NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

April 5, 1971

MEMORANDUM

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned
U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,469,436

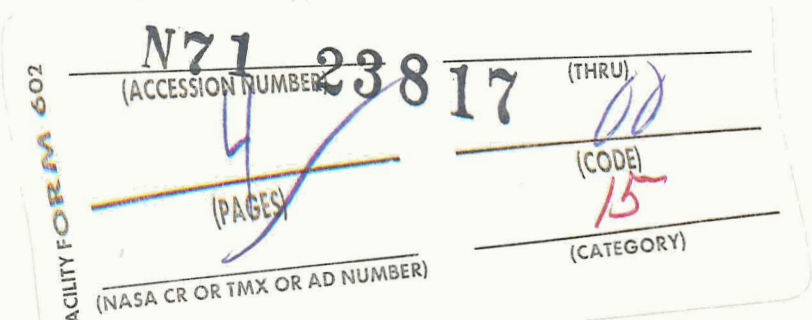
Corporate Source : Lewis Research Center

Supplementary
Corporate Source :

NASA Patent Case No.: XLE-06773

Gayle Parker

Enclosure:
Copy of Patent



N71-23817

Sept. 30, 1969 C. A. GYORGAK ETAL 3,469,436

EXTRUSION DIE FOR REFRACTORY METALS

Filed June 14, 1967

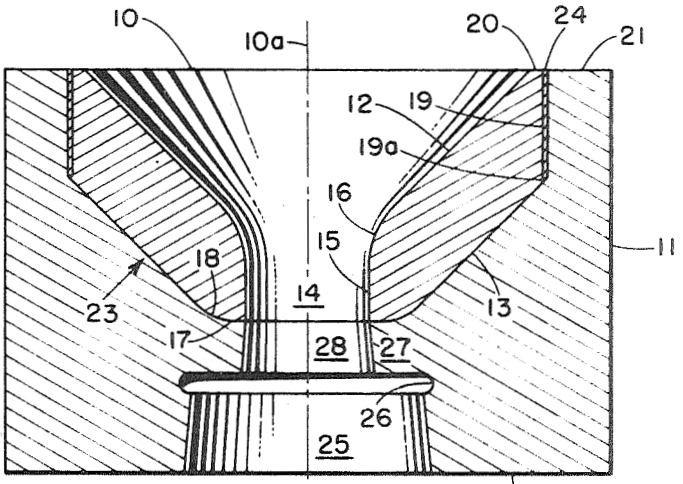


FIG. 1

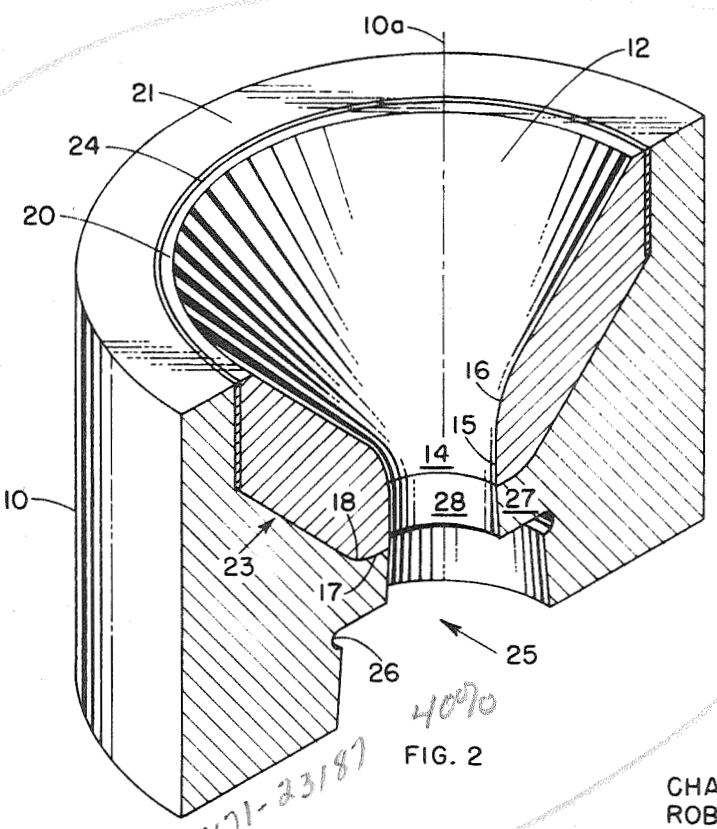


FIG. 2

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3,469,436

EXTRUSION DIE FOR REFRACTORY METALS

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U.S. Cl. 72—467 9 Claims

ABSTRACT OF THE DISCLOSURE

An extrusion die for refractory metals comprising a frusto-conical die nib fitted into a frusto-conical receptacle in a die nib holder, a cylindrical throat in the small end of the die nib opening into a cup in the lower surface of the die nib holder, a tapered passage being disposed between the throat and the cup in the die nib and contiguous with the throat.

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to extrusion dies and is directed more particularly to a die nib and a holder for the extrusion of refractory metals.

In the extrusion of refractory metals, the dies used have a very limited life because of the high temperatures at which such operations are conducted and because of the wear caused by the passage of the extruded material through the die. To overcome these problems, refractory metal coatings have been applied to extrusion dies in some cases. However, these coatings are relatively thin and the die must be replaced after one or two extruding operations.

Somewhat more successful results have been achieved by forming a brittle die nib of the metallic carbides of tungsten, tantalum or titanium. The die nib is supported in a housing of relatively elastic metal such as hot work tool steel.

With the use of brittle die nibs premature failure, nevertheless, often occurs. The reason for such failure is that high stress concentrations are provided between the die nib and the holder during the extruding operation due to the high temperatures and the pressures generated by the material being extruded. These stresses cause spalling and disintegration of the die nib.

The principal attempts to minimize stress concentrations in the brittle die and holder type of extrusion die have been directed toward the die nib and die nib holder configurations. In general, the brittle die nibs and holders of the prior art have complex shapes and are difficult and expensive to machine.

