Jan. 6, 1948. R. E. SLATER 2,433,929

CONICAL DIE FOR METAL DRAWING

Filed May 11, 1944

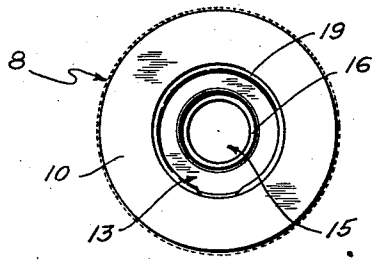


Fig. 1

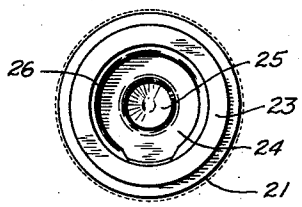


Fig. 3

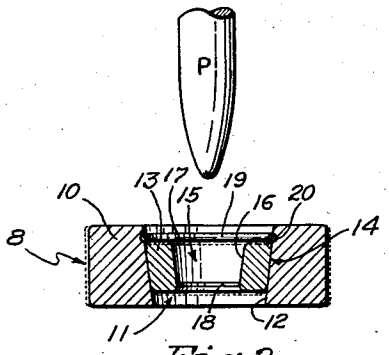


Fig. 2

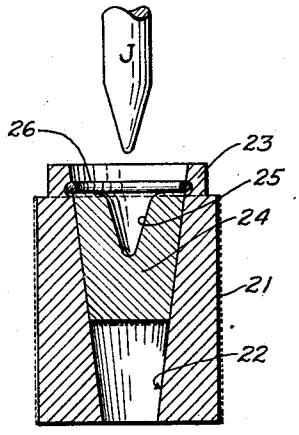


Fig. 4

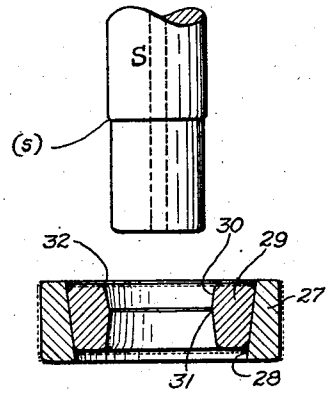


Fig. 5

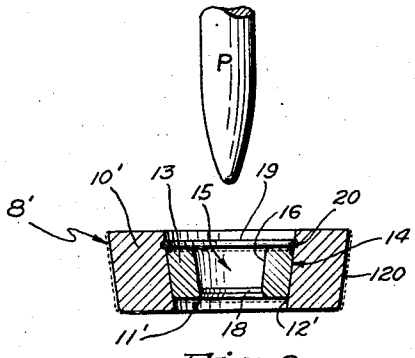


Fig. 6

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Patented Jan. 6, 1948

2,433,929

UNITED STATES PATENT OFFICE

2,433,929

CONICAL DIE FOR METAL DRAWING

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Application May 11, 1944, Serial No. 535,011

3 Claims. (Cl. 113—49)

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The present invention relates broadly to the art of metal working, and, more especially, to the art of forming metallic cup-shaped articles. For the purpose of illustration, the present invention will be described in connection with its application to the art of manufacturing small arms ammunition components, but it will be understood that the embodiments shown are exemplary only and that the invention includes all modifications within the scope of the appended claims.

In general, ammunition components such as cartridge cases and bullet jackets are formed from a blanked disk of brass, gilding metal, steel or other suitable material by means of punch and die assemblies which are adapted to shape the metal disk to the required shape and size. One of the outstanding problems in the manufacture of small arms ammunition components has been that of producing components of predetermined size within allowable tolerances of the order of one ten-thousandths inches in order that the finished cartridges may be substantially uniform and meet specifications. The immediate cause of deviations in the size of the components has been due primarily to worn and defective punches and dies.

