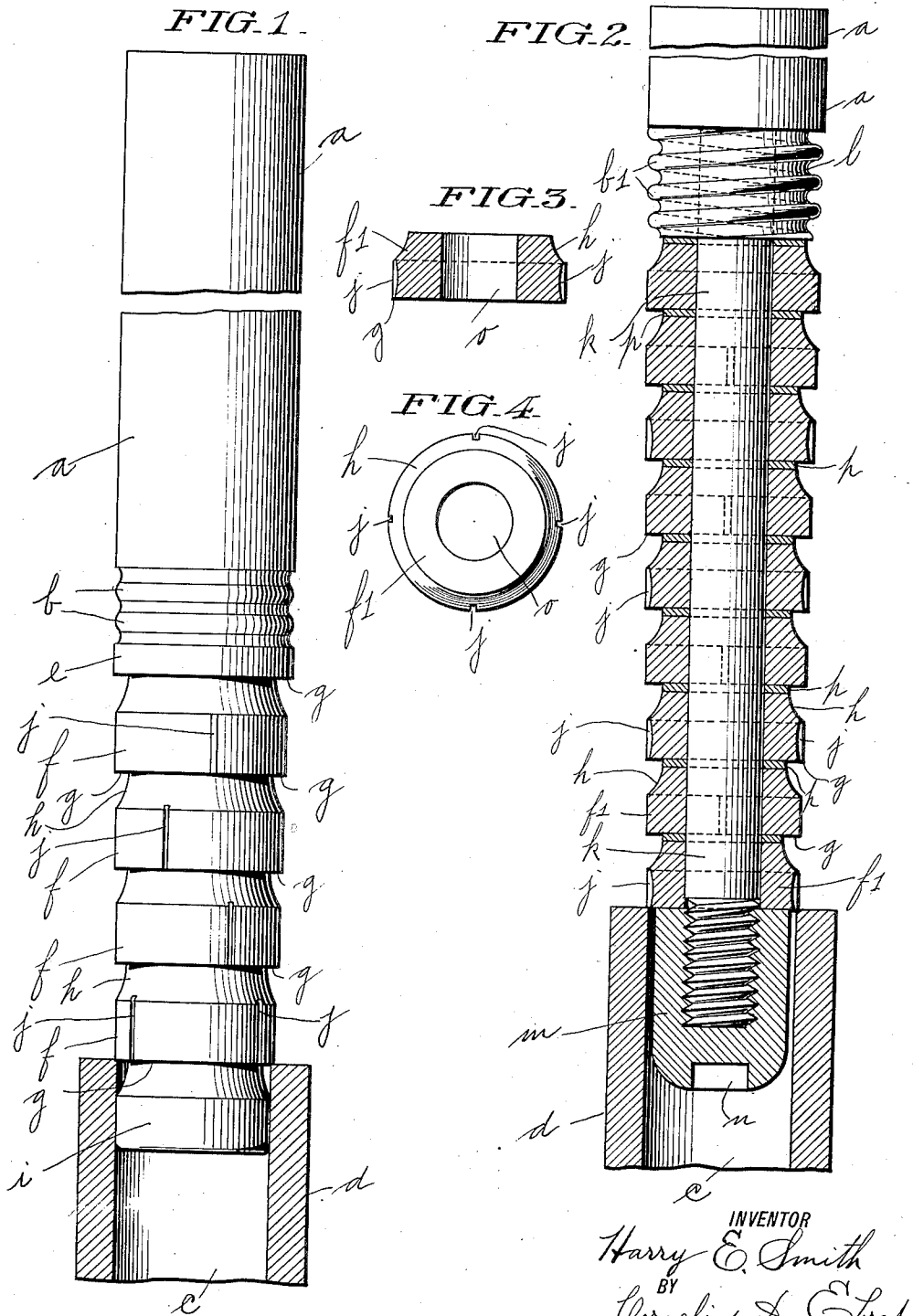


1,359,541.

Patented Nov. 23, 1920.



