segments **12***a*, so that the inner tube **76** will at all times be fully confined between the housing and the segments as best illustrated in FIG. 5.

A valve **90** is disposed in fluid conduit **78** for selectively admitting fluid pressure through the line **78** into the inner tube **76** or relieving fluid pressure from inner tube **76** through line **78** and thence out through bleeder line **92** which may have a bleeder valve **94** therein for adjusting the rate of bleed-off from the inner tube **76**. This combination of an adjustable fluid pressure source and valve means to permit bleed-off at any desired rate allows full operator control of the pressure applied to the inner tube **76** and hence of the radially inwardly directed force of the holder segments **12***a* against the die ring **34***a*, thereby allowing operator control over the effective working strength of the die ring relative to the workpiece. At the same time, the flexible nature of the inner tube **76** with either liquid or gas under pressure therein, allows the desired self-aligning action of the die segments.

By employing a pneumatic or gaseous pressure source, the net effect of the radially inwardly directed force of the inner tube **76** on the die segments **12***a* will be that of an adjustable biasing force, or an adjustable spring, since the gas under pressure is resilient. On the other hand, if a hydraulic or liquid fluid pressure source is employed, then the general effect will be of a substantially nonresilient or generally rigid inward force applied to the segments, but nevertheless a force which will be equalized over the entire annular array of holder segments **12***a* so that there will be a measure of resiliency as between the respective segments.

In the embodiment of the invention shown in FIGS. 5 and 6, the fastener means for securing the die holder together is shown in the form of a plurality of bolts **96** which extend through the front support plate **44***a*, housing **74**, rear support plate **46***a* and into support body **66***a*, at spaced intervals around the periphery of the apparatus.

It will be noted in FIG. 5 that the inner surface **20***a* presented by the annular array of holder segments **12***a* is a straight cylindrical surface of non-stepped configuration. In this case, the die ring **34***a* is radially encompassed by this cylindrical surface **20***a*, and the die seat is provided by the flat forward end surface **98** of a die ejector tube **100** which extends from the rear through the openings **70***a* and **22***a* in the support body **66***a* and the rear support **46***a*, respectively. While this die ejector tube **100** has the advantage of providing a convenient means for ejecting the deformed die **34***a* after the latter has been expanded during a tube drawing operation such as a tapering operation, it has the disadvantage of presenting a fixed seat against which the die **34***a* expands, thereby introducing a friction factor to the overall operation that is not present when the stepped die holders **12** of FIGS. 1 to 4 are employed. However, it will be apparent that the stepped die holder like that best shown in FIGS. 1 and 4 may be employed in the general type of die holder apparatus of FIGS. 5 and 6 wherein the inner tube is employed, or that the ejector type of die holder may be employed in the spring biased type of holder mechanism shown in FIGS. 1 to 4, without departing from the invention. Similarly, although the other forms of the invention shown in FIGS. 6 through 12 and hereinafter described are illustrated with die holder segments having the stepped configurations, it is to be understood that the ejector-type arrangement of FIG. 5 may be alternatively employed in these other configurations.

Although the inner tube housing **74** of FIGS. 5 and 6 is of annular configuration when assembled, it may be provided in two or more segments to facilitate assembly of the apparatus.

Referring now to FIGS. 7 and 8 of the drawings, these figures illustrate a third form **10***b* of the invention which is similar in construction to the first form **10** shown in FIGS. 1 through 4, except for the fact that the die holder segments **12***b* are each individually biased radially inwardly by a separate coil compression spring **28***b* which is supported for adjustable compression on a respective jack screw **102**. The jack screws **102** are threadedly engaged through the respective spacer blocks **52***a*, and each have torqueing means such as a screwdriver-receiving slot **104** exposed on the outside of the die holder **10***b* for radial adjustment of the jack screw **102** and consequent adjustment of the compressive force of the respective spring **28***b* radially inwardly against the respective holder segment **12***b*. The springs **28***b* are each compressed between a flange **106** on the respective jack screw **102** and the outer end of the respective holder segment **12***b*. The inner end portion **108** of each jack screw **102** is slidably engaged within an axial recess **110** in the outer end of the respective segment **12***b* to retain the jack screw **102** and compression spring **28***b* properly radially oriented relative to the respective holder segment **12***b*.

The jack screw type of adjustment provided in the third form of the invention illustrated in FIGS. 7 and 8 allows selective individual adjustment of the supporting force of each die holder segment **12***b* against the periphery of the die **20** to accommodate drawing operations wherein the elongated structure being drawn will vary from round. On the other hand, the jack screws can be collectively adjusted to all apply substantially the same radially inwardly directed force against their respective die holder segments **12***b* so as to apply a uniform peripheral force against the die **20**, and such inward force can be adjusted by adjustment of all of the jack screws the same amount.

