Feb. 7, 1956 H. WHITESELL 2,733,556

GRINDING AND POLISHING AND THE LIKE

Filed Nov. 3, 1953 3 Sheets-Sheet 1

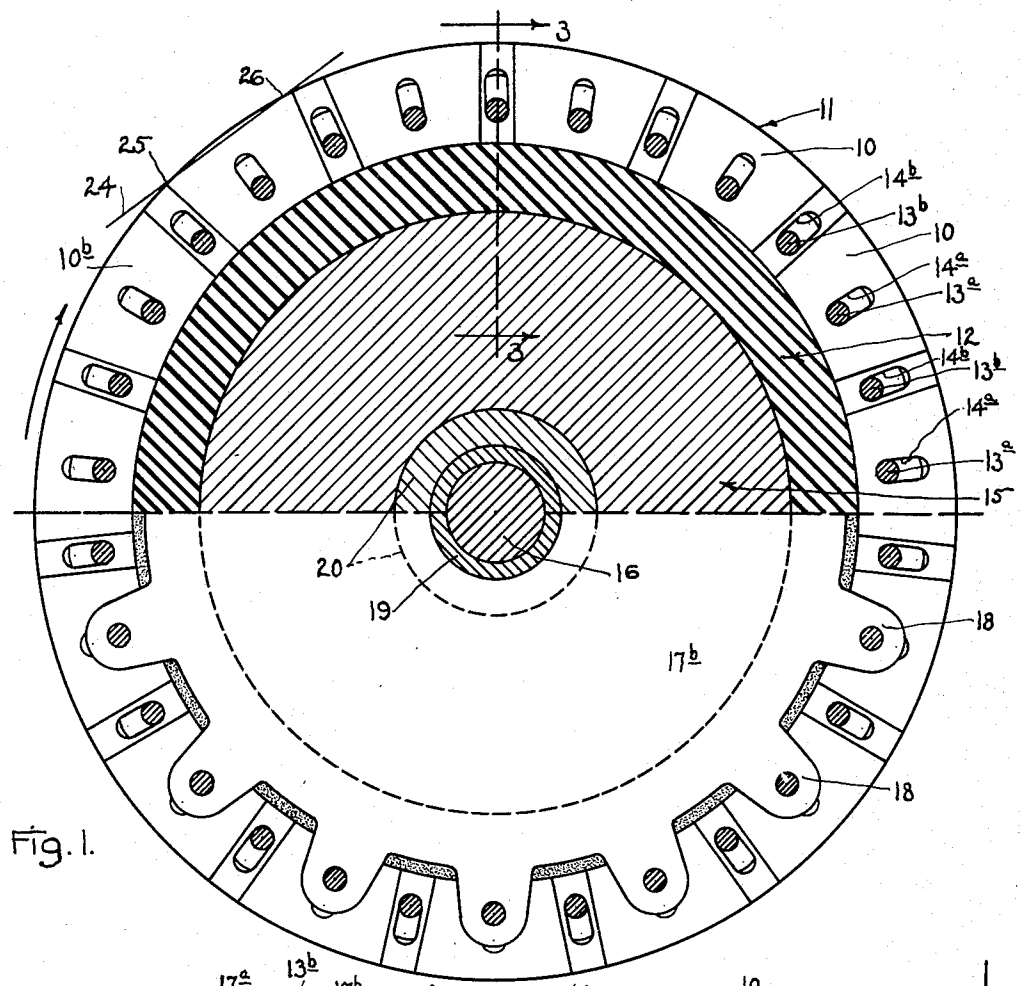


Fig. 1.

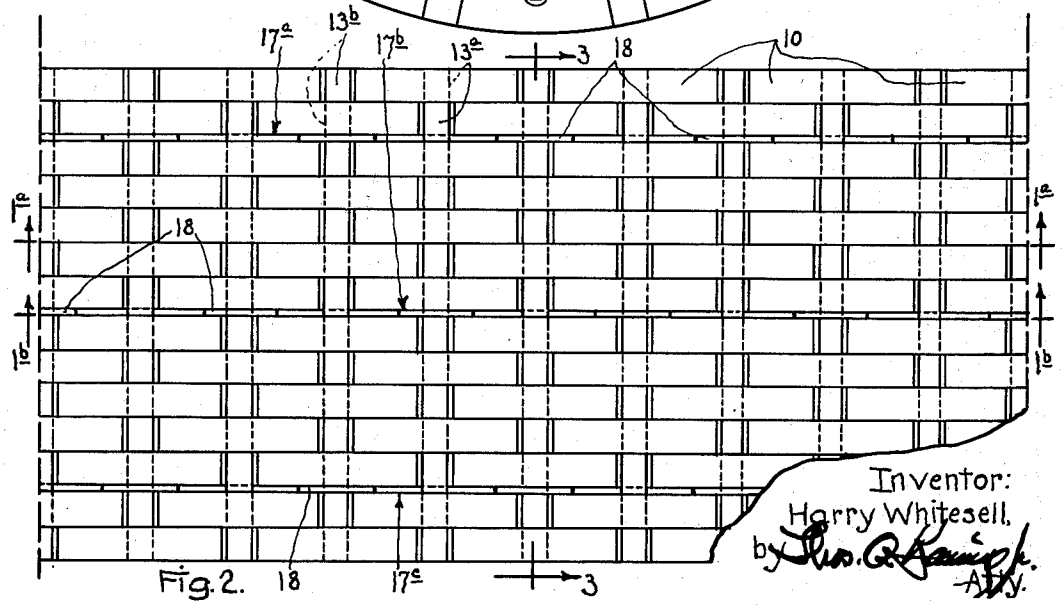


Fig. 2.

