Dec. 16, 1947. W. J. BLAZEK 2,432,855

METAL REMOVING TOOL

Filed Jan. 28, 1944 4 Sheets-Sheet 1

Fig. 1

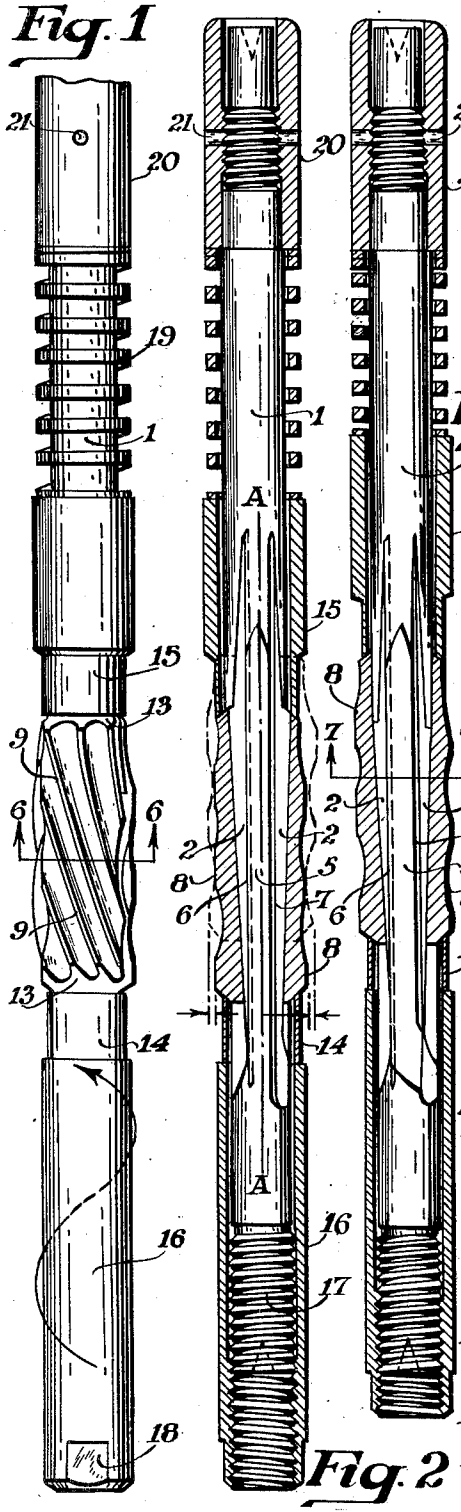


Fig. 2

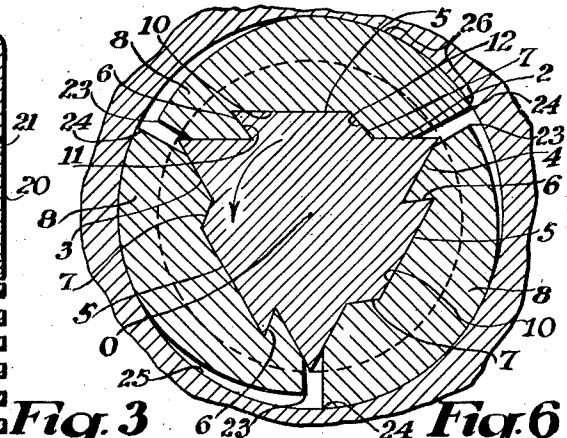


Fig. 3

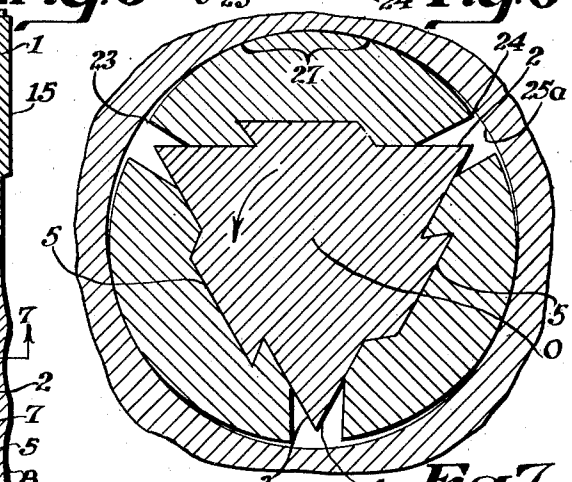


Fig. 6

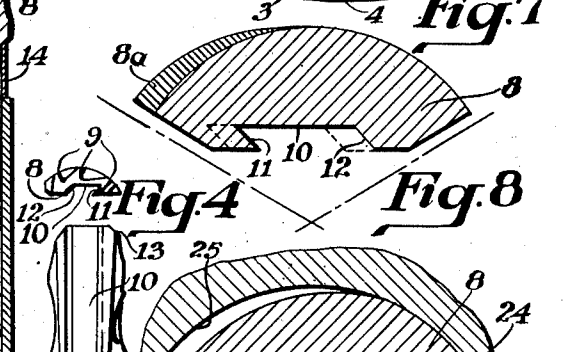


Fig. 7

Fig. 8

Fig. 4

Fig. 9



Fig. 5

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METAL REMOVING TOOL

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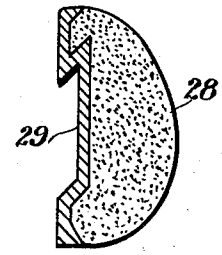


