Sept. 15, 1964 M. L. EBNER ET AL 3,148,564

GROOVING TOOL

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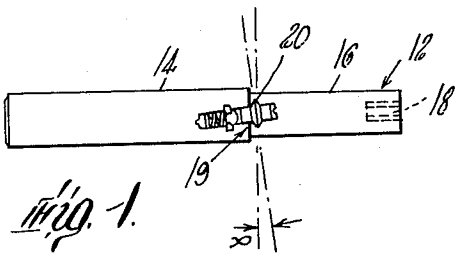


Fig. 1.

Fig. 2.

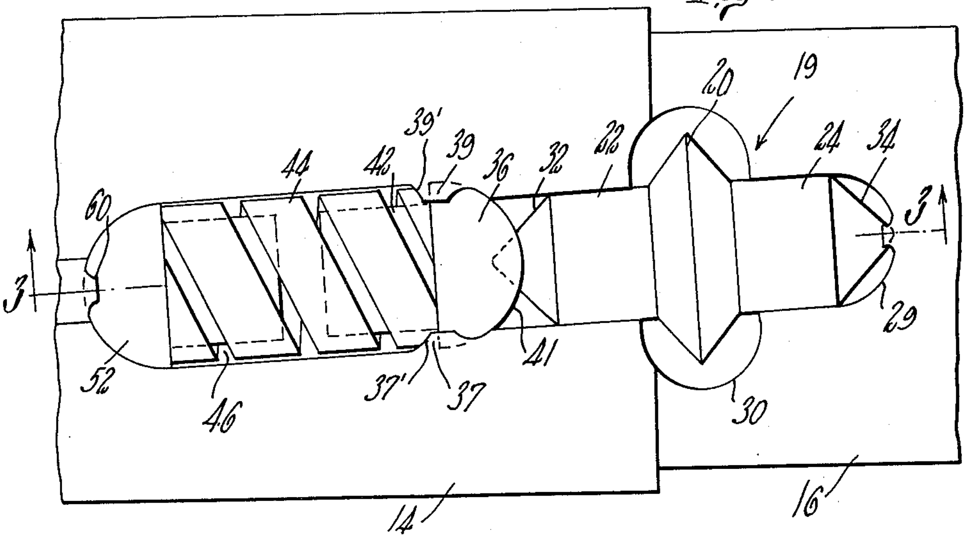
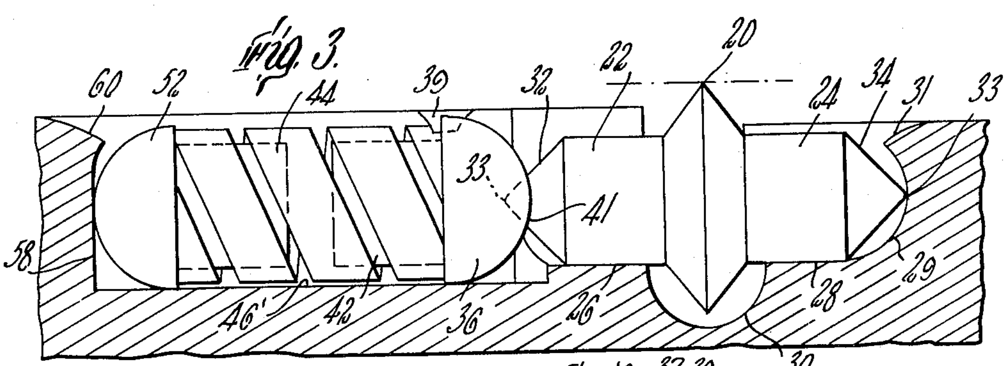


Fig. 3.



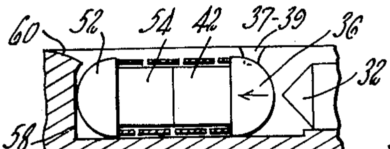


Fig. 3A

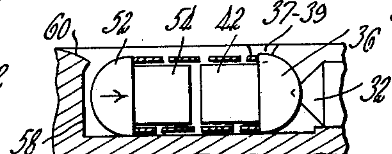


Fig. 3B

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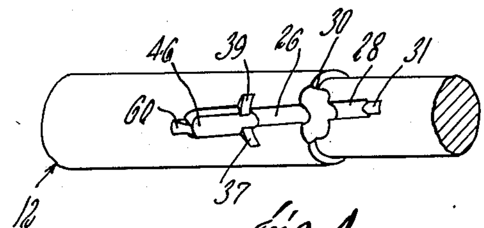

Fig. 4.