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GRINDING AND POLISHING AND THE LIKE

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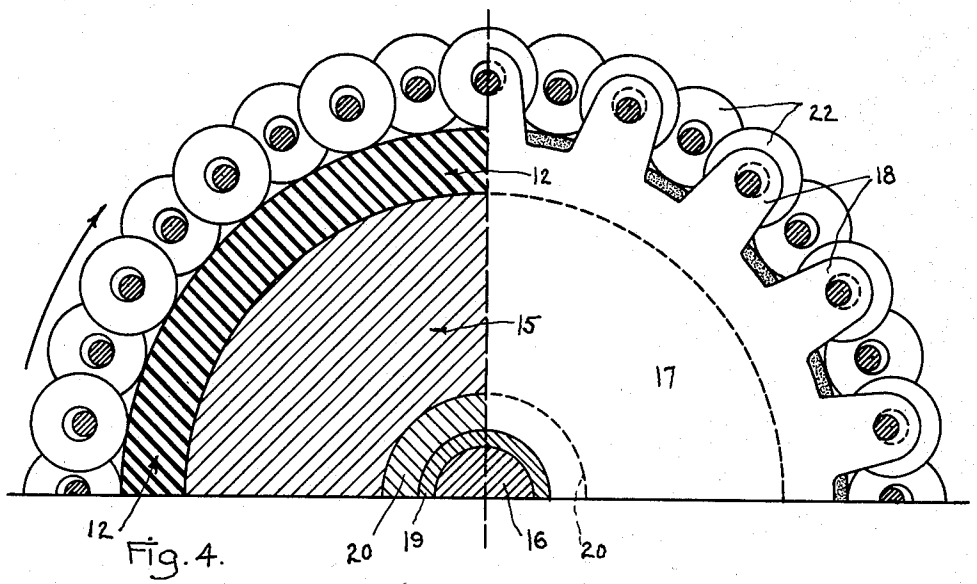


Fig. 4.

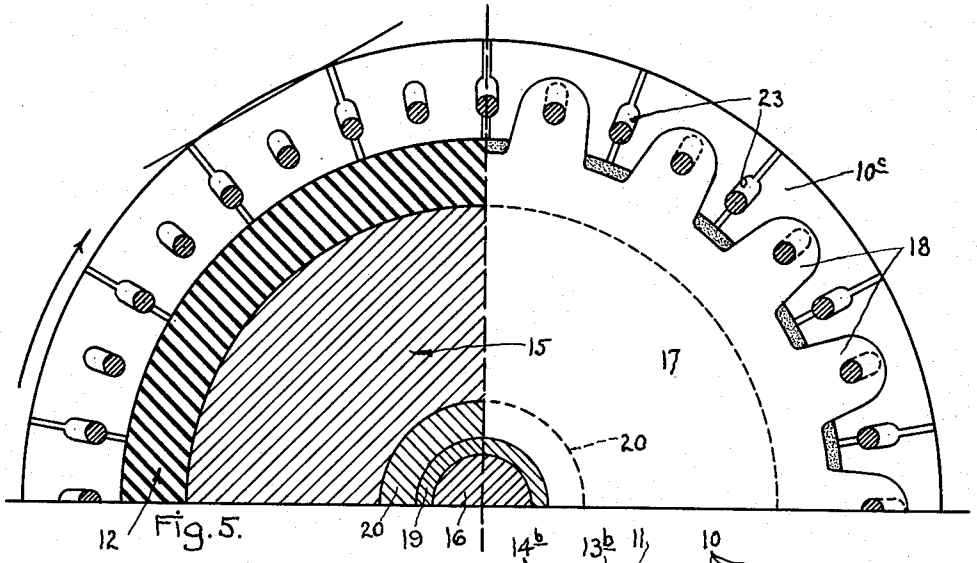


Fig. 5.

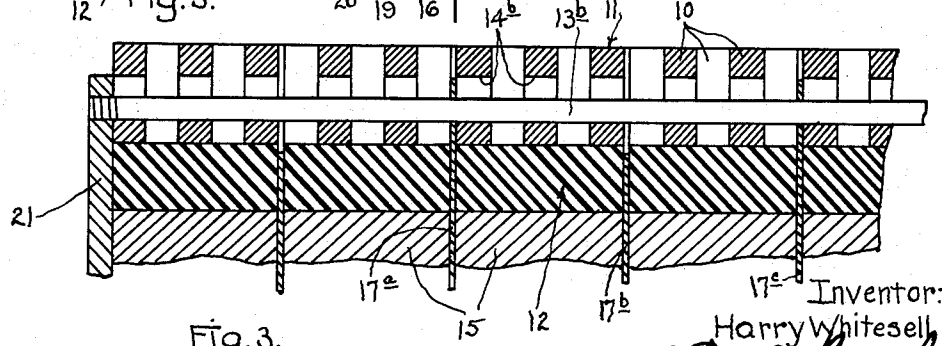


Fig. 3.

