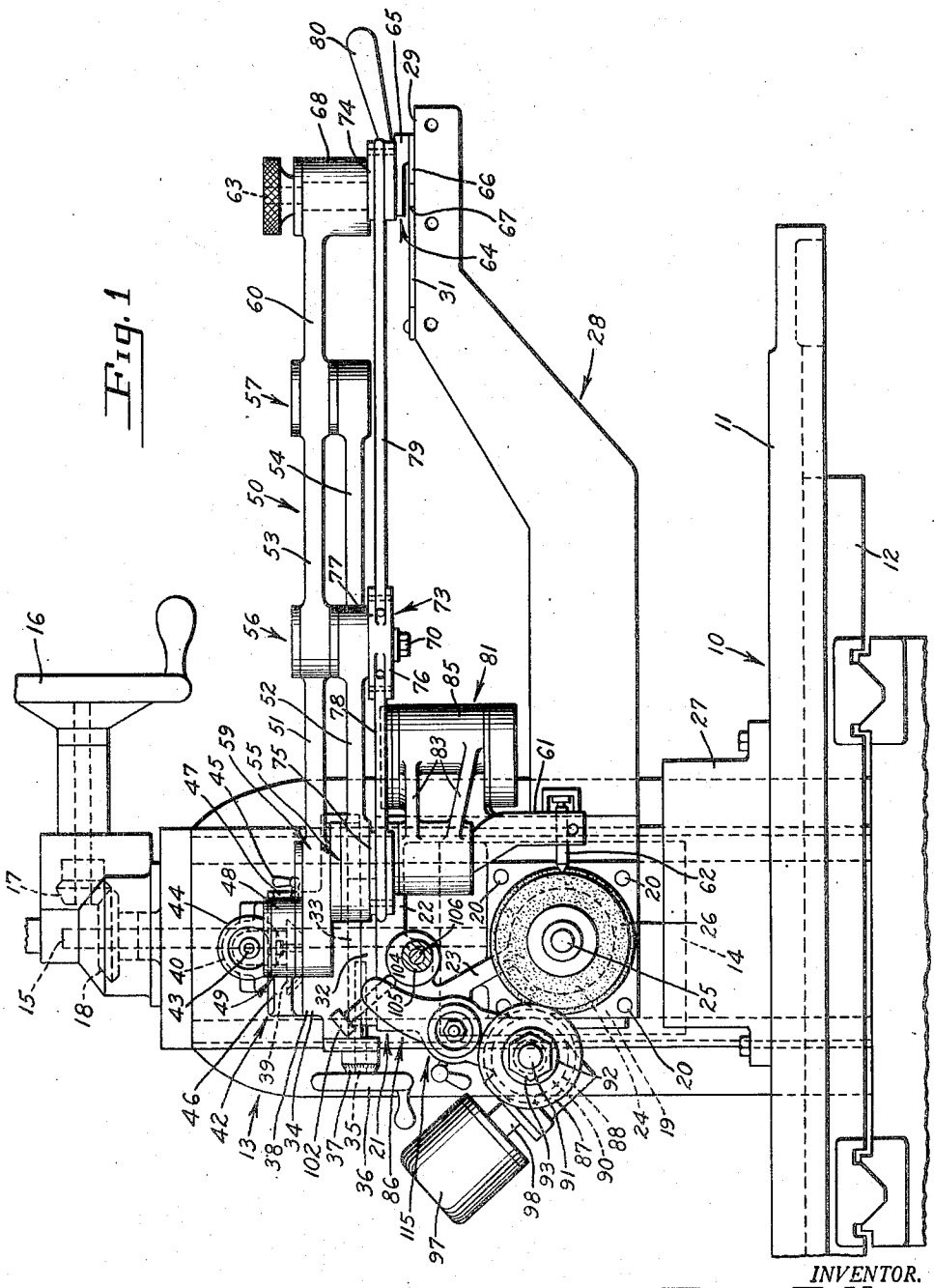
Sept. 26, 1950 F. E. HAWLEY 2,523,698

METHOD OF MAKING DIAMOND LOADED ABRASIVE ARTICLES

Original Filed Dec. 27, 1946 3 Sheets-Sheet 1

Fig. 1



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METHOD OF MAKING DIAMOND LOADED ABRASIVE ARTICLES

Original Filed Dec. 27, 1946 3 Sheets-Sheet 2