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UNITED STATES PATENT OFFICE.

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BROACHING.

1,359,541.

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To all whom it may concern:

Be it known that I, HARRY E. SMITH, a citizen of the United States, residing in Berwyn, county of Chester, and State of Pennsylvania, have invented certain new and useful Improvements in Broaching, of which the following is a specification.

My invention relates to broaching, and more particularly to broaching in which a broaching instrument or tool is pushed or pressed, as by a punching press or similar source of power, into or through the hole which is to be enlarged to a predetermined diameter, and withdrawn in reverse direction, or dropped into a receptacle beneath the member broached.

In accordance with my invention, as distinguished from draw broaching, the stroke or travel of the cutting tool is relatively short and may be rapidly recurrently accomplished, whereby a relatively great number of pieces of work, as bushings, etc., may be broached in a relatively short time.

In accordance with my invention, the broaching tool may be formed of a single piece of metal or, in my preferred structure, the tool comprises one or more separate cutters assembled upon an arbor with a detachable pilot and detachable polishing structure.

For an understanding of my invention and for an illustration of one of various forms my structure may take, reference is to be had to the accompanying drawing, in which:

Figure 1 is a vertical elevational view of a broaching tool with a cored member to be broached shown in section.

Fig. 2 is a view, partly in elevation and partly in section, of my preferred type of broaching tool, the member to be broached being shown in section.

Fig. 3 is a cross sectional view of an individual cutter.

Fig. 4 is a top plan view of the same.

Referring to Fig. 1, the broaching tool is shown as of a single piece of any suitable metal, preferably high speed tool steel. The stem *a* is adapted to be held in the head of a press, not shown, the press being a machine of well known type, similar to punch presses, wherein a vertically reciprocating head forces a tool vertically downward and thereafter withdraws it vertically or is permit-

ted to drop into a receptacle at the end of the downward stroke. Beneath the stem *a* are the polishing rings *b*, which are machined or ground with accuracy to the diameter to which it is desired finally to bring the cored or otherwise formed hole *c* in the piece of work *d* which may be a bushing or any other structure, of cast iron, steel, bronze or other alloy, or any material suitable for undergoing a broaching operation. The diameter of the stem *a* is preferably slightly less than the diameter of the polishing rings *b*. Beneath the polishing rings *b* may be provided a guide member or cutter element *e* of slightly less diameter than the rings *b*. Beneath the member *e* is a series of cutter elements or members *f* of any suitable or desired number, these cutters diminishing in diameter toward the lower end of the tool. The lower edges *g* of these cutter elements are their cutting edges. Each cutter member is recessed, as indicated at *h* beneath the cutting edge of the cutter next above. At the lower end of the tool is formed a pilot *i* sufficiently small in diameter to enter the hole *c* of the work *d*.

The cutter members *f* have in their cylindrical surfaces the vertical slots *j*, the slots in neighboring cutter elements being staggered or angularly displaced with respect to each other. These slots may be formed by a milling tool or in any other suitable manner. Preferably they are slots with curved bottoms of varying depth of the character hereinafter referred to in connection with Figs. 2 and 3.

In operation, the stem *a* having been placed in the head or socket of the operating press, the successive pieces *d* are brought beneath the broaching tool when in elevated position in such position that the holes *c* will be entered by the pilot *i* when the tool descends. The pilot serves as a guide to prevent the work *d* from becoming improperly displaced, once the broaching operation is begun, with respect to the vertical axis of the tool. As the tool descends, each cutter shaves or removes by its downward movement a plurality of chips from the interior surface of the hole *c*. A plurality of chips is caused to be formed by the slots *j*, which prevent a circumferentially continuous chip from being formed. This breaking up of the chips, as by slots *j*, is of im-

portance in effecting proper discharge of the removed metal from the tool. The volume of the removed chip should always be less than the volume of the recess h into which it is forced in advance of the cutting edge which is removing it. The recess h should be of great enough volume to prevent packing of the metal chips therein, since packing of the chips would require additional work on the part of the operator in removing them between successive descents of the broaching tool.

