March 7, 1944. W. M. FAIRBAIRN ET AL 2,343,500

HONING APPARATUS

Filed Jan. 21, 1942

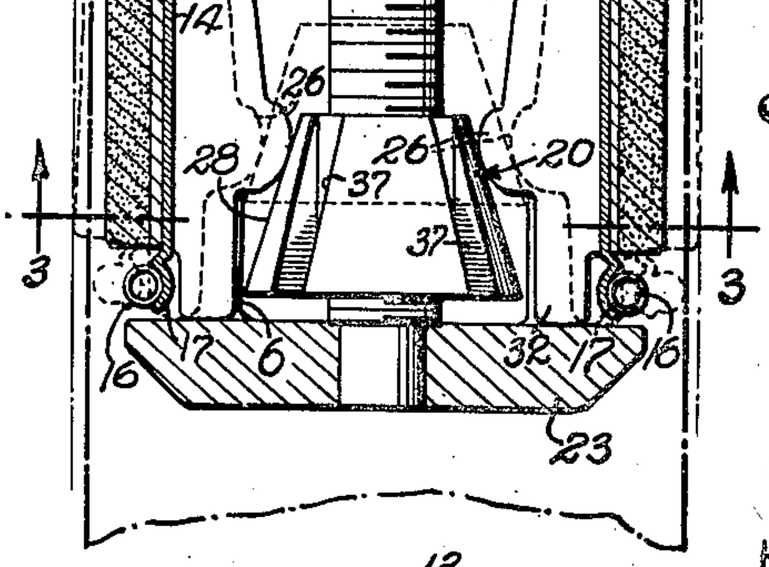

Fig. 2

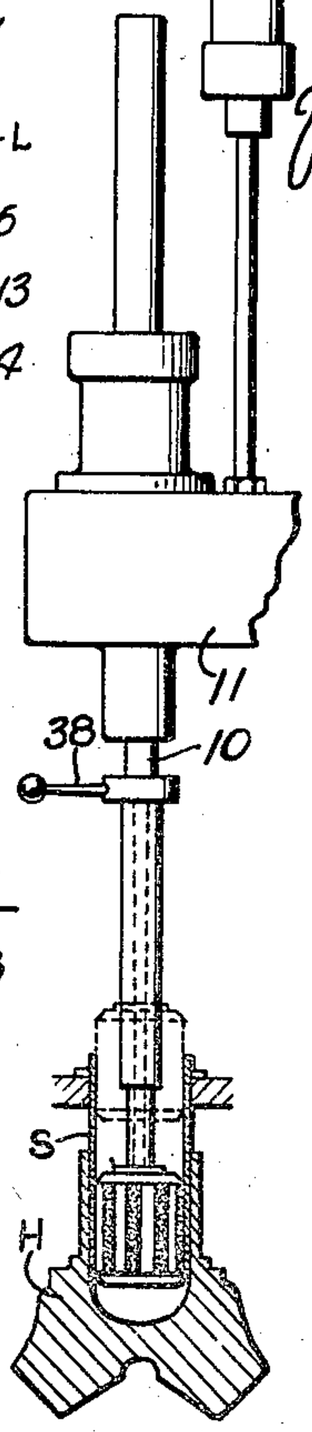

Fig. 1

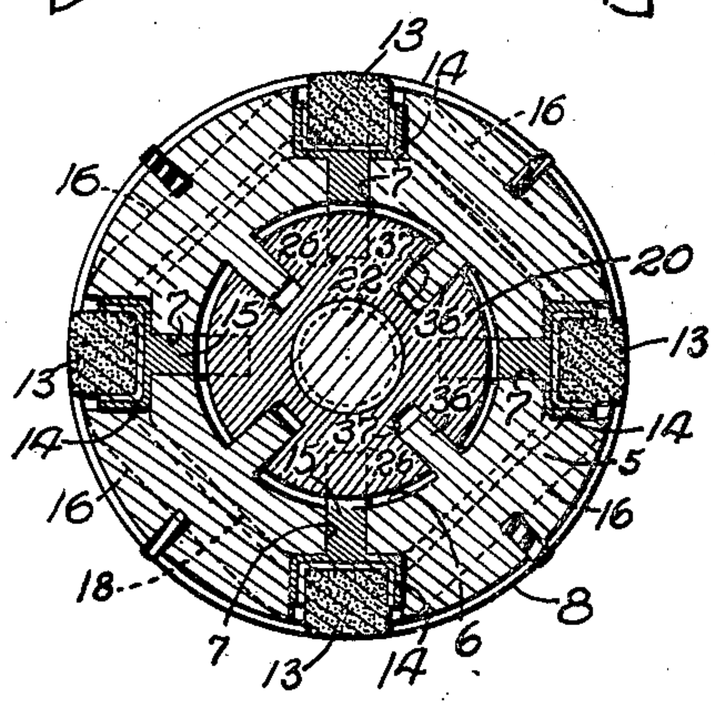

Fig. 3

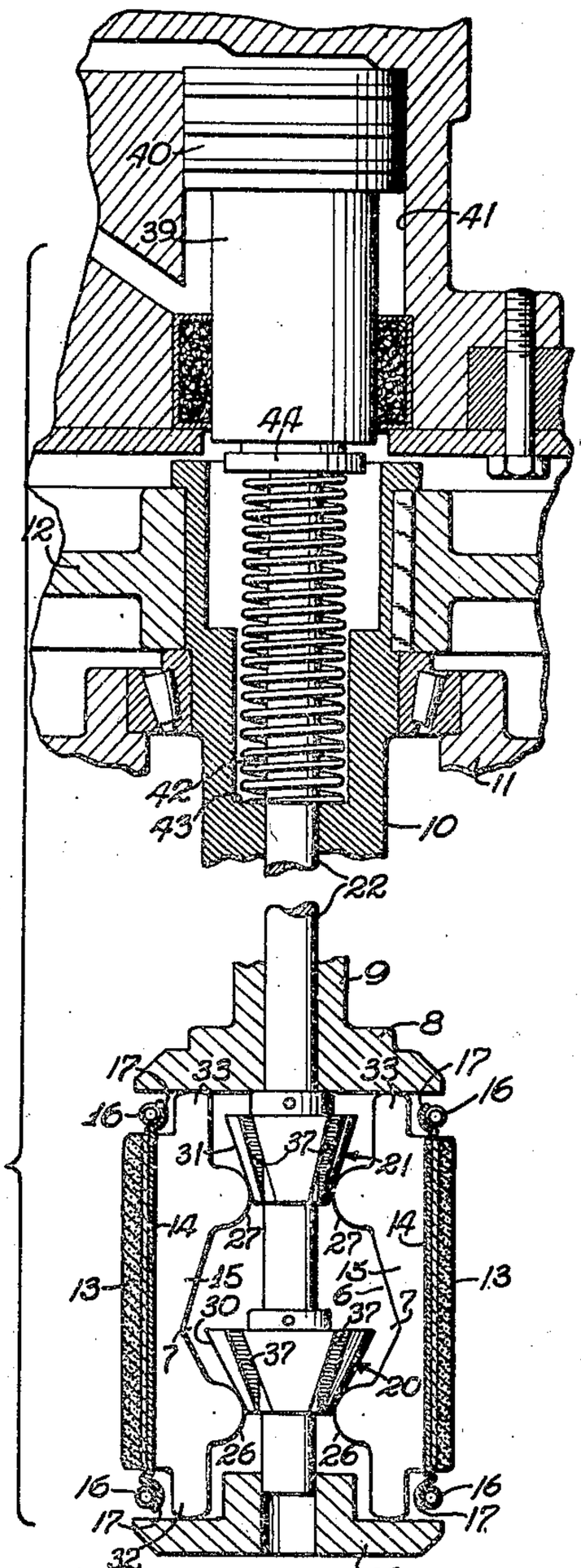

Fig. 4

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HONING APPARATUS

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11 Claims. (Cl. 51—184.3)

The invention relates to an improved method of and apparatus for finishing and rectifying irregularities in cylindrical surfaces by a honing or lapping process.

The primary object of the invention is to provide an improved method of honing whereby irregularities such as taper adjacent the blind end of a closed cylinder may be quickly and efficiently removed and the cylinder walls finished to substantial parallelism in a normal honing cycle.

Another object is to provide a honing tool of novel and advantageous construction particularly suitable for carrying out the improved honing method.

Other objects and advantages of the invention will become apparent from the following detailed description of the preferred embodiments illustrated in the accompanying drawing, in which:

Figure 1 is a view showing the manner in which the honing tool is mounted in a honing machine and applied to a workpiece, the workpiece being shown in section.