Fig. 10

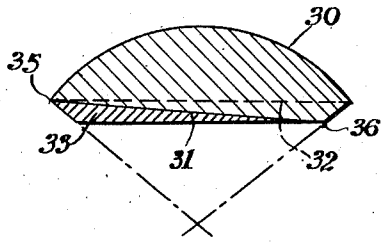


Fig. 11

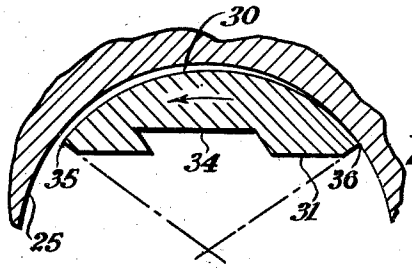


Fig. 12

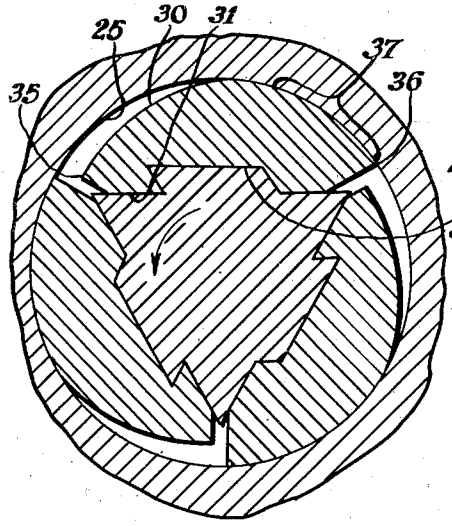


Fig. 13

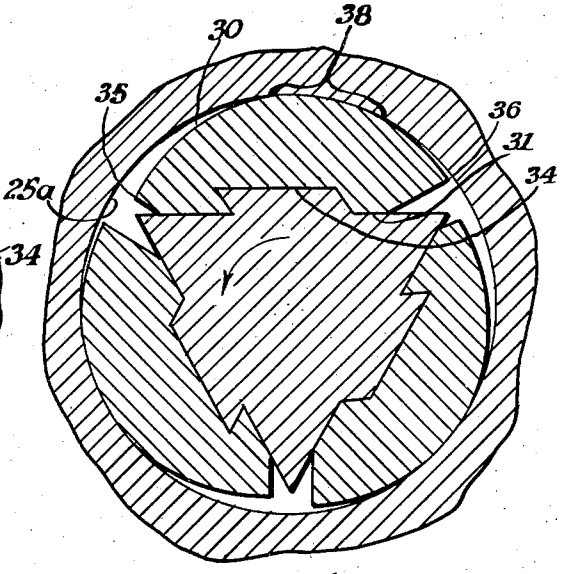


Fig. 14

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METAL REMOVING TOOL

