United States Patent

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[72] Inventor William H. Phillips, Jr.
Northbergen, N.J.

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[73] Assignee Carmet Company
Pittsburgh, Pa.

[54] **DIE ASSEMBLY**
5 Claims, 2 Drawing Figs.

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[50] Field of Search 72/467

[56] References Cited

UNITED STATES PATENTS

1,986,777	1/1935	Patterson	72/467 X
3,178,925	4/1965	Nolan et al.	72/467 X
3,436,953	4/1969	Hajikano	72/467

FOREIGN PATENTS

565,080	10/1944	Great Britain	72/467

Primary Examiner—Milton S. Mehr
Attorneys—Richard A. Speer, Vincent G. Giola and Howard R. Berkenstock, Jr.

ABSTRACT: A die assembly for use in forming operations such as hot extruding wherein the forming insert is frustoconical in shape and is cold-pressed into a sleeved support casing with the major base facing the exit side of the assembly and is supported under axial load by a backer bushing affixed to the support casing.

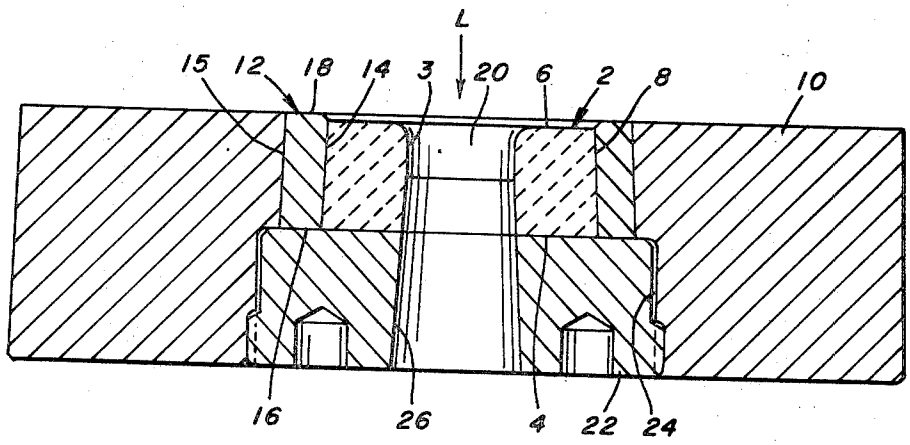


FIG. 1.