Fig. 2

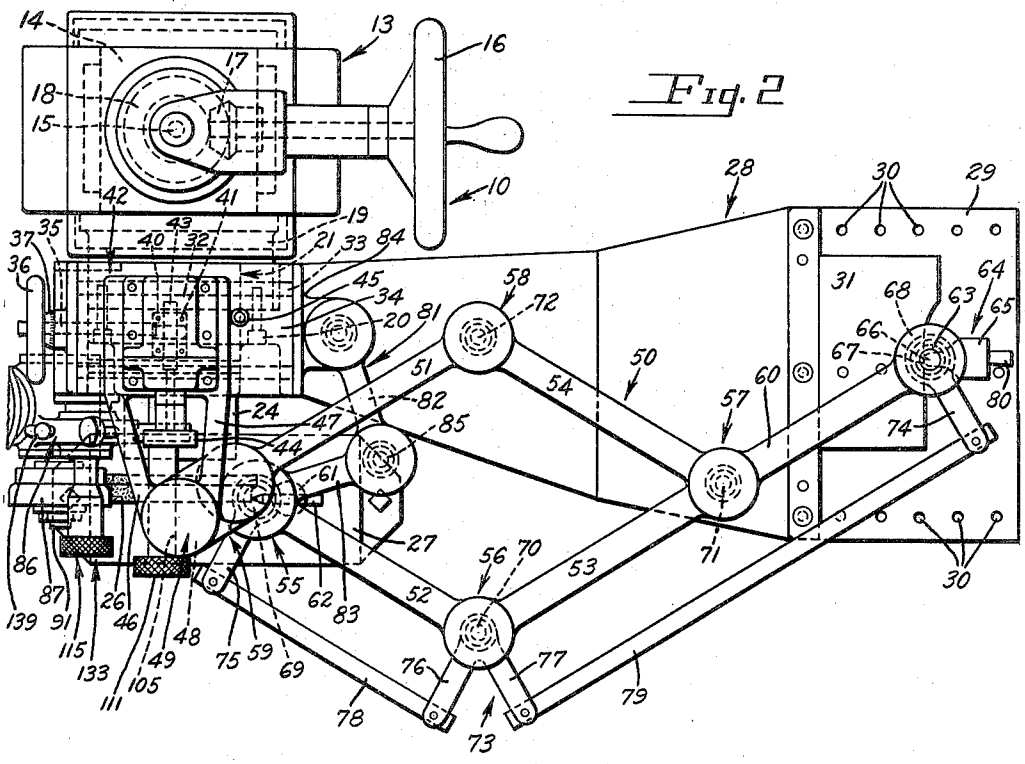
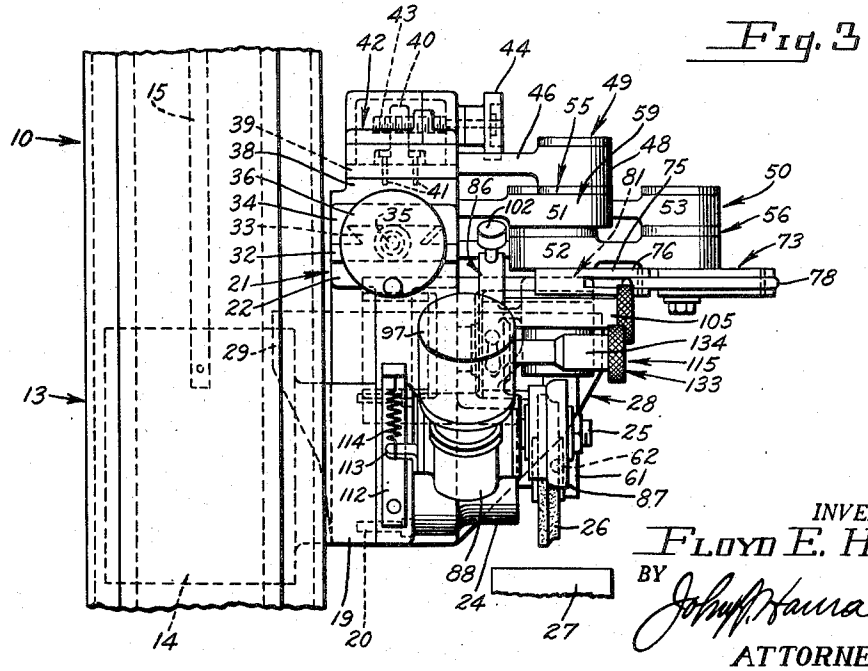


Fig. 3



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METHOD OF MAKING DIAMOND LOADED ABRASIVE ARTICLES

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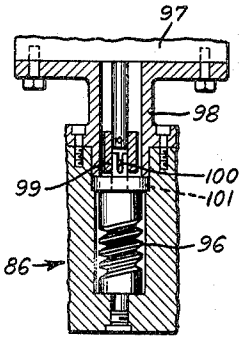


