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Verduzco et al.

[11] **3,918,288**

[45] **Nov. 11, 1975**

[54] **DIE**

[75] Inventors: **Miguel A. Verduzco**, Chicago; **James W. Dally**, Park Forest, both of Ill.

[73] Assignee: **LaSalle Steel Company**, Hammond, Ind.

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[21] Appl. No.: **62,255**

[52] **U.S. Cl.** ..... **72/467**; 76/107 A

[51] **Int. Cl.**[2] **B21C 3/00**

[58] **Field of Search** ..... 72/467; 76/107 A; 29/447

[56] **References Cited**

UNITED STATES PATENTS

2,349,652	5/1944	Fenner	72/467
2,647,847	8/1953	Black	29/447
3,014,583	12/1961	Huffman	72/467 X
3,360,846	1/1968	Schellstede	29/447

Primary Examiner—C. W. Lanham

Assistant Examiner—Robert M. Rogers

[57] **ABSTRACT**

This invention is addressed to a new and improved die for use in extrusion and drawing operations which includes an annular casing, a die nib which is shrunk fit into a central opening in the casing and means exerting a compressive force on the die nib in the axial direction whereby the die nib is subject to both radial and axial compressive stresses.

1 Claim, 10 Drawing Figures

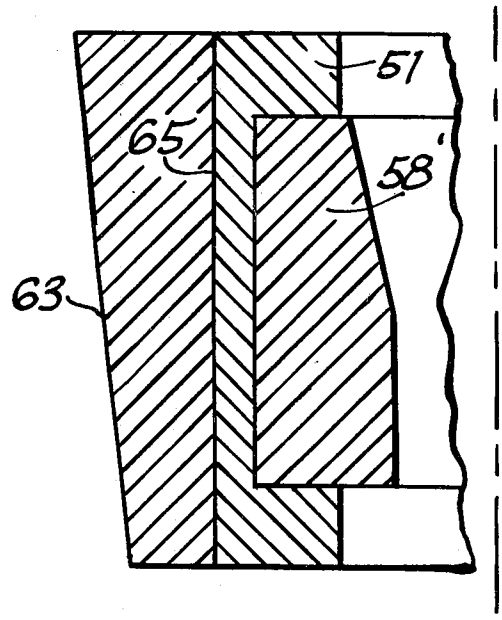


FIG. 1

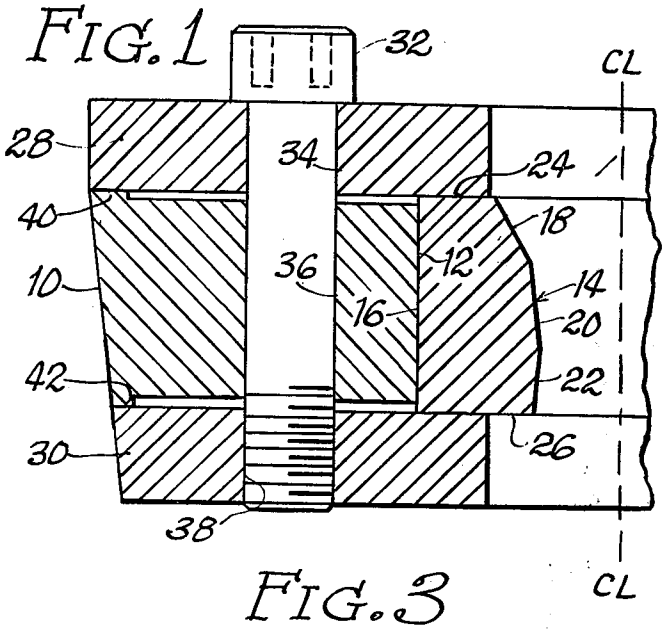


FIG. 2

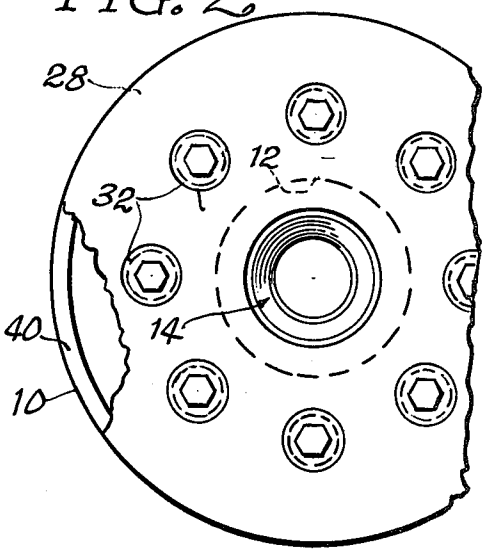


FIG. 3

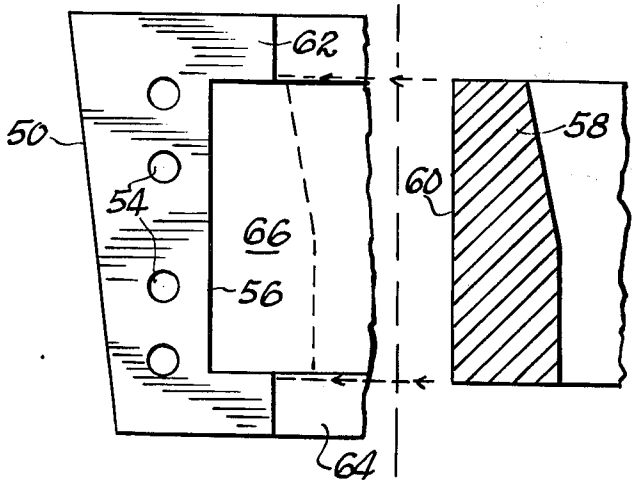


FIG. 4

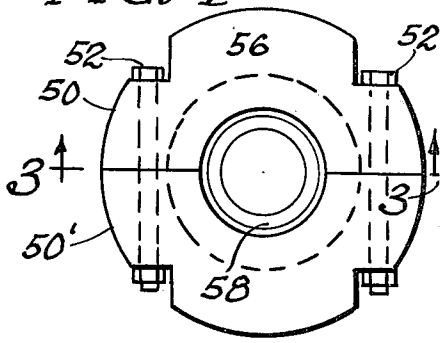
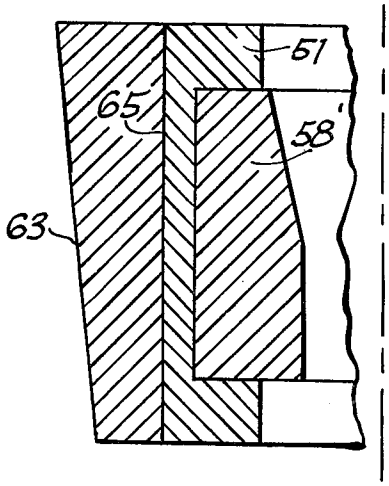