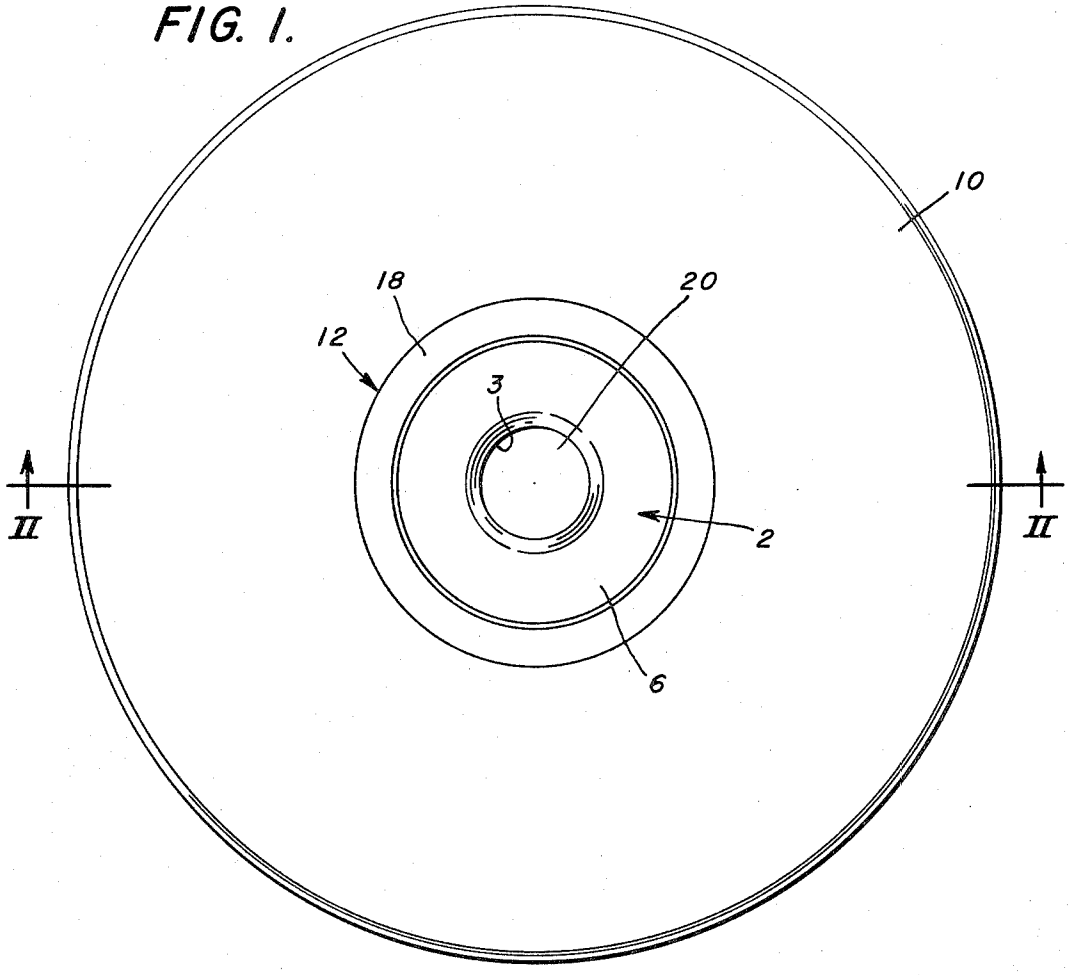
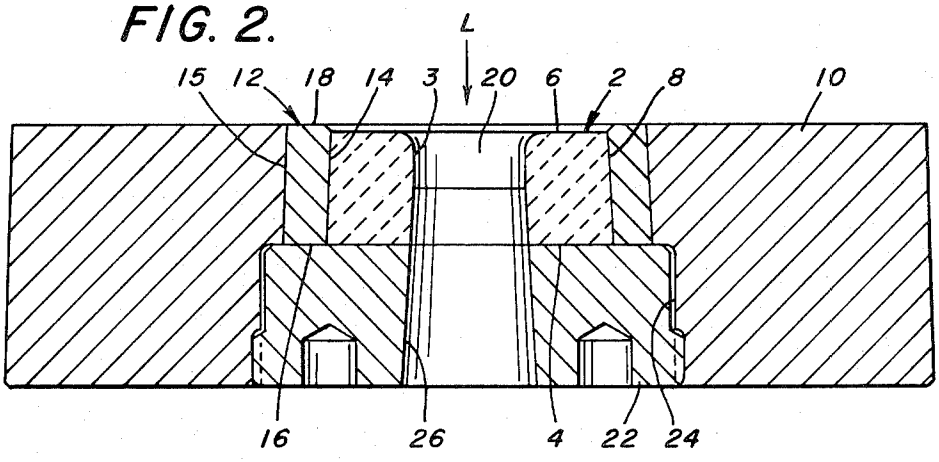


FIG. 2.



INVENTOR.
WILLIAM H. PHILLIPS
By Howard R. Berkenstock, Jr.
Attorney

DIE ASSEMBLY

BACKGROUND OF THE INVENTION

Dies for hot extruding or drawing metals such as copper, brass, or stainless steel, rod or tubing, are subject to extreme temperatures and pressures. At best, conventional dies wear rapidly and must be replaced frequently. The die material conventionally used may be combinations of tungsten and chromium steels or other alloys, perhaps including cobalt to increase the hot hardness of the material and create a more wear-resistant surface. Despite the concentration of efforts on the development of a satisfactory die material, hot extrusion dies regardless of the die or insert material currently available are subject to one or more of the following failure modes: (1) radial cracking of the insert, (2) laminar cracking of the insert; (3) washout of the extrusion contour and the die bearing; (4) heat checking; and (5) closing of the die bearing. Failure of the insert in any category occurs in conventional use generally after extruding one to five billets. If the cracking is not too severe, the dies are run to destruction; however, it may be necessary to recut the dies a small amount after a few pushes to reestablish the forming surfaces. Recutting is a costly operation. Press efficiency is reduced by frequent replacement of dies. In addition to introducing nonuniformity in size of the extruded product by frequent recutting, quality of the product is poor until the cracked die is recut. By way of example, dies for extruding copper and brass rod composed of a stellite insert shrunk fit into a hardened, high-temperature steel casing crack radially after only three to five pushes. Following 25 to 50 pushes, these radial cracks open up necessitating a recut of about 0.020 inch. This recut cycle continues throughout the use life of the die.

