

Jan. 30, 1945.

K. B. GUINEY

2,368,355

PORTHOLE EXTRUSION DIE

Filed Aug. 2, 1941

2 Sheets-Sheet 2

Fig. 3.

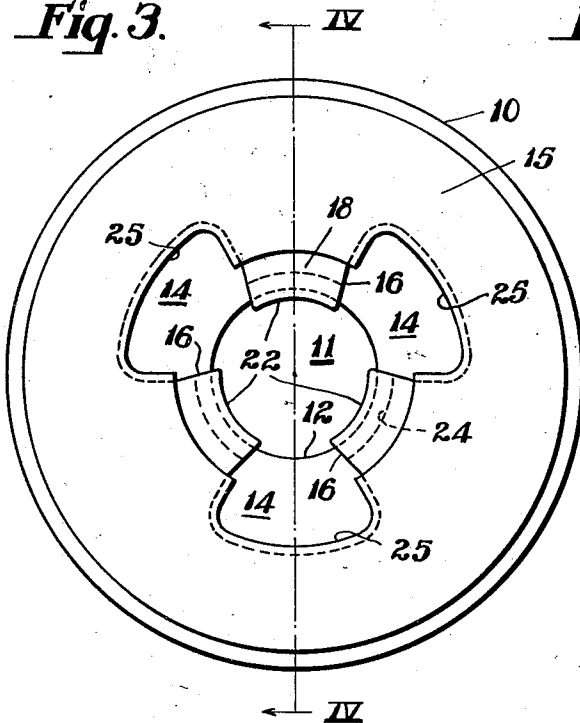


Fig. 4.

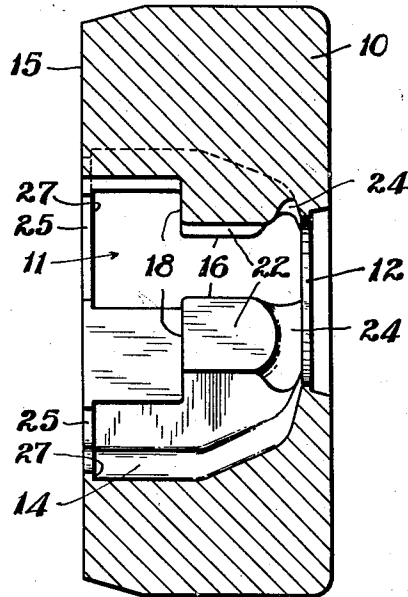


Fig. 5.

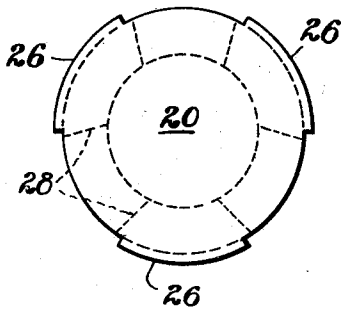


Fig. 6.

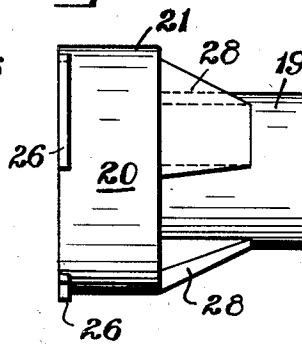


Fig. 7.

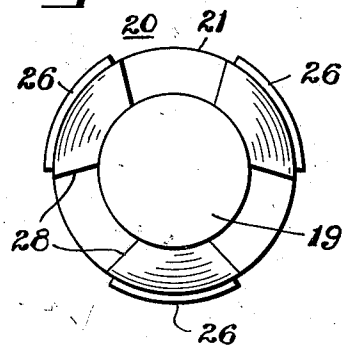
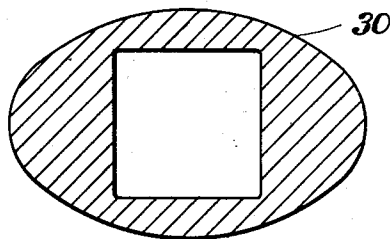


Fig. 8.



INVENTOR

Karl B. Guiney

BY

J. Ernest Low.

ATTORNEY

UNITED STATES PATENT OFFICE

2,368,355

PORTHOLE EXTRUSION DIE

Karl B. Guiney, La Fayette, Ind., assignor to
Aluminum Company of America, Pittsburgh,
Pa., a corporation of Pennsylvania

Application August 2, 1941, Serial No. 405,298

3 Claims. (Cl. 207—17)

This invention relates to improvements in extrusion and is particularly concerned with a die or tool assembly for the production of seamless tubular shapes or sections from unperforated billets or metal charges.