FIG. 5



INVENTORS
Miguel A. Verduzco
James W. Dally
by McDougall, Hersh
and Scott Attys

FIG. 6

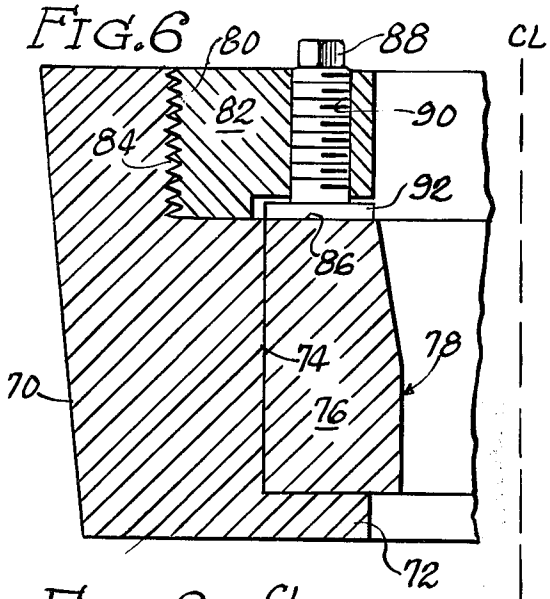


FIG. 7

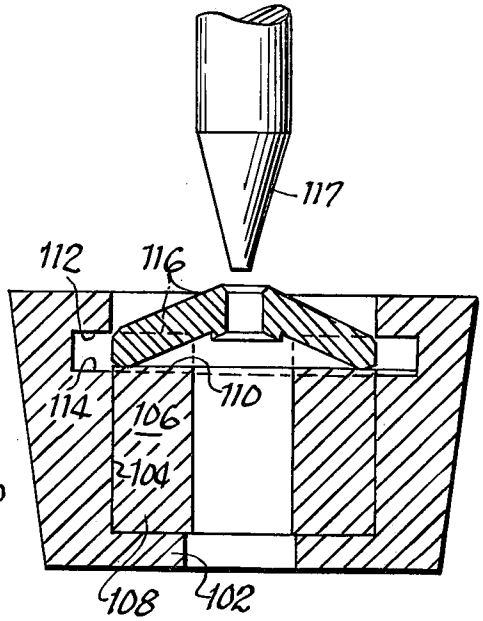


FIG. 8

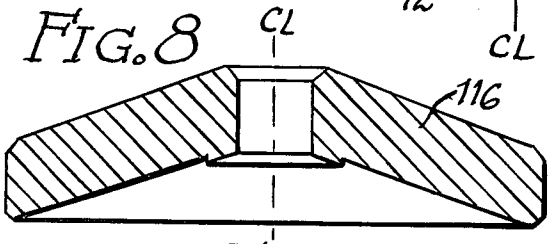


FIG. 9

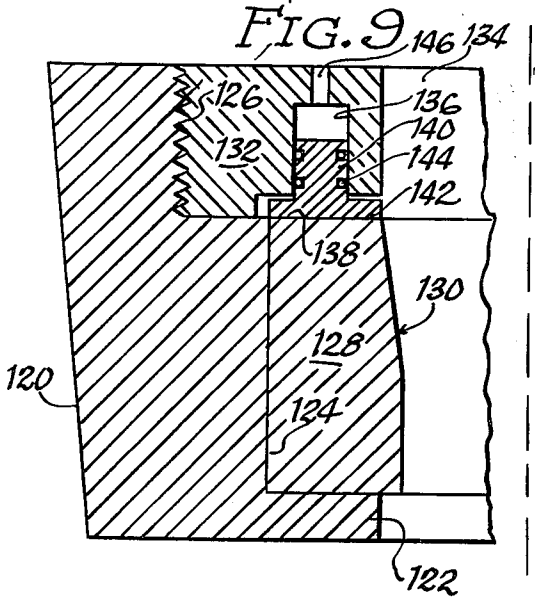
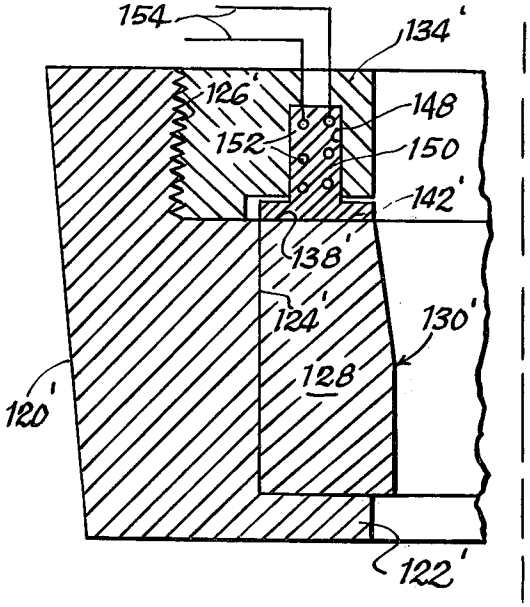


FIG. 10



DIE

This invention relates to drawing and extrusion dies, and more particularly to drawing and extrusion dies which are radially and axially prestressed.