Fig. 5

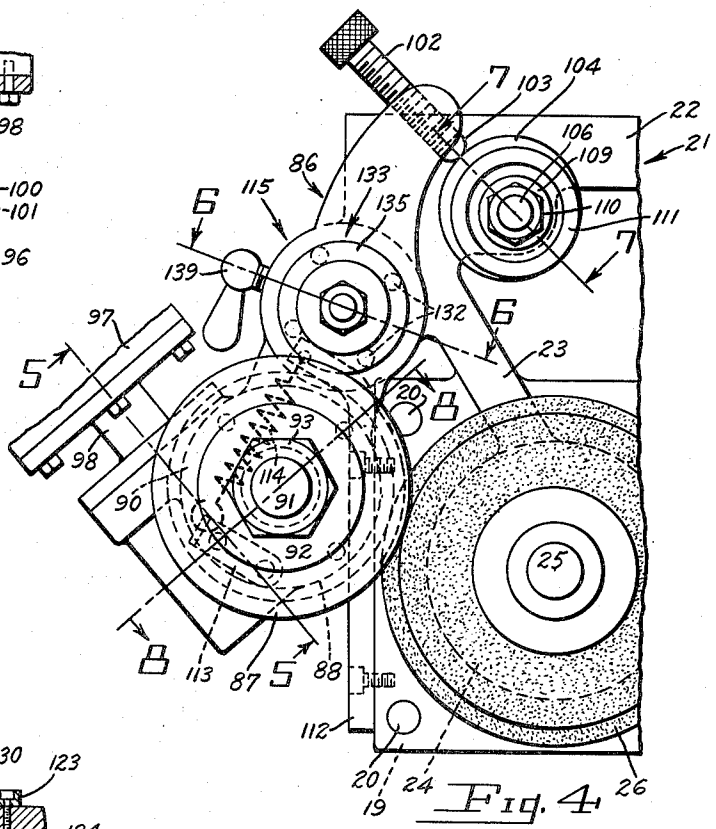


Fig. 4

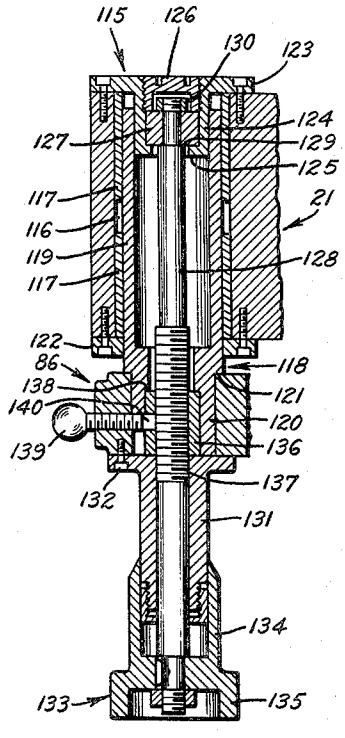


Fig. 6

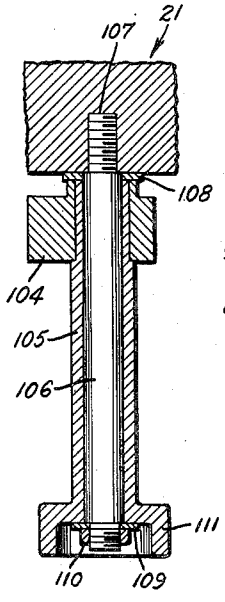


Fig. 7

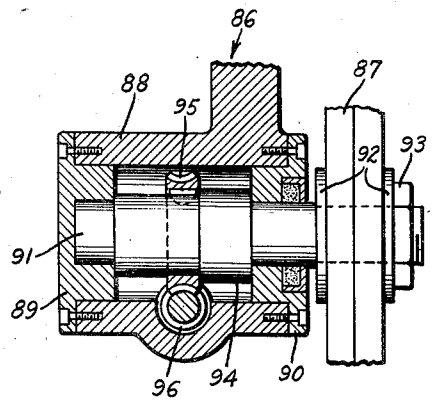


Fig. 8

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UNITED STATES PATENT OFFICE

2,523,698

METHOD OF MAKING DIAMOND LOADED ABRASIVE ARTICLES

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Original application December 27, 1946, Serial No. 718,818. Divided and this application March 10, 1948, Serial No. 14,104

2 Claims. (Cl. 51—293)

1

This invention relates to new and useful improvements in grinding machines and has particular relation to means for dressing form grinding wheels while in place on a grinding machine and which means is also useful for the making of formed diamond loaded abrading wheels for use in the form grinding of cemented tungsten carbide or other tough material.

An object of the invention is to provide an improved method for the manufacture of diamond loaded abrading devices especially adapted for the form grinding of cemented tungsten carbide or the like.

Other objects and advantages of the invention will become apparent from a consideration of the following detailed description taken in connection with the accompanying drawings wherein a satisfactory embodiment of the invention is shown. However, it is to be understood that the invention is not limited to the details disclosed but includes all such variations and modifications as fall within the spirit of the invention and the scope of the appended claims.