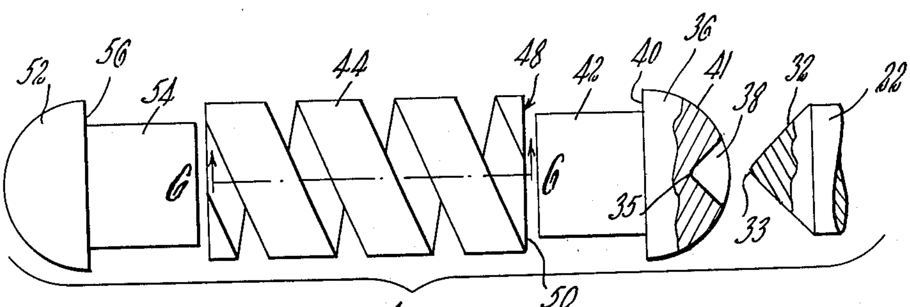

Fig. 5.

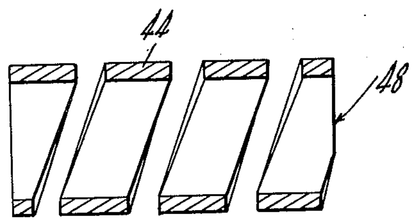

Fig. 6.

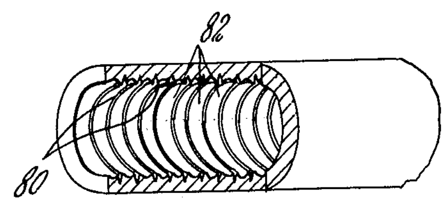

Fig. 7.

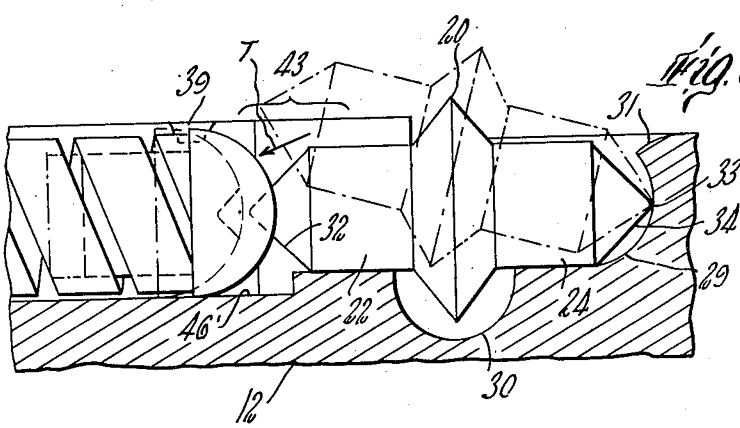

Fig. 8.

United States Patent Office

3,148,564
Patented Sept. 15, 1964

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GROOVING TOOL

Merrill L. Ebner, Arlington, Richard H. Krock, Brookline, and Donald B. Avery, Boston, Mass., assignors to Equipment Development Corporation, Natick, Mass., a corporation of Massachusetts

Filed May 29, 1962, Ser. No. 198,588
14 Claims. (Cl. 80—6)

This invention relates to a tool for decreasing the size of metal bores and the like by rolled deformation.

In automotive engines, wear of valve guide bores causes loss of compression and excessive oil and gasoline consumption. Instead of installing new valve guide inserts in the cylinder head or block, it is desirable to resize the worn guides, as this requires less labor and avoids keeping spare parts for various engines. An effective method for such resizing has been to roll into the inner surface of the worn guide a spiral groove, thereby forcing the metal between the turns of the groove to project as a spiral thread having an inside diameter slightly smaller than that desired. The diameter of this thread can then be slightly increased to the exact desired dimension by reaming.