In cold drawing operations, it has been common practice for many years to make use of compound dies with the work section of the die, often referred to in the art as the nib, formed of a hard brittle material such as tungsten carbide, shrunk into a metal casing. Such casings are usually formed of an annular piece of metal with the central opening being dimensioned slightly less than the outer dimension of the nib. Thus, the casing is heated to a temperature sufficient to cause expansion of the casing whereby the nib can be inserted into the central opening. As the metal casing cools, it contracts, thereby subjecting the nib in the central opening thereof to relatively high compressive stresses in a radial direction.

The compressive stresses developed in the radial direction of the nib during the shrinkage described above serve to prevent failure of the die by crack propagation along a plane perpendicular to the circumferential direction.

However, experience in cold and warm drawing and extrusion operations has indicated that radially prestressed dies may also fail by fracture along a plane perpendicular to the axial direction. Such failures can become a serious problem in drawing and extrusion, particularly during warm drawing and/or extrusion operations in which the effect of temperature combined with excessive drawing or extrusion stresses results in a high incidence of die failure.

Photoelastic stress analyses of drawing dies have shown that large tensile stresses develop at the entrance of the die, and at transitions in geometry along the die contour. Without limiting the present invention as to theory, it is believed that these stresses are related to failure and accelerated wear of dies. In addition, it has been found that thermal shocks can be developed on the surface of the die in the course of warm drawing and extrusion operations. Thus, is is believed that the combined effect of thermal shocks and drawing or extrusion stresses is at least in part responsible for crack propagation, and hence die failure.

In accordance with the present invention, it has been found that die failure and acceleratered die wear can be prevented or substantially minimized by means of radially and axially prestressed dies.

Radially and axially prestressed dies are known to the prior art as represented by U.S. Pat. No. 3,248,972. However, in the die disclosed in this patent, the axial stresses which can be developed are somewhat limited by the geometry of the die and casing assembly, such that only limited advantages can be derived, particularly during warm drawing or extrusion operations. In addition, the prestressed die disclosed by this patent has a relatively complex geometry which contributes undesirably to manufacturing costs and to ease of assembly.

It is accordingly an object of the present invention to provide a new and improved prestressed die which overcomes the foregoing disadvantages.

It is a more specific object of the invention to provide a radially and axially prestressed die which prevents or substantially minimizes die failure and/or accelerated die wear, even during warm extrusion and drawing operations.

It is yet another object of the invention to provide a radially and axially pre-stressed die in which use is made of mechanically and/or thermally induced stress.

These and other objects and advantages of the invention will appear hereinafter, and, for purposes of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawings in which:

FIG. **1** is a schematic sectional view on one side of the axis of symmetry of a die embodying the features of the invention;

FIG. **2** is a top view of the die illustrated in FIG. **1**;

FIG. **3** is an exploded schematic sectional view of another embodiment of the invention taken along one side of the axis of symmetry;

FIG. **4** is a top view of the die illustrated in FIG. **3**;

FIG. **5** is an alternative embodiment to that shown in FIGS. **3** and **4**;

FIG. **6** is a schematic sectional view of yet another embodiment of the invention on one side of the axis of symmetry;

FIG. **7** is a schematic sectional view of another embodiment of the invention on both sides of the axis of symmetry;

FIG. **8** is a partial sectional view on both sides of the axis of symmetry of the stressing ring element of the embodiment of FIG. **6**;

FIG. **9** is a schematic sectional view of another embodiment of the invention in which use is made of hydraulic pressure to induce axial stress in the die; and,

FIG. **10** is a schematic sectional view of another embodiment of the invention similar to that shown in FIG. **8** in which use is made of thermal means to induce axial stress in the die.

