The present invention relates to cylinder surfacing tools, also known as cylinder honers, and has to do more particularly with a cylinder surfacing tool of the type embodying a plurality of abrasive elements arranged for expansion and contraction.

An object of the invention is to provide a cylinder surfacing tool wherein the abrasive elements are expandable and contractable through a large range of expansion and are maintained substantially in parallelism throughout such range.

Another object is to provide a device of the foregoing character that is expandable and contractable through a large range of movement and in which the pressure exerted thereby on the cylinder wall is substantially constant in all positions within the range of expansion, without the necessity for any manual adjustments.

A further object is to provide a cylinder surfacing tool having a novel linkage for providing a large range of expansion of the abrasive units while unusual stability is maintained.

Another object is to provide a surfacing tool having linkage as referred to which includes parallel links with widely spaced points of support relative to the size of the tool, whereby unusual stability is provided.

Still another object is to provide a surfacing tool that is simple and inexpensive to build, is rugged and durable, and requires a minimum of replacement of parts over a long period of use.

Another object is to provide a cylinder surfacing tool having a novel abrasive unit that is readily attachable to and detachable from the tool.

A further object is to provide a novel abrasive unit for a surfacing a tool.

Other objects and advantages will appear from the following detailed description taken in conjunction with the accompanying drawings in which:

- Fig. 1 is an elevational view of the cylinder surfacing tool in fully expanded position;
- Fig. 2 is an elevational view of the tool nearly fully contracted and disposed in a cylinder, as in a surfacing operation;
- Fig. 3 is a bottom view of the tool in expanded condition;
- Fig. 4 is a top view of a portion of the tool;
- Fig. 5 is an elevational view of the body of the tool;
- Fig. 6 is a sectional view taken on line 6-6 of Fig. 1;
- Fig. 7 is a longitudinal sectional view of an assembled surfacing unit;
- Fig. 8 is an exploded perspective view of the parts of a surfacing unit;
- Fig. 9 is a diagrammatic illustration of a linkage arrangement utilized in the hone; and
- Fig. 10 is similar to Fig. 9 with the linkage in a different position.

The device illustrated in the drawings embodying the principles of the invention includes a central supporting element which takes the form of a body 12 having a bore 13 extending longitudinally and axially therethrough.

The bore 13 is internally threaded at 14 in its upper end for reception of a suitable driving element, as, for example, a flexible shaft (not shown). The body 12 has a plurality of wings 15 extending radially outwardly, corresponding to the number of surfacing units 19 (hereinafter described in detail), which is preferably three, and arranged for supporting, or at least partially supporting, the surfacing units. Each wing 18 is provided with downwardly extending and laterally opposed ears 20 having aligned apertures for receiving a pin 22 for pivotally mounting the surfacing units and forming a pivot axis 22'. The ears are connected as by a top element 24, and the space between the ears of each pair opens through to the bore 13 as shown at 25 in the sectional part of the view of Fig. 1. The body 12 also has a downwardly extending portion provided with lugs 28 corresponding respectively with the wings 18 but at positions substantially diametrically opposite thereto. Each abrasive unit 19 is pivotally mounted on links 32 and 34 constituting a parallel linkage for radial swinging movement of the units maintained parallel with the axis of rotation of the tool. Pins 29 pivotally mount the appropriate ends of the links 34 on the lugs 28, forming axes 29' which are disposed in a plane below the plane of the axes 22'.

The link 33 of the linkage for each unit takes the form of a channel and constitutes a rigid main supporting arm 31 in the outer end of which is pivot pin 33 pivotally mounted the surfacing unit, forming a pivot axis 33'. The link 32 at its inner end is pivotally mounted on the pin 22, and at this location it is of substantial width having wide spaced points in transverse direction, i.e., adjacent opposite ends of the pin 22. Accordingly, the necessary strength and stability is provided for withstanding the substantial stresses imposed on it in the rotation of the tool. Extending beyond the inner pivot axis 22' is a short arm or lever 36 (see Figs. 1 and 4) formed as an extension of the arm 31 and extending through the opening or slot 25 in the body into the bore 13. The lever 36 is disposed at a predetermined angle relative to the arm 31, namely, in this instance 113°36', for a purpose brought out fully hereinafter. The lever 36 is formed as an extension of a corresponding flange of the channel of the arm 31; the three extensions or levers 36 are arranged in an overlapping relation tangent to a base circle as shown in Fig. 6 whereby they may be extended a substantial distance into the bore, and past the central axis thereof.