As the tool descends, the successive cutting members f enlarge the diameter of the hole c , the uppermost cutter making the final cut to effect a diameter which is only slightly less than the finished diameter. The uppermost cutter is preferably not provided with slots j , since these slots leave a scoring, ridge or rib in the surface of the hole c , but since these slots are staggered in the lower cutter members the successive cutters remove the scorings or ridges left by the preceding cutters. The uppermost cutter, however, removes the scorings left by the cutter immediately beneath. Following the uppermost cutter come the burnishing or polishing rings b , which polish the surface as left by the uppermost cutter, the stroke of the tool generally being such as to carry the polishing rings b completely through the hole in the work d . The succeeding upward stroke of the press then withdraws the tool from the work d , a suitable wiper or equivalent instrumentality coming automatically into position above the work d and preventing it rising during the upward withdrawal of the broaching tool, as well understood in the punch or pressing art. In case the tool is loosely held in a socket in the press head, it will drop after completion of the broaching stroke in a suitable receptacle below the work piece d .

Referring now to Figs. 2, 3 and 4, my preferred structure of sectional or composite broaching tool comprises a stem a to which is attached, preferably integrally, an arbor k , the stem a and arbor k preferably being of low carbon steel or softer grade of steel than employed for the cutting and polishing members, in order that the arbor structure may withstand twisting, bending or other deformation more readily than were it of tool steel or other hard steel such as preferably used for the cutters and polisher. Against the shoulder at the under side of the stem a is placed the polishing or burnishing structure l , which in this case comprises any suitable number of polishing ribs or rings b^1 , which in this case form a helix like a thread, as distinguished from the non-helical or parallel arrangement indicated at b , Fig. 1. This polishing ring structure has an axial hole whereby it may be slipped or pressed on to the arbor k to the position illustrated.

Beneath this polishing ring structure is a series of independent or individual cutter elements f^1 , of any suitable or desired number, diminishing in diameter toward the lower end of the tool, and all held in place upon the arbor k which extends through holes in them by the pilot m , which is threaded upon the lower end of the arbor k holding the cutters and polishing ring structure in close contact with each other. The pilot m has a square or other suitably shaped socket n for receiving a wrench or equivalent for forcing it on the threads of the arbor k against the lowermost cutter f^1 , as indicated. Obviously, any other suitable formation or construction may be employed for application of an instrument to thread the pilot m on to the arbor k .

Each of the cutter members may take the form indicated in Figs. 3 and 4, where g is the cutting edge and h a reduced portion forming beneath the cutting edge of the element next above in the series a recess for receiving the chips, as described in connection with Fig. 1. Each cutter element has a hole o , which receives the arbor k with a suitably close fit, as for example, a pressing fit. In the substantially cylindrical surface of the cutter element are milled a suitable number of preferably equally spaced slots j which, as shown, have a curved or arcuate bottom. These slots may be formed by a circular milling cutter of any suitable radius, but preferably approximately equal to the length of the cylindrical surface of the cutter member f^1 . These slots have material or substantial depth, whether straight or arcuate. When arcuate the slots have material depth even at their shallowest points at the advance or cutting edge and the back edge of the cylindrical surface of the cutter member. Arcuate slots as indicated serve to prevent binding within them of the rib or ridge left by them on the wall of the hole undergoing the broaching operation, thereby lessening danger of fracture of the cutter element adjacent the slot. While arcuate slots as indicated are suitable, particularly for structure similar to that shown in Fig. 1, where the cutter members are integral and closely adjacent because of the available space for the slotter instrument, as milling cutter, it will be understood that in the sectional structure of Figs. 2, 3 and 4 the slots in the cutter members need not be arcuate in shape, but may be in general of such formation that the depth of the slot increases with distance away from the advance or cutting edge of the slot.

In assembling the various cutters upon the arbor k , they are so positioned that the slots j in one cutter member are angularly displaced with respect to the slots in the cutter member immediately above.