Fig. 2 is a vertical sectional view of one type of honing tool embodying the features of the invention.

Fig. 3 is a transverse sectional view of the honing tool taken along the line 3—3 of Fig. 2.

Fig. 4 is a sectional view of a power actuated honing tool embodying the features of the invention, conventional tool actuating mechanism being shown by way of illustration.

The improved honing method is particularly adapted for finishing internal cylindrical surfaces which develop a slight taper or other irregularity as a result of processing steps to which they are subjected after being bored or otherwise machined to approximately the desired dimensions. An example is the cylinder assembly commercially used in aviation engines of the radial type shown in section in Figure 1 of the drawing. In the manufacture of cylinder assemblies of this character, a head H of aluminum alloy or other suitable material is shrunk on the end of a cylinder sleeve S which constitutes one cylinder of the engine. The compressive action of the head on the sleeve introduces a slight but very objectionable taper which is greatest adjacent the head or closed end of the cylinder.

The removal of the taper thus formed presents a difficult problem since the presence of the cylinder head prevents overrunning of the honing tool at that end of the cylinder in accordance with the practice commonly employed in finishing open ended cylinders. Moreover, in a closed end cylinder it is difficult to effect a localized honing action by "short-stroking," that is, by reciprocating the honing tool through a series of relatively short strokes in operative engagement with the particular area to be reduced. The improved honing method of the present invention eliminates this difficulty by regulating in a novel manner the pressures exerted on the work by different areas of the honing tool whereby the tool is enabled to remove the irregularity in what may be termed a normal honing cycle in which the tool is traversed from one end of the workpiece to the other without short-stroking or other operations requiring exceptional skill or special attention on the part of the machine attendant.

More particularly stated, the present invention contemplates the removal of the objectionable taper or other irregularities by a differential expansion of the honing tool which causes a greater pressure and consequently a more rapid cutting action in the area containing the irregularity. We have discovered that the desired pressure differential may be obtained by forcing the opposite ends of the individual abrasive elements of the tool radially outwardly at different but accurately coordinated rates. It might be expected that this would cause the abrasive elements to tilt longitudinally or shift out of parallelism but in actual practice it has been found that parallelism of the working faces of the elements is maintained at all times while in contact with the work surface. This may be attributable to a yielding of the parts involved. As a result, however, the abrasive action is substantially increased adjacent one end of the tool. The tool is positioned, of course, so that the increased abrasive action takes place in the area containing the irregularity to be removed.

In honing a workpiece in accordance with the improved method, the work and honing tool are relatively rotated and simultaneously relatively reciprocated so as to traverse the tool repeatedly from one end of the work to the other. During these movements, the tool is expanded differentially as above described so that a greater pressure is exerted on the area of the work from which the greatest amount of stock is to be removed. This differential expansion of the tool may be effected in various ways as will appear presently.

Referring now to the drawing, the honing tools selected to illustrate preferred differential ex-

panding mechanisms each comprises an elongated core or body member 5 (Fig. 3) herein shown as generally cylindrical in cross section. A central bore 6 extends longitudinally through the tool body and from this bore a plurality of openings or guide slots 7 extend radially to the periphery of the body. Rigidly secured to one end of the body by means of a flange 8 (Figs. 2 and 4) is a tubular driver 9 by which the tool may be rotated and reciprocated. For this purpose the driver is attached to a spindle 10 (Fig. 4) journaled in a reciprocatory head 11 and rotatably driven by suitable gearing 12 in well known manner.

Arranged in an annular series around the exterior of the tool body 5 are a plurality of elongated abrasive elements or honing stones 13 of suitable abrasive material. The abrasive elements extend longitudinally of the body and are preferably in the form of bars or sticks of generally rectangular cross section having the outer face or working surface slightly rounded to conform approximately to the contour of the bore to be honed as shown in Fig. 3.

The abrasive elements 13 are mounted on the tool body for radial movement toward and from the rotational axis of the body so that their working faces may be shifted into or out of operative engagement with the surface of the work. To this end each element is cemented or otherwise secured in a holder 14 preferably constructed of metal so as to provide rigid support for the element throughout its entire length. A flange-like guide member 15 projecting from the back of the holder engages in one of the guide slots 7 in the tool body to maintain the holder in assembled relation with the body and to guide the holder in its radial movements relative thereto.