This method of resizing requires a tool that is sufficiently small to move through the valve guide and sufficiently simple and inexpensive to enable its purchase by automotive repair shops. The tool heretofore used is in the form of a rod having a pilot cylinder to first engage the worn valve guide, an immediately following reduced diameter cylinder, and a grooving wheel recessed in the reduced cylinder near the pilot cylinder and set at a lead angle with its axis generally parallel to the rod surface and at an angle to the rod axis. The wheel is mounted to rotate within a transverse slot in the rod portion of reduced diameter, so as to project therefrom sufficiently to roll the metal to the required extent, by means of axles seated in longitudinal grooves in the rod at either side of the wheel slot.

In order that the tool may rebuild valve guides worn various amounts, a set of wheels of different diameters is provided with the tool, and the wheel mounting must be such as to permit removal and replacement of the wheel. The transverse slot is therefore of a size to accommodate the largest diameter wheel. In the past the wheel has been removably and rotatably held in its mounting by means of tabs pressed out of the axle groove wall at the pilot side of the wheel to overlie the end of the corresponding axle, preventing outward movement thereof, while the other axle was held in its groove by means of an overlying wire wrapped around the rod in a circumferential groove in the rod. With this arrangement, in order to insert or remove a wheel, it was necessary to distort the wire so that the corresponding wheel axle could be inserted or removed from beneath it. Also, the wheel slot was made wide enough to permit longitudinal movement of the wheel to slide the end of the other axle in and out from under the tabs.

With the tool as described, serious difficulty has been experienced due to wobbling of the wheel, particularly after the tool had been in use for some time. This wobbling not only produced an irregular thread of different diameters along its length but occasionally caused a tool to jam in a valve guide, either because the wheel became nonrotatably bound in its mounting or because it had become so skewed as to turn a circular instead of a spiral groove, thus becoming locked in the groove against further progress in either direction. Such jamming is a serious problem, since it ordinarily necessitates breaking out or reaming out the tool, with injury to the valve guide as well as to the tool.

We have determined that this wheel wobbling difficulty with the prior tool has been due to several factors.

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One is that the wheel in use was pressed against the wall of the slot away from the pilot end and had a tendency to ride up the wall, tilting the wheel. This tendency became worse in use, as the pressure on the opposite axle caused it to wear and deepen the bottom of its groove. Also, the retaining wire when stretched a number of times for wheel replacement tended to become permanently distorted, thus improperly retaining and permitting play in the wheel and even at times projecting out from the tool and obstructing movement. Another cause was that the wheel was not restrained from sliding longitudinally which, with some lateral play permitted by the rotation clearance between the sides of the grooves and the axles, caused wear on the grooves increasing the wobbling play of the wheel.

The principal object of this invention is to provide an improved tool of the type described in which these difficulties are overcome.

Another object is to enable easy assembly of the tool and frequent interchange of grooving wheels without damage to the tool.

Another object is to provide an inexpensive tool which has a long life and which can produce smooth, closer tolerance bores in automotive engine valve guides than could be reliably obtained with previous tools.

According to our invention, two end bearings are provided for the wheel, one engaging the end of each axle, each adapted to restrain its axle from both axial and transverse movement. The bearing for the axle at the trailing end of the tool is fixed while the bearing for the other axle is movable longitudinally of the rod but restrained against lateral movement and is maintained under pressure against the axle end by a compression spring held in a longitudinal recess in the rod. The movable bearing can be pressed away from the fixed bearing, to release the wheel from or insert it into its bearings.

With this construction, the pressure on the wheel as it is advanced through a valve guide forces its trailing axle against the fixed end bearing. Movement in the opposite longitudinal direction is restrained by the spring and movable end bearing. Lateral movement is prevented by both end bearings. By properly proportioning the length of the axles and the transverse slot in which the wheel rotates, the wheel can be prevented from contacting the sides of the slot. Hence, the conditions which produced wheel wobble in the prior tool are eliminated.

The construction preferably includes a spring of special design to meet the requirements, formed by winding a rectangular cross-section steel strip helically to a diameter substantially less than that of the reduced diameter portion of the tool body which can be readily seated and compressed into a groove in the rod to exert a total force of about 1 pound through its bearing and associated axle to force the other axle end against the fixed bearing.