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GRINDING AND POLISHING AND THE LIKE

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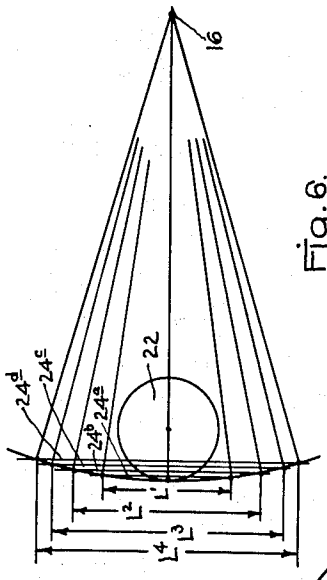


Fig. 6.

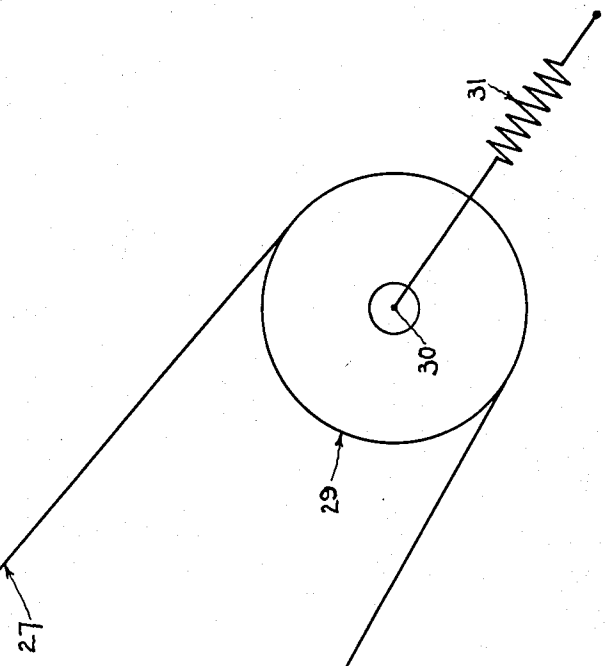
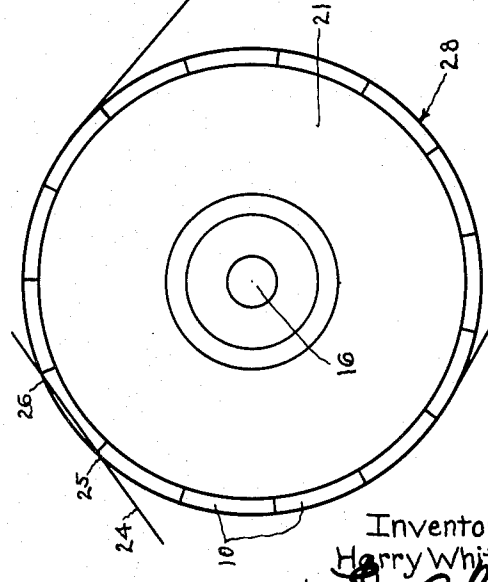


Fig. 7.



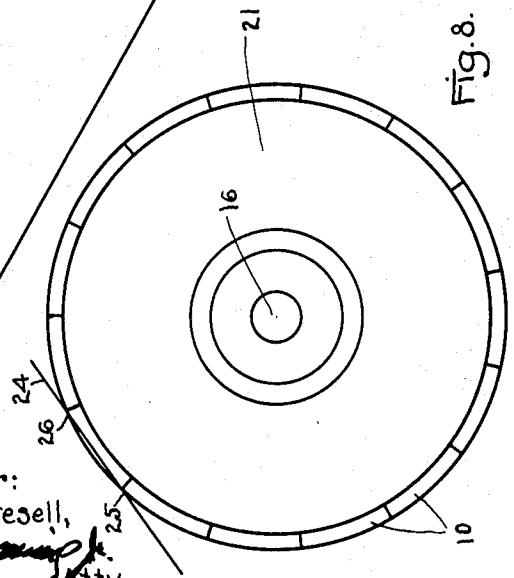


Fig. 8.