A further problem is experienced in that the operating temperature during extrusion ranges approximately 1,200° to 2,100° F. With a die insert conventionally shrunk fit at room temperature to about 0.003 inch per inch of its outside diameter, operation at the extrusion temperature causes the casing supporting the die to expand more than the insert to become unsupported. The result of extruding with the unsupported die is radial failure. A severe cracking of the insert often results in breakup of the die.

Ceramic and other high-hardness die materials have come into limited use recently and exhibit good wear-resistant characteristics; however they are relatively brittle and have low tensile strengths. It is critical to keep such dies under compression or very low tensile stresses throughout their use. Failure to provide an adequate loading on such brittle die materials permits radial and/or laminar cracking, at least causing the finish of the extruded product to be marred. As with the previous alloy die bodies, the recent low tensile dies have been mounted in the die assembly structure by a conventional shrink fitting procedure. Thus, the new die inserts in a conventional assembly suffer a similar loss of compressive loading due to the greater expansion of the retainer casings supporting the insert.

The die assembly of my invention provides a die mounting structure Which overcomes the previous support disadvantages experienced with conventional inserts as well as new ceramic-type inserts by providing a die fit into a retainer sleeve, before assembling into the support casing.

SUMMARY OF THE INVENTION

This invention relates to a die assembly for use in forming operations such as extruding of metals under high temperature and pressure including a die body of a generally frustoconical shape having a forming surface lining an axial opening therethrough. The die body is loaded in a retainer casing within a sleeve, both having a sloping inside diameter complementary to the slope of the conical shape of the die body and the sleeve being interposed between the die body and the retainer casing. Backing means support the die body and sleeve against the axial forces developed in the forming operation.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of the die assembly of my invention.
FIG. 2 is a sectional view of my invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, reference numeral 2 indicates a die insert which may be a brittle, high-hardness material such as a calciastabilized zirconium oxide, available from the Carmet Company under the trade name *Ceramidie*. The insert 2 in the disclosed example has an opening defined by forming surfaces 3 for extruding round brass rods three-fourth inch in diameter. Insert 2 is frustoconical in shape, having a major base 4 of approximately 1.95 inches in diameter, a minor base 6 of approximately 1.875 inches in diameter and a depth of 0,75 inch. Sides 8 of insert 2 exhibit a slope of 3° from the axis of the die in the example. The degree of slope may be varied so long as there is sufficient slope to eliminate the shear loading in the insert. Insufficient taper results in placing the insert in shear when either hot-shrunk or cold-pressed into the retainer casing 10 causing failure as previously discussed. Surrounding insert 2 is sleeve 12 which in the example is AISI-type M-2 steel, hardened to a hardness of 54 to 56 RC. In the example, the sleeve has a tapered inner wall 14 and outer wall 15 complementary to that of the side 8 of insert 2 which in the example is 3° from the axis. In the example disclosed, sleeve 12 has a diameter of 2.52 inches on base 16 corresponding to the major base 4 of insert 2. Sleeve 12 exhibits a diameter of 2.437 inches at base 18 corresponding to minor base 6 of insert 2. The depth of sleeve 12 is approximately 0.799 inch. Insert 2 and sleeve 12 are contained in retainer casing 10 having a generally cylindrical shape with an opening 20 to accommodate the sleeve-containing insert. In the embodiment disclosed wherein the sides 14 and 15 of sleeve 12 are tapered, opening 20 has a diameter of 2.4297 inches increasing to 2.5135 inches in diameter at the area corresponding to the large base 4 of the insert 2. The overall dimensions of retainer casing 10 in the disclosed embodiment are 1.75 inches in thickness by 6.25 inches in diameter. Casing 10 in the example is of AISI-type H-19 steel, hardened to 46 to 48 RC.

In the preferred embodiment, backer bushing 22 is contained within an opening 24 in casing 10. It will be noted that the diameter of the backer bushing may be greater than the combined diameter of the sleeve 12 and insert 2, being approximately 2.8 inches in diameter. The opening 26 in bushing 22 corresponds to that defined by the metal forming surfaces 3 of insert 2. So positioned, bushing 22 supports insert 2 and sleeve 12 across the back of said insert and sleeve absorbing the axial load placed upon the insert 2 by the extruding operation.