In the drawings:

Fig. 1 is a front elevational view of an upper portion of a grinding machine incorporating the features of the invention;

Fig. 2 is a top plan view thereof;

Fig. 3 is an end elevational view of the mid-portion of the machine;

Fig. 4 is an enlarged front elevational view showing the crusher roll mounting in relation to a grinding wheel;

Fig. 5 is a sectional view taken as along the line 5—5 of Fig. 4;

Fig. 6 is a sectional view taken as along the plane of the line 6—6 of Fig. 4;

Fig. 7 is a sectional view taken as along the plane of the line 7—7 of Fig. 4; and

Fig. 8 is a sectional view taken as along the plane of the line 8—8 of Fig. 4.

The present application is a division of my application Serial No. 718,818, filed December 27, 1946. In the parent application I claim the machine herein disclosed, the present application containing claims to my new method of making diamond loaded abrading devices.

Referring in detail to the drawings and at first more particularly to Figs. 1, 2 and 3, at 10 is generally indicated a grinding machine including a longitudinally movable table 11 mounted on a saddle 12 movable in directions transverse to those in which the table is movable. At the rear of the table 11 and saddle 12 is a vertical tool post 13 including a vertically adjustable means or

2

slide 14. This slide is adapted to be raised and lowered by suitable means, as by a vertical screw 15 fixed to the slide.

A hand wheel 16 is fixed with relation to and is adapted to rotate a bevelled gear 17 meshing with a bevelled gear 18 threaded to the screw or shaft 15. Clearly, on turning of the hand wheel 16, the resultant operation of the gears 17 and 18 will cause the screw or shaft 15 to be raised or lowered depending on the direction in which the hand wheel is turned and will cause a corresponding movement of the slide 14.

Movable with the slide 14 is a bed or block 19 to which bolts 20 secure a bracket 21, the latter including an upper shelf-like portion 22, an angularly disposed front wall portion 23 and a hub-like portion 24 braced by the wall portion 23 and mounting a shaft 25 to which is fixed an abrasive form grinding wheel 26. It is noted that the wheel 26 is located over any suitable work holder, as a magnetic chuck 27, removably fixed to the table 11 for movement therewith relative to the abrasive wheel 26. Thus, the chuck is adapted for the supporting of work to be ground and the moving of such work back and forth beneath the abrasive wheel. Clearly, the wheel head described is adapted for vertical adjustment with the block 19, relative to the chuck and table, on manipulation of the hand wheel 16.

Mounted on the bracket 21 for movement therewith and with the entire wheel head is a bracket or extension 28 preferably of channel or other rigid construction, projecting to one side of the bracket 21 and on its upper side at its outer end including a table-like portion 29. This portion 29 is provided with a series of bolt receiving holes or openings 30 adapted for use in fixing clamps or other means in place when such clamps or other means are used for locating and securing a template in place, as the template 31.

Integral with or secured to the upper side of the shelf-like portion 22 of the bracket 21 is a block or portion 32 provided with a dove-tail way 33 mounting a slide 34. A screw 35 having a hand wheel 36, or other turning means, fixed thereto is adapted to feed the slide 34 on the block or portion 32 in directions transverse of the axis of the abrasive wheel mounting shaft 25. Preferably, a micrometer scale 37 is associated with the wheel 36 whereby the amount of turning of the wheel and the amount of feed of the slide 34 is accurately shown so that the operator will know, as he makes an adjustment of the slide 34, the exact extent of such adjustment.

On the upper side of the slide 34 and fixed

thereto or integral therewith is a block 38 provided on its upper side with a dove-tail way 39 having a nut 40 fixed thereto as by means of bolts 41. On the block or portion 38 and adapted for movement along the way 39 is a second slide 42. Such second slide carries a screw 43 threaded through the nut 40 and provided with a hand wheel or manipulating portion 44 adapted for use in manually turning the screw whereby to feed the slide 42 along the way 39 in directions transverse to those in which the slide 34 is adjusted on manipulation of the hand wheel 36. A suitable micrometer scale may be associated with the hand wheel or portion 44.

Preferably, a suitable locking means, such as one in the nature of a screw, is provided to be operated by the hand or finger piece 45 for locking the slide 42 to the ways 39 in the desired position of adjustment of said slide. Clearly, on release of the locking device 45 and manipulation of the hand piece 44 the slide 42 and all parts carried thereby will be adjusted in directions parallel with the longitudinal axis of the abrasive wheel mounting shaft 25.

The slide 42 includes a forwardly directed portion, integral with the slide or fixed thereto, comprising a pair of arms 46 and 47 at their outer ends supporting an eye or pivot member 48. As shown, the arms 46 and 47 are generally below and at the sides of the hand piece 44. The eye or pivot portion 48 comprises a portion of a main pivot 49 suspending a pantograph means generally designated 50 from the outer end portion of the slide 42.