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United States Patent Office 2,733,556 Patented Feb. 7, 1956

2,733,556

GRINDING AND POLISHING AND THE LIKE

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Application November 3, 1953, Serial No. 389,990

23 Claims. (Cl. 51—141)

This invention relates to improvements in grinding and polishing, and the like. In such operations the rate at which the material will be removed from the work body depends largely on the length of the scratch produced by the grinding element or elements engaging such work body. That is to say, for a given hardness and quality of material used in the grinding tool the rate of removal of the material from the work body will depend largely on the lengths of the scratches produced in such work body by the grinding element. When the tool is formed of very hard material and is unyieldingly supported during the grinding operation it is evident that, for operations in which the grinding tool rotates about an axis of rotation during the grinding operation, the scratches must be short, with correspondingly limited rate of stock removal from the work body. That this is true is evident since the non-yieldability of such grinding element necessarily limits the area of contact thereof with the work body. If the pressure exerted between the grinding tool and the work body be increased so as to increase the depth of the "cut" which will be produced by the tool, to correspondingly increase the lengths of the scratches it will be seen that such attempted increase in the rate of stock removal must necessarily result in production of curved groove like depressions in the surface of the work body, the lengths of the scratches being dependent solely on the depth of penetration of the rotating tool into the body of the material of the work body itself.

It has been proposed in my co-pending application for Letters Patent of the United States, Serial No. 377,521, filed August 31, 1953, to form the contact wheel which carries the abrasive grinding or polishing belt of yieldable material so that during rotation of such wheel the lengths of the scratches produced by the belt at the location of the contact wheel may be correspondingly increased, thereby substantially increasing the rate of removal of material from the work body. It is now desired to obtain the benefits of long scratch effects by the use of belts travelling over contact wheels of substantially non-yieldable or hard material, or by use of abrasive wheels of either hard material or semi-elastic material but which wheels are so constituted that they comprise the abrasive elements themselves and produce the desired long scratch effects. That is to say, it is a prime feature and object of the present invention to make possible the very substantial increase in scratch lengths and cutting rates which are desired, but without relying on the use of high contact pressures between the wheels and the work bodies needed to secure deep cuts, and, if desired, to secure these benefits and advantages while still making it possible to use hard, substantially non-elastic materials in the wheel itself.

In one embodiment of the features of my present invention I provide a work wheel or "contact wheel" which is provided with numerous segments of hard or substantially non-elastic material which comprise the working or polishing or grinding surface proper, and which segments are backed by an elastic support against inward radial movement; but such elastic support permits inward radial movement of such segments under pressure of the work body. Under this arrangement these segments may be forced inwardly radially under the working force pressure, thus enabling the contact to be maintained between each segment and the surface of the work body for a substantial amount of the angular movement of the grinding or polishing element. Accordingly, the lengths of the scratches produced on the surface of the work body may be greatly increased without correspondingly increasing the depth of the "cut" produced in such work body surface. With such elastic or yieldable backing for the segments each segment produces its effect during a rotative angular movement of the wheel corresponding to the chord drawn between the point of engagement of such segment with the work body surface and the point of departure from such engagement; and this long scratch effect is produced notwithstanding the fact that the segment itself is made of substantially non-elastic or non-yieldable material.

According to another embodiment of the features of my present invention I may include an abrasive belt or surface which travels over such segments during the wheel rotation, the actual abrasive effects being produced by such belt or like surface; but in this case, too, the segments are formed of substantially non-elastic or non-yieldable material, but are supported against the backing of yieldable or elastic material which resists but permits inward radial movement of each segment under the inward radial force developed during the grinding or polishing operation. Thus the lengths of the scratches are greatly increased with this belt arrangement, similar in effect to the effect produced when the segments themselves are in direct contact with the surface of the work body.

When the segments themselves are in direct contact with the work body surface, they are formed of abrasive, but hard and substantially non-elastic material, or they may be formed of elastic or yieldable material but of abrasive qualities and characteristics, but each such abrasive segment or body comprising a portion of the working surface of the wheel is able to yield inward radially under the pressure exerted against it by the work body, thus ensuring a greatly increased length of the scratch which it produces on the work body surface.

When the wheel segments are formed of abrasive material, they may comprise any suitable abrasive material as a homogenous segmental body, or they may comprise suitable abrasive material in granular or like form, bonded or bound into the desired segmental form by suitable binder. In either the former or the latter case, however, the segments are conveniently formed by a suitable moulding process, either with or without the application of heat during the operation, and generally under heavy pressure applied during the moulding operation. Examples of suitable bonding or binding materials are such materials as resinoids, rubber, and other binder materials, and in such proportions as will ensure the desired abrasive qualities in the segments when finished. Examples of suitable abrasive materials which may be used in forming such abrasive segments are emery, aluminium oxide, garnet, diamond, silicon carbide, and other materials, in granular form, and bonded together as previously explained herein.

When a segmented wheel is used in the grinding or polishing operation it is seen that as each segment comes to the work surface of the work body there will be produced a shock or blow of the wheel segment against the work body surface, and when the wheel is rotating rapidly and when there are numerous of the segments around the wheel, it is evident that the work body is subjected

to a very rapid hammermill action in addition to the grinding action itself. This double effect will greatly enhance the grinding action produced by the equipment.

It is to be noted, however, that due to this hammermill effect it is desirable to use material in the production of the segments which material is able to take the shocks and severe treatment produced by such very rapid impact effect as just referred to. The resinoid and/or rubber binder materials, and other materials of like characteristics, are therefore very well adapted to the present uses. It is a further feature and object of the present invention to provide a wheel construction such that the peripheral segmented portion of segments of desired or selected materials and hardness may be of built up construction, readily assembled or disassembled for substitution of segments of other or replacement materials. Thereby the usefulness of a given wheel structure may be greatly widened and its useful life increased.