As previously discussed, ceramic and other high-hardness die inserts are exceptionally weak under tension and shear loads. The die assembly of the invention offsets these weaknesses and takes advantage of the high compression capacity of the material to utilize the extreme wear-resistance of these materials at the extrusion temperatures. Thus, the dimensions of the assembly elements; insert 2, sleeve 12, casing 10 and bushing 22, are interrelated to take advantage of these desirable characteristics of the materials involved. As was mentioned above, the sleeve 12 can be cold-pressed into the casing 10. The high compression preloading of the sleeve allows it to withstand the tangential tensile forces induced by insert 2. In this manner, the sleeve 12 is also compressed sufficiently to counteract the difference between its coefficient of expansion and that of the insert 2 and casing 10, thus insuring optimum preload of the insert 2 throughout the complete hot work cycle. Insert 2 is cold-pressed into the sleeve casing assembly at room temperature to an interference fit between the die insert 2 and the sleeve 12 of 0.008 inch per inch of the outside diameter of the insert providing a high compression loading. This figure may be varied for different material other than the *Ceramidie* insert and the tool steels, AISI H-19 and M-2, utilized in the example to produce the desired loading.

In the example described above, the interference fit prescribed produces a tangential compression preload to the inside diameter of the insert of 185,325 p.s.i. Conventional assemblies using stellite inserts in a hot-shrink fit achieve a total interference fit only of about 0.003 inch per inch. The use of sleeve **12** in the assembly drastically reduces the tangential tension load at the inside diameter of the casing **10** in the example of the invention to 76,008 p.s.i. It has been observed that insertion of an insert directly into a casing without interposition of a sleeve **12** there between would result in a tangential tension load at the jointure of an insert and casing of 97,297 p.s.i. Heating the assembly structure to an extruding temperature of 1,200° F. yields a compression preload in the insert inside diameter of 104,399 p.s.i., thus, illustrating that the insert is maintained in a high compression loading configuration. The tangential tension loading at this temperature in the casing inside diameter with sleeve **12** incorporated is 47,727 p.s.i. Without sleeve **12**, observations show tension loading of the casing to be increased to approximately 55,000 p.s.i. Minimization of case stress by the use of sleeve **12** eliminates case creep rupture permitting the use of high compression loading of the inserts. As was previously noted, the sleeve **12** and insert **2** are assembled on a 3° per side taper in the example. Such a tapered assembly eliminates shear loading in the insert allowing the forces of loading to be uniformly transferred across the sloping surfaces of the insert and the sleeve during pressing. As was noted previously, backer bushing **22** supports the insert **2** as well as the sleeve **12** under axial loading during the extrusion. Supporting the insert **2** and sleeve **12** in such a manner prevents deflection of the insert under load which would otherwise induce laminar cracking of the insert and deterioration in the surface of the extruded product.

It may now be appreciated by those familiar with the art that every element of the assembly interacts with each and every other element of the assembly to provide an insert completely supported in compression which values tension loading in the casing and eliminates shear loading. It will also be evident to those familiar with the art that variations in tool steel and size of the elements may be made without departing from the scope of the invention disclosed herein. Adaptation of the teachings may be make to accommodate extruding a plurality of rods, or the like in a single assembly, or to accommodate different cross sections to shape tubings and the like.

I claim:

1. A die assembly for use in extrusion operations comprising a ceramic die body having a sloping outer peripheral surface defining a frustum which has a major base at one end of larger area than a minor base at its other end, the material to be extruded being forced against said minor base, a die opening extending axially through said die body, a metallic sleeve surrounding and in compressive engagement with said die body and having a sloping inner peripheral surface complementary to the sloping outer surface of the die body, said sleeve having a sloping outer peripheral surface which slopes in the same direction as its inner peripheral surface such that the radial thickness of said sleeve is essentially constant along its axial length, the end surface of said sleeve of larger diameter being essentially coplanar with said major base of the die body, casing means having a bore therethrough with a sloping peripheral surface which receives said sleeve and die body, and backer bushing means in engagement with said major base of the die body and said larger-diameter end surface of the sleeve for supporting the sleeve and die body against the axial forces induced thereon during an extrusion operation.

2. The die assembly of claim **1** wherein said die body is frustoconical.

3. The die assembly of claim **2** wherein the slope of the peripheral surface of said bore in the casing means is equal to the slope of the die body and the slope of the peripheral surfaces of said sleeve.

4. The die assembly of claim **3** wherein said die body is interference fit in said sleeve at least 0.004 inch per inch of the outside diameter of said insert.

5. The die assembly of claim **1** wherein said sleeve is mounted into the casing means with sufficient interference fit to withstand the tangential tensile stresses induced by the die body and of sufficient compression to counteract the difference in coefficients of expansion of the die body, the sleeve and the casing means.

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