Filed Jan. 28, 1944 4 Sheets-Sheet 3

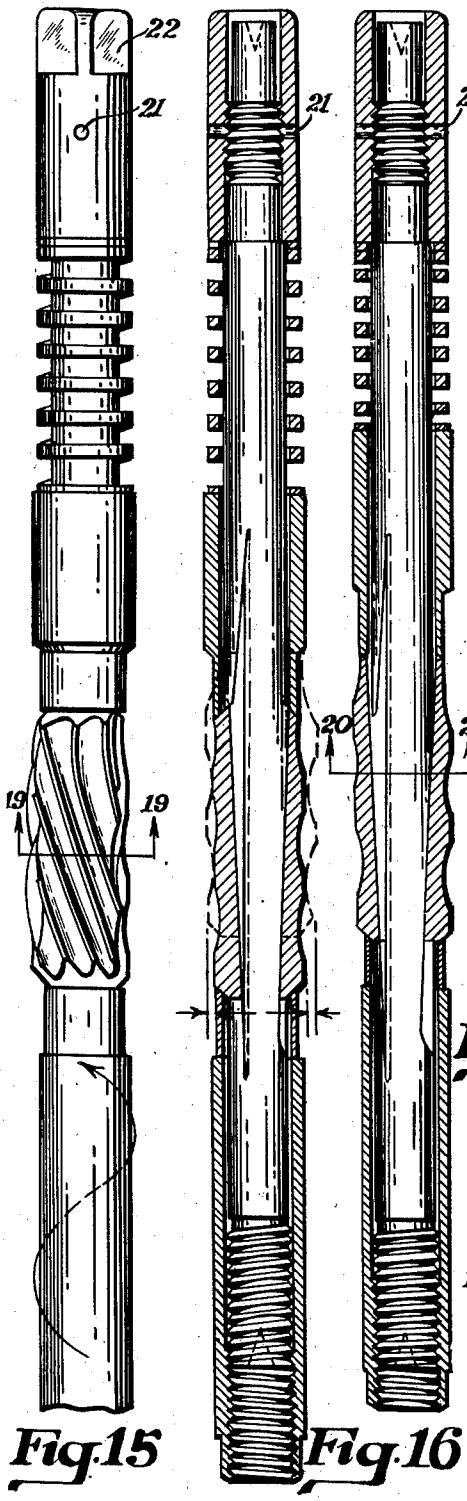


Fig. 15

Fig. 16

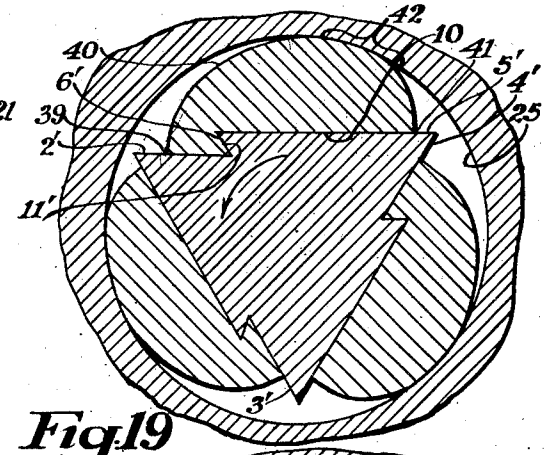


Fig. 19

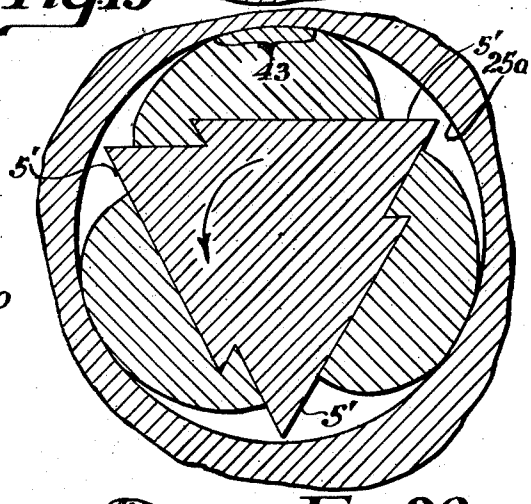


Fig. 20

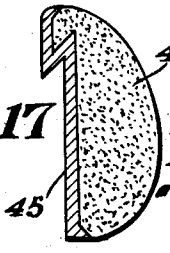
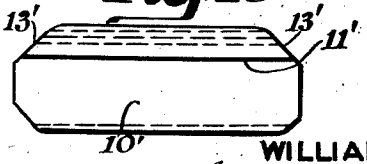


