March 28, 1939. H. KOESTER 2,151,776

METHOD AND APPARATUS FOR FORMING METAL SCREW BLANKS

Filed Jan. 31, 1938

Fig. 1.

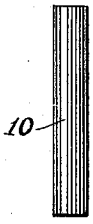


Fig. 2.

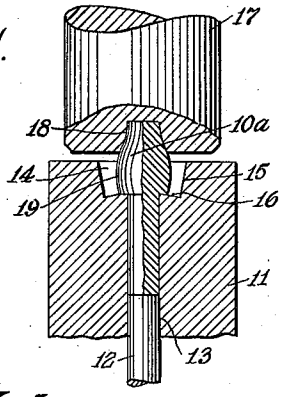


Fig. 3.

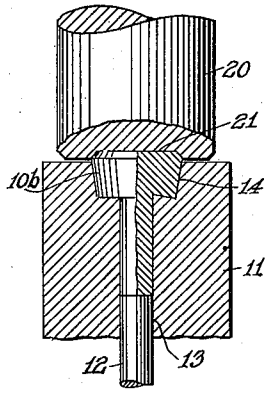


Fig. 4.

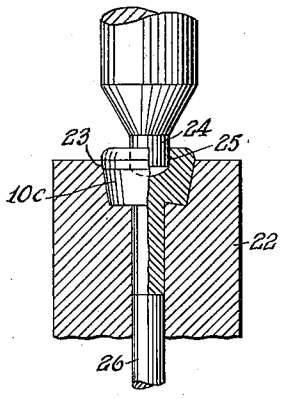


Fig. 5.

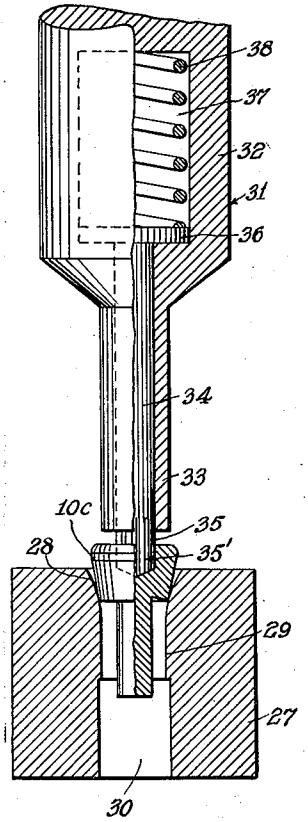


Fig. 6.

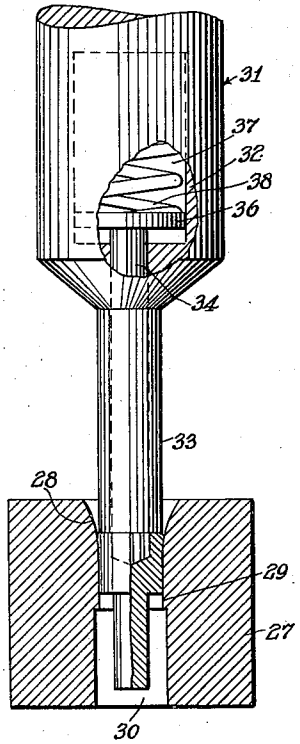
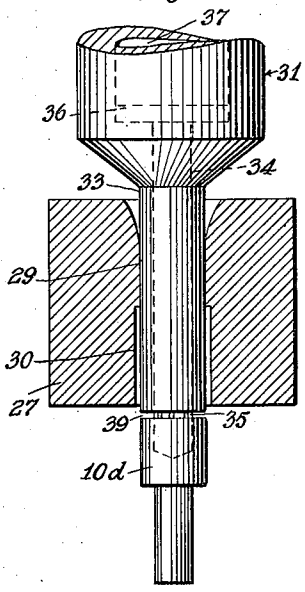


Fig. 7.



INVENTOR.
HERMAN KOESTER
BY Fred C. Schuetz
ATTORNEY.