The concepts of the invention reside in a die comprising an annular casing and a die nib shrunk fit into the central opening of the casing which gives rise to the desired radial prestressing of the nib. Axial prestress of the nib can be induced through mechanical and/or thermal means in a simple and efficient manner whereby die failure and/or accelerated die wear can be prevented or substantially minimized.

Referring now to the drawings, there is shown in FIG. **1** one embodiment of the invention in which use is made of mechanically and thermally induced stress in the axial direction. The die schematically illustrated in FIG. **1** is shown only on one side of the axis of symmetry or center line CL for the sake of simplicity, with the understanding that the cross section of the die on the other side of the axis of symmetry is identical.

The die comprises an annular casing including an annular body **10** defining a substantially cylindrical central opening or bore **12** adapted to receive in a shrink fitting relationship a nib **14** having a substantially cylindrical outer surface **16** having a diameter slightly larger than the diameter of bore **12** cylindrical abutting the surface of central opening **12.** Nib **14** may have a variety of geometric configurations for effecting drawing or extrusion operations. As shown in FIG. **1,** the nib **14** has an approach surface **18,** a blend surface **20** and a bearing surface **22.** For a more detailed description of the internal geometry of the die nib, reference can be made to U.S. Pat. No. 3,157,274. However, it will be understood by those skilled in the art that a wide variety of other die nibs suitable for the drawing and extru-

sion of metals can similarly be employed in the practice of the present invention.

Nib **14** has an axial dimension which is somewhat greater than the thickness of body **10** whereby the upper and lower portions **24** and **26,** respectively extend axially beyond the body **10.** The nib **14** and casing body **10** are sandwiched between a pair of annular plates **28** and **30,** and secured by means of a plurality of bolts **32** adapted to be thermally prestressed spaced radially about plates **28** and **30** and extending in an axial direction through a bore **34** in plate **28** and bore **36** in body **10.** Bolts **32** may be secured by, for example, means of a threaded bore **38** in lower plate **30.** The spacing of bolts **32** about the plate **28** can best be illustrated by reference to FIG. **2** of the drawings. Thus, it will be apparent that the bolts **32,** as they are tightened, operate to exert a compressive force on the portions **24** and **26** of nib **14** in abutting relation with plates **28** and **30,** respectively, to thereby axially prestress the nib **14.**

In order to insure that the compressive forces exerted by plates **28** and **30** be uniformly distributed over the surfaces of nib **14,** it is preferred that plates **28** and **30** be in as close to a parallel relation as possible when the nib **14** is in a state of compression. For this purpose, it is generally preferred to provide body **10** with a pair of annular flange elements **40** and **42** about the periphery of body **10** to abut the internal surfaces of plates **28** and **30,** respectively.

In assembling the die illustrated in FIG. **1,** body **10** is heated to an elevated temperature sufficient to cause thermal expansion thereof whereby nib **14** can be fitted into the central opening **12** with portions **24** and **26** extending in an axial direction beyond the upper and lower surfaces of body **10,** respectively, as described and shown. Thereafter, the body is allowed to cool, and plates **28** and **30** are positioned, preferably after surfaces **24, 26, 40** and **42** have been ground to remove any oxides formed on these surfaces during the heating operation. Bolts **32** are then heated, threaded in position as shown in FIGS. **1** and **2** and tightened to a predetermined torque.

As bolts **32** cool, they contract thereby subjecting nib **14** to further compressive forces in addition to those developed by the tightening of bolts **32** at an elevated temperature. Thus, the die nib **14** is subjected to radial compression as a result of shrinkage from the first heating step, and to axial compression as a result of the tightening and cooling of bolts **32** in the second step. It has been found that the heating of the body **10** and the bolts **32** should be carried out in separate operations to insure the development of maximum compressive forces.

As will be appreciated by those skilled in the art, the axial stresses to which the nib is subjected may be conveniently controlled by regulating the torque applied to bolts **32** and the temperature to which the bolts are heated. For most applications, preheating temperatures of 1,000° to 2,000° F. for the bolts are sufficient.