Fig. 21

Fig. 17

Fig. 18



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METAL REMOVING TOOL

Filed Jan. 28, 1944 4 Sheets-Sheet 4

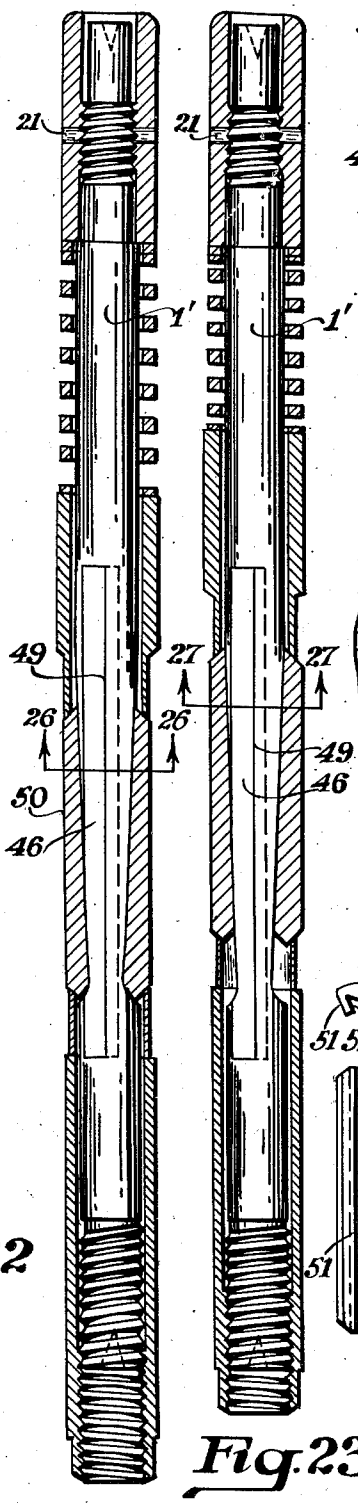


Fig. 22

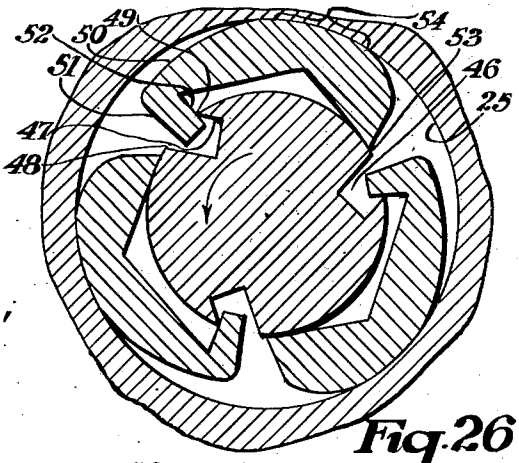


Fig. 26

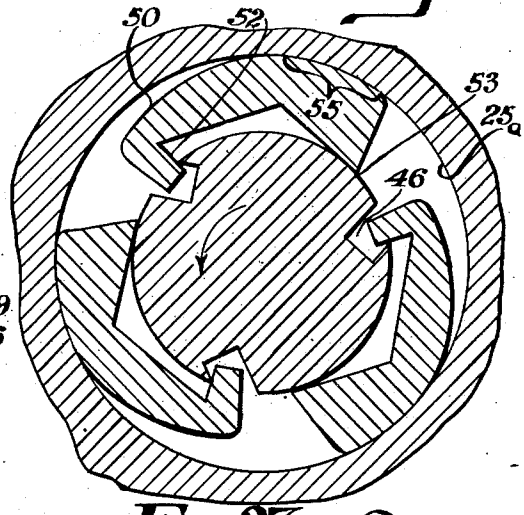


Fig. 27

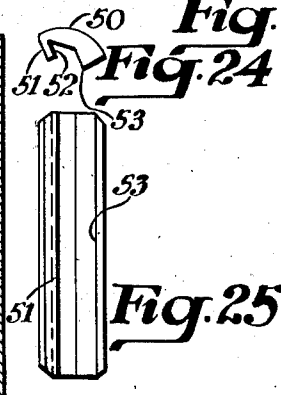


Fig. 24

Fig. 25

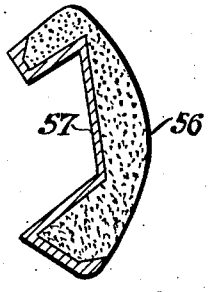


Fig. 28

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UNITED STATES PATENT OFFICE

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METAL REMOVING TOOL

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Application January 28, 1944, Serial No. 520,037

6 Claims. (Cl. 77—75.5)

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This invention relates, as indicated, to metal removing tools, but has reference more particularly to reamers and hones of the expansion type.

Tools of the aforesaid type, in accordance with the prior art, comprise a mandrel and two or more segments, each having a plurality of cutting edges, the segments being mounted on the mandrel in such a manner as to be expansible in relation to the mandrel. All of the cutting edges, whether the tool be a reamer or a hone, lie on the periphery of a circle or cylinder, with each segment forming an arc of the circle or a part of the cylinder. If, in such an expansion tool, the segments simply move outwardly or radially from the mandrel, then only the central portion of the cutting edges or surface of each segment is effective to remove metal. This follows from the geometric truth or axiom that a smaller or circumscribed circle, i. e., that formed by the cutting edges or surfaces of the segments, can be tangent to a larger or circumscribing circle, i. e., that formed by the bore or opening which is being reamed or honed, at but one point.

This removal of metal by only the central portions of the segments is highly objectionable because, in the case of a reamer, such portions become dulled, while the remaining portions of the cutting surfaces remain sharp. In the case of a hone, such central portions tend to become loaded while the remaining areas of the honing surfaces remain unloaded. Thus, in the case of a tool consisting of three segments, only about one third of the effective cutting edges or surfaces are utilized.

It has been proposed, as in Evans Patent No. 1,902,062, to utilize more than merely the central portions of the cutting surfaces of the segments by providing means consisting of segment-supporting surfaces which extend across the axis of the mandrel, but I have found that the manufacture of reamers in accordance with the patent is not only expensive, but extremely difficult from the machining and inspection standpoints.

The present invention, accordingly, has as its primary object the provision in cutting tools of the character described of new and improved means for utilizing more than the central portions of the cutting surfaces of the segments.

Another object of the invention is to provide means of the character described, which are economical and easy to machine and which can be easily and accurately inspected.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims; the annexed drawings and the following description setting forth in detail certain structures embodying the invention, such disclosed structures constituting, however, but a few of the various structural forms in which the principle of the invention may be used.