The arms of the pantograph means 50 are designated 51, 52, 53 and 54 and it is pantograph arm 51 which is pivoted at 49 to the slide 42. Arm 52 is pivoted to arm 51 in spaced relation to the pivot 49 as at 55 while an intermediate pivot 56 connects the arms 52 and 53. In addition, arms 53 and 54 are pivoted together as at 57 and an intermediate pivot 58 connects the arms 51 and 54.

It is here noted that the intermediate pivots 56 and 58 are of the same construction and that the pivot 57 is located intermediate the ends of the arm 53. The portion of arm 51 between the pivots 49 and 55 is designated 59 and the portion of the arm 53 beyond the pivot 57 is designated 60. The relation of the length of portion 59 to that of portion 60 determines the ratio of movement of a tool to that of movement of a stylus as will appear.

In spaced relation to the pivot 55 a shaft 61 is rotatably suspended from the arm 52. Toward its lower end said shaft 61 mounts a tool holder 62 and the relation of the parts is such that under the best conditions the shaft supports the tool holder at a level to have such holder present the cutting edge of a tool (as a diamond or other tool) in the exact center line of the grinding wheel 26.

Under some conditions, as when using an octohedron shape of diamond, the cutting edge may initially be below the center line of the wheel and then as the radius of the diamond is renewed, its cutting edge is higher and finally is slightly above the center line of the wheel. In the present instance, the tool is sometimes a diamond, as when dressing the abrasive wheel 26, and is sometimes a cemented tungsten carbide piece, as when dressing a brass disc as will be described, although it will be understood that any tool suitable for either purpose may be used.

From the free or outer end portion of the arm portion 60 (see Figs. 1 and 2) a shaft 63 is rotatably suspended. At its lower end shaft 63 carries a head-like formation 64 including a portion 65 extending radially with respect to the center line of said shaft and having secured to its lower end a stylus 66 adapted to be turned with the shaft 63 as an axis and to be fed across a working face of the template 31, all as will be described, and for the purpose set forth.

Since the tool holder and stylus are both mounted by the pantograph means 50, rectilinear movement of the stylus will be duplicated by the tool holder and owing to the relationship of the arm portions 59 and 60, the movements of the tool holder will be on a reduced scale as compared with that of the stylus.

Stylus 66, as here shown, comprises a metal plate secured against the lower end of the head 64. The forward end of the stylus comprises a rounded or circular portion 67, comprising the active portion of the stylus proper, and the center of the radius of this circular portion is the longitudinal center of shaft 63. The free end portion of arm portion 60 is enlarged by a head-like portion 68 in which the vertical stylus carrying shaft 63 has bearing.

The details of the construction of the various pivots 55, 56, 57 and 58 are fully set forth in the application of Frederick C. Victory and John Robert Moore, Ser. No. 555,952, filed September 27, 1944, and now matured into Patent 2,452,509. However, it is here noted that pivot 55 includes a stud 69 comprising an extension of or the upper portion of the shaft 61, pivot 56 includes a stud 70, pivot 57 includes a stud 71, and pivot 58 includes a stud 72 corresponding with the stud 70 of pivot 56.

On the shank of stud 70 there is mounted a bell crank 73 adapted to turn freely about said stud. Fixed to the stud or shaft 63 carrying the stylus 66 is a lever 74 while fixed to the stud 69 of the tool carrying shaft 61 for turning movement therewith is a lever 75. Bell crank 73 includes arms 76 and 77 of which the arm 76 is connected with lever 75 by a link 78 pivoted at its respective ends to the arm and lever and similarly a link 79 is pivoted at its respective ends to the bell crank arm 77 and the lever 74.

Fixed on the shaft 63 is a hand lever 80. With this construction, it will be seen that on turning of the shaft 63 (and thus the stylus 66) the lever 74 will be shifted and through the link 79, bell crank 73 and link 78, will impart a similar movement to the lever 75. As this lever is fixed to the stud 69 of the tool carrying shaft 61, it will be understood that turning of the shaft 63 about its axis results in the exact same movement of the shaft 61 about its axis.

Thus, by means of the described linkage connecting the stylus supporting shaft 63 and the stud 69 of the tool (diamond) supporting shaft 61, the angular orientation of the stylus normal to the working face of the template 31 governs that of the diamond or other tool relative to a given object, in this case the face of the wheel or disc being dressed.

The shaft 61 is suspended from the arm 52 and necessarily has rectilinear movement therewith and also has turning movement relative thereto as influenced by the linkage construction above described. However, shaft 61 is actually supported independently of arm 52 whereby the weight of the pantograph and any force applied thereto will not and cannot cause movement of the shaft such as to force the tool holder 62 toward the wheel 26.