In the production of seamless tubular extruded shapes or sections, it is known to employ what are commonly termed "porthole" extrusion die assemblies. Such porthole die assemblies usually comprise a front male or mandrel die and a back or female die so arranged that the metal of an unperforated billet, or solid metal charge, divides itself under the influence of pressure into streams of metal which flow through the front die and around the mandrel where it coalesces in a mixing chamber adjacent the entrance to the die orifice. Continued extrusion pressure causes the metal to be extruded through an orifice defined between an aperture in the female die and the mandrel to produce a seamless, hollow extruded section. It will be appreciated that extrusion die assemblies of this general type have eliminated the necessity of using perforated or hollow metal billets in the production of seamless tubular shapes, and for this reason these die assemblies have found ready acceptance in the extrusion field.

Known types of porthole extrusion dies have certain inherent structural characteristics, which contribute largely to the development of excessive pressures, and which often result in heavy die breakage with its attendant high operating maintenance. These pressures differ for different metals and alloys, and are particularly noticeable at the beginning of an extrusion operation, as distinguished from the pressures experienced after the metal of a billet has begun to flow under the applied extrusion force. No attempt is made to explain all of the factors contributing to the excessive pressures herein referred to, which for high strength aluminum alloys often initially reach 150,000 pounds per square inch, or higher, as measured in terms of the cross-sectional area of the extruded section. These excessive pressures are, however, known to bear a definite relationship to the ratio of the perimeter of the extruded shape or section to its metal volume, to non-symmetry of configuration of the extruded shape, and to the location and cross-sectional area of the metal-flow passages through the die structure. Of these variables the latter is usually the only one over which a tool designer or operator has any control for a given extruded product, and it is to this end that the present invention is primarily directed.

It is an object of the present invention to provide a die assembly of the porthole type which has all of the advantages of present dies of this general class, but which also incorporates improved and superior features of construction. It

is a further object of this invention to provide a porthole extrusion die of sturdy construction incorporating improved metal-flow passages for alleviating the excessive pressures now experienced in dies of this general type. Another object of the invention is to provide a multipart die structure incorporating features of construction which insure against any relative or shifting movement between the several parts in their assembled relationship. Another object of the invention is to provide a porthole extrusion die of compact construction which is adaptable to presently employed types of standard extrusion presses and extrusion die equipment, and which is readily disassembled on completion of an extrusion run, as for replacement of the die, or for any other purpose. A further object of the invention is to provide an extrusion die structure of the porthole type which incorporates features of construction which reduce, if not entirely eliminate, the excessive stresses normally developed in extrusion dies of this general type.

Other objects and advantages of the invention will present themselves on consideration of the following specification when read in conjunction with the drawings appended hereto and forming a part hereof, in which:

Fig. 1 illustrates a front view of a die assembly embodying the novel features of the invention;

Fig. 2 illustrates a sectional elevation taken along the line II—II of Fig. 1 and disclosing, in addition, fragmentary portions of a cooperating extrusion billet cylinder and ram;

Fig. 3 illustrates a view similar to Fig. 1 with the mandrel of that view removed;

Fig. 4 illustrates a sectional elevation taken along the line IV—IV of Fig. 3;

Figs. 5, 6, and 7 illustrate front, side, and rear elevational views, respectively, of the mandrel member of the die structure of the invention; and

Fig. 8 illustrates a cross-sectional view through a representative seamless tubular extruded shape capable of production with the die structure of the invention.

On reference to the drawings, it will be noted that the preferred die structure selected for purposes of illustrating and describing the present invention comprises a female die member 10 and a male die member or mandrel 20. The female die member 10 is preferably constructed from a die block provided with a stepped bore or aperture, generally identified by the reference numeral 11, which terminates in a die aperture 12. The aperture 12 may be of any desired configuration in that it controls the exterior contour or perimeter of the section to be extruded.

In its preferred construction the female die 10 is formed with a plurality of recesses 14 extend-

ing radially outwardly from the wall of bore 11 nearest the front face 15 of the die 10. The recesses 14 are separated intermediate their length through the die 10 by means of inwardly extending, shouldered webs or ribs 16 which serve to define a restriction in the bore 11 nearest the die aperture 12, as well as present a plurality of coplanar, shelf-like abutments 18 within the bore 11.

The mandrel 20 is constructed for cooperative assembly within the bore 11 in female die 10. The mandrel in general is formed with a shank portion 19 and flanged head portion 21. On assembly within bore 11, the head 21 is snugly received within the bore 11 and is supported in end thrust relationship upon the abutments 18. In this assembled position the shank 19 fits snugly within the restricted portion of bore 11, defined by inner surfaces 22 of ribs 16, and extends through the die aperture 12 to define therebetween any desired die orifice, depending upon the particular cross-section of the tip end of shank 19 and die aperture 12. Normally the shank 19 is of uniform cross-section over a substantial portion of its length.