Heretofore, dies and, in particular, drawing dies have comprised a metal annulus having a central aperture, the walls of which are tapered to provide a suitable approach angle; and a relatively narrow cylindrical land which is ground and polished to an accurate diameter which determines the size of the drawn workpiece. The force required to draw the case must necessarily be above the yield point of the metal being used and, for brass, is substantially fifty thousand pounds per square inch. This force is provided by means of a reciprocable punch which strikes the blank with a sudden relatively sharp blow or impact and drives the blank down through the draw die aperture. The initial impact or force of the blow on the die is great and this together with the force required to draw the metal through the die subjects the latter to radial stresses which have been found to be great enough to expand the die aperture. Although the degree of expansion may be extremely small, it is nevertheless sufficient to form oversize cases. Moreover, the repeated expansion and contraction of the die hereinafter termed "breathing" causes metal fatigue resulting in failure of the die. Further, since the friction on the walls of the die aperture is enormous, it is common practice to harden the dies or at least the walls of the die apertures by heat treatment or nitriding

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to secure maximum hardness. The term "hardness" as hereinafter used shall be understood to mean the ability to withstand abrasion. However, maximum hardness is accompanied by maximum brittleness, and a relatively short life when subjected to repeated expansion and contraction.

As a result, the die maker's prob'em has been that of selecting a specific metal which, when hardened for wear resisting qualities, will have sufficient endurance to withstand fatigue for a reasonable length of time. The most satisfactory metals for drawing dies are the relatively expensive high carbon, high chromium and tungsten carbide steels. Attempts have been made also to make a draw die by sweating a relatively hard ring die into the cylindrical seat of a holder. However, due to the brittleness of the ring die, its enforced expansion with each stroke of the draw punch is greater than its contraction following withdrawal of the punch from the die resulting in a gradual enlargement of the die aperture and the relatively rapid development of surface fissures which are believed to cause "brassing up" and similar malfunctioning of the die.

An object of the present invention is to provide an improved die assembly which is relatively inexpensive and has a long life. A further object is to provide a die assembly capable of shaping articles consistently and accurately to predetermined size. A still further object is to provide a die assembly comprising a relatively elastic holder and a substantially nonbreathing ring die, the latter being movably mounted in the holder.

These and other objects, features and advantages of the invention will be more particularly described in the following specification.

In the drawing:

Fig. 1 is a plan view of the drawing die assembly of this invention.

Fig. 2 is an elevation in section of the drawing die assembly of Fig. 1.

Fig. 3 is a plan view of a die assembly for pointing bullet jackets.

Fig. 4 is an elevation in section of the pointing die assembly of Fig. 3.

Fig. 5 is an elevation in section of a cutoff die assembly.

Fig. 6 is an elevation in section of a modification of the drawing die assembly shown in Figs. 1 and 2.

Referring to the drawing, the drawing die assembly, indicated generally at 8, comprises an annulus or ring shaped holder 10 having a central

aperture 11 characterized by substantially straight tapered walls 12, the angle of taper being substantially 7° to the center line of the aperture. The degree of taper as specified has been found to function successfully in die assemblies used for drawing .30 caliber brass cartridge cases. It will be understood, however, that the angle of taper may vary depending upon such considerations as the characteristics of the metal being drawn, and, in particular, its hardness and ductility, the size of the drawn article, and the elastic limit of the metal comprising the holder.

The walls 12 of the tapered aperture are preferably ground and polished while both the top and bottom surfaces of the holder 10 are ground to a smooth finish. The holder is adapted to be relatively elastic so as to expand and contract readily, and, to this end, may comprise a carbon tool steel hardened by heat treatment and annealing to have a Rockwell hardness within the range of forty-seven to fifty-three on the "C" scale. Steel within this hardness range has the elasticity of spring steel and under loads less than its elastic limit is enabled to withstand repeated expansion and contraction without developing progressive fractures or permanent set.