This is more fully disclosed in the above men-

tioned application of Victory and Moore but here the means for the described purpose is shown as comprising an articulated bracket generally designated 81. Said bracket includes arms 82 and 83 of which the arm 82 is mounted to swing horizontally on a pivotal mounting including ear portions 84 secured to or cast with the bracket 21 above described.

Arms 82 and 83 are pivoted together as at 85 and it will be understood that the entire bracket 81 may be swung horizontally through pivotal mounting on the ears 84 and that the bracket arms may have relative pivotal movement in the pivotal connection 85. The shaft 61 is rotatable in the bracket arm 83 but it will be clear that the bracket supports the said shaft against tilting movement, such as might occur if only the pivot 49 was depended upon to support the entire pantograph structure. The weight of the pantograph and any force applied thereto will not cause tilting of the shaft 61 in a manner to carry the tool holder 62 toward the grinding wheel 26.

The structure as above described, with the exception of the slide 42 and its particular construction and the particular means for adjusting it, is all more fully set forth in the Victory and Moore application above identified. It is thought that the operation and mechanism so far described will be understood, but briefly it is pointed out that as the stylus 66 is moved with respect to the template 31, the diamond or other tool carried by the holder 62 will be given the exact same movement with respect to the wheel 26 or other wheel or disc mounted on the shaft 25.

According to the present invention, combined with the wheel dressing means above described is a hardened, shaped crushing roller which may be used for crushing a grinding wheel to the desired contour and according to the method of the invention for another purpose. In the present construction, such roller is mounted for swinging movement whereby it may be readily and quickly moved into and out of operative position and means for mounting and positioning the roller and adjusting it are provided. The roller is provided of a shape depending upon the shape of the abrasive wheel to be crushed, and while for that operation a serrated roller may be used, for the second purpose above suggested a smooth roller is desired.

According to one method of use of the crushing roller, the pantograph mounted diamond or other tool is first used to give the abrasive wheel 26 the desired contour. Thereafter the dressed wheel is used to grind this exact contour into the crushing roller. The reverse of the desired contour of the grinding wheel may be ground into a hardened, cylindrical dressing roller when but a shallow form is required. Otherwise, the hardened crushing roller should be roughed approximately to shape and then finished ground by the dressed wheel 26 to the exact reverse contour. In either event, the crushing roll having been ground to the desired contour, it is moved away from the grinding wheel 26 and the machine used in the customary manner for form grinding.

As the abrasive wheel begins to wear, contact is again established between the wheel and the hardened crushing roller and the latter is used to dress the abrasive wheel. This latter operation may be repeated as often as desired until the crushing roller begins to lose its true shape, whereupon the abrasive wheel is dressed with the diamond or other tool and then used to again dress the crushing roller. In this way, a considerable saving is effected on the diamond or other tool since the abrasive wheel between the dressings with the diamond or other tool will be dressed a number of times by engagement with the crushing roller.

To the desired end, an arm generally designated 86 is pivotally mounted on the bracket 21. This arm is pivoted intermediate its ends and at its lower end supports a crusher roller 87 positioned to be brought against the abrasive wheel 26 and to be swung outwardly away from the same as the arm 86 is rocked in one direction or the other on its pivotal mounting. The pivotal mounting for the arm 86 is shown in detail in Fig. 6 and will later be fully described.

At its lower end said arm includes a cylindrical head-like portion 88 the ends of which are closed by bearing plates 89 and 90 which bearing plates serve to mount a shaft 91 having the crushing roller 87 removably mounted thereon and located as between washers 92 and held in place by nut 93. Between the bearings 89 and 90 the shaft 91 is of enlarged diameter whereby it includes shoulders 94 engaging such bearing members to the end that the shaft is held against endwise movement.

Fixed on the shaft 91 within the head 88 is a worm gear 95 constantly meshing with a worm gear 96 connected to be driven by an electric motor 97. The shaft of said motor passes through a tubular housing 98 and is pinned or otherwise fastened to a coupling element 99 (see Fig. 5) which is likewise connected by a pin and slot connection 100 with a coupling element 101 integral or fixed to the worm 96. With this construction it will be clear that whenever the motor 97 is energized the crushing roller 87 will be driven and the same is driven at a relatively low speed.

Threaded through the upper portion of the arm 86 is an adjusting screw 102 the inner rounded end portion 103 of which constantly bears against a cam 104 formed with or secured to an elongated tube or sleeve 105 turnable on a stud 106 threaded into a socket in the face of the bracket 21 as shown at 107 (Fig. 7). The sleeve 105 is located between washers 108 and 109 and a nut 110 threaded on the outer end of the stud 106 may be reasonably tight against the washer 109 so that the sleeve 105 will be frictionally held in any position to which it may be turned on the stud. For convenience in turning of the sleeve and thus the cam 104, the former is provided with an enlarged head-like portion 111.