These, and other important features of the invention will be further described in connection with the drawings, wherein:

FIG. 1 is a plan view of a preferred embodiment of a tool;

FIG. 2 is a similar plan view, partially broken away, on a magnified scale;

FIG. 3 is a side cross-sectional view taken on line 3—3 of FIG. 2;

FIGS. 3A and 3B are cross-sectional views of the spring assembly, similar to FIG. 3, showing its positions when compressed;

FIG. 4 is a perspective view of a part of the rod body of the tool of FIG. 1;

FIG. 5 is an exploded view on a magnified scale of the spring assembly of FIG. 1;

FIG. 6 is a cross-sectional view of the spring taken on line 6—6 of FIG. 5;

FIG. 7 is a partially broken away perspective view of a valve guide whose bore has been resized with the tool of FIG. 1; and

FIG. 8 is a view similar to FIG. 3, showing the action of the tool in receiving a grooving wheel.

Referring to FIG. 1, the tool of this embodiment comprises a rod member **12** having a cylindrical pilot portion **14** sized to engage a worn valve guide bore, an adjacent reduced diameter cylindrical portion **16** slightly smaller than the new diameter of the bore to be produced, a hexagonal driver socket **18** at the trailing end of the tool, and a grooving wheel member **19** having a grooving wheel **20** set with its axis generally parallel to the surface of the rod, but at an angle to the rod axis, so the wheel has a lead angle α.

Referring to FIGS. 2 and 3, the wheel member has two axles **22** and **24**, one extending to each side of the wheel **20**. Each seats in a corresponding groove in the rod, its inner surface bearing upon the groove bottom **26**, **28**. The axles position the outer part of the wheel periphery beyond the surface of pilot portion **14**. The wheel extends into recess **30** free from contact with the tool body. The ends **32** and **34** of the axles are conical, their sides preferably including an angle of 90°, with rounded tips **33** preferably having a .005 inch radius.

Referring to FIGS. 2, 3 and 5, an axially movable bearing member **36** has a rounded end surface **41**, preferably spherical. In the middle of this surface, there is formed a conical bearing opening **38**. The conical sides of the opening include an angle larger than the included angle of the conical sides of axle end **32**, preferably an angle of 100°, and the bottom **35** of the opening is rounded with a radius larger than the axle tip, preferably a radius of about .010 inch. These differences in form between the bearing opening and the axle permit the axle to freely rotate even when axle and bearing are forced together and not exactly aligned.

The bearing member **36** has an abutment surface **40** and a projection **42** on the side opposite from the conical opening. A helical spring **44** is seated in groove **46** of the rod member, generally aligned with axle **22**. The spring has an end opening **48** into which the projection **42** of the bearing member is fitted, and the end surface **50** of the spring engages abutment surface **40**. The inner surface of the bearing head rests upon the bottom **46'** of groove **46**. Two tabs **37** and **39**, integral with the walls of the groove **46** overlie the groove to restrain the bearing member and by it, the spring, from transverse movement outwardly and align them with the lead axle **22**.

A generally rounded end member **52** at the opposite end of the spring preferably has the same outer form as bearing member **36** and rests on groove bottom **46'**. It has a projection **54** inserted in a corresponding end opening of the spring and an abutting surface **56** engaging the corresponding end surface of the spring. A tab **60** integral with the wall **58** at the end of groove **46**, overhangs the groove and the head of the member to restrain it from outward transverse movement.

The bearing for rear axle **24** comprises two parts, an end wall **29** of groove **28** which is rounded at its sides and bottom at a radius of curvature greater than that of the axle tip and a projecting tab **31** that is integral with the rod and extends over the end of the groove. These cooperate to restrain the axle transversely and rotatably support it without wobble when the tapered end of the axle is pressed rearwardly between them by the spring.

Referring to FIG. 6, the spring member is formed of a helically wound strip of rectangular cross-section. It is by this particular cross-section that high torsional resilience is provided in the confines of the small recess that is possible in the small tool for automative engine valve guides. The spring is formed of pretempered carbon spring steel which is as hard as possible while still allowing rolling of the strip into the helical form. Suitable steel has an elastic limit in torsion of between about

110,000–125,000 p.s.i. An appropriate size spring has a length of ¼ inch, a diameter of $\frac{1}{10}$ inch, a maximum closed length of .178 inch, and a strip rectangular cross-section of .040 inch width and .012 inch thickness.

The dimensions of the wheel member, the spring and the grooves are proportioned so that the spring when inserted in its groove **46** and pressing upon the tapered end **32** of leading axle **22**, forces the wheel member rearwardly against the end wall **29** with a total force of obout 1 pound, which produces a very high unit pressure on the ends of the axles because of the small area upon which the force acts. To achieve this force with the spring described in detail above, the groove **46** and wheel member **19** are sized to cause the spring to be compressed a distance about ⅙ of its uncompressed length.