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METHOD AND APPARATUS FOR FORMING METAL SCREW BLANKS

Herman Koester, Waterbury, Conn., assignor to The Bristol Company, Waterbury, Conn., a corporation of Connecticut

Application January 31, 1938, Serial No. 187,784

9 Claims. (Cl. 10—7)

This invention relates to cold-formed, socketed or hollow screws and method of, and apparatus for, making blanks for the same, with particular reference to the manner of forming the head portion and causing the internal socket to assume a predetermined contour adapted for operative engagement by a suitably formed wrench or key. It has heretofore been proposed to make screws of this class by a process which includes providing a solid cylindrical blank of metal with an enlargement at one end, forming a socket in the enlarged end, and forcing the blank by an angular or non-circular punch through a die opening that is smaller in diameter than the enlarged end of the blank, thereby drawing the metal of that portion onto the punch and causing the interior contour of the socket to conform to the exterior contour of the punch. Such a method is set forth in U. S. Letters Patent No. 960,244, issued to W. G. Allen, June 7, 1910. From a study of the principles involved, it will be apparent that in this method the operation by which the socket is caused to assume its final form is in the nature of a drawing action, whereby, during the forming process, the fibres of the metal are in a state of tension, with a resultant tendency to inherent weakness of the finished product at a point where, under conditions of use, it is likely to be submitted to relatively great stresses.

Another process involves the use of a non-circular punch which enters the original socket in the blank, the tip of the punch engaging the bottom of the socket and forcing the metal into a cylindrical mold with a generally radial flow, the walls of the mold serving to restrict the flow until it closes in upon the punch. In this process, as in the former, the final conformation of the blank is effected by force applied to the metal by the tip of the punch, from which action is inseparable a certain splitting, shearing, or drawing tendency, by which the fibres of the metal are placed in a state of tension.

It is an object of this invention to provide a method and apparatus for forming screw blanks of the nature set forth, in which the final forming operation, including the conformation of the interior of the socket to the desired contour, shall be effected with the metal wholly in a state of compression, tending to concentrate the distribution of the fibres in the portion of the blank lying between the hollow head and the shank of the screw. It has been found that screws made from blanks formed according to this process, when tested under controlled conditions, show a resistance to breaking as much as fifteen percent higher than similar screws made from blanks of the same material formed by different methods.

It is proposed to accomplish the desired result by providing for use on a heading machine of the conventional type a forming member embodying two distinct sections—a longitudinally yielding mandrel adapted to enter a previously formed recess in a blank, and having its contour formed to the desired cross-section of the socket, and an annular portion surrounding said mandrel and having a substantially flat face smaller in diameter than the previously enlarged portion of the blank, and adapted to engage the same, extruding it solely by compression through a die aperture of substantially the same diameter as that of the annular portion of the forming member.

The nature of the invention, however, will best be understood when described in connection with the accompanying drawing, in which:

Fig. 1 is a side elevation of a blank of uniform diameter, as cut from suitable bar or wire stock.

Fig. 2 is a side elevation, partially in section, showing the first step in the upsetting or heading process.

Fig. 3 is a similar view, showing the second step in the heading process.

Fig. 4 is a similar view showing the initial step in forming the socket.

Fig. 5 is a side elevation, partially in section, of the combined extrusion member and mandrel, and of the die through which the blank is finally extruded, showing said parts of the mechanism in the position of initial engagement with the blank.

Fig. 6 is a similar view showing the flat-faced extrusion member and enclosed mandrel in engagement with the blank and having forced it part way through the die.

Fig. 7 is a similar view of the engaging parts of the punch, mandrel and die, showing said parts in the position of final engagement with the blank after extrusion through the die.