The elastic holder 10 is adapted to receive and support a ring die 13 which is a substantially truncated cone-shaped annulus provided with a tapered rim 14 and a central aperture 15 having tapered walls 16 concentric with and substantially parallel to the tapered rim 14. The tapers of the rim 14 and walls 16 of the aperture are substantially 7° to the center line of the aperture and correspond substantially to the taper of the walls 12 of the holder aperture 11 to the end that the walls 12 may support the rim of the ring die substantially uniformly throughout the drawing operation. The die assembly shown in Fig. 2 is suitably designed to maintain this relationship between the ring die and holder while drawing .30 caliber brass cartridge cases. It may be desirable, however, to modify the construction of the holder in order to more effectively maintain this relationship between the holder and ring die when drawing heavier cases such as .50 caliber cases for which greater drawing forces are required.

In practice, whether drawing a heavy or light case, the drawing operation is initiated by a sudden blow of the draw punch which creates a peak load at the mouth of the die holder. This peak load is of momentary duration and decreases almost immediately to assume a substantially constant value, hereinafter termed the drawing load, throughout the remainder of the drawing operation. Consequently, there is a tendency for the mouth of the aperture 11 of the holder to be expanded disproportionately to the expansion of the lower portion of the aperture, thereby effecting nonuniform support of the rim 14 of the ring die. To offset this circumstance, the supporting walls of the holder aperture 11' may be made substantially of uniform thickness throughout by reducing the thickness of the walls of the holder adjacent the lower ends thereof, as indicated at 120 in Fig. 6, whereby the drawing force is enabled to expand the lower portion of the aperture 11' of the holder 8' an amount more nearly equal to the expansion of the upper portion or mouth of the aperture.

The walls 16 of the ring die aperture 15 comprise substantially straight tapered surfaces which extend from a radius 17 adjacent the upper

edge of the ring die aperture to a land 18 adjacent the lower edge thereof. The land 18 is characterized by substantially cylindrical walls parallel to the center line of the aperture 15, the diameter of the land being the measure of the outside diameter of a drawn case. Both the tapered walls 16 and the cylindrical walls of the land 18 are lapped and polished to provide mirror smooth surfaces. The outer tapered rim 14 of the ring die is ground and polished to make a nice fit in the tapered aperture 11 of the holder 10, the ring die normally being freely mounted therein.

The ring die 13 comprises a suitable metal such as steel which has been treated to acquire maximum hardness and to be relatively incompressible and nonexpansive or "nonbreathing," and hence is enabled to hold the predetermined dimensions of its land 18 to within very close tolerances throughout the drawing operation as hereinafter described.

Extreme hardness is generally accompanied by brittleness at the expense of endurance or resistance to fatigue failure but, as hereinafter explained, the endurance of the ring die 13 is not a necessary factor in its construction. In fact, hardness is substantially the only requirement of the ring die, and hence other less expensive metals than the high carbon, high chromium steels may be used. For example, cast iron has been found to be ideally suited for making extremely hard, long wearing ring dies. It may be noted too that the ring die is considerably smaller than the older types of drawing dies, and hence even though made of the more expensive steels would be proportionately less expensive.

As shown in Fig. 2, the ring die 13 is adapted normally to seat freely in the holder and may be retained therein by means of a snap ring 19 adapted to seat in a groove 20 in the walls 12 of the aperture 11 adjacent to and circumscribing the upper edge thereof. Although the snap ring provides suitable retaining means, it will be understood that any means fixed to the holder 10 and adapted to prevent the ring die from slipping out of the mouth of the aperture 12 may be used. Such means should not, however, interfere with the free expansion of the holder.

In use, the die assembly 8 is fastened securely in a press in axial alignment with a drawing punch P. A metal blank or disk is placed over the die assembly whereupon the punch is released and driven down onto the blank. As mentioned above, when the punch first engages the blank in the die, the force of the blow is a peak load. Heretofore this peak load has accelerated the rate of wear of the tapered walls of the die aperture thereby developing depressions or "craters" tending to form cases of varying diameter. Moreover, surface compression of the walls of the die promoted hardness and brittleness, and hence reduced the endurance and life of the die. However, in the improved die assembly of this invention, the ring die 13 is normally freely seated in the aperture 12 of the elastic holder 10, and hence when the punch first strikes the blank forcing it into the ring die, the latter, being extremely hard and relatively incompressible and nonexpansive, is forced down into the aperture of the holder as indicated by the dotted lines of Fig. 2, the holder expanding radially due to the wedging action between the tapered rim of the ring die and the tapered walls 13 of the holder. The actual movement of the ring die and expansion of the holder are very minute but for the sake of illustration