Another embodiment of the invention is illustrated in FIGS. **3** and **4** of the drawings, in which use is made of thermally induced stress. Again, the drawings illustrate the die on one side of the axis os symmetry or the center line. As shown in FIGS. **3** and **4,** the die includes a pair of complementary semi-annular casing elements **50** and **50'** which can be secured together by means of, for example, a plurality of bolts **52** extending through casing elements **50** and **50'** by way of bores **54** in casing elements **50** and **50'.**

Casing elements **50** and **50'** together define a central opening bounded by a cylindrical surface **56** on the interior of the casing elements having a diameter which is slightly less than the diameter of a nib **58** having an outer corresponding cylindrical surface **60.** Casing elements **50** and **50'** are also provided with a pair of axially spaced flange members **62** and **64.** Flange members **62** and **64** are adjacent to cylindrical surface **56** and therewith define a central recess **66** adapted to receive the nib **58** in a shrunk fitting relationship in both the axial and radial directions.

Shrink-fitting in an axial direction is insured by the fact that flange members are spaced such that the distance between their internal surfaces is slightly less than the axial dimension of nib **58.**

Thus, in assembling the die of this embodiment, the casing elements are heated to an elevated temperature sufficient to cause expansion of the casing elements to enable the nib **58** to be inserted in the central opening defined by cylindrical surface **56** and flange elements **62** and **64.** After the nib is inserted, the casing elements are positioned to enclose the nib and allowed to cool, thereby developing an axial compressive stress on the die nib **58.** Thereafter, the bolts **52** are heated and threaded into the cold casing and allowed to cool. The bolts **52** thus contract on cooling to introduce a radial stress to nib **58.** As will be appreciated, the development of radial stresses will also serve to slightly increase the axial stresses already induced as described above.

Using this concept of the invention axial stresses as high as 150,000 psi can be developed, depending on the strength of the flange elements. Best results are usually achieved when the axial dimension of the nib exceeds the distance between the internal surfaces by an amount from 0.005 to 0.050 inches. The temperature to which the casing elements are heated will, of course, depend upon the relative dimensions of the nib and casings. For the dimensions described above, it is generally sufficient to heat the casing elements to a temperature within the range of 1,000° and 2,000° F.

An alternative embodiment of the die assembly shown in FIGS. **3** and **4** of the drawing is described in FIG. **5** of the drawing, and includes a die nib **58'** and an inner casing **51** and **51'** having a similar configuration to casing **50** in FIGS. **3** and **4.** Only casing element **51** is illustrated in FIG. **5** for convenience. Inner casings **51** and **51'** are provided with a substantially cyclindrical outer surface **65.** Instead of using bolts in this embodiment to maintain the casing elements **51** and **51'** together, use is made of an annular ring **63** having an inside diameter which is slightly less (by, for example, tolerances of from 0.005 to 0.100 inches) than the outside diameter of casing elements **51** and **51'.**

In this embodiment, the casing elements **51** and **51'** are heated and positioned to enclose nib **58'.** After the casing elements **51** and **51'** have cooled, ring **63** is heated to a temperature sufficient to enable the assembly of casing elements **51** and **51'** enclosing nib **58'** to be inserted into the central opening thereof. Thus, in this embodiment radial stress is induced by means of the annular ring **63** and axial stress by the casing elements as in the embodiment of FIGS. **3** and **4.**

Another embodiment of the invention, which makes use of mechanically induced axial stress is illustrated in

FIG. 6 of the drawing. In this embodiment the die is formed of an annular casing having an annular flange element 72 extending radially inwardly. The inner surface of casing 70 adjacent to flange element 72 is formed of a cylindrical surface 74. Thus, annular flange 72 and cylindrical surface 74 form a recess 76 which is adapted to receive a die nib 78 in a shrunk fit relation. As is the case of the preceding embodiments, the outer diameter of nib 78 is slightly greater than the diameter of surface 74 whereby the nib 78 is fitted into recess 76 while casing 70 is at an elevated temperature.