Other objects and uses of the invention will appear from a detailed description of the same, which consists in the features of construction and combinations of parts hereinafter described and claimed.

In the drawings:

Figure 1 shows a cross-section through a typical wheel embodying the features of my present invention, being a two-part section, the upper one-half section being taken on the line 1^a—1^a of Figure 2, looking in the direction of the arrows, and the lower one-half section being taken on the line 1^b—1^b of Figure 2, looking in the direction of the arrows;

Figure 2 shows a partial development of the peripheral surface of the wheel shown in Figure 1, and shows a number (14) of the sets of segmental elements in their relationship to each other and to the intermediate rod supporting plates;

Figure 3 shows a partial longitudinal section of the wheel structure shown in Figures 1 and 2, being a section taken on the lines 3—3 of Figures 1 and 2, looking in the directions of the arrows;

Figure 4 shows a semi-cross-section through a modified form of wheel embodying the features of my present invention, in which modification use is made of circular or ring shaped segmental elements; this figure being a two-part section, the left-hand half-section corresponding to Figure 1^a, and the right-hand half-section corresponding to Figure 1^b;

Figure 5 shows a semi-cross-section through another modified form of wheel embodying the features of my present invention, in which modification use is made of segmental shaped blocks similar in form to those shown in Figure 1; but in the present case said blocks are of size to come substantially together in each circular grouping, and the blocks are notched on their side faces to receive and accommodate the axially extending intermediate block supporting rods; and this figure shows a two-part section, the left-hand half-section corresponding to Figure 1^a, and the right-hand half-section corresponding to Figure 1^b;

Figure 6 shows diagrammatically the manner in which the length of the scratch varies with the amount by which the segmental block is forced inwardly radially against the elastic resistance force of the backing block, assuming that the segmental blocks are formed of substantially non-elastic material;

Figure 7 shows diagrammatically an installation of grinding and/or polishing equipment including a contact wheel embodying the features of the present invention, and in which installation an abrasive material coated flexible material belt is used, running over the contact wheel, so that the abrasive action is produced by the surface coating of such belt, but under conditions dictated by the construction and functional operation of the contact wheel embodying the features of my present invention; and

Figure 8 shows diagrammatically an installation including a wheel embodying the features of my present invention, but in which wheel embodiment the segments are formed of abrasive material, so that the grinding and/or polishing function is performed by the elements of the wheel itself, no abrasive belt being included in the installation.

Referring first to Figures 1, 2 and 3, the wheel therein shown includes the peripheral blocks **10** which are built into and supported in the wheel in such manner as to provide the peripheral, more or less segmental cylindical surface **11**. These blocks are so supported and built into the wheel that they may shift radially through a radial distance sufficient to enable production of the functional effects presently to be set forth in fuller detail; and elastic resistance elements are provided radially inwardly of such blocks to resist such inward radial movement of the blocks. In the embodiment shown in Figures 1, 2 and 3, such elastic resistance elements comprise annular bodies of elastic material, **12**, formed of rubber or other suitable material, and having the elastic characteristics needed to produce the desired resistance effects, according to the wheel design in question. The blocks **10** are supported against outthrow under centrifugal or other forces by the axially extending rods 13^a and 13^b. Conveniently the rods of the group 13^a extend through radially elongated slots 14^a formed in the blocks through which the rods 13^a extend, and the rods of the group 13^b extend through radially elongated slots 14^b formed in the blocks through which the rods 13^b extend, the blocks of the two groups breaking joints as will presently appear in further detail. Conveniently, also the elastic annular bodies **12** are set onto cylindrical supports **15**, which are axially supported on or around the shaft **16**, the details of which construction will soon appear. However, I wish to emphasize that although I have herein disclosed some of the details of the physical structure embodying the various elements thus far referred to, still I do not intend to limit myself to such detailed structural features, except as I may limit myself in the claims to follow.

With the foregoing statement I shall describe the detailed structure further as follows:

Conveniently the blocks **10** are supported within the wheel periphery in successive groups, each group including a number of the blocks lying in a common plane normal to the axis of rotation. Preferably, also the blocks in successive groups break joints with each other, as shown in Figure 2. By this arrangement the effects of the joints between successive blocks during rotation are substantially eliminated, and more uniform grinding or polishing action is produced.

The longitudinally extending rods 13^a and 13^b may be supported in any convenient manner. In the arrangements shown in Figures 1, 2 and 3 I have provided the plates 17^a, 17^b, 17^c etc., lying in planes normal to the axis of rotation, and provided with peripheral through openings through which the rods extend. As illustrated in Figure 2, the blocks are set together in successive series, each series including the blocks of five of the groups, and the plates 17^a, 17^b, 17^c, etc. being located between the successive series of five groups each. The plates are provided with the outwardly extending ears **18** through which the rods extend. Conveniently a sleeve **19** is set over the shaft, and the plates **17** are strung onto this sleeve. Spacers **20** are set on the sleeve between the central portions of the successive plates, and, if desired said spacers may be connected to the respective plates by welding, riveting or otherwise. These spacers are of size to fully extend between the successive plates; and the cylindrical supports **15** are set onto the spacers such supports being of full dimension between the successive plates as indicated in Figure 3. Thus each of the elastic resistance elements **12** secures full support for its inside cylindrical surface, and for the full distance between the successive plates.