The link 34 is pivoted at its outer end by means of a pivot pin 37 in an extended end of a rigid arm 39 of the surfacing unit, forming a pivot axis 37'. The links 32 and 34 are of course of the same length, and the respective pivot axes on the opposite ends are positioned for maintaining the abrasive units parallel with the axis of rotation.

The abrasive units are yieldingly biased outwardly by means of a compression spring 40 surrounding a spring guide 42 which is in the form of a rod reciprocably mounted in the bore 13 of the body. A suitable spring retainer 44 is fitted on the lower end of the rod, and the spring is confined and compressed between the retainer and the under surface of the body. The upper end of the rod has a pair of head members or flanges 46 and 48 guided in the bore 13 and spaced apart for receiving the inner ends of the extensions 36 on the arms 32. Upon movement of the rod 42 in either direction, the surfacing units are positively swung in or out, but they are biased outwardly by the spring 40. If one or more of the surfacing units are forceably swung inwardly, the remaining units are swung inwardly also, through their mutual positive connection between the head elements 46 and 48.

A washer 49 of rubber-like material is interposed be-
between the lower head element 46 and the inturned flange 51 at the lower end of the body, to provide a resilient limit stop for the units in their outward movement.

Each surfacing unit 19 includes a carrier 50 which takes the form of a channel having transverse end edges 56, and side flanges 58. Substantially midway of the carrier the flanges are provided with apertures for receiving the pin 33 mentioned above. One of the flanges at its lower end has an integral and rigid extension thereof forming the arm 39 mentioned above. The pivot axes 33' and 37' are parallel and 22' and 29' form a parallelogram of the lines interconnecting them. A substantial distance, in radial direction, exists between the axes 33' and 37'. This distance is equal to and determined by the diametric distance between the axes 22' and 29' as shown.

The expanded and collapsed positions of the surfacing tool or cylinder hone are shown in Figs. 1 and 2 respectively, from which it will be seen that the expansion is unusually great. For example, in one specific embodiment, the diameter is about 10/30" in expanded position and about 21/4" in contracted position. In contracted position the axes 33' and 37' are parallel and 22' and 29' form a parallelogram of the lines interconnecting them. Being required that some extension be provided in order to effect a surfacing operation with the body also disposed in the cylinder to be surfaced. The wide spacing between the pivot axes 22' and 29' is substantially equal to the diameter of the body, since the axes are substantially at the periphery of the body. The fact that these axes are within the axial projection of the body enables the links to be contracted or collapsed within that projection. The wide spacing between the pivot axes 22' and 29' makes possible a great expansion of the surfacing units while maintaining unusual stability in the device.

Mounted on each carrier is an abrasive unit 52 which includes a channel-shaped mounting member 71 and an abrasive element or stone 72. The channel is formed of spring material, such as steel, and includes a web 68 and side flanges 70, and at the ends of the web are extensions 74 bent out of the plane of the web in the direction of the flanges and turned under, forming yieldable gripping elements or hooks. The abrasive unit is attached to the carrier by engagement of the gripping elements 74 over the end edges 56 of the carrier web. The flanges 70 engage the flanges 54 of the carrier and prevent displacement from the carrier in the transverse directions. The abrasive element or stone 72 is mounted on the outer surface of the mounting channel 71 by suitable means, such as by cement. The abrasive unit can be mounted on and detached from the carrier simply by snapping it onto and off of the carrier.