The series of holders and abrasive elements are yieldably held in their inner or "contracted" position by suitable resilient means such as annular springs 16 engaging with hook-like extensions 17 at opposite ends of the respective holders, the body member 5 being suitably recessed as indicated at 18. The honing tool is ordinarily inserted in the work while in this contracted condition and, when properly positioned therein it is "expanded," that is, the holders are shifted radially outwardly until the working faces of the abrasive elements contact the surface to be operated on. This outward shifting of the abrasive element is effected by adjusting mechanism arranged within the central bore of the tool body.

The adjusting mechanism in its preferred form comprises a plurality of members adapted to exert a wedging action on the carriers 14. These members may be of any suitable character but by way of illustration we have shown a pair of cam members spaced apart longitudinally of the tool body and arranged to coact with the abrasive element holders 14 upon movement of the members axially of the tool body. As indicated above, this adjusting mechanism is so constructed that the cam members tend to impart a slightly greater displacement to the abrasive elements at one end of the tool than at the other end. For honing cylinders such as the cylinder S shown in Fig. 1 in which the taper is at the bottom or blind end, the increased displacement force is applied to the abrasive element at the end farthest removed from the tool driver.

To more clearly illustrate this differential action, the extreme position to which the elements would move if unconfined by the work surface is shown on an exaggerated scale in Fig. 2 by the dotted lines indicating the working faces of the elements and their relative inclination with respect to reference lines L which are parallel to the axis of the tool. In actual practice this difference in displacement or tilting of the elements does not occur but the elements are forced against the work surface indicated by the broken line L' so that the working face of each element contacts the surface throughout the entire length of the element. Obviously, a substantially greater pressure is exerted on the work adjacent the lower end of the tool by reason of this differential action of the actuating mechanism. The pressure increase is reflected by a corresponding increase in the metal removing action of the honing stones over the area in which the lower section of the tool is traversed during the major portion of the honing cycle, that is, the area adjacent the lower end of the cylinder S. Moreover, the cutting action of the abrasive elements is further increased by the wedging action of the tapered surface on the elements. The net result is that the tapered area is quickly and accurately reduced so as to leave the cylinder walls parallel throughout their entire length.

In the exemplary tool illustrated in the drawing, two adjusting cam members 20 and 21 are provided. The particular cam members illustrated are of generally frusto-conical form thus presenting active cam surfaces disposed at an angle to the rotational axis of the tool body. The cam members are suitably mounted on a tool adjusting rod 22 extending through the tubular driver 9 and having a bearing in a cap member 23 secured to the lower end of the tool body in a manner which permits convenient removal when it is desired to replace or alter the relative spacing of the cam members. The cam surfaces of the member are arranged to coact with followers 26 and 27 herein shown as rounded lugs extending inwardly from the holder flanges 15 adjacent the opposite ends thereof. It will be understood of course that cams and followers of other suitable forms may be employed and that the followers may be constructed separately from the holders if desired.

Outward shifting of the abrasive holders is effected by shifting the cam members relative to the holders in an upward direction as viewed in Fig. 2 or in a downward direction as viewed in Fig. 4. Obviously similar results could be obtained by shifting the cam members toward and from each other if one member is reversed from the position shown so that the cam surfaces slope in opposite directions.

To effect the differential adjustment of the abrasive elements of the tool, the adjusting mechanism provided by the invention includes two sets of differently inclined actuating surfaces operative respectively to impart different degrees of movement to opposite ends of the abrasive elements in response to movement of the adjusting rod through a given distance. The actuating surfaces may be arranged to act either directly or indirectly on the abrasive element holders. Thus, for direct action, the two sets of actuating surfaces may respectively constitute the active or working faces of the cam members 20 and 21 coacting directly with the followers associated with the holders. For indirect action the actuating surfaces are interposed between the cam members and the adjusting rod and are preferably in the form of screw threads having different leads. Adjusting mechanism arranged for the latter type of operation is illustrated in Fig. 2

in which the members 20 and 21 are formed with cam surfaces 28 and 29 having the same inclinations with respect to the axis of the tool body.

Hone adjusting mechanism of the direct acting type is illustrated in Fig. 4 in which it will be observed that the member 20 is formed with a cam surface 30 which is more steeply inclined than the corresponding cam surface 31 of the member 21. To prevent the abrasive element holders 14 from sliding longitudinally and thus equalizing the camming effect of the members 20 and 21, the holder flanges 15 are provided at opposite ends with extensions 32 and 33 adapted to abut respectively against the driver flange 8 and the cap member 23, both of which are rigidly attached to the tool body.