A suitable end plate or block such as shown at **21** is

set against each end of the so-built up wheel, and conveniently the rods 13 are secured into these end plates or blocks, as by threading, as shown in Figure 3; it being understood that there is an end plate or block against the right-hand face of the wheel, which, however, is not shown in Figure 3 due to lack of space on the drawing. Of course the wheel is suitably journalled for high speed rotation, and is driven in convenient manner.

During construction of the wheel the parts may be so proportioned, including the radial dimension of the resistance elements, that some compression is initially produced in said elements, so that the outward radial forces developed against the blocks during running will include such "pre-loading" force, or, if desired, no such pre-loading may be produced when no such compressive force or effect is required during the assembling of the wheel. It will also be understood that during running of the wheel substantial centrifugal forces will be developed in the blocks, which forces will be additive to those due to the presence of the resistance elements, whether the latter be pre-loaded or not. Any inward force developed against a block or blocks must therefore be sufficient to overcome the centrifugal force thus developed, as well as any pre-loading force, before any inward displacement of the block towards the axis of rotation may be produced. Furthermore, assuming that the conditions of Hook's law obtain, it is evident that, in the case of no pre-loading, the amount of inward displacement will be directly proportional to the size of such inward force; and that in the case of any pre-loading, the curve showing variation of inward force with amount of inward displacement will be raised by the amount of the pre-loading, plus the centrifugal force.

The permissible inward displacement of the blocks by pressure exerted against them, as by pressure of the work body against the periphery of the wheel, will be limited by the amount of force needed to effect such displacement, and the permitted radial movement, as determined by the lengths of the slots 14 in the blocks. The characteristics of design and material of the elements 12 should be such that, under extreme pressures enough compression of the said elements 12 may be produced to allow substantially full inward block displacement as limited by the lengths of the slots 14. Of course, upon withdrawing such pressure against the blocks they will restore to their extreme outwardly limited positions, as determined by the engagement of the slot ends with the rods 13.

Before proceeding further with a functional analysis of the grinding and polishing effects produced by wheels embodying my present improvements, I shall describe briefly the modified forms of wheel shown in Figures 4 and 5. The wheels of these two modifications are substantially the same in outlines as the wheel already described; but the following principal points of difference between these wheels and that of Figures 1, 2 and 3 are noted:

In the arrangement of Figure 4 the blocks comprise small wheels or disks 22 which are strung on the rods in successive groups, with the disks of successive groups breaking joints as clearly indicated in Figure 4; and each such disk is provided with a central opening of size larger than the rod which extends through such disk. Thus each disk may be displaced inwardly against the element 12, according to the principles already discussed. It is now noted that due to the fact that each disk is of much smaller diameter than the diameter of the complete wheel it is seen that even for extreme amounts of inward-radial movement of the disks, against the effects of centrifugal forces and the resistance of the element 12 against which the disk or disks press, the contacting portion of each disk against the surface of a work body will almost always be a point or at most a small discrete area, so that substantially a point contact occurs between each disk and the work body surface, thus in effect producing true scratches on the work body surface, and corresponding lines of material removal from the work body. It is further noted that when using this disk form of the blocks, each disk is more or less free to rotate gradually on its own rod support, thus continually presenting new point elements of engagement to the surface of the work body. Thus, too, each such disk may wear more or less evenly around its periphery. However, the rate of disk rotation will generally be small due to the frictional engagement of each disk with the elastic element 12 against which it presses; and that frictional engagement will generally be large in amount. The coefficient of friction of the metal of the disk against the material of the elastic body (generally some form of rubber) may and frequently will be actually larger than the coefficient of friction of the disk against the metal surface of the work body being treated.

The arrangement shown in Figure 5 is similar to that shown in Figures 1, 2 and 3; but in the case of Figure 5 each of the blocks 10^c is provided with the lateral face recesses 23 which may accommodate the proximate rods, thus permitting the blocks of each group to be set closer together, center to center than is possible in the arrangement of Figures 1, 2 and 3.