The operation is substantially the same as

that described in connection with Fig. 1, the tool being pressed downwardly through the hole *c* in the work *d*, each cutter member removing chips which accumulate in the recesses *h* and which are broken up by the slots *j*. Following the uppermost cutter member *f*¹ the polishing rings *b*¹ engage and polish or burnish to finish diameter the wall of the hole *c*. Due to the helical arrangement of the polishing ribs or elements *b*¹ there is produced a desirable action in that the contact of a rib *b*¹ with the wall of hole *c* is not always at the same height in the hole *c*, but progresses in height or vertical position in a helical path, effecting polishing or burnishing more readily and perfectly.

Due to variations in the nature of the material of the work *d*, as variation of alloys, variations as between relatively hard and relatively soft materials, the volume occupied by the removed chips of these different materials varies. It is accordingly often desirable to vary the volume of the recess *h* to suit the particular metal operated upon. To this end there may be provided washers or shims *p*, which may be placed upon the arbor *k* between the neighboring elements or members, as shown in Fig. 2.

The cutter members *f*¹ are preferably of high speed tool steel, machined, slotted, hardened and ground to size. Similarly, the polishing member or element is machined from high speed tool steel, hardened and ground to size.

The composite or sectional broaching tool above described in connection with Figs. 2, 3 and 4 is preferred because the number and sizes of cutters may be varied at will to suit different characters of work or work pieces of different materials or compositions. Different alloys or compositions require different constructions of broaches; therefore, if the broach is made integral, as in Fig. 1, it may not be suitable for further use on work of different compositions or nature unless it is annealed, and remachined to form suitable for the new use. This difficulty is overcome by the sectional or composite broach of Fig. 2, where any suitable number of cutter members differing from each other in any suitable amounts as to diameter, etc., may be assembled in combination, the number of combinations being great.

Furthermore, in the case of an integral or solid broach, as in Fig. 1, the fracture or destruction of any one part renders useless all the other parts, and necessitates the substitution of a complete new instrument or tool, at considerable cost. With the sectional broach of Fig. 2, however, the fracture or destruction of any one of the cutter elements or of the polishing ring structure does not necessitate the abandonment of the entire structure, but allows substitution of a new part for any damaged part, at far less

cost than the reproduction of an equivalent solid or integral broach of the character illustrated in Fig. 1.

The sectional broach of Fig. 2 allows variation of the volume of the recess between cutters for different materials operated upon, making it possible for a given equipment of cutters, arbor, etc., to serve for varying materials, whereas in the case of an integral or solid broach as in Fig. 1 entirely new and individual tools usually must be provided.

In broaching, it has been found that the polishing rings may become worn to some extent and cause the finished diameter of the hole *c* of the work *d* to be smaller than desired or to vary beyond the limits of tolerance. With the sectional broach of Fig. 2, however, it is only necessary to replace the worn polishing member with one of suitable size, thereby restoring the life of the entire broaching instrument to normal. Furthermore, with the sectional structure of Fig. 2, involving an arbor *k* of low carbon steel or steel softer than the tool steel required for the cutting and polishing elements, greater twisting, bending or other deformation is withstood than in the case of Fig. 1; and should the arbor *k* be accidentally bent or deformed to such degree as to render the instrument as a whole useless, it is only necessary to provide a new arbor *k* and assemble thereon the cutters and polishing ring removed from the damaged arbor.

In broaching the work or members *d* in which the holes *c* are cored in founding or casting, as when the members *d* are of bronze or the like, the cored holes vary materially in diameter, and so much so that a pilot, as *i*, of an integral broach, Fig. 1, will not suit for a wide range of initial diameters of the holes. With the sectional broach, however, having a removable pilot *m*, pilots of different diameters may be substituted from time to time to suit the diameters of the cored or otherwise formed holes *c*.

By the sectional construction, by simply suitably changing the number of cutters and suitably relating their diameters, large or deep cuts may first be taken in a series of work pieces *d* and then by changing cutters small finishing cuts may be taken.