The links 32 are of maximum width relative to the width of the surfacing units to the end of stabilizing the units against cocking or turning movement about vertical axes, i.e., axis parallel with the axis of rotation of the tool. To this end also the links 34 are arranged so as to be in tension responsive to the intended direction of rotation of the tool. These links are offset from the axis of rotation, as they must be because of the spring 40 and spring guide, and are arranged tangentially to a base circle concentric with the axis of rotation. The direction of offset is such that they are disposed in a leading attitude relative to the direction of rotation of the tool which is clockwise as viewed from the top of Fig. 1 and counterclockwise as viewed in Fig. 3. In this direction of rotation the links 34 are in tension and prevent the surfacing units from cocking or turning.

The angular relation between each arm 31 and the corresponding lever 36, their location relative to the axis of the tool, and the spring rate and initial loading of the spring 40 are so chosen as to produce substantially uniform honing pressure throughout the range of expansion of the hone.

For convenience in description, reference is made to the diagrams of Fig. 9 which represents a link in its expanded or maximum diameter position, and Fig. 10 which represents the link in its contracted or minimum diameter position.

The hone is so constructed that each link 32, including the arm 31 and lever 36, swings through an angle (θ) between minimum diameter and maximum diameter positions, which preferably is approximately 47°, but which angle may be any angle within the range of approximately 30° and approximately 60°. It being noted that such in its maximum diameter position the arm stands at an angle of substantially more than 60° from the hone axis, the hone may bend when moved axially in the cylinder. Where the angle θ is less than 30° it will ordinarily be found more efficient to employ another type of hone.

I have found that it is preferable to construct the link 32 so that the arm 31 and the lever 36 extend at an angle of 90° plus 1/4 of the angle (θ) through which the link swings between the minimum and maximum diameter positions and to so mount the link that it moves through equal angles (αl and αs) on either side of a plane W perpendicular to the axis of the hone. In other words, in the preferred construction the angle αl is equal to the angle αs. Thus in the preferred form of my invention the angle between the arm 31 and the lever 36 is 112 1/2° (i.e.,

\[ 90° + 47° \]

as mentioned above).

To the end of providing a substantially uniform force (P) on each stone when the link is in both the minimum diameter position and the maximum diameter position, I provide a spring 40 which is initially stressed to provide a force F1 on the lever when the hone is in maximum position which force F1 is computed in accordance with the formula

\[ F_1 = \frac{P R \cos \theta}{r \cos \alpha_1} \]

where P is the force which it is desired be exerted on the stone by the arm 31, R is the effective length of the arm 31, and r is the effective length of the lever 36. The spring rate is so selected as to produce a force F2 on the lever 36 when the link is in minimum diameter position which force is computed in accordance with the formula

\[ F_2 = \frac{P R}{r \cos \alpha_1} \]

Where, as in the preferred form of my invention, the lever swings through equal angles αl and αs on opposite sides of the perpendicular plane W, the force F2 may be computed by the formula:

\[ F_2 = \frac{F_1 \cos \theta}{\cos \theta} \]

I have found that where the spring is so stressed and the spring rate is such as to exert a substantially equal force P on the stone in both the minimum diameter position and in the maximum diameter position, it will also exert a substantially equal force on the stone in all positions between the minimum diameter position and the maximum diameter position.

Although as mentioned the corresponding angle between the lever 36 and arm 31 is as stated above, namely, 90° plus one-half of the angle of the swing, the angle may be varied somewhat from the preferred magnitude. It may be increased or decreased somewhat and the pressure of the abrasive units on the cylinder wall may nevertheless be maintained constant, by providing appropriate variation in other ele-
ments of the structure, as in the expanding spring 40. In the structure above described, the spring is compressed to such an extent that approximately 32% of the compression of the spring is utilized in expanding the units from minimum diameter position to maximum diameter position. As an example of the application of variation of values, the angle mentioned may be increased or decreased approximately 10% from the magnitude given, i.e., be made 103¼° or 123¼° where the angle of swing is 47° and uniform pressure by the units on the cylinder wall nevertheless be maintained if, in the former case, approximately 19% of the compression of the spring is utilized, and in the latter case, approximately 41.5% of the compression is utilized.