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In said annexed drawings:

Fig. 1 is an elevation of an expansion reamer having incorporated therein the principal features of the invention;

Fig. 2 is a longitudinal cross-sectional view of the reamer shown in Fig. 1, in the unexpanded condition;

Fig. 3 is a view similar to Fig. 2, but showing the reamer in the substantially fully-expanded condition;

Fig. 4 is an end elevation of one of the reamer segments;

Fig. 5 is an elevation of the bottom face of one of the reamer segments;

Fig. 6 is a cross-sectional view, taken on the line 6—6 of Fig. 1, but with the cutting teeth of the reamer segments not shown in cross-section;

Fig. 7 is a view similar to Fig. 6, taken on the line 7—7 of Fig. 3;

Figs. 8 and 9 are views illustrating in a more or less diagrammatic manner steps in the making of the reamer segments shown in Fig. 1;

Fig. 10 is a cross-sectional view of a hone segment similar to the reamer segments shown in Figs. 1 to 9 inclusive;

Figs. 11 and 12 are views similar to Figs. 8 and 9, but illustrating a modified method of forming the reamer segments;

Figs. 13 and 14 are views similar to Figs. 6 and 7, respectively, but utilizing the reamer segment of Figs. 11 and 12;

Figs. 15, 16 and 17 are views corresponding to Figs. 1, 2 and 3 respectively, but of a somewhat modified form of the invention;

Fig. 18 is an elevation of the bottom face of one of the reamer segments shown in Fig. 15;

Fig. 19 is a cross-sectional view, taken on the line 19—19 of Fig. 15;

Fig. 20 is a cross-sectional view, taken on the line 20—20 of Fig. 17;

Fig. 21 is a cross-sectional view of a hone segment similar to the reamer segments of Figs. 15 to 20 inclusive;

Figs. 22 and 23 are views similar to Figs. 2 and 3 respectively, but showing a further modification of the invention;

Fig. 24 is an end elevation of one of the reamer

segments of the form of reamer shown in Figs. 22 and 23;

Fig. 25 is an elevation of the bottom face of the reamer segment of Fig. 24;

Fig. 26 is a cross-sectional view, taken on the line 26—26 of Fig. 22;

Fig. 27 is a cross-sectional view, taken on the line 27—27 of Fig. 23, and

Fig. 28 is a cross-sectional view of a hone segment similar to the reamer segments shown in Figs. 22 to 27 inclusive.

Referring more particularly to Figs. 1 to 9 inclusive of the drawings, it will be seen that an expansible reamer made in accordance with the invention comprises a mandrel 1, which for a portion of its length is cut or milled to provide flat bearing surfaces 2, 3 and 4, which are tapered or inclined to the axis O of the mandrel. As shown in Figs. 6 and 7, a transverse section through the mandrel which intersects these surfaces will be in the form of an equilateral triangle, the sides of which form chords of a circle, which is represented by the dotted lines in Fig. 6, and the center of which is the center O of the mandrel.

Each of the surfaces 2, 3 and 4 is provided with a track or segment guide 5, which, as clearly shown in Figs. 2 and 3, extends longitudinally and the base thereof is substantially centrally of the surface 2, 3 or 4, as the case may be, and is laterally inclined to provide a leading surface 6 which is disposed at an acute angle to the surface 2, 3 or 4, and a trailing surface 7 which is disposed at an obtuse angle to the surface 2, 3 or 4. As shown most clearly in Fig. 2, the outer edges of the surfaces 6 and 7 are parallel with lines A—A which lie in the surfaces 2, 3 and 4 and represent the intersection of such surfaces by radial planes extending from the center O and at right angles to the surfaces 2, 3 and 4. It may be noted at this point that the tracks 5 extend longitudinally of the mandrel and substantially centrally of the surfaces 2, 3 and 4, in contradistinction to the surfaces 31 and 32 in Evans Patent No. 1,902,062, which slant across the axis of the mandrel.

Mounted on the tracks 5 are metal cutting segments 8, which collectively form a reamer, each segment being generally cylindriform and spirally-fluted to form a plurality of reamer teeth 9, as shown in Figs. 1 and 4, the cross-section of such teeth being omitted from Figs. 6 and 7 in order to permit a clearer description of the cutting action of the reamer in the unexpanded and expanded condition, it being understood that the direction of rotation of the reamer is indicated by the arrows in Figs. 6 and 7. If desired, the cutting teeth on one segment may be spiralled oppositely from the spiralling of the cutting teeth of another segment, as described in the aforesaid Evans patent.

As shown in Figs. 4, 5, 6 and 7, each of the segments is provided on its under surface or base with a longitudinally extending recess or keyway 10 having side walls 11 and 12 which are inclined to correspond with the inclination of the surfaces 6 and 7 respectively of the tracks 5. With the segments mounted on the tracks, as shown in Fig. 6, the surfaces 6 of the tracks 5 engage the side walls 11 of the segments and in this manner not only insure a positive drive of the segments when the mandrel is rotated in the direction indicated by the arrow, but also provide a cam action which tends to hold the segments firmly against the mandrel.

In order to insure parallelism of the cutting surfaces of the segments with the axis of the mandrel, the segments are tapered longitudinally, as shown in Figs. 2 and 3, to conform with the taper or inclination of the surfaces 2, 3 and 4 of the mandrel.