By my method and structure hereinbefore described, it is possible very materially to increase the speed of broaching. For example, where by draw broaching 40 to 100 bushings *d*, with holes *c* of approximately 1 inch diameter and 1½ inch length, could be broached in one hour, by my invention 90 bushings per minute, or 5400 per hour, of the same size, can be broached. The improvement in speed and in results due to my invention are in part due to the fact that the broaching tool is pushed or pressed through the work, as distinguished from drawn therethrough. Furthermore, the

length of the broaching instrument in draw broaching is very considerably greater than my broaching tool which, due to the fact that it is pressed or pushed through the work and because there are relatively fewer cutter elements increasing more rapidly in diameter, is and may be very considerably shorter than the draw broaching tool. This decrease in length is a further factor in increasing the output or speed of operation.

For example, in accordance with my invention the broaching tool for broaching a bronze bushing having a hole 1 inch in diameter and $1\frac{1}{2}$ inches long, the over-all length of pilot, cutters and polishing rings may be approximately 5 inches. On the other hand, for draw broaching the same bushing, the broaching tool has a length of approximately from 1 to 3 feet.

The speed of the cutter elements with respect to the work piece by my method is high and, I believe, far higher than has ever heretofore been attained in broaching operations, particularly as compared with draw broaching. For example, in broaching a bronze bushing having a hole 1 inch in diameter, the actual cutting speed is approximately 720 feet per minute as compared with not more than 250 feet per minute in the case of draw broaching. This may be approximately the speed for diameters up to approximately 3 inches. For diameters from approximately 3 to approximately 5 inches, a cutting speed of approximately 300 feet per minute may be employed; for diameters of approximately 5 to approximately 8 inches the cutting speed may be approximately 150 feet per minute; and for diameters approximately 8 inches and upwardly approximately 75 to 100 feet per minute.

What I claim is:

1. A broach comprising an arbor, a plurality of individual cutter members of progressively increasing diameters and having holes through which said arbor extends, said cutters having longitudinal slots, the slots of different cutters occupying different angular positions, and a pilot holding said cutter members in fixed position on said arbor.

2. A sectional broach comprising an arbor and a shoulder on one end thereof, a polishing member, a plurality of cutter members of progressively different diameters, said

polishing member and said cutter members having holes receiving said arbor, and a pilot between which and said shoulder said cutter members are held in fixed position on said arbor.

3. A sectional broach comprising a stem, an arbor of smaller diameter, a plurality of cutter members of progressively increasing diameters and having holes receiving said arbor, and a pilot between which and said stem said cutter members are held in fixed position on said arbor.

4. A sectional broach comprising an arbor having a shoulder, a polishing member, a cutter member, and a pilot holding said cutter member and said polishing member in fixed relation on said arbor with respect to said shoulder.

5. A sectional broach comprising an arbor having a shoulder, a polishing member, a plurality of cutter members of different diameters, and a pilot holding said polishing member and said cutter members on said arbor, said polishing member adjacent said shoulder.

6. A sectional broach comprising an arbor, a polishing member comprising a helically disposed polishing ring or bead, a plurality of cutter members of different diameters, and a pilot holding said polishing member and said cutter members on said arbor.

7. A broaching tool comprising polishing structure comprising a helically disposed polishing rib.

8. A broaching tool comprising polishing structure comprising a rounded polishing rib extending helically around the axis of the tool an angular distance greater than one revolution.

9. A sectional broach comprising an arbor having a shoulder on one end thereof, said arbor screw threaded adjacent the other end thereof, a polishing member comprising a helically disposed polishing ring, a plurality of cutter members of different diameters, said polishing member and said cutter members having holes receiving said arbor, and an internally screw threaded pilot on the screw threaded end of said arbor holding said polishing member and said cutter members in fixed position on said arbor.

In testimony whereof I have hereunto affixed my signature this 11th day of April, 1919.

HARRY E. SMITH.