Accordingly, it is an object of the invention to provide an improved long-life extrusion die.

It is another object of the invention to provide a brittle die nib and a die nib holder which are relatively inexpensive and easy to machine.

Another object of the invention is to provide a die nib and a die nib holder configurated to minimize destructive stress concentrations.

Still another object of the invention is to provide an extrusion die including a die nib and a die nib holder, the die nib holder being configurated to fully support the die nib such that destructive stress concentrations are minimized and the life of the nib is greatly extended.

Other objects and advantages of the invention will become apparent from the following description and accompanying drawing in which:

FIG. 1 is a sectional view taken on a plane passing through the longitudinal axis of the die nib and die nib holder embodying the invention; and

FIG. 2 is a perspective sectional view, in full, of the die nib and holder.

Referring to FIG. 1 it will be seen that an extrusion die embodying the invention may comprise a die nib **10** and a die nib holder **11**. The die nib holder **11** is preferably fabricated from hot work tool steel. The die nib insert **10** may be machined from a suitably hard brittle material such as a carbide of tungsten, tantalum or titanium. However, alumina, zirconia, thoria or hafnia may likewise be utilized as the material for the die nib.

The die nib insert **10** comprises a generally frusto-conical body having parallel interior and exterior frusto- conical surfaces **12** and **13**, respectively.

The included angle of the frusto-conical die nib interior surface may be between 40 and 160 degrees. In a preferred embodiment of the invention, an included angle of 90 degrees has been found to produce good results.

The material to be extruded is directed into the large open end of the nib **10** along a longitudinal axis **10***a* and is formed into a desired rod as it passes through a throat portion **14** of the die nib. The throat portion **14** comprises a cylindrical passage formed by an annular wall **15** concentric with the longitudinal axis of the die nib.

In order to reduce undesirable stress concentrations in the throat portion **14**, a first annular radiused portion **16** is interposed between the annular wall **15** and the frusto-conical exterior surface **13** of the die nib **10** is smoothly and gradually merged with an annular flat end portion **17** lying generally in a plane perpendicular to the axis of the die nib by means of a second annular radiused portion **18**.