In the form of adjusting mechanism shown in Fig. 2, the cam members are threaded for engagement with threaded sections 34 and 35 of the adjusting rod 22. These sections of the rod are provided with threads having different leads and therefore present differently inclined actuating surfaces for coaction with the correspondingly inclined surfaces formed by the threads in the cam members. Due to this difference in inclination one cam member, in this instance, the member 20, is moved through a greater distance than the other member for each revolution of the adjusting rod. To prevent rotation of the cam members, the tool body 5 is provided on its interior with suitable radial key projections 36 engageable in complementary slots 37 in the members. Any suitable means such as a lever 38 may be utilized for rotating the adjusting rod.

Referring now to Fig. 4, the cam members 20 and 21 in this instance are pinned or otherwise rigidly secured to the adjusting rod 22 in fixed spaced relation and appropriate movements are imparted thereto by endwise shifting of the rod. While any suitable means may be employed to impart the desired movements to the rod 22, hydraulic mechanism has been found particularly suitable for this purpose. To this end the adjusting rod 22 is extended upwardly through the spindle 10 of the honing machine and operatively secured to a plunger 39 having a piston enlargement 40 working in a cylinder 41 disposed above and coaxially of the spindle. A coiled compression spring 42 interposed between an internal shoulder 43 formed in the spindle 10 and a collar 44 fast on the rod normally urges the rod upwardly whereby the cam members are withdrawn to a position which permits movement of the abrasive elements to be shifted to their inner or contracted position by the springs 16. Introduction of pressure fluid into the upper end of the cylinder 41 shifts the piston and adjusting rod downwardly and the cam members thus become effective to force the abrasive element outwardly into expanded position. Due to the steeper cam surface 30 provided on the cam 20 as compared with the cam surface 31 on the companion member 21, the lower ends of the abrasive elements will be displaced a greater amount than the upper ends of these elements.

It will be apparent from the foregoing that the invention provides a novel and efficient method for removing taper or other slight irregularities from internal cylindrical surfaces. The invention also provides an improved honing tool which greatly facilitates the finishing of work in accordance with the new method. This tool embodies adjusting mechanism adapted to effect a differential expansion of the abrasive elements which renders the tool operative to remove taper from a cylindrical surface by simply rotating the tool and simultaneously reciprocating it through a normal working stroke between the positions shown in dotted and solid lines in Fig. 1. No short stroking or other localized action requiring the operator's attention is necessary for this purpose and consequently the time required for finishing the work and cost of this operation are materially reduced. Moreover, the tool may be adjusted to remove exactly the right amount of stock in each operation, thus insuring greater accuracy in the finished workpiece and more uniformity in successive workpieces. The mechanism provided for this purpose is simple and inexpensive in construction and is readily applicable to honing tools of various types in general use.

We claim as our invention:

1. A honing tool comprising, in combination, a rotatable body member, a plurality of elongated abrasive elements arranged in an annular series around said member, a holder for each abrasive element supported on and guided by said member for movement radially of the rotative axis of the member, adjusting means including members acting on opposite ends of said holders, and means operative to produce a relative movement between said members and said holders so as to positively shift the holders outwardly with respect to the body member, said adjusting means including differently inclined actuating surfaces effective to impart a predetermined greater degree of movement to the ends of the holders adjacent one end of the tool than to the ends adjacent the other end of the tool.

2. A honing tool comprising, in combination, a rotatable body member, a plurality of elongated abrasive elements arranged in an annular series around said member, a holder for each abrasive element supported on and guided by said member for movement radially of the rotative axis of the member, and adjusting means acting on said holders including differently inclined actuating surfaces operative to shift the holders outwardly at one rate adjacent one end of the member and at a predetermined different rate adjacent the other end of the member.

3. A tool for honing internal cylindrical surfaces comprising, in combination, a rotatable body member having an axial bore, elongated abrasive elements supported on said member for radial movement relative thereto, means for moving said elements outwardly including a pair of similar actuating members disposed within said bore and arranged to act respectively on opposite ends of the abrasive elements, and means operable to actuate said members simultaneously but at predetermined different rates to move the opposite ends of abrasive elements outwardly at correspondingly different rates.