Referring to the drawing, a blank 10, Fig. 1, of suitable length and uniform cylindrical cross-section is first cut off from rod or wire stock. This blank is next upset to form a head thereon, which action is effected in two upsetting operations, bringing the blank successively into the forms shown in Fig. 2 and Fig. 3. While this part of the process presents no particular novelty, and for it no invention is claimed, yet, in order that there may be had a clear understanding of the whole process of forming the screw blank, it is outlined briefly as follows:

The blank 10 is inserted in a lower die 11 above a conventional knock-out pin 12 closely fitting an axial aperture 13 of the same diameter as that of the blank 10. (It will be understood that in this description the terms "upper", "lower", etc., are purely relative, and that the process may be carried out as effectively in a machine having horizontally disposed die parts as in one wherein those elements are vertically disposed.) The upper end of the blank in this position projects through a die cavity 14 formed in the upper face of the die 11 coaxial with the aperture 13 and having its outer surface 15 conformed to a truncated cone and its bottom surface 16 departing slightly from a true flat into a conical conformation rising toward the center, and forming in the contour line of the section of the die an acute angle with the cylindrical surface of the aperture 13.

Cooperating with the lower die 11 is an upper movable die 17 having in its working face a tapered aperture 18 adapted to receive the projecting end of the blank before and during the initial upsetting step. Thus, when the die 17 is brought down upon the die 11 with sufficient force, there will be formed upon the blank a relatively wide-bottomed upset portion 19, projecting slightly over the conical surface 16, but not completely filling the cavity 14, the whole blank now having the form shown at 10a.

After the blank has been shaped as described, it is next shaped into the form shown at 10b, Fig. 3, this being effected by the die 11, carrying the partially upset blank, being brought into operative relationship with a die 20 having in its working face a recess 21 in the form of a shallow truncated cone of maximum diameter substantially the same as that of the recess 14 in the die 11. When the dies 20 and 11 are brought together, the upset portion 19 on the blank 10a will be caused to fill completely the recesses 14 and 21, resulting in the formation on the blank of a head having a contour as indicated in Fig. 3, and adapted for the initial step in forming the socket.

After having been shaped to the conformation shown at 10b in Fig. 3, the blank may, if desired, be annealed, it then being transferred to a die 22 as shown in Fig. 4. The die 22 is similar to the die 11, but the cavity therein is made slightly deeper than the cavity 14 by the addition of a short cylindrical portion as at 23, to accommodate the axial flow of metal attending the punching of the recess later to be developed into a socket. A punch member 24, having a cylindrical tip portion, preferably with a rounded end, is then brought into engagement with the flattened top of the blank, and forced thereinto to a distance predetermined by adjustment, thus forming a recess 25 of a depth less than the desired ultimate depth of the socket, and of a diameter substantially equal to the maximum desired diameter of the finished socket. In this step of the process, the flow of metal in the direction of punching being prevented by the presence of a knock-out pin 26, and lateral flow by the walls of the die cavity, the metal has no alternative but to flow backwards along the punch in a generally axial sense, filling the short cylindrical space 23, resulting in a recessed blank as shown at 10c, having a head portion of axial length slightly greater than that of the head before recessing. The flow of the metal solely in a direction longitudinal of, and in opposition to, the movement of the punch has been found to produce a molecular condition which results in a blank better suited to formation by, and producing a stronger ultimate product after, the extrusion process now to be set forth, than is obtainable in blanks having a recess punched with restriction as to the outward radial flow of the metal.

The final forming of the blank is effected by a combination of forming tools shown in detail in Fig. 5. These comprise a die member 27 having formed therein an aperture with a smoothly tapered entrance portion 28 of maximum diameter somewhat greater than the minimum diameter of the lower part of the conical head on the blank 10c, and a cylindrical portion 29 of diameter equal to the desired final diameter of the head portion of the completed blank. Beneath the cylindrical portion 29 is a cylindrical portion 30 of slightly greater diameter than that of portion 29, relieved to permit free passage of the completed blank.