It is preferable, although not absolutely necessary, to provide a mixing or coalescing chamber adjacent the entrance to the die orifice. Such a chamber has been provided in the die structure herein described in the form of an undercut groove 24 disposed at the ends of ribs 16 immediately in front of the die aperture 12.

The front or forward end of mandrel 20 (i. e., the head portion 21) is preferably perfectly flush with the front face 15 of die member 10. This mode of construction provides a true, flat shearing face for removal of the unextruded butt or heel of an extrusion billet on completion of an extrusion operation, it being understood that it is customary to provide reciprocity means for separating the die assembly from its associated billet cylinder for such a shearing operation.

Each recess 14 is provided with a flange 25 in the plane of the front face 15 of die member 10. Arcuate flanges 26 are also provided on the head end 21 of mandrel 20 and in the same plane as flanges 25. Flanges 26 are preferably each of an arcuate length which provides a snug fit between oppositely disposed ends of flanges 25. In effect, then, the entrance to each passageway, formed by recesses 14 and cooperating assembled mandrel 20, is provided with a continuous perimetric flange, in the form of flanges 25 and 26, which serves as an abrupt shearing edge at the entrance to each passageway. Also, the radial outward extension of flanges 26 into interlocking engagement with opposite ends of flanges 25, serves to accurately register mandrel 20 within the bore 11 of die member 10.

In the preferred construction of the extrusion die assembly of this invention, the cooperating surfaces of mandrel 20 and bore 11 are cylindrical. That is, flanged head 21 is preferably cylindrical and is received within a cylindrical portion of bore 11. Also, shank 19 of mandrel 20 is preferably cylindrical adjacent that portion which fits within the cylindrical bore formed by the arcuate surfaces 22 of ribs 16.

The passageways formed between the recesses 14 and mandrel 20 constitute a significant feature of the extrusion die structure of this invention. By reference to Figs. 2 and 4, it will be noted that the passageways are abruptly relieved at 27 immediately adjacent their entrance and thereafter extend forwardly into the extrusion

die in a direction which is parallel to the longitudinal axis of the die. The passageways, then, turn inwardly towards the center of the die where they terminate forwardly of the die aperture 12 in the mixing chamber 24. In this connection, circumferentially spaced, tapering ribs 28 are preferably provided on the shank 19 of mandrel 20 below arcuate flanges 26, which ribs serve to provide an inner wall for each passageway along its inwardly-turned portion.

In the operation of the extrusion die above described, the mandrel 20 is inserted within bore 11 of female die 10 in such a manner that the tip portion of shank 19 cooperates with die aperture 12 to provide a desired die orifice. It will be understood that the die aperture 12 and tip portion of shank 19 are so selected in their configuration that an extruded shape of any desired cross-section may be produced. For example, on reference to Fig. 8, it will be seen that the exterior contour of an extruded section 30, that is readily produced by the extrusion die of this invention, is elliptical whereas the interior bore is generally square. To produce this section, the tip end of mandrel shank 19, which extends into die aperture 12, would of necessity be square, and the die aperture 12 would be elliptical. Furthermore, in the production of extruded section 30, it would be required that mandrel member 20 be assembled in proper relationship within female die 10 in order to insure correct disposition of the square aperture with respect to the outside elliptical perimeter. This proper assembly is insured through the provision of outwardly extending flanges 26 on the head end 21 of mandrel 20 which engage the ends of flanges 25 and accurately register the mandrel and secure it against rotational movement with respect to the die aperture 12.

An unperforated billet or solid metal charge, heated to the proper temperature and placed within billet cylinder 32 associated with the die structure of this invention, is brought into abutting relationship with the front face 15 of die 10 under the influence of power-operated extrusion ram 33, continued pressure through the medium of ram 33 causing the metal of the unperforated billet to flow in streams through the passageways formed by recesses 14 and cooperating mandrel 20 into the mixing chamber 24 and through the die orifice formed between aperture 12 and the tip of mandrel shank 19. As a result of the particular die structure of the extrusion die assembly of this invention, the initial excessive pressure normally required to extrude an unperforated billet through a porthole type extrusion die is greatly reduced because of the abrupt shearing edges provided in the form of flanges 25 and 26 at the entrance to each of the passageways through the die. Not only do flanges 25 and 26 relieve this initial excessive pressure, but the relief 27 in the passageways afforded by flanges 25 and 26, and the parallel walls of the passageways permit forward flow of the metal streams over a considerable length of the die passage without introducing any substantial lateral frictional resistance to flow as is normally experienced with passageways which change direction abruptly following their entrance to the die structure. It is not until the streams of metal are deflected inwardly by the inwardly-turned walls of the passageways that any lateral frictional resistance is imparted to the metal flow through the die structure of this invention. At this stage in the extrusion operation the metal

of the billet has commenced to flow freely and readily fills out the interior hollow portions of the die structure. Following complete filling out of the interior hollow portions of the die structure, the metal of the billet serves to internally support the die structure against subsequently required reduced pressure necessary to expel the metal of the billet through the die orifice formed between die aperture 12 and the tip of mandrel shank 19 extending into the die aperture.