With the described arrangement, when the sleeve 105 is turned to dispose the high portion of the cam 104 under the rounded end 103 of the screw 102, the arm 86 is rocked in a manner to bring the crushing roller 87 inwardly into engagement with the abrasive wheel 26. When the low portion of the cam is under the inner end of the screw 102, the arm 86 may rock in the opposite direction or in a direction to carry the crushing roller 87 outwardly away from the abrasive wheel 26. Thus, the crusher roller is easily, quickly and accurately brought to active position and easily and quickly moved from such position.

Preferably means are provided for automatically swinging the arm 86 and the parts carried thereby to such outward position when the sleeve 105 is turned to present the low portion of cam 104 to the screw 102. To the desired end, a

bracket 112 is shown as fastened to an edge portion of the bracket 21 and a bracket or clip 113 is fastened to a portion of head 88. A coil spring 114 is anchored at its respective ends to these brackets and the construction and arrangement is such that this spring is constantly tending to rock the arm 86 in a clockwise direction or in a direction to carry the crushing roller 87 away from the abrasive wheel.

Assuming that the screw 102 is so adjusted that the crushing roller will be forced against the abrasive wheel when the high portion of cam 104 is brought under the screw, then in order to bring the roller against the wheel it is but necessary to turn the sleeve 105 to present the high portion of cam 104 to the inner end of screw 102 (see Fig. 4) when the crushing roller is forced against the abrasive wheel.

After the abrasive wheel has been dressed, the sleeve 105 is partially rotated so that the low portion of cam 104 is presented to the inner end of the screw 103. At such time, the spring 114 causes rocking of the arm 86 in a manner to keep the inner end of the screw against the cam and to shift the crusher roller outwardly away from the abrasive wheel.

The pivotal mounting for the arm 86 is generally designated 115 (see Fig. 6) and prior to entering into a detailed description of the machine's operation, the details of such pivotal mounting, which is also an adjustable mounting, are here given. Mounting 115 includes a tubular opening 116 formed through the bracket 21 and in which are located a pair of bearing sleeves 117 rotatably and slidably mounting a hollow member 118 comprising a tubular portion 119 located in the bearings and an outer portion 120 of less diameter than the portion 119 and having a shoulder 121 at its inner end. The arm 86 is disposed on the reduced diameter portion 120 of the member 118. A cap 122 closes the outer end of the opening 116 about the tubular part 119 and holds a bearing sleeve within such opening. The inner end of the opening is closed by a cap 123 which includes an inner tubular portion 124 having an inturned flange 125.

A nut or cap 126 is threaded in the outer end portion of said tubular portion 124. Received by said tubular portion and located between its flange 125 and the cap 126 is a block 127 serving as an anchor for the inner end of arotatable bar 128. Since such bar includes a shoulder 129 against the outer side of the block 127 and has a nut 130 threaded thereon and against the inner side of said block, it will be clear that the bar is held against longitudinal movement by the block. However, the bar may turn relative to the block.

Bar 128 is of considerable length and extends outwardly through the member 118. On an outer portion of the bar is a tubular stem 131 turnable relative to the bar and fixed to the arm 86 as by screws 132. Fixed to the extreme outer end of the bar 128 is a hand piece 133 including a tubular portion 134 overlapping the outer end of the stem 131 and a head portion 135 adapted to be gripped to turn the bar.

Within the reduced diameter portion 120 of the member 118 is a nut 136 through which the bar 128 passes and having threaded engagement with the intermediate portion 137 of said bar. Nut 136 being located between the inner end of the sleeve 131 and an internal shoulder 138 of the member 118 is incapable of movement longitudinally relative to said member. A

set screw 139 passes through the intermediate portion of the arm 86 and the reduced portion 120 of member 118 and at its inner end bears against a locking lug or block 140 having threads formed thereon to mesh with the threads 137 of the bar 128.

With the described construction, it will be understood that on the screw 139 being tightened as the arm 86 is rocked to carry the crushing roller 87 toward and from the wheel 26, the entire pivotal mounting 115 will be rocked and all the parts will move together as a unit. However, this mounting of the arm 86 includes an adjustment for shifting the arms in the direction of the longitudinal axis of the shaft 25 so as to dispose any particular crushing roller in line with any particular thickness of abrasive wheel.

Thus, on loosening of the screw 139 and turning of the hand piece 135, the bar 128 will be rotated. However, such bar may not move longitudinally, being anchored by the block 127. Therefore, as the bar is turned, the nut 136 will be fed along the threads of the bar and will shift the member 118 inwardly or outwardly in the bearings 117 locating the arm 86 in the desired position. Thereafter, the screw 139 is tightened to lock the parts in this new position.