4. A honing tool for operating on cylindrical surfaces comprising, in combination, a rotatable body member having an axial bore, a series of elongated abrasive elements disposed longitudinally of said member and arranged in an annular series thereon, means guiding said elements for movement radially of the rotative axis of the member, a rotatable adjusting rod extending through the bore in said member and having screw threaded sections within the bore, the screw threads of the respective sections having different leads, and similarly sloping cam members threaded on the respective sections of said rod and posi-

tioned to act on opposite ends of the abrasive elements and tending to shift the ends outwardly at different rates in response to the rotation of said rod.

5. A honing tool comprising, in combination, a body member having a central longitudinal bore, a series of elongated abrasive elements extending longitudinally of the member in circumferentially spaced relation and radially movable relative thereto, an adjusting mechanism within said bore including a pair of cam members each having a cam surface inclined with respect to the axis of said body and arranged to coact respectively with cam engaging means disposed adjacent opposite ends of the abrasive elements, the inclination of said cam surfaces being such that the ends of the abrasive elements are displaced equal amounts by equal movements of the cam members, and adjusting means operative to impart different degrees of movement to said cam members tending to displace the abrasive elements a greater amount at one end than at the other end.

6. A honing tool for operating on generally cylindrical surfaces comprising, in combination, a rotatable body member having a central longitudinal bore, a series of elongated abrasive members arranged in an annular series around said body and disposed longitudinally of the same, a carrier for each element supported and guided on said body for movement radially thereof, each of said carriers having a pair of spaced members projecting into said bore, cam members disposed within said bore and positioned to coact with the projecting members of the carriers, means for shifting said cam members relative to the projecting members at different rates thereby tending to displace the opposite ends of the carriers different amounts, and means for preventing the carriers from moving in the direction of movement of the cam members.

7. A honing tool for operating on cylindrical surfaces comprising, in combination, a rotatable body member having an axial bore, a series of elongated abrasive elements disposed longitudinally of said member and arranged in an annular series thereon, means guiding said elements for movement radially of the rotative axis of the member, an adjusting rod disposed within said bore and shiftable axially thereof, and cam members rigid with said rod positioned to act on opposite ends of the abrasive members in response to the shifting of the rod, one of said cam members having a steeper slope than the other cam member and tending to effect a non-uniform outward movement of the respective ends of the abrasive elements.

8. A honing tool comprising, in combination, a body member having a central longitudinal bore, a series of elongated abrasive elements extending longitudinally of the member in circumferentially spaced relation and radially movable relative thereto, an adjusting mechanism within said bore including a pair of cam members each having a cam face inclined with respect to the axis of said body member and arranged to coact respectively with cam engaging means disposed adjacent opposite ends of the abrasive elements, said cam faces being differently inclined so as to displace the ends of the abrasive elements different amounts in response to equal movements of the cam members, and means operable to move said cam members in a direction to effect either an inward or an outward movement of the abrasive elements.

9. A honing tool for operating on cylindrical surfaces comprising, in combination, a rotatable body member having a central longitudinal bore, a series of elongated abrasive members arranged in an annular series around said body and disposed longitudinally of the same, a carrier for each element supported and guided on said body for movement radially thereof, each of said carriers having a pair of spaced members projecting into said bore, cam members disposed within said bore and positioned to coact with the projecting members of the carriers, said cam members having cam faces inclined at different angles to the projecting members so as to displace the opposite ends of the carriers different amounts in response to equal movements of the members, and means operable to move said cam members in a direction to effect either an inward or an outward movement of the carriers.

10. A honing tool comprising, in combination, a generally cylindrical body, a plurality of elongated abrasive elements assembled substantially parallel to the axis of said body and arranged in an annular series thereon, means on the body guiding said elements for movement radially of the body, cam members coacting with opposite ends of said elements operable to move the same outwardly, and a shiftable adjusting member operable to actuate said cam members, said members being formed so as to impart predetermined different degrees of movement to the opposite ends of said elements in response to the shifting of said adjusting member through a given distance.

11. A honing tool comprising, in combination, an elongated body member having an axial bore, a plurality of abrasive elements supported on the body member for movement relative thereto, means for moving said elements radially of the body member including a pair of cam members disposed within said bore and arranged to act respectively on opposite ends of the abrasive elements, and a shiftable adjusting member operable to actuate said cam members, said adjusting member and said cam members being constructed and arranged so as to move the opposite ends of the abrasive elements at predetermined different rates in response to the shifting of said adjusting member.

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