have been indicated as measurable distances. In this connection, it should be noted that the force tending to expand the holder is measured by the horizontal component of the force applied to the ring die by the punch and that the magnitude of the horizontal component varies with the angle of taper of the engaging surfaces of the ring die and holder. Hence, the selection of the angle of taper which, in the present embodiment, is substantially 7° is primarily governed by comparison of the maximum horizontal force component and the elastic limit of the holder. For optimum performance, the horizontal force component should be substantially less than the elastic limit of the holder to preclude progressive fracture and permanent set thereof. The aforesaid ability of the ring die to move downwardly into the expanding holder effectively dissipates the peak load on the ring die thereby reducing wear thereof and increasing the life of the die assembly as well as that of the draw punch press. Moreover, the displacement of the ring die effectively prevents the stresses in the ring die from building up sufficiently to cause any substantial change in the diameter of the land 13, that is to say, the ring die does not "breathe" to any substantial degree, and hence is free from the deteriorating effect of metal fatigue and retains its predetermined land dimensions throughout the drawing operation.

After the punch has drawn the blank through the ring die, the punch is carried up out of the die and the case is stripped from the punch in any suitable manner. As soon as the ring die and holder have been relieved of the drawing load, the holder contracts and in so doing its tapered wall 12 automatically cams the ring die 13 back up into its original or normal position in the aperture of the holder.

The foregoing description relates to the drawing die assembly shown in Figs. 1, 2 and 6. Figs. 3 and 4 illustrate a bullet jacket pointing die assembly which embodies a recessed die and die holder constructed on the principles of the above described drawing die assembly. The holder 21 is a comparatively long cylindrical member provided with a central aperture 22 having substantially 7° tapered walls and an upstanding flange 23 on its upper end for securing the holder in a press. Seated in the tapered aperture 22 is a truncated cone-shaped die 24 having a central ogival recess 25, the surface of which is lapped and polished to predetermined dimensions. The physical characteristics of the metal of the holder and of the die are comparable to those of the drawing die assembly described above, the cylindrical holder 21 being relatively elastic and the die 24 extremely hard and brittle. The latter is adapted normally to be seated relatively freely in the aperture 22 of the holder and to be retained therein by means of a suitable snap ring 26 which is shown seated in an annular groove adjacent the bottom of the flange 23.

When the jacket pointing punch J engages and drives a bullet jacket blank down into the die recess 25, the die 24 is enabled to move downwardly in the tapered aperture 22 of the holder due to the "nonbreathing" characteristics of the die and the elasticity of the holder, thereby relieving the die from excessive wear at the mouth of the recess 25 and precluding premature destruction of the die by metal fatigue. It should be noted that the improved jacket pointing die assembly also obviates any necessity for providing a spring mounting for the pointing punch J which has been a requirement in the construction of

older types of pointing punches and which has inevitably introduced variations in the effective stroke of the punch. By eliminating the spring mounting, the pointing punch is enabled to form bullet jackets consistently of uniform shape and wall thickness. Furthermore, by providing a nonbreathing bullet pointing die, each bullet formed in the die has a perfectly uniform ogive. Heretofore it has frequently been noted that the ogives of bullets formed in expandable dies have been irregular or "blown" giving rise to extremely poor accuracy on firing.

Following the jacket pointing operation and substantially simultaneously with the withdrawal of the pointing punch from the recess 25 of the die 24, the holder contracts and restores the die 24 to its normal position therein.