A forming tool 31, adapted to coact with the die 27 in finally forming the blank, is made up of two main portions, both adapted to engage the material of the blank during the forming process, but in such a manner as to segregate the nature of stresses exerted between these members and the blank, the stress in the one member being wholly axial, and in the other wholly radial. To this end, the tool comprises a housing portion 32 which terminates in an extended annular extruding member 33 having an outside diameter substantially the same as that desired for the head of the finished blank, and adapted to pass through the aperture portion 29 in the die 27. Its inside diameter is substantially equal to the maximum desired diameter of the final form of the socket to be formed in the blank.

Within the housing portion 32, extending through the annular member 33 and free for limited longitudinal movement therein, is an extended mandrel member 34 having a tip portion 35 which is provided with grooves or flutes 35', or is otherwise conformed to the contour and dimensions of the non-circular socket which it is desired to form in the blank. This mandrel terminates in a head portion 36 positioned inwardly of the housing portion 32, and is movable in a cylindrical chamber 37 formed in the body thereof. A compression spring 38, contained within the chamber 37, tends to maintain the mandrel member 34 in a position where tip portion 35 projects its maximum distance out of the annular extruding member 33, and to an extent not less than the maximum depth required for the finished socket.

In the forming process, the blank 10c, after again annealing if desired, is first positioned by a releasing grip (not shown in the drawing) in the path of the tool 31, which is then brought into engagement with the blank, carrying it into the die 27, as shown in Fig. 5. The strength of the spring 38 is sufficient to assure positive seating of the tip of the mandrel 34 in the recess previously formed in the blank, but not to exert appreciable extruding force upon the blank as the latter enters the tapered aperture portion 28 of the die 27. Consequently, as the headed portion of the blank is definitely engaged by the tapered walls of the aperture portion 28, both the blank and the mandrel member are momentarily brought to rest, the spring 38 yielding as the housing portion 32 and the extruding member 33 continue to advance toward the die 27.

As the annular flat faced extruding member 33

engages the flattened top portion of the blank, the latter is forced more deeply into the tapered aperture portion **28**, the first wedging action on the sides of the head causing its metal to flow in such a manner that the walls of the recess grip the tip portion **35** of the mandrel **34**, and, as the blank continues to be forced into the tapered portion of the die, to conform to the shape of the mandrel. The metal of the upper portion of the head will flow in upon the mandrel; and, as the diameter of the head becomes lessened with its passage through the narrow aperture portion **29**, not only will the flutes or other characteristic conformations of the mandrel be completely filled with extruded metal, but the surplus metal attendant upon the reduction in cross-section of the head portion of the blank will be caused to flow in a generally longitudinal sense relative to the mandrel, causing the head portion of the blank to be lengthened. The gripping action of the metal upon the tip of the mandrel, coupled with the force of the spring **38**, will prevent the mandrel being forced back into the housing; and, as the metal of the blank is compressed or extruded toward the mandrel, the latter will advance at a higher rate than the extruding member, so that as the head is built up and elongated by the flowing metal, the socket will assume a depth greater than that of the originally punched recess. This action, which is shown in Fig. 6, will continue until the blank has been forced all the way through the cylindrical portion of the die aperture, whereupon the blank will have assumed its final form as at **10***d*.

With the dies suitably proportioned and adjusted in relation to the dimensions and metallurgical characteristics of the original blank, the finished blank **10***d* may be caused to assume such dimensions that the base of the head, originally containing a slightly conical recess, formed by the part **16** of the blanking die, will assume a substantially flat conformation, as shown in Fig. 6, while the depth of the finished socket, while greater than that of the original recess, will be slightly less than the possible distance which the mandrel **34** may project from the annular extruding member **33**. The latter condition being fulfilled, the blank, immediately upon the head portion passing through the cylindrical aperture portion **29**, will be forced away from the extruding member **33** by action of the compression spring **38** forcing the mandrel **34** to its extreme projected position, thus leaving a slight space, as at **39**, between the annular face of the extruding member and the head of the completed blank, thus facilitating removal of the finished blank by means of automatic stripping mechanism (not shown in the drawing). Thus there has been provided a method of and means for forming a screw blank by a process in which the metal is subjected only to an action in the nature of extrusion under compression, rather than drawing under tension, and therefore is not at any time made subject to the weakening strains attendant upon forming the metal under conditions of tension or outwardly exerted radial stress.