We may next explore more fully the functional effects produced during the grinding or polishing operation by devices embodying my present improvements. In this connection I here mention again the fact that wheels embodying my present improvements may be formed of material having the desired abrasive qualities in its own body, or of neither abrasive or non-abrasive material with a flexible belt running over the wheel, and having a surface provided with the abrasive quality. To the end of such study, reference may again be had to Figure 1. Therein I have shown by the line 24 a surface line of a work body which is sustained against the wheel periphery with force sufficient to displace the block inwardly some distance. It is seen that this line subtends a chord between the points 25 and 26, the length of which chord is dependent on the amount of the inward radial displacement, and on the radius of the wheel periphery prior to the displacement (that is, the normal radius of the wheel). Mathematical analysis will show that the length of the chord may be expressed as follows

$$L=\sqrt{2d-d^2} \qquad \text{I}$$

where L equals the length of the half-chord and d equals the displacement, so that the full chord length equals double the value indicated by said equation. Study of this equation will show that for small angles of embracement represented by such chord the length of the chord varies almost directly as the amount of displacement, and for all practical purposes this condition may be assumed as true. If it be assumed that the wheel is rotating in the direction of the arrow in Figure 1, and that a section of the work body is held against the wheel at the line 25—26 (or against the flexible belt riding on the wheel), as rotation continues clockwise the block 10^b will be pressed inwardly, with increase of force needed to effect such inward radial movement due to the needed compression of the elastic material body 12, until the center of such block has come to the location of such elemental area of the work body. At that instant the block will be most fully displaced inwardly. Then, as the wheel movement continues the block will move out to larger and larger radii positions, with corresponding reduction of the required displacing force, until finally the point 25 comes to the location of the elemental area 26 of the work body. Then that particular block will have completed its function for the wheel rotation in question, and other succeeding blocks will go through similar functional processes.

In Figure 6 I have repeated the foregoing functional analysis in order to simplify an understanding of the process being investigated. The locations of several

chords of successive values of displacement are shown for better understanding and clarity of the analysis.

It is further noted that the abrasive force developed between each block and the surface of the work body undergoes a progressive increase up to the center of the chord, and then progressively decreases to zero at the leaving end of the chord. Also, that when the elastic body **12** is pre-loaded the total pressure exerted at the beginning and terminating ends of the chord are the amount of such pre-loading, and that at intermediate chord locations the pressures are all increased by the amount of the pre-loading, plus the centrifugal force.

The analysis just above given for the form shown in Figures 1, 2 and 3 is also valid as respects the forms shown in Figures 4 and 5, subject to possible modification in case of rotation of the disks of the form shown in Figure 4.

It is also now seen that as the successive blocks of a group come into engagement with the work body surface there is necessarily produced a hammermill effect. This, combined with the improved abrasive effect serves to ensure a greatly increased rate of stock removal from the surface of the work body. In fact, the "aggressiveness" of the grinding or polishing device is magnified several times as compared with previously known and practised devices and operations.

It remains to consider the fact that these improvements may be used in connection either with wheels in which the blocks themselves are formed of abrasive material, some of which materials have previously been suggested by way of illustration, or in connection with grinding and polishing devices of the flexible belt-abrasive surface type. In Figure 7 I have shown, more or less schematically, an arrangement in which the belt **27** travels over the wheel **28**, of the type previously disclosed herein, and over the idler wheel **29**. This latter wheel may be supported in such manner that its axis **30** may be drawn under a spring force produced by the spring **31** in direction away from the contact wheel **28**, to thus retain the belt tightly in contact with such contact wheel. The surface of the work body in contact with the contact wheel is shown by the line **24**, and the effects produced are closely similar to those produced in the analysis of the form shown in Figures 1, 2 and 3. A slight modification of effect might, however, be traced to the presence of the belt whose flexibility would nevertheless exert an influence on the extent of displacement of the blocks, and have other modifying influences. If, however, the belt's flexibility were sufficient to affect the transmission of the displacing forces to the wheel blocks it is probable that only slight modification of the functions would be produced by the belt.

In the showing of Figure 8 it is assumed that the blocks are formed of abrasive material, and that no belt is run over the contact wheel itself. Insofar as the functional operations of the blocks formed of such abrasive material is concerned the analysis previously given respecting the showing in Figures 1, 2 and 3 would apply as respects the wheel of Figure 8. I have already mentioned by way of example various abrasive materials which may be used in the formation of the blocks but I wish to emphasize the fact that it is desirable to use block materials which are of sufficient toughness to withstand the severe shocks incident to their functioning in the intended manner; or, alternatively, blocks of abrasive material may be used which shall include in their composition, materials of some elasticity so that, combined with their strength and toughness they will withstand the aforesaid shocks, etc.

The peripheral bodies may be of any degree of hardness or softness, or any degree of abrasiveness or non-abrasiveness desired, according to the effect which it is desired to produce on the surface of the work body, whether a grinding effect, either fine or coarse, a polishing effect, either fine or coarse, or a combined grinding and polishing effect.

I claim:

1. An abrasion producing unit including a wheel element, means to journal said wheel element for rotation about an axis, said wheel element including a plurality of axially extending body supporting rods lying substantially within a circular cylindrical surface coaxial with the axis of wheel rotation, and including means to support said rods in said cylindrical surface, a plurality of bodies strung on each of said rods at regularly spaced axial locations, each body being provided with a through opening to receive the corresponding supporting rod and of size greater than such rod measured in direction radially of the wheel to permit movement of such body on such rod in radial direction with respect to the wheel and to limit outward radial movement of such body, elastic means in the wheel urging said bodies outwardly radially with respect to the axis of wheel rotation, the supporting rods and the through openings in the bodies being constituted to limit the outward radial movements of the bodies at locations with those portions of their surfaces which are at greatest radial distance from the axis of wheel rotation lying substantially within the surface of a cylinder which is co-axial with the axis of wheel rotation, and abrasive surface material lying substantially at said greatest wheel radial distance portion of each body and travelling angularly with such body.