The pivot point of the radius which describes the curvature of the first annular radiused portion is positioned such that the curved surface generated by its rotation is tangent to both the wall **15** of the throat **14** and to the inner surface **12** of the die nib **10**. The above-described location of the radius pivot point is subject to the condition that the radius be less than the distance between the interior and exterior surfaces **12** and **13**, respectively. The radius is further limited in that, while it should be as great as possible to provide a smooth, gradual merger between the wall **15** and the inner surface **12**, it should be as small as possible to provide the longest possible nontapering throat area. A radius equal to a value between one-quarter and three-quarters of the distance between the interior and exterior surfaces **12** and **13**, respectively, is a satisfactory dimension, one-half this distance being preferred.

The radius which describes the second annular radiused portion is subject to most of the same requirements as the radius of the first annular rediused portion. However, there is no substantial advantage in making this radius as great as possible. A radius of between one-eighth and three-eights of the distance between the interior and exterior surfaces **12** and **13**, respectively, has been found to be satisfactory. The preferred length of the radius of the second annular radiused portion is approximately one-fourth the distance between the interior surface **12** and the exterior surface **13**.

The large end of the die nib **10** is defined by an annular wall **19**, the surface of which is parallel to and concentric with the longitudinal axis of the die nib. The annular wall **19** joins the exterior surface at a juncture **19***a*. A flat surface **20** lying in a plane generally perpendicular to the axis of the die nib is disposed between the inner

surface 13 and the wall 19 at the large end of the frusto-conical die nib.

The die nib holder 11 may comprise a generally cylindrical metallic body having upper and lower flat surfaces 21 and 22, respectively. The upper and lower surfaces 21 and 22 are parallel to each other and perpendicular to the longitudinal axis of the die nib and the die nib holder.

In order to fully support the die nib, a generally frusto-conical receptacle 23 is formed in the upper surface of the die nib holder. The receptacle 23 is configurated substantially the same as the exterior surface 13 of the die nib. The over depth of the receptacle is substantially the same as the height of the die nib and its diameter in any plane perpendicular to the axis is substantially the same as the diameter of the die nib in a corresponding plane.

In a preferred embodiment of the invention the die nib 10 is retained in place by the difference of expansion between it and the die nib holder 11, that is, a shrink fit is employed. This shrink fit provides lateral constraint on the die nib 10 by the die nib holder 11 to prevent the die nib from disintegrating during the extruding operation.

The shrink fit is a function of the temperature and speed of extrusion and causes the lateral constraint to increase with temperature and speed. Accordingly, the lateral constraint must not be allowed to become great enough to cause elastic deformation of the die nib holder because such deformation would have the adverse effect of destroying the compressive force component exerted on the circumference of the die nib by the holder.

The die nib and holder materials appropriate to provide this retaining characteristic are readily ascertainable by one skilled in the extrusion die art after consulting a table of coefficients of expansion for the materials from which the die nib 10 and the die nib holder 11 are to be made. This choice of materials is within the scope of the work normally performed by one skilled in the metal working art and, hence, will not be described here.

If desired, a shim such as a band of relatively soft metal 24, such as copper, may be disposed between the die nib wall 19 and the die nib holder 11. This arrangement provides the desired lateral constraint on the nib while allowing a greater latitude in the selection of the materials from which the die nib and the die nib holder are made.

The material being extruded passes out of the die holder 11 through a cup 25 formed in the lower surface 22 thereof. The cup 25 serves to support a hollow cylindrical guide (not shown) for the extruded material. The inner surface of the cup 25 may be threaded to receive, for example, a pipe which serves as a guide or straightener for the extrudate. In order to inhibit the formation of cracks around the end of the cup located inwardly of the die holder lower surface 22, a round-bottomed annular groove 26 is provided around that end of the cup.

To the end that the die nib 10 will be fully supported in the area of the flat die nib end portion 17 whereby spalling and cracking is prevented, an annular shoulder 27 is formed by an extrudate passage 28. This passage 28 puts the throat portion 14 of the die nib in communication with the cup 25 formed in the lower surface 22 of the die nib holder 11.

The diameter of the extrudate passage 28 is the same as the diameter of the throat portion 14 where the shoulder 27 abuts the flat end portion 17. This arrangement provides full support for the throat portion 14 of the die nib. Additionally, the extrudate passage 28 is essentially contiguous with the throat portion 14. This establishes a smooth transition surface whereby the extrudate material is not subjected to steps or flanges which might adversely affect its surface.