I claim:

1. Means for forming a socketed screw blank or the like from a cylindrical blank with recessed head, comprising a die having therein an aperture with cylindrical section of diameter less than the diameter of said blank and with a tapered section forming an approach thereto and adapted to receive the blank, together with an annular extrusion member adapted to engage said blank for forcing it through said cylindrical section, and a coaxially disposed mandrel permanently mounted in the extrusion member, movable axially thereto and adapted to project beyond the same to enter the recess in said blank to an extent limited by the bottom of the recess, the protruding terminal portion of the mandrel bearing peripheral conformations to impart a predetermined contour to the walls of said recess as the material of the blank is laterally compressed upon the said terminal portion under the action of the extrusion member.

2. Means for forming a socketed screw blank or the like from a cylindrical blank with recessed head, comprising a die having therein an aperture with cylindrical section of diameter less than the diameter of said blank and with a tapered section forming an approach thereto and adapted to receive the blank, together with an annular extrusion member adapted to engage said blank for forcing it through said cylindrical section, and a coaxially disposed mandrel yieldably mounted in the extrusion member and adapted to project beyond the same to enter the recess in said blank to the full extent of its depth, the protruding terminal portion of the mandrel bearing peripheral conformations to impart a predetermined contour to the walls of said recess as the material of the blank is laterally compressed upon the said terminal portion under the action of the extrusion member.

3. Means for forming a socketed screw blank or the like from a cylindrical blank with recessed head, comprising a die having therein an aperture with cylindrical section of diameter less than the diameter of said blank and with a tapered section forming an approach thereto and adapted to receive the blank, together with an annular extrusion member having an annular flat pressure face of an outside diameter equal substantially to that of the finished head of the blank and an innner diameter equal substantially to that of the final form of the finished socket, said face being adapted to engage said blank for forcing it through said cylindrical section, and a coaxially disposed mandrel permanently mounted in the extrusion member, movable axially thereto and adapted to project beyond the same to enter the recess in said blank to an extent limited by the bottom of the recess, the protruding terminal portion of the mandrel bearing peripheral conformations to impart a predetermined contour to the walls of said recess as the material of the blank is laterally compressed upon the said terminal portion under the action of the extrusion member.

4. Means for forming a socketed screw blank or the like from a cylindrical blank with recessed head, comprising a die having therein an aperture with cylindrical section of diameter less than the diameter of said blank and with a tapered section forming an approach thereto and adapted to receive the blank, together with an annular extrusion member adapted to engage said blank for forcing it through said cylindrical section, and a coaxially disposed mandrel portion mounted in the extrusion member and adapted to project beyond the same to enter the recess in said blank to the full extent of its depth, longitudinally yieldable relatively to the extrusion member, and having a protruding terminal portion bearing peripheral conformations to impart a predetermined contour to the walls of said recess as the material of the blank is laterally com-

pressed upon the said terminal portion under the action of the extrusion member.

5. Means for forming a socketed screw blank or the like from a cylindrical blank with recessed head, comprising a die having therein an aperture with cylindrical section of diameter less than the diameter of said blank and with a tapered section forming an approach thereto and adapted to receive the blank, together with an annular extrusion member having an annular flat pressure face at one end adapted to engage said blank for forcing it through said cylindrical section and the other end of said member being enlarged to afford a housing, a mandrel mounted in the extrusion member coaxially therewith and longitudinally movable relatively thereto, and resilient means mounted in the housing of the extrusion member bearing upon an end of the mandrel to extend its opposite end beyond the flat pressure face, the protruding terminal portion being adapted to enter said recess and bearing longitudinal flutes to impart a predetermined contour to the walls of said recess as the material of the blank is laterally compressed upon the said terminal portion under the action of the extrusion member.