The segments, moreover are beveled at the ends, as at 13, and are clamped between slidable collars 14 and 15. The collar 14 is positioned on the mandrel by means of an adjusting nut or sleeve 16 which is internally-threaded for engagement with a threaded portion 17 of the mandrel. One end of the sleeve 16 is provided with flats 18 for engagement by a wrench, whereby the sleeve may be rotated to adjust the position of the collar 14. The collar 15 is urged towards the collar 14 by means of a spring 19 which bears against a stop sleeve 20 which is pinned to the mandrel as by a pin 21 and is provided with flats, not shown, for engagement by a wrench or other tool, whereby the mandrel may be rotated or driven in the direction indicated by the arrow in Fig. 1.

The expansion of the segments of the reamer, as thus described, is effected by rotation of the nut or sleeve 16 while the reamer, as a whole, is maintained stationary. This results in a combined axial and radial movement of the segments against the tension of the spring 19, from a position, as shown for example in Fig. 2, to a position, as shown for example in Fig. 3.

The cylindriform contours of the cutting segments, be they truly circular, elliptical, parabolic, or otherwise, are generated, respectively, about an axis which represents the center or average axis of convergence of radial planes produced through the generating lines of each of the cylindriform surfaces. Since the cylindriform surfaces are circumscribed by the cylinder represented by the internal circumference of the work, they must be scribed from lesser radii, requiring that the generating or average axis of each of the segments falls on the side of the mandrel axis nearest the segment regarded, and parallel thereto. And since it is desired to have the cutting segment engage the work in its trailing portions, the generating or average axis of the cylindriform segments each should fall upon the trailing side of the segment with respect to a radial plane of the revolutionary axis of the mandrel which passes through the longitudinal axis of the tracks 5 at said mandrel. This may be regarded as the median plane of each segment.

It follows from this that at the minimum diameter for which the reamer is intended, and which is represented by the bore 25 in Fig. 6, only the trailing portion 24 of the cutting surface of each segment, which portion is approximately indicated by the bracket 26 in Fig. 6, is effective to remove metal from the bore, and that at the maximum diameter for which the reamer is intended, and which is represented by the bore 25*a* in Fig. 7, only the central portion of the cutting surface of each segment, which portion is approximately indicated by the bracket 27 in Fig. 7, is effective to remove metal from the bore. It also follows that as the tool is expanded, the portion of the cutting surface of each segment which is effective to remove metal shifts from the trailing edge 24 towards the leading edge 23.

The leading edges 23 of the segments can be located closer to the mandrel axis than the trailing edges, that is to say, the proper eccentricity of cylindriform curvature may be imparted thereto, by various methods, one of which is diagrammatically represented in Figs. 8 and 9. According to this method, segments having longitudinally extending recesses 10 and cutting sur-

faces of truly arcuate contour, are mounted upon a dummy mandrel, having tracks represented by the dotted lines in Fig. 8, such tracks being displaced from the position of the tracks of a mandrel such as shown in Fig. 6 sufficiently to position the cutting surfaces of the segments eccentrically to the axis of the dummy mandrel. Then, by rotating the dummy mandrel about its axis and against a grinding or cutting wheel or other cutting tool, portions of the segments diagrammatically illustrated by the shaded area **8a** in Fig. 8 are removed. When such segments are then mounted on a working mandrel as shown in Fig. 9, which corresponds with Fig. 6, the leading edges **23** of the segments will be located closer to the axis O of the mandrel than the trailing edges.

It will thus be apparent that all of the advantages inherent in the expansible reamer of the Evans patent are obtained in the reamer as described, but that most, if not all, of the disadvantages have been eliminated, since it is considerably easier and less expensive to form or machine the tracks and recesses in the mandrel and segments respectively when they extend parallel with the generating lines of the conical or tapered portions of the mandrel than when at an angle to such lines. Moreover, it is much easier to gauge or accurately inspect the reamer than it is in the case of a reamer made in accordance with the Evans patent.

The tracks **5** need not necessarily be formed integrally with the mandrel, but may consist of separate elements which may be removably secured to the surfaces **2**, **3** and **4** of the mandrel, and thus easily replaced in the event that they wear out. Moreover, the track need not form a part of or be attached to the mandrel, but may form an integral part of or be attached to the segments, in which event, the recesses would be formed in the surfaces **2**, **3** and **4** of the mandrel, instead of in the segments. If desired, a separate key might be used, in which case, both the mandrel surfaces **2**, **3** and **4** and the bottom surfaces of the segments would be recessed to accommodate such a key.

The invention is applicable as well to hones and other metal removing and finishing tools as it is to reamers.

Referring to Fig. 10 of the drawings, a hone segment is shown which is made interchangeable with the reamer segments shown in Figs. 1 to 9 inclusive. The hone or honing segment preferably consists of a body portion **28** formed or molded of honing stone and mounted on a metallic backing **29**, the composite structure being substantially identical in cross-section with the reamer segment of Fig. 1. Since the reamer and hone segments are interchangeable, it is only necessary, in order to convert the reamer of Fig. 1 into a hone, to remove the reamer segments and insert the hone segments.

Although the reamer which has been described comprises three segments, it will be understood that any desired number of segments may be used. It will be further understood that each segment has more than one cutting edge, the term "cutting edge" being used herein in a broad sense to include not only the reamer teeth but the cutting particles of a hone as well as any other form of metal removing edge.