If, instead of 47°, the angle of swing of the arm is 60°, or approximately at the practical maximum indicated above, the desired angle between the arm and lever is 90° plus one-half the angle of swing, or 120°. In this case, the spring is so constructed and arranged, in order that constant pressure will be exerted by the units, that 50% of its compression would be utilized; similar to the conditions outlined above, in this instance also considerable latitude is permitted in variation of magnitude of the angle selected between the arm and the lever, and a spring having different characteristics is selected. For example, if the angle mentioned is 10° greater than the preferred value, or 130°, the spring arrangement is such that approximately 59.2% of its compression is used, and if it is 10° less, or 110°, approximately 39% of its compression is used.

The surface units are positively maintained in parallelism with the axis of rotation of the tool in all positions within their range of movement, through the rigidity of the parallel links. The links 32 and 34 are spaced apart a maximum distance at a position intermediate of their range of movement, the condition occurring at a position adjacent the midpoint of the range. This relation enables maximum stability of the hone in fully expanded position consistent with maximum compactness of the links within the axial projection of the body in contracted position.

The links are interconnected so that they all move in unison and the tool is more effectively centered in the cylinder being surfaced. Substantially uniform pressure is imposed on the upper and lower ends of the units. This is particularly effective, as compared with previous forms of surfacing tool, where the force between the drive elements and the tool must be disposed at an angle to the cylinder. More nearly uniform pressure of the surfacing units on the cylinder in such cases is made possible by the present device. A limited amount of play is provided between the surfacing units, links and body, to adjust for minor variations in the surface of the cylinder.

As will be seen from the foregoing tool of the present invention has numerous advantages. An unusually wide range of movement is provided. The widely spaced points of support provide great rigidity. The device is simple and rugged; it is inexpensive, requiring a minimum of machining operations and having a relatively large number of stamped or folded parts.

The mutual connection or interlock between the various linkages is an advantage, particularly in view of the fact that the device is of great diameter in its expanded position. It would be impossible for the user to hold the device in one hand and with the other handle completely around the surfacing units in an expanded condition, and on the other hand it may not be convenient for the user to use both hands for collapsing the surfacing units. But because of the interlock mentioned, the user need only grasp one of the surfacing units and move it inwardly and this movement positively swings all of the other units inwardly so that he can easily insert the device into the cylinder to be worked on.

I claim:

1. A surfacing unit for a cylinder surfacing tool comprising a channel-shaped carrier having a flat web with substantially straight end edges, and flanges with aligned apertures for receiving a pivot element, and one of the flanges having a rigid extension spaced longitudinally from said apertures with an aperture in its extended end whereby to provide complementary pivot axes spaced in a direction having a component perpendicular to the web, and an abrasive unit mounted on the face of the web opposite that from which the flanges extend.

2. A surfacing unit for a cylinder surfacing tool comprising a channel-shaped carrier having a web, an outer face with flanges extending in the direction opposite the outer face, and the web having substantially straight end edges, and an abrasive unit removably mounted on the carrier including a flat strip of spring material having its end portions rolled out of the plane of the principal portion of the strip, and a flat abrasive element secured to the face of the principal portion which faces in the opposite direction from the rolled ends, the rolled ends being releasably clamped over the end edges of the web of the channel.

3. A rotatable cylinder surfacing tool comprising a rotatable body, a plurality of surfacing units, pivotally connected links connected to the units for swinging movement respectively in planes parallel to the axis of rotation of the body, the pivot connections of said links defining a parallelogram, the links being disposed adjacent parallelism to the axis of rotation of said body in the inner position of the units, and at least certain of the links having actuating levers extending inwardly beyond their pivot axes on the body and disposed at such an angle to the respective links that their range of movement is disposed equally on both sides of the normal to the axis of rotation of said body, and spring means acting on the extended ends of the levers yieldingly biasing the units outwardly, the range of movement of the links being within approximately 60°, and the extent of compression of the spring means utilized in moving the units outwardly through their full range of movement being within approximately 20% and approximately 60% of the maximum compression thereof.