6. Means for forming a socketed screw blank or the like from a cylindrical blank with recessed head, comprising a die having therein an aperture with cylindrical section of diameter less than the diameter of said blank and with a tapered section forming an approach thereto and adapted to receive the blank, together with an annular extrusion member having an annular flat pressure face at one end adapted to engage said blank for forcing it through said cylindrical section and the other end of said member being enlarged to afford a housing, a mandrel comprising a rod passing through the extrusion portion of the extrusion member, its protruding tip bearing longitudinal flutes and adapted to enter said recess, the other end of the rod terminating in a head portion within the housing, and a compression spring within the housing bearing upon said head to cause said tip to protrude beyond the said extrusion member.

7. In the manufacture of socketed screws or the like: the process of forming a socketed blank from a solid cylindrical blank with a recessed enlargement at one end, which comprises forcing the blank through a circular die opening smaller than the enlarged end of the blank by applying pressure thereto solely by means of the annular flat face of a hollow extrusion member with outside contour equal substantially to the diameter of said opening; and, prior to the engagement of the annular flat face with the blank, introducing from the said hollow member into the recess of said blank a mandrel portion of predetermined conformation, the mandrel being free for axial movement relatively to the extrusion member and exerting substantially no extrusion pressure upon the blank and the movement of said mandrel being temporarily interrupted with the extrusion member continuing through the die, whereby as the blank is forced through said die opening solely by the annular face of the extrusion member the metal of said enlarged portion of the blank is laterally compressed onto the introduced mandrel portion, and the recess in said enlargement is caused to assume a contour corresponding to the cross-section of the introduced mandrel portion and a depth independent of the axial dimension of said mandrel.

8. In the manufacture of socketed screws or the like: the process of forming a socketed blank from a solid cylindrical blank with a recessed enlargement at one end, which comprises forcing the blank through a circular die opening smaller than the enlarged end of the blank by applying pressure thereto solely by means of the annular flat face of a hollow extrusion member with outside contour equal substantially to the diameter of said opening; and, prior to the engagement of the annular flat face with the blank, yieldingly introducing from the said hollow member into the recess of said blank a mandrel portion of predetermined conformation and to the full depth of said recess, the mandrel exerting substantially no extrusion pressure upon the blank, whereby as the latter is forced through said die opening solely by the annular face of the extrusion member the metal of said enlarged portion of the blank is laterally compressed onto the introduced mandrel portion, and the recess in said enlargement is caused to assume a contour corresponding to the cross-section of the introduced mandrel portion.

9. In the manufacture of socketed screws or the like: the process of forming a socketed blank from a solid cylindrical blank with an enlargement at one end, which comprises first punching a recess in the enlargement of the blank by punch and die means conformed to limit metal flow under the action of the punch to a direction substantially in opposition to the direction of the force applied to said punch, forcing the blank through a circular die opening smaller than the enlarged end of the blank by applying pressure thereto solely by means of the annular flat face of a hollow extrusion member with outside contour equal substantially to the diameter of said opening; and, prior to the engagement of the annular flat face with the blank, introducing from the said hollow member into the recess of said blank a mandrel portion of predetermined conformation, the mandrel being free for axial movement relatively to the extrusion member and exerting substantially no extrusion pressure upon the blank and the movement of said mandrel being temporarily interrupted with the extrusion member continuing through the die, whereby as the blank is forced through said die opening solely by the annular face of the extrusion member the metal of said enlarged portion of the blank is laterally compressed onto the introduced mandrel portion, and the recess in said enlargement is caused to assume a contour corresponding to the cross-section of the introduced mandrel portion and a depth independent of the axial dimension of said mandrel.

HERMAN KOESTER.