The projections **42** and **54** which are inside the spring are specially related. Referring to FIG. 3A, when the spring is compressed in the direction of the arrow displacing bearing member **36** slightly more than is required to release the grooving wheel, the projectoins **42** and **54** are so long that their ends engage and prevent further movement of the bearing member. This occurs before the bearing member head can move free of the tabs **37** and **39**, so the spring assembly is retained and cannot be accidentally dislodged when it is compressed to release the wheel.

Referring to FIG. 3B, when the spring is compressed from the opposite direction, end member **52** can be moved free of tab **60** before the projections **42** and **54** engage so the spring can be readily installed and replaced.

In manufacture of the tool body, the rod is first formed to the proper dimensions. For resizing, a $\frac{5}{16}$ inch diameter valve guide, for instance, the pilot cylinder **14** has a diameter of .309 inch and the reduced portion **16** has a diameter of .273 inch. The rod is milled to provide appropriate grooves and wheel recess, the rounded end wall **29** being formed by a ball end mill. Then a mandrel is inserted in the groove where tabs **37** and **39** are to be formed, the mandrel having the same shape as the bearing member to be retained. The wall of the groove is peened or staked, e.g. by a hammer and punch, driving the material of the rod down upon the mandrel, forming the tabs. A plunging operation is then performed in which a cylindrical cutter is lowered vertically into the groove, cutting the spring side of tabs **37**, **39** to produce the arcuate surfaces **37'** and **39'**. The plunging tool is accurately positioned relative to the groove end **58** to ensure the tabs will restrain the spring even when it is compressed to release the wheel member. Tabs **60** and **31** are peened or staked without a mandrel being required.

The tool rod can also be produced by investment casting techniques.

In operation, the pilot portion of the tool is introduced into a bore whose diameter is to be reduced and the grooving wheel **20** engages a notch formed in the mouth of the bore. Then the tool is rotated in the feeding direction by means of a suitable turning tool engaged with the driver socket **18**. The force of the wheel member against the work piece causes the axles **22** and **24** to press against the longitudinal groove bottom surfaces **26** and **28**. Although the grooves are wider than the axles to avoid interference with them, no wobble occurs due to the axial bearings. The feeding forces and the spring urge the tapered axle end **34** rearwardly towards fixed wall **29** while the spring maintains the movable bearing **36** in tight engagement with the tapered end of the leading axle, whereby the wheel member is firmly positioned axially. The small area of contact between the wheel member axles and their end bearings, less than $\frac{1}{16}$ inch in diameter, makes the effective moment arm at which the bearing pressure is transmitted negligible. This minimizes the tendency for the axles to move laterally with respect to the fixed bearing, or to impose torque on the spring, thereby making the wheel rotate freely.

Referring to FIG. 7, the wheel **20** deforms and cold works the bore walls producing helical groove **80** from which the metal is forced to flow into lands or thread **82** of a substantially lesser diameter than the worn bore. The tool rolls from one end of the bore to the other very smoothly without wobble and without danger of jamming, forming a substantially uniform and regular spiral thread very suitable for reaming.

Referring to FIG. 8, an access opening **43** is defined between the tabs **37**, **39** and the axle end **32**, into which an object such as the end of a paper clip or Allen wrench can be inserted, and a thrust applied to the bearing as indicated by the arrow T. Or a thrust in the same direction can be applied directly to the wheel member. This compresses the spring, the head **36** sliding rearwardly to the dotted line position allowing the wheel to pivot into and out of its recess while the head and spring remain restrained by tabs **37**, **39**. The amount of compression is limited by engagement of the ends of projections **42** and **54** so that the rounded head **36** remains restrained by tabs **37** and **39**.

It will be appreciated that those bearings provided by the rod can be formed with simple milling cuts and peening and the conical opening of the movable bearing can be formed by drilling before insertion into the rod. The device is inexpensive to manufacture, and the grooving wheel is stably positioned. It is thus prevented from wobbling and jamming and can form substantially uniform grooves and threads. Because of the manner in which it is held, the wheel and axle journals of the device of this invention do not wear out nearly as fast as was the case with the prior mounting.