4. A rotatable cylinder surfacing tool comprising a rotatable body, a plurality of circumferentially spaced abrasive units, linkage means mounting each unit for swinging movement in a plane disposed parallel to the axis of rotation of said body, the pivotal connections of said linkage means defining a parallelogram, the linkage for each unit including an actuating link pivoted on the body and having an outer arm and an inner lever terminating adjacent the axis of rotation of said body, spring means expandable along the axis of rotation of said body acting through the levers for constantly biasing the links, and thereby the units, outwardly, the construction and arrangement being such that a lever swings through an angle symmetrical relative to a plane perpendicular to the axis of rotation of said body and containing the axis of the link, whereby it forms an angle α₁ with and on one side of the plane when the unit is in maximum-diameter position and an angle α₂ equal to α₁ on the other side of the plane in minimum-diameter position, the construction and arrangement further being such that the units exert constant pressure on a cylinder wall in all positions of expansion between minimum-diameter position and maximum-diameter position in response to force exerted by the spring means progressively between a force F₁ in minimum-diameter position to an F₂ in maximum-diameter position according to the formulas

\[
F_1 = \frac{PR}{r \cos \alpha_1}
\]

and

\[
F_2 = \frac{PR \cos \theta}{r \cos \alpha_2}
\]

where P is the force exerted by the unit, R is the effective
length of the outer arm, and \( r \) is effective length of the lever.

5. A rotatable cylinder surfacing tool comprising a rotatable body, a plurality of circumferentially spaced abrasive units, linkage means mounting each unit for swinging movement in a plane disposed parallel to the axis of rotation of said body, the pivotal connections of said linkage defining a parallelogram, the linkage for each unit including an actuating link pivoted on the body and having an outer arm and an inner lever terminating adjacent the axis of rotation of said body, spring means expandable along the axis of rotation of said body acting through the levers for constantly biasing the links, and thereby the units, outwardly, the construction and arrangement being such that a lever swings through an angle relative to a plane perpendicular to the axis of rotation of said body and containing the axis of the link, whereby it forms an angle \( \alpha_1 \) with and on one side of the plane when the unit is in maximum-diameter position and an angle \( \alpha_2 \) on the other side of the plane in maximum-diameter position, the construction and arrangement further being such that the units exert constant pressure on a cylinder wall in all positions of expansion between minimum-diameter position and maximum-diameter position in response to force exerted by the spring on the levers progressively between a force \( F_2 \) in minimum-diameter position to an \( F_1 \) in maximum-diameter position according to the formulas

\[
P_2 = \frac{PR}{r \cos \alpha_2}
\]

and

\[
P_1 = \frac{PR \cos \theta}{r \cos \alpha_1}
\]

where \( P \) is the force exerted by the unit, \( R \) is the effective length of the outer arm, and \( r \) is effective length of the lever.

6. A rotatable cylinder surfacing tool comprising a rotatable body, a plurality of surfacing units, pivotal link means mounting the units on the body for swinging movement in planes disposed parallel to the axis of rotation of the body between a contracted position and an expanded position, the pivotal connections of said pivoted link means for each surfacing unit defining a parallelogram, spring means urging the units to expanded position, said spring means being constantly under compression and the rate of the spring means and the initial compression thereof with the units disposed in contracted position being such that substantially constant pressure is exerted by the units on the wall of a cylinder being surfaced throughout the range of movement of the units.

7. A rotatable cylinder surfacing tool comprising a rotatable body member, a plurality of elongated surfacing units, and a linkage system for each of said units arranged to carry the corresponding unit radially outward of said body member in constant parallelism with the axis of rotation of said body member, each of said linkage systems including two links each connected at one end to said body member and at its other end to said surface unit, the resulting four pivotal connections defining a parallelogram, and the two pivotal connections on said body member being disposed on opposite sides of the pivotal axis of said body member and being so oriented that a line joining said connections forms a substantial angle with the axis of rotation of said body member.

8. The elements of claim 7 in which said angle is at least 30°.

9. The elements of claim 7 in which that portion of each of said surfacing units extending between the two pivotal connections thereon is recessed to permit nesting of linkage systems when said surfacing units are in contracted position.

10. The elements of claim 7 in combination with an arm extending from one of said links for operating said linkage system, said arm extending normal to and to one side of the axis of rotation of said body member when the corresponding surfacing unit is substantially midway between its extended position and its contracted position.

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