In employing the means of the invention, when a new crusher roller is being placed in operation, its contour will be machined approximately to that desired. Now the hardened crusher roller is brought into contact with the periphery of the abrasive wheel. At this time, the crushing roller is power driven by the motor 97 but only at a slow speed and the grinding wheel 26 is driven only by contact with the crushing roller. Continued feeding of the crusher roller into the wheel produces on the wheel the obverse of the contour of the crusher roller on the wheel face.

This results in a savings in the use of the diamond or other tool carried by the pantograph means and further results in rather rapidly bringing the abrasive wheel to approximately the desired contour. The roughed out abrasive wheel is thereafter dressed in the conventional manner using the pantograph means. The freshly dressed wheel being now exactly correct in contour, the crusher roller is ground by the wheel to an exact shape. This is accomplished by bringing the crusher roller into contact with the abrasive wheel while both are power driven, the crusher roller at this time being also driven at a relatively slow speed.

The crusher roller has been shifted into engagement with the abrasive wheel by turning of the cam 104, the screw 102 being properly adjusted to have the cam force the roller against the wheel. Also, it will be understood that the member 118 will have been properly adjusted longitudinally for locating the crusher roller in radial alignment with the wheel. After the crusher roller is properly shaped, the cam is further rotated or is shifted back to bring its lower point under the inner end of the screw 102 whereupon the spring 114 rocks the entire crusher roller mounting in a clockwise direction to carry the crusher roller away from the abrasive wheel.

The formed abrasive wheel is now used in the regular manner and the crusher roller is ready for use to redress the abrasive wheel whenever necessary. One advantage of dressing the abrasive wheel by bringing the crusher roller against the same is that a freer grinding surface is generated on the wheel by action of the crusher

roller. There is the additional advantage of saving wear on the pantograph mounted diamond or other tool. Further, the cooler grinding action obtained when using the roller crushed wheel results in less heating and distortion of the work piece. This permits of the grinding of greater contour widths than would otherwise be possible without abnormal heating and distortion of the work piece.

When the crusher roller becomes worn or needs restoration of detail, it is re-ground as previously described by regenerating its contour with a freshly dressed abrasive wheel or with a wheel that has been freshly dressed using the pantograph means. When, in any instance, the roller crushed grinding wheel fails to reproduce sufficient fidelity of detail on the work, the wheel is dressed directly from the template by means of the pantograph mounted diamond or other tool providing greater accuracy through elimination of the intermediate step of grinding the roller and thereafter using the latter to form the wheel.

In all of the described operations the maintenance of relative locations of the contour on the template, wheel, crusher roller and work is inherent in the construction of the device. All of these structures, with the exception of the template, are mounted on the bracket 21 or on the table 11. Thus, any adjustment of the entire pantograph means by adjustment of the bracket 21 identically adjusts the wheel 26 and the roller 87.

The machine provides for the enjoyment of the advantages of either method of wheel dressing; that is, by the diamond or by the crushing roller, the structure for the performance of both methods being incorporated in the same machine and being quickly available for optional use without loss of relative location. The present construction permits the contour to be ground on the crusher roller while it is mounted on the bearings on which it is mounted when it is used to crush the wheel. This provides for accuracy by eliminating the errors resulting from changing the roller from one shaft or bearing to another.

To sum up briefly the advantages of the present construction, it is pointed out that heretofore forming of wheels for contour grinding has been done by either of two methods; namely, (1) roller crusher dressing; and (2) diamond dressing. There are inherent advantages and disadvantages in both methods. The present invention provides for or facilitates the use of either method at any time the operator may choose. This permits the operator to easily take advantage of the method most desirable at any particular time or for any particular job.

The entire pantograph means and the parts mounted thereon, together with the entire crushing roller means and its associated parts, are mounted on the movable wheel head so that when the latter is adjusted the dressing mechanisms remain in the same relation to the abrasive wheel as previous to any such adjustment. Movement of the slide 34 by the calibrated screw means described causes feeding of the entire pantograph means into or toward the abrasive wheel a measured amount or an amount readily determined from a reading of the micrometer scale 37. This feeding of the slide 32 moves the tool or diamond toward the abrasive wheel and governs stock removal therefrom.

However, it is pointed out that the arm 86 and the crushing roller means carried thereby are not mounted on the slide 34 but are mounted on the bracket 21 on which said slide is mounted. Therefore, adjustments of the slide 34 do not result in any change in position of the crushing roller mechanism relative to the grinding wheel.

The slide 42 is adjustable at right angles to the slide 34 and permits offsetting of the entire pantograph means so that the same may be swung to position the diamond laterally of the abrasive wheel for forming and dressing contours on the side of the latter as well as on the edge or face thereof, when such is necessary or desired.

However, adjustments of slide 42 have no bearing on the crushing roller and its associated parts since regardless of any adjustments of said slide, the crushing roller and associated parts remain in the