Despite the aforesaid individual or collective adjustment of the jack screws **102**, by applying the adjustable forces on the segments **12***b* through compression springs

28*b* the die holder will have a self-centering action similar to that of the first form of the invention shown in FIGS. 1 to 4 and the second form of the invention shown in FIGS. 5 and 6.

FIGS. 9 and 10 illustrate a fourth form of the invention which is similar to the third form shown in FIGS. 7 and 8 in that the die holder segments **12***c* may be individually adjusted for application of varying inward forces upon the die **20***c*, but which differs from the third form of FIGS. 7 and 8 by employing fluid pressure actuation means instead of strictly mechanical means for applying the radially inwardly directed forces to the die holder segments **12***c*.

Thus, in the fourth form **10***c* shown in FIGS. 9 and 10, the die holder segments **12***c* are ball-bearing supported for floating radial movement between front and rear support plates **44***c* and **46***c*, respectively, and instead of employing spacer blocks, the rear support plate **46***c* has an integral, forwardly directed cylindrical peripheral flange **112** thereon. Each of the die holder segments **12***c* is provided with an individual fluid pressure actuated cylinder **114** which is supported on the outside of flange **112** and has a plunger **116** which projects radially inwardly through a respective hole **118** in flange **112** and has a rounded inner end which seats in a complementary rounded cup **120** in the outer end of the respective die holder segment **12***c*.

Single-acting cylinders **114** will normally be sufficient for the present purpose, and each of the cylinders **114** is supplied with fluid under pressure through a respective individual supply conduit **122**, these supply conduits **122** each communicating with a common selector manifold **124** through a respective valve **126** which in one position will allow fluid pressure from the selector manifold **124** to pass through conduit **122** to the respective cylinder **114**, and in its other position will allow bleed-off of fluid pressure from the respective cylinder **114** through conduit **122** and thence out through bleeder line **128** and bleed control valve **130**.

The selector manifold **124** is supplied with fluid under pressure from an adjustable fluid pressure source **132**, and the selector manifold is operable to supply fluid pressure collectively to all of the cylinders **114**, or selectively to any number of the cylinders **114**.

The fluid pressure can be collectively relieved from the cylinders **114** through selector manifold bleeder line **134** as controlled by bleed control valve **136** therein.

It will thus be seen that the fourth form of the invention illustrated in FIGS. 9 and 10 of the drawings is similar to the second form shown in FIGS. 5 and 6 in that both of these forms provide for collective fluid pressure control of the radially inwardly directed forces of the die holder segments against the die, which control allows for self-centering of the die relative to the workpiece. The fourth form of FIGS. 9 and 10 is likewise similar to the second form of FIGS. 5 and 6 in that when the fluid pressure is gaseous or pneumatic the holder segments are resiliently biased against the die ring, whereas with liquid or hydraulic fluid pressure which is substantially incompressible the die segments are more rigidly held in position, although collectively shiftable for self-alignment.

However, the fourth form of FIGS. 9 and 10, by employing individual fluid pressure actuated cylinders **114**, permits selective individual control of the radially inwardly directed forces of the respective die holder segments against the die, which cannot be achieved in the second form of the invention shown in FIGS. 5 and 6.

In FIGS. 9 and 10 the die holder apparatus has been illustrated in an expanded condition wherein the die holder segments **12***c* have been shifted radially outwardly from their innermost positions illustrated in phantom lines to outer positions illustrated in full lines as a result of drawing a tube **138** over a tapered mandrel **140** so as to give the tube **138** a tapered configuration. The solid die ring **20***c* is shown in the approximate configuration it will have after such a tapering operation, the die **20***c* having an initial size and configuration corresponding substantially to that of the die **20** shown in FIGS. 1 and 2. The die ring and die holder segments have been illustrated in this expanded condition in FIGS. 9 and 10 to show that even after such expansion the wedge-shaped die holder segments are still quite closely spaced, with very little clearance therebetween, so that they still substantially completely circumscribe the die ring and provide substantially complete circumferential support to the solid die ring therein.

FIGS. 11 and 12 illustrate a fifth form of the invention which is the same in all respects as the first form shown in FIGS. 1 to 4 except for the addition of a series of brake pads **142** mounted in complementary recesses **144** in the front support plate **44***d*. One brake pad **142** is provided for each of the die holder segments **12**, the brake pads **142** being frictionally engageable against the front surfaces **14** of the respective segments **12** so as to resist expansion of the die holder segments. The magnitude of this frictional force on each die holder segment **12**, which in turn results in a radially inwardly directed constricting force on the die ring **34**, is adjustable by means of an adjusting screw **146** engaged in a threaded bore **148** extending through the front support plate **44***d*.