In general, two distinct pressures are experienced in extruding material through porthole type dies. First, the initial pressure required to overcome frictional resistance to the initial flow of the metal of an unperforated billet into the hollow interior of this type of extrusion die; second, the extrusion pressure required to finally expel the metal from the interior of the die through the die orifice to produce an extruded section. The initial pressure usually exceeds the secondary pressure, and it has been discovered that the provision of the perimetric shearing flange adjacent the entrance to the passageways in cooperation with a substantial length of relieved passageway immediately following the perimetric flanges has reduced the initial pressure normally experienced to a value which is directly reflected in the useful life of porthole type dies.

The second extrusion pressure encountered in the use of porthole dies is normally below that initially required to fill out the interior of the die. This may be explained in terms of a secondary extrusion operation wherein the metal being extruded flows over itself instead of in direct contact with substantial surface areas of the interior hollow portions of the die structure. The resistance to flow of the metal under extrusion is considerably less within itself than the restraint caused by frictional contact between the metal of the die structure and the metal being extruded. This phenomenon can be looked upon as a double extrusion operation, the initial extrusion operation being through a die existing in the die structure of the present invention in the form of the perimetric flange (flanges 25 and 26) adjacent the entrance to each passageway through the die structure, and a secondary extrusion operation wherein the metal of the billet filling out the interior of the extrusion die flows within itself and is finally expelled through the die orifice formed between die aperture 12 and the mandrel tip of shank 19.

Although a specific illustration has been resorted to in describing the contribution to the art represented by this invention, it is to be understood that the invention is susceptible of a wide variety of uses in the production of extruded products from various ferrous or non-ferrous metals, aluminum, magnesium, and their alloys being particularly adaptable to extrusion by means of the apparatus herein disclosed, and the invention is not to be limited except as defined in the appended claims.

What is claimed is:

1. In an apparatus for extruding hollow sections from unperforated billets, the combination of a female die having a cylindrical bore therethrough terminating in a die aperture, said bore being restricted and defined for a portion of its length in front of said die aperture by inwardly extending, radially disposed ribs presenting shoulders normal to the axis of the bore, a headed

mandrel member received within said bore in bearing engagement with the walls thereof and with its head abuttingly supported upon said shoulders in axial pressure resisting relationship with respect to said female die, a plurality of recesses in said female die serving in cooperation with said mandrel to provide circumferentially spaced passageways through the female die at a point between said ribs, said passageways terminating in front of said die aperture, and a shearing flange on the female die at the entrance of each passageway providing an abrupt relief shoulder therein, and upstanding flanges on said mandrel cooperating with the flanges on said female die to complete the continuity thereof and to lock said mandrel against rotative movement.

2. An extrusion die structure of the porthole type comprising a female die member having a cylindrical bore therethrough terminating in a die aperture, circumferentially disposed inwardly extending ribs serving to restrict the diameter of said bore adjacent the die aperture, the front ends of said ribs forming co-planar shoulders normal to the axis of the bore at a point intermediate the length thereof, a cylindrical mandrel member having a head portion and a shank portion, said head portion being radially supported on the wall of said bore in front of said ribs and supported in end thrust relation against the co-planar shoulders, the shank portion of the mandrel being radially supported upon the faces of said ribs within the restricted bore and having a portion extending into the die aperture to form a die orifice therewith, a plurality of recesses in the female die radially disposed around the cylindrical bore, said recesses extending through the female die at points between said ribs and cooperating with the mandrel member to provide passageways through said die, and upstanding flanges on said die at the entrance to said recesses and on the head portion of the mandrel member providing a continuous perimetric shearing flange restricting the entrance to and abruptly relieving each passageway through the die structure, whereby the streams of metal forced past said flanges are of smaller cross sectional area than the cross sectional area of the passageway behind said flanges.

3. In a porthole die assembly for extruding unpierced billets, a die member having a stepped bore therein communicating at its small diameter end with a die aperture, a headed mandrel supported in said bore in bearing contact with the walls thereof and having an extension cooperating with said die aperture, a coalescing chamber surrounding said mandrel adjacent said die aperture, a plurality of circumferentially spaced passageways leading from the front face of said die member to said coalescing chamber and having walls paralleling the axis of said mandrel, and a continuous peripheral flange for each of said passageways forming a continuous restricted coaxial entry way therefor, said flanges providing sharp shearing edges at the front side thereof and abrupt relief shoulders in said passageways, the step in said bore and the adjacent face of the head of said mandrel being perpendicular to the axis of the die whereby the mandrel is held against axial movement under extrusion pressure without radially stressing said die member and may be withdrawn therefrom head end foremost.

KARL B. GUINEY.