The end of casing 70 opposite flange 72 is provided with a second generally cylindrical recess 80 having a greater diameter than the recess defined by surface 74 which is adapted to receive an annular retaining ring threadably engaged with casing 70 by means of threads 84. As shown in FIG. 6, retaining ring is superposed over the upper surface 86 of nib 78.

Retaining ring 82 is provided with a plurality of stressing bolts 88 spaced about the annulus of the ring and threadably engaged in a bore 90 extending through retaining ring 82 and terminating in a flat plate aligned with the upper surface portion 86 of nib 78 and in abutting relation therewith.

Thus, in assembling the die of this embodiment, the casing 70 is first heated to a temperature sufficient to enable nib 78 to be inserted in recess 76, the nib inserted and assembly allowed to cool, thereby giving rise to the radial stress on nib 78 described above.

Thereafter, retaining ring carrying stress bolts in a raised position is tightened into recess 80 whereby the plate portions 92 of bolts 88 are aligned with the surface 86 of nib 78. A stress can be applied to the nib by tightening bolts 88 whereby the plate portion 92 thereof exerts a compressive force on the nib in an axial direction. As will be appreciated by those skilled in the art, the stress applied to the nib can be varied by varying the torque applied to bolts 88.

Another die in which use is made of mechanically induced stress is shown in FIGS. 7 and 8 of the drawing. In this embodiment, the die includes an annular casing 100 having a radially inwardly extending annular flange element near one end thereof. The inner surface of casing 100 adjacent to flange 102 is formed of a cylindrical surface 104. Thus, annular flange 102 and cylindrical surface 104 define a recess 106 adapted to receive a die nib 108 in a shrink fit relation. As is the case in the preceding embodiments, the outer diameter of nib 108 is slightly greater than the diameter of the recess defined by surface 104 whereby nib 108 is fitted into recess 106 while casing 100 is at an elevated temperature. It will also be observed in FIG. 7 that the axial dimension of nib 108 is slightly greater than the axial dimension of surface 104 whereby the upper surface 110 of nib 108 positioned in recess 106 extends axially beyond cylindrical surface 104.

Adjacent to the top of cylindrical surface 104, casing 100 defines an annular groove 112, the lower surface 114 of which lies in a plane coincident with the radial plane defining the upper limit of surface 104. Groove 112 is adapted to receive a stressing ring which is an annular ring 116, having the cross section shown in FIG. 8, and a camber prior to insertion into groove 112 defined by housing 100 in an axial direction extending away from the nib 108.

In assembling the die of this embodiment, casing 100 is heated to an elevated temperature to cause sufficient expansion to enable nib 108 to be inserted in recess 106 in abutting relation with flange 102. Thereafter, the nib and casing assembly is allowed to cool to thereby develop the desired radial stress on nib 108. Then the stressing ring 116 is pressed into groove 112 with the camber extending away from surface 110 of nib 108, with the help of the tool 117 shown in FIG. 7. Because the deformation of the ring is large, pressing of the ring must be done while it is heated to a temperature between 1000° – 2100° F. Hot pressing permits deforming of the ring until it is placed in position. The position of ring 116 in groove 112 is shown by broken lines in FIG. 7.

Compressive loads or stress induced by means of a stressing ring in accordance with this embodiment can be high although the load may be somewhat localized. Thus, in this embodiment of the invention, stresses as high as 100,000 psi can be achieved.

An axially stressed die in which the axial stress can be easily varied is schematically illustrated in FIG. 9. In this embodiment, the casing 120 has the same general configuration as the embodiment shown in FIG. 6, including an annular flange element and an axially intermediate cylindrical surface 124 and a threaded surface 126 opposite flange 122. Surface 124 and flange 122 define a recess 128 adapted to receive a die nib 130 in a shrink fit relationship. Threaded surface 126 defines a recess 132 which is adapted to receive a retaining ring or plug 134 in threaded engagement.