The extrudate passage 28 is tapered such that it increases in diameter in a direction away from the die nib. This tapering of the passage 28 is very gradual so that the shoulder 27 gives substantial support to the annular flat end portion 17 while adequate clearance is provided between the end of the passage 28 adjacent to the annular groove 27 and the material being extruded. While the preferred taper of the extrudate passage is 5 degrees with respect to the longitudinal axis 10*a*, any taper between 3 and 10 degrees will be satisfactory.

In cases where no extrudate guide or straightener is to be used, the cup 25 and the round-bottomed annular groove 26 may be eliminated. Thus, the extrudate passage 28 would then open directly into the lower surface 22 of the die nib holder.

FIG. 2 is a perspective sectional view, in full, of the extrusion die shown in FIG. 1 and like parts are identified by like numerals. The cylindrical exterior wall surface of the die nib holder 11 as well as the annular ring disposed between the die nib holder 11 and the die nib are clearly shown in FIG. 2. Also shown is the smooth transition made by the throat portion 14 into the extrudate passage 28.

It will be understood that the extrusion die described above may be changed or modified without departing from the spirit and scope of the invention as set forth in the claims appended hereto.

What is claimed is:

1. A refractory metal extruding die comprising:
a frusto-conical die nib having inner and outer parallel surfaces,
a cylindrical throat disposed between the inner and outer surfaces at the small end of the die nib coaxial with the longitudinal axis of the die nib,
the die nib terminating at its smaller end in a flat annular surface lying in a plane perpendicular to the longitudinal axis,
a first radiused annular portion being disposed between the flat annular surface and the exterior surface at the small end of the die nib,
a second annular radiused portion being disposed between the throat and the interior surface at the small end of the die nib,
a die nib holder having a receptacle formed in an upper surface thereof to receive the die nib small end first in a frictionally retained relationship,
said receptacle conforming substantially to the outer surface and the flat annular surface at the small end of the die nib,
an extrudate passage formed in said holder between the receptacle and a lower surface of the die nib holder coaxially with the longitudinal axis of the die nib,
said extrudate passage tapering from a diameter substantially equal to that of the die nib throat at its receptacle end to a larger diameter at its other end to form an annular shoulder, whereby the die nib is fully supported on its outer surface adjacent to the throat.

2. The extrusion die set forth in claim 1 in which the included angle of the die nib is between approximately 40 degrees and approximately 160 degrees.

3. The extrusion die set forth in claim 1 in which the included angle of the die nib is approximately 90 degrees.

4. The extrusion die of claim 1 in which the extrudate passage tapers approximately five degrees.

5. The extrusion die of claim 1 in which the exterior surface of the die nib merges with a cylindrical wall at the large end of the die nib, an annular ring of relatively soft metal being disposed around the cylindrical wall portion of the die nib between the same and the die nib holder to minimize undesirable stress concentrations.

6. The extrusion die set forth in claim 1 in which an annular round-bottomed groove is disposed adjacent to the extrudate passage around the upper end of a down-

wardly opening cup formed in the lower surface of the die nib holder.

7. The extrusion die set forth in claim 1 in which the included angle of the die nib is approximately 90 degrees and the taper of the extrudate passage is approximately 5 degrees and in which an annular groove is disposed adjacent to the extrudate passage around the upper end of a downwardly opening cup formed in the lower surface of the die nib holder.

8. The extrusion die of claim 1 in which the radius of said first radiused annular portion is equal to approximately half the distance between the inner and outer parallel surfaces and the radius of said second radiused annular portion is equal to approximately one-quarter the distance between the inner and outer parallel surfaces.

9. The extrusion die set forth in claim 8 in which the included angle of the die nib is approximately 90 degrees and the taper of the extrudate passage is approximately 5 degrees.

References Cited

UNITED STATES PATENTS

880,563	3/1908	McTear	72—467 X
1,637,109	7/1927	Honig	72—467 X
1,817,680	8/1931	Pratt	72—467
2,027,787	1/1936	Ridgway et al.	72—467
2,350,465	6/1944	Keshian	72—467
3,178,925	4/1965	Nolan et al.	72—467 X

FOREIGN PATENTS

108,713	10/1943	Sweden.

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