Referring to that form of the invention shown in Figs. 11, 12, 13 and 14, the segments, in this case, have truly arcuate cutting surfaces **30**, but the bottom surface **31** of each segment is so formed that it will not be parallel with the chord

32 of the surface **30**. This is accomplished by removing that portion **33** of the segment which is indicated by the shaded area in Fig. 11. After the segment is thus formed, a longitudinal recess, as indicated in Fig. 12, is cut in the base of the segment, the bottom face **34** of such recess being parallel with the surface **31**.

When the segments, as thus formed, are mounted on a mandrel, as shown in Fig. 13, the leading edges **35** of the cutting surfaces **30** are disposed closer to the axis of the mandrel than the trailing edges **36**, with the result that in the unexpanded condition of the reamer, shown in Fig. 13, only the trailing portions of the cutting surfaces, indicated by the bracket **37**, is effective to remove metal from the bore **25**. In the fully expanded condition of the reamer, as shown in Fig. 14, only the central portion of the cutting surface, indicated by the brackets **38**, is effective to remove metal from the bore **25a**. Here again, it will be apparent that as the tool is expanded, the portion of the cutting surface of each segment which is effective to remove metal shifts from the trailing edge **36** towards the leading edge **35**.

Although a hone segment corresponding to the reamer segment of Figs. 11, 12, 13 and 14 has not been illustrated, it will be understood that such a hone can be readily made in a manner similar to the construction of the hone segment shown in Fig. 10.

In that form of the invention shown in Figs. 15 to 20 inclusive, the construction is considerably simplified by extending the tracks **5'**, corresponding to the tracks of that form of the invention shown in Fig. 6, laterally to the trailing edges of the surfaces **2'**, **3'** and **4'**, which correspond with the surfaces **2**, **3** and **4** respectively, and by elimination of those portions of the base of the segments shown in Fig. 6, which are disposed to the trailing side of the inclined side wall or edge **12**.

In this way, machining costs are reduced, but the same results are obtained with the reamer, since the drive or rotation of the reamer segments is effected in the same manner as in Fig. 6, that is by interengagement of the inclined edges **6'** of the mandrel with the correspondingly inclined edges **11'** of the segments. The segments are beveled at their ends, as at **13'**.

The segments may be formed in the manner shown in Figs. 8 and 9 or in the manner shown in Figs. 11 and 12. In either case, the leading edges **39** of the cutting surfaces **40** are disposed closer to the axis of the mandrel than the trailing edges **41**, with the result that in the unexpanded condition of the reamer shown in Fig. 19, trailing portions of the cutting surfaces, indicated by the bracket **42**, are effective to remove metal from the bore **25**. In the fully expanded condition of the reamer, shown in Fig. 20, only the central portion of the cutting surface, indicated by the brackets **43**, is effective to remove metal from the bore **25a**. As the tool is expanded, the portion of the cutting surface of each segment which is effective to remove metal shifts from the trailing edge **41** towards the leading edge **39**.

Referring to Fig. 21 of the drawings, a hone segment is shown which is made interchangeable with the reamer segments shown in Figs. 15 to 20 inclusive, and consists of a body portion **44** formed or molded of honing stone and mounted on a metallic backing **45**. the composite structure being substantially identical in cross-section with the reamer segment of Fig. 15.

In that form of the invention shown in Figs. 22 to 27 inclusive, the intermediate portion of the mandrel 1', instead of being made of triangular cross-section, as in the previously-described forms of the invention, is left circular, in cross-section and trackways or grooves 46 are formed in such portion, such grooves having parallel side walls 47 and 48 which extend somewhat rearwardly with respect to the direction of rotation of the mandrel, so that the walls 47 form with the periphery of the mandrel hook-like portions, as shown in Fig. 26.

The edges 49 of these hook-like portions extend longitudinally of the mandrel, but are inclined to the axis thereof. Moreover, they may be considered as lines which represent the intersection of the periphery of the tapered portion of the mandrel by radial planes drawn from the axis of the mandrel.

The reamer segments which are employed in connection with such mandrel are shown in Figs. 24 and 25, and are longitudinally tapered, as shown in Fig. 22 to correspond with the taper of the inclination of the edges 49. Moreover, each segment has a cutting surface 50, which is of truly arcuate form, and has a hook-like flange 51 at one edge having an inner surface 52 which is engaged by the edge 49, the opposite edge 53 resting on the periphery of the tapered portion of the mandrel.