Plug 134 defines a recess 136 which is axially aligned with an upper surface 138 of nib 130 positioned in recess 128. A portion of recess 136 is occupied by a hydraulic ram 140 having an inverted T-shaped cross section with the base 142 in surface contact with surface 138 of nib 130. If desired, ram 140 can be provided with one or more sealing means 144, such as piston rings or the like, to insure a fluid tight seal between ram 140 and the side of recess 136. Recess 136 is also provided with means 146 to introduce a hydraulic fluid to recess 136.

In assembling the die of this embodiment, casing 120 is first heated to enable nib 130 to be inserted into recess 128 and is then allowed to cool to thereby develop the radial stresses in the manner described. Thereafter, plug 134 is screwed into position with base 142 of ram 140 in surface contact with surface 138 of nib 130. A hydraulic fluid is then introduced to recess 136 to thereby cause ram 140 to exert a compressive force in an axial direction on nib 130 and create the desired stress.

This embodiment of the invention is particularly advantageous in that the axial compressive forces exerted upon the nib. can be easily varied during extrusion or drawing operations by varying the pressure of the hydraulic fluid. In this way, the optimum axial stress for each application can be determined and maintained.

As will be appreciated by those skilled in the art, recess 136 in plug 134 and the hydraulic ram 140 positioned therein may be continuous annular elements extending about mid-radius throughout plug 134 to thereby insure that uniform compressive axial forces will be exerted on the surface 138 of nib 130. Alternatively, plug 134 can be formed with a plurality of recesses or pressure chambers 136, each with a separate hydraulic ram, uniformly spaced about surface 138 of nib 130.

A variation of the embodiment shown in FIG. **9** is schematically illustrated in FIG. **10** of the drawing in which use is made of a thermal ram instead of a hydraulic ram. As shown in FIG. **10,** plug **134'** is provided with a continuous or discontinuous bore or recess **148** which is adapted to receive a thermal ram **150** formed of a metal having a high coefficient of thermal expansion having an inverted T-shaped cross section with the base **142'** in surface contact with surface **138'** of nib **130'**. Thermal ram **150** is provided with heating means formed in the ram, such as insulated heating coils **152** which are connected to a source of electric current (not shown) by means of leads **154.**

Thus, once the die is assembled, a current is fed to the heating elements to thereby heat the thermal ram, which in turn causes thermal expansion of the ram. As will be apparent, expansion occurs in the axial direction whereby base **142'** of the ram exerts a compressive force on surface **138'** of nib **130'** to create the desired axial stress.

In this embodiment of the invention, the amount of stress developed on the nib can be conveniently varied to determine the optimum stress by controlling the amount of current supplied to the heating elements.

It will be apparent from the foregoing that we have provided new and improved drawing and extrusion dies which can be simply and efficiently pre-stressed prior to use in both the radial and axial directions. In many of the embodiments described the casing and/or parts thereof in which the die nib is mounted for use are completely reusable when the nib has been worn, which represents a significant economic savings because the casings are generally machined to close tolerances and are therefore relatively expensive to manufacture. It will be apparent that the concepts of the invention are applicable not only to drawing and extrusion dies as described above, but also to other types of dies.

It will be understood that various changes and modifications can be made in the details of construction, procedure and use without departing from the spirit of the invention, especially as defined in the following claims.

We claim:

1. A die comprising a casing having axially spaced flanges extending inwardly to define a central opening in the casing, a die nib having an axial dimension greater than the spacing between the flanges of said casing and a diameter greater than the diameter of said central opening positioned in said central opening whereby the die nib is adapted to be received in the central opening when the casing is at an elevated temperature whereby the nib in the central opening is subjected to axial and radial stresses on cooling of the casing, and a ring about the casing having a central recess corresponding to the outer surface of the casing, with the ring being adapted to receive the casing when the ring is at an elevated temperature whereby the ring exerts a radial stress on the die nib on cooling.

* * * * *