2. Means as defined in claim 1, wherein the abrasive surface material which lies substantially at the peripheral arcuate surface of each body comprises a portion of such body.

3. Means as defined in claim 2, wherein each of the bodies is composed of abrasive material.

4. Means as defined in claim 1, wherein the bodies are formed of material which is substantially non-elastic.

5. Means as defined in claim 1, wherein the bodies are formed of material which is elastic.

6. Means as defined in claim 1, wherein each of the bodies comprises substantially non-elastic abrasive material.

7. Means as defined in claim 1, wherein each of the bodies comprises elastic abrasive material.

8. Means as defined in claim 1, wherein the abrasive surface material which lies substantially at the greatest radial distance portion of each body comprises abrasive material surface of a belt travelling on the rod supported bodies.

9. Means as defined in claim 1, wherein the rod supported bodies have arcuate peripheral surfaces comprising substantially portions of a cylindrical surface which is co-axial with the axis of wheel rotation for all radial positions of such bodies.

10. Means as defined in claim 1, wherein the rod supported bodies comprise annular disks strung on the rods and journalled on the rods for rotation of said disks on the rods with their greatest wheel radial distance portions lying within the peripheral cylindrical portion of the wheel element.

11. An abrasion producing unit comprising a wheel element, means to journal said wheel element for rotation about an axis, a plurality of rods, means to support said rods within the wheel element and lying substantially within a cylindrical surface co-axial with the axis of rotation, a plurality of bodies having arcuate peripheral surfaces, lost-motion means to support each of said bodies on a rod, the lost motion means which supports each body on a rod including a through opening in such body of size greater than the rod in direction extending radially of the wheel, elastic means urging the bodies outwardly radially with respect to the axis of wheel rotation, said lost-motion supporting means being constituted to limit the outward radial movement of the bodies under the urging of the elastic means, and abrasive surface material lying substantially at the peripheral arcuate surface of each body and travelling with such body.

12. Means as defined in claim 11, wherein the abrasive

surface material which lies substantially at the peripheral arcuate surface of each body comprises a portion of such body.

13. Means as defined in claim 12, wherein each of the bodies comprises abrasive material.

14. Means as defined in claim 11, wherein the abrasive surface material which lies substantially at the peripheral arcuate surface of each body comprises abrasive material surface of a belt travelling on the arcuate bodies.

15. An abrasion producing unit comprising a wheel element, means to journal said wheel element for rotation about an axis, an even number of rods, means to support said rods within the wheel element and lying parallel to the axis of wheel rotation and within a cylindrical surface co-axial with the axis of wheel rotation and at locations substantially equidistant around the wheel element, the rods comprising two sets of rods, each set including alternate rods measured around the wheel element and the rods of each set alternating with the rods of the other set, a series of groups of arcuate bodies having arcuate peripheral surfaces, each such group including one-half as many bodies as the number of rods and the bodies of each group lying within a plane extending normal to the axis of wheel rotation, and lost motion means to support each body on a rod and including a through opening in such body of size greater than the rod in direction extending radially of the wheel element, the bodies of each group being located on the rods of a set of rods and the bodies of successive groups being located on the rods of the two sets in alternation, whereby the bodies of each group break joints with the bodies of the adjacent groups of bodies, and abrasive surface material lying substantially at the peripheral arcuate surface of each body and travelling with such body.

16. A unit as defined in claim 15, together with elastic means urging each of the bodies radially outwardly on its rod of support.

17. A unit as defined in claim 16, wherein said elastic means comprises a cylindrical body of elastic material having its outer cylindrical surface in engagement with the radially inward portions of all of the bodies, and means to support said body of elastic material within the wheel element and coaxial with the axis of wheel rotation.

18. Means as defined in claim 16, wherein said elastic means normally retains each of the bodies in its most outwardly moved position radially of the wheel element.

19. Means as defined in claim 16, wherein each of the bodies is of segmental contour with its convex surface lying in the outer perimeter of the wheel element and is of angular embracement extending between two of the rods of the set other than that set including the rod on which such body is located.

20. Means as defined in claim 16, wherein each of the bodies comprises a disk of open center annulus form, and wherein the rod on which such body is located extends through the open center of such disk.

21. Means as defined in claim 20, wherein the open center of each disk is circular and of size greater than the diameter of the rod on which such disk is located.

22. Means as defined in claim 15, wherein the means to support the rods within the wheel element comprises a series of disks lying in planes normal to the axis of wheel rotation and spaced apart axially of the wheel element distances which are multiples of the dimensions of the bodies in direction parallel to the axis of rotation, and wherein the rods are supportingly connected to the peripheral portions of such disks.

23. Means as defined in claim 22, together with spacer elements located between the proximate faces of such disks, and wherein the dimensions of such spacer elements in direction parallel to the axis of rotation are substantially equal to the additive sum of the dimensions of the bodies located between the disks spaced by such spacer elements.

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