A further application of the principles of the invention is illustrated in the embodiment of Fig. 5 which shows, in section, a cutoff punch and die assembly for shot shells embodying a metal die holder 27 comprising a relatively elastic steel having a central aperture 28 of substantially 7° taper. Seated relatively freely in the aperture 28 is a hard "nonbreathing" ring die 29 having a central aperture consisting of a tapered approach or mouth portion 30 and a land having substantially cylindrical walls 31 which are lapped and polished to a predetermined diameter. The upper edge or rim of the taper 30 is adapted, with the top surface of the die, to provide a shearing edge 32. When the drawing and cutoff punch S engages and drives the blank down into the die aperture, the blank is drawn out into a cup-shaped article which, after attaining a predetermined length, is cut off at its upper end by cooperation of a shoulder *s* of the punch with the shearing edge 32 of the die 29.

Heretofore the work done on the shearing edge of a cutoff die has produced excessive wear due to the substantially rigid mounting of the die. Consequently, the shearing edge became oversize in a relatively short time and produced ragged torn edges on the upper end of the drawn article. Moreover, the die aperture was appreciably increased in diameter as the punch forced the blank down therein thereby increasing the distance between the shearing edge 32 of the die and the shearing shoulder *s* of the punch. This circumstance also precluded the formation of sharply and smoothly sheared edges on the upper end of the drawn article.

In the improved cutoff die assembly shown in Fig. 5, the substantially inelastic ring die is enabled to move downwardly in the elastic holder under the impact of the shearing punch S thereby relieving the shearing edge 32 of the ring die from the peak load. Further, due to the "nonbreathing" characteristics of the ring die, its aperture including its land 31 maintains its original and predetermined diameter throughout the entire cycle of operations, and hence the shearing shoulder *s* of the punch S and the shearing edge 32 of the die are always properly spaced so as to effect a clean cut at the upper edge of the drawn article.

The die assemblies shown and described have many advantages over previous types of dies such as relatively low cost and a greater degree of accuracy. Further, the improved die assemblies have substantially three times the life of dies which have been previously used thereby cutting down overall cost and enabling increased rates of production.

What is claimed is:

1. A die assembly for shaping workpieces comprising a die, an elastic die holder, said die and die holder having mutually engaging surfaces which are uniformly and continuously tapered throughout their extent to support said die freely in said holder and below the upper edge thereof and to enable said die to move from a normal position in said holder to a lower position in said holder so as to reduce the impact on said die of the force initiating the workpiece shaping operation and simultaneously to expand said elastic holder radially during the downward movement of said die to dissipate the forces of said impact which tend to change the geometry of said die, the angle of taper of said uniformly and continuously tapered surfaces being not substantially less than 7°, whereby said die will be moved upwardly to its normal position in said elastic holder due to the subsequent radial contraction of said holder following the workpiece shaping operation.

2. A die assembly for shaping workpieces comprising a hard substantially nonexpansible die, an elastic die holder, said die and die holder having mutually engaging conical surfaces which are uniformly and continuously tapered throughout their extent, the angle of the taper being substantially 7° to support said die freely in said holder and below the upper edge thereof and to enable said die to move from a normal position in said holder to a lower position in said holder so as to reduce the impact on said die of the force initiating the workpiece shaping operation and simultaneously to expand said elastic holder radially during the downward movement of said die to dissipate the forces of said impact which tend to change the geometry of said die.

3. A die assembly for shaping workpieces comprising a die, an elastic die holder, said die and die holder having mutually engaging surfaces which are uniformly conical throughout their extent to support said die freely in said holder

and below the upper edge thereof and to enable said die to move from a normal position in said holder to a lower position in said holder so as to reduce the impact on said die of the force initiating the workpiece shaping operation and simultaneously to expand said elastic holder radially during the downward movement of said die to dissipate the forces of said impact which tend to change the geometry of said die, the angle of the slope of said uniformly conical surfaces being such that said die will be moved upwardly to its normal position in the elastic holder due to the subsequent radial contraction of said holder following the workpiece shaping operation, and a snap ring in said holder adapted to be engaged by said die in its normal position in said holder to prevent egress of said die therefrom and to limit the upward movement of said die to its normal position in said holder following each shaping operation.

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