It will be understood that changes can be made in the specific details of the foregoing embodiment within the spirit and scope of the invention.

What is claimed is:

1. In a tool for resizing a generally cylindrical bore to a decreased diameter comprising a rod adapted to be rotatably driven and having a leading cylindrical pilot portion to engage the bore to be resized, an adjacent second cylindrical portion of a lesser diameter, a recess in said second portion near said first portion, a single removable grooving wheel mounted in said recess at a lead angle to said rod, the periphery of said wheel projecting beyond the outer surface of said first cylindrical portion, said wheel having a leading axle and a trailing axle, and each axle bearing on the bottom of a corresponding groove in said rod, the improvement comprising two end bearings, one engaging the end of each axle, each shaped to restrain its axle from both axial and transverse movement, the bearing for the leading axle being defined by a movable bearing member movable axially of the rod, a compression spring held recessed in said rod, having one end abutting a fixed surface and the opposite end pressing said movable bearing member toward said wheel, and means restraining said movable bearing member from transverse movement.

2. The tool of claim 1 in which the bearing for the trailing axle is fixed, formed by the end wall of the groove in which said axle seats.

3. The tool of claim 1 adapted to resize automotive engine valve guides wherein the spring comprises a helically wound steel strip of rectangular cross-section, the spring having a diameter substantially less than that of said second rod portion, and the spring axially aligned with said wheel, exerting an axial force of about 1 pound through said movable bearing upon the end of the corresponding wheel axle.

4. The tool of claim 1 wherein each of the end bearings has a bearing surface engaging the corresponding axle over an area less than $\frac{1}{16}$ inch in diameter.

5. The tool of claim 1 wherein each of said axles is tapered and has a rounded tip, and the bearing surface of each of said end bearings is rounded with a radius of curvature greater than that of the tip of the corresponding axle.

6. The tool of claim 1 wherein said compression spring is cylindrical, having an opening at the movable bearing end, said movable bearing member having a surface abutting against said spring, and a projection extending into said opening, said movable bearing member axially slidably engaging said restraining means, said movable bearing member projection restraining the corresponding end of said spring from outward transverse movement.

7. The tool of claim 1 wherein a limit stop is provided, said bearing member is adapted to engage said limit stop when said movable bearing member is pressed away from the other bearing member, the stop being positioned to allow the bearing member to be moved to release said wheel member, and positioned to prevent movement of said bearing member free from said restraining means.

8. The tool of claim 7 wherein the spring is hollow throughout and said limit stop comprises a projection extending inwardly of said spring toward said movable bearing member.

9. The tool of claim 1 wherein said movable bearing member has a generally rounded head, the head being slidably seated in a groove generally aligned with the axis of said wheel, and said restraining means comprising at least one tab integral with said tool rod, said tab extending generally transversely over said groove, slidably engaging the head and, in cooperation with the bottom of said groove, holding it and the spring generally axially aligned with said axis.

10. The tool of claim 9 wherein said tabs comprise portions of the groove walls peened over said groove, the spring side of said tabs cut vertically to the curve of said bearing member head.

11. The tool of claim 1 wherein the fixed surface end of said spring that is held recessed in said rod is disposed in a grove in said rod, a locking tab integral with said rod, extending over said groove, said locking tab restraining said spring end from transverse movement out of said groove.

12. The tool of claim 11 wherein said fixed surface end of said spring includes a generally rounded head, the locking tab engaging the outer periphery of said head, the head bearing upon an end wall of said groove.

13. The tool of claim 2 wherein the bearing for the trailing axle that is shaped to restrain said axle from both axial and transverse movement is defined by an end wall of the groove having rounded sides, bottom and a locking tab integral with said rod, said locking tab lying over the end of said groove.

14. A tool comprising a metal body member, a groove in the surface of said member, a grooving wheel recessed in said groove of said body member with a portion of its periphery projecting beyond the surface of said member, the wheel having two axles, one projecting from each side and disposed in said groove, the axle on the leading side of the tool having a tapered end seated in a movable bearing member carried by the end of a compression spring, the spring recessed in said body member and pressing said bearing against said axle, a tab means integral with said rod overlying each end of said spring, restraining it from outward transverse movement, the other axle of said wheel member having a tapered end seated in an end bearing defined by an end wall of the groove having rounded sides and bottom and a projection integral with said rod overlying the end of said groove.

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