It will be apparent that appropriate manipulation of the adjusting screws **146** will permit either individual or collective adjustment of the radially inwardly directed constricting force of the die holder segments **12** on the solid ring **34**.

While the instant invention has been shown and described herein in what are conceived to be the most practical and preferred embodiments, it is recognized that departures may be made therefrom within the scope of the invention, which is therefore not to be limited to the details disclosed herein, but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

I claim:

1. Apparatus for holding a drawing die ring which comprises an annular array of at least three generally wedge-shaped segments which define generally radially inwardly directed surface means peripherally engageable about the drawing ring to support the ring generally coaxially between the segments, said segments being radially shiftable between a contracted position and an expanded position, and force-applying means engageable with said segments opposing movement of the segments from said contracted position toward said expanded position.

2. Apparatus as defined in claim **1**, which includes a pair of spaced, opposed, generally flat support surfaces arranged generally normal to the axis of said annular array of segments between which said segments are disposed, said surfaces at least partially confining the segments in the axial direction and being spaced apart slightly more than the axial thickness of the segments to permit free sliding movement of the segments in the radial direction.

3. Apparatus as defined in claim **2**, which includes guide means engageable between each of said segments and at least one of said support surfaces, said guide means maintaining said segments generally radially oriented and guiding the segments in their shifting movement in generally radial paths.

4. Apparatus as defined in claim **3**, wherein said guide means includes ball bearing means engageable between both of said support surfaces and each of said segments.

5. Apparatus as defined in claim **1**, wherein said inwardly directed surface means defined by said segments is of stepped configuration, presenting an axially facing shoulder against which said die ring seats during a drawing operation.

6. Apparatus as defined in claim **1**, wherein said force-applying means comprises spring means peripherally en-

gaged with each of said segments so as to bias the segments radially inwardly toward said contracted position.

7. Apparatus as defined in claim 6, wherein said spring means comprises a tension spring loop peripherally engaged about said annular array of segments.

8. Apparatus as defined in claim 6, wherein said spring means comprises a separate spring member peripherally engaged against each of said segments, and adjustable support means for each of said springs permitting independent adjustment of the radially inwardly directed force of each spring against its respective segment.

9. Apparatus as defined in claim 1, wherein said force-applying means comprises fluid pressure actuated means peripherally engaged with each of said segments and selectively operable to apply radially inwardly directed force to said segments.

10. Apparatus as defined in claim 9, wherein said fluid pressure actuated means comprises housing means peripherally arranged about said annular array of segments, flexible inner tube means peripherally disposed about said annular array of segments within said housing, and means connected to said inner tube means for introducing fluid pressure therein.

11. Apparatus as defined in claim 9, wherein said fluid pressure actuated means comprises a separate fluid pressure responsive device peripherally engaged against each of said segments, and fluid pressure supply means connected to each of said fluid pressure responsive devices for selectively actuating said devices both collectively and independently.

12. Apparatus as defined in claim 11, wherein said fluid pressure responsive devices are hydraulic cylinders each having a generally radially oriented plunger engageable against a respective segment.

13. Apparatus as defined in claim 1, wherein said force-applying means comprises a separate brake pad member generally axially engageable with each of said segments, and adjustable support means for each of said brake pad members permitting independent adjustment of each brake pad member in the axial direction.

14. Apparatus as defined in claim 1, wherein the summation of the included angles of the wedges is approximately 360°, whereby said wedges form a generally closed ring in said contracted position.

15. Apparatus as defined in claim 1, which includes approximately sixteen of said segments.

16. Apparatus as defined in claim 9, wherein said fluid pressure actuated means is hydraulically actuated.

17. Apparatus as defined in claim 9, wherein said fluid pressure actuated means is pneumatically actuated.

18. Apparatus as defined in claim 1, wherein said annular array of segments has front and rear sides in the axial direction, said apparatus including support means on at least said rear side of the segments and having a passage therethrough arranged generally coaxially of the segments, and an ejector tube slidably mounted in said passage and having a front end defining an axially facing annular shoulder, said ejector tube being slidable between a retracted drawing position wherein said shoulder is proximate said rear side of the segments and serves as a seat against which said die ring abuts during a drawing operation, and an extended ejection position wherein said shoulder is shifted forwardly at least part way through said inwardly directed surface means defined between the segments so as to eject the die ring forwardly from between the segments upon completion of a drawing operation.

References Cited

UNITED STATES PATENTS

712,974	11/1902	Smith	72—465
1,735,850	11/1929	Boedeker	72—285
2,294,138	8/1942	Strock	72—467
2,413,595	12/1946	Wiser	72—468
3,213,663	10/1965	Coan	72—468
3,327,513	6/1967	Hinshaw	72—274

FOREIGN PATENTS

1,131,174	6/1962	Germany.

LOYELL A. LARSON, Primary Examiner

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72—285, 467