The cutting surfaces of the segments are cut to a diameter which is equal to or slightly less than the minimum diameter for which the tool is intended and the segments are mounted upon the mandrel. In the unexpanded condition of the segments, only the central portions of the cutting surfaces of the segments, indicated by the bracket 54 in Fig. 26, are effective to remove metal from the bore 25. As the tool is expanded, the trailing or rear portions of the segments move radially outwardly to a slightly greater extent than do the leading or forward portions thereof, so that in the fully expanded condition, shown in Fig. 27, the trailing portions of the cutting surfaces of the segments, indicated by the bracket 55, are effective to remove metal from the bore 25*a*. In this case, the shift of the effective cutting portion of the cutting surfaces of the segments is the reverse of that in the previously described forms of the invention. In other words, as the tool is expanded, the portion of the cutting surface of each segment which is effective to remove metal shifts from the leading edge towards the trailing edge of the cutting surface.

Referring to Fig. 28 of the drawings, a hone segment is shown which is made interchangeable with the reamer segments shown in Figs. 22 to 27 inclusive, and consists of a body portion 56 formed or molded of honing stone and mounted on a metallic backing 57, the composite structure being substantially identical in cross-section with the reamer segment of Fig. 24.

It is to be understood that the forms of my invention, herewith shown and described, are to be taken as preferred examples of the same, and that various changes in the shape, size and arrangement of parts may be resorted to, without departing from the spirit of my invention, or the scope of the subjoined claims.

Having thus described my invention, I claim:

1. An internal cutting tool of the expansible type comprising a revoluble mandrel for insertion within the starting bore of a hollow workpiece to be acted upon, the axis of revolution of said mandrel and the longitudinal axis of said bore being substantially coincident when said mandrel is in operative position therein; a plurality of cutting segments carried by said mandrel for rotation thereby, said cutting segments having generally cylindriform work surfaces disposed about said mandrel so that the generating lines of said work surfaces lie substantially parallel to the axis of said mandrel and so that the radial planes of their generating lines respectively converge about axes that are parallel to the axis of the mandrel but off-set therefrom in directions of the trailing edge of each of said segments, respectively; and means for expanding said segments by moving them in paths the longitudinal axes of which lie wholly within the radial planes of the mandrel's axis.

2. An internal cutting tool of the expansible type comprising a revoluble mandrel, a plurality of cutting segments carried by said mandrel for rotation thereby, the working surfaces of said cutting segments being generally cylindriform, and being disposed about and secured for relative motion to said mandrel, the axes about which said cylindriform working surfaces are generated being parallel to and eccentrically disposed relative to the revolutionary axis of the mandrel, and means for moving said segments in straight lines (which collectively define generatrices of a frusto-cone) axially of the mandrel to effect the expansion thereof relative to each other.

3. An internal cutting tool of the expansible type comprising a revoluble mandrel having a tapered portion intermediate its ends, straight trackways extending along said tapered portion for engaging cutting segments, the long axis of each trackway lying within a radial plane of the revolutionary axis of said mandrel, a plurality of cutting segments disposed about said mandrel in association with said trackways, said segments having generally cylindriform work surfaces, the axes about which said surfaces are generated being parallel to the revolutionary axis of said mandrel but eccentrically disposed in relation thereto in that the axis of each segment falls on the near side (with respect to the segment) of the mandrel's axis and upon the trailing side (with respect to the direction of revolution of the mandrel) of the radial plane of the mandrel's axis which projects through the long axis of its associated trackway.

4. A metal removing tool comprising a tapered mandrel circular in cross section; a metal removing segment extending longitudinally along the mandrel and being slidable along the mandrel; means forming a pivotal driving connection between the mandrel and a longitudinal edge portion of the segment, the surface of the segment facing the mandrel being concave relative to the mandrel and the other longitudinal edge portion of the segment engaging the mandrel whereby the segment may pivot about said pivotal connection as the segment is moved longitudinally on the mandrel; and means for sliding the segment along the mandrel and for urging the segment in engagement with the mandrel.

5. A metal removing tool comprising a tapered mandrel circular in cross section; a metal removing segment extending longitudinally along the mandrel and being slidable along the mandrel, said segment carrying a metal removing surface having a contour of less radius than the minimum radius of the diameter of the work piece to be engaged by the segment; means forming a pivotal driving connection between the mandrel and the longitudinal edge portion of

the segment, the surface of the segment facing the mandrel being concave relative to the mandrel and the other longitudinal edge portion of the segment engaging the mandrel whereby the segment may pivot about said connection as the segment is moved longitudinally on the mandrel for causing the metal engaging surface of the segment to engage different surfaces of the work piece as the effective diameter of the tool is varied; and means for sliding the segment along the mandrel and for urging the segment in engagement with the mandrel.

6. A metal removing tool comprising a mandrel having a tapered portion circular in cross section; a longitudinally extending slot in said portion of the mandrel, the plane of one surface of said slot being angular with respect to the radial plane of said portion for forming an acute angular edge with the periphery of the mandrel; a metal cutting segment adapted to be carried by the mandrel; said segment having a projection along its leading edge extending loosely in the slot and engaged by said acute edge for forming a pivotal driving connection between the mandrel and segment, the surface of said segment

adjacent to the mandrel being concave whereby said segment is out of engagement with the mandrel intermediate the leading and trailing edges of the segment; and means for sliding the segment along the mandrel and for urging the segment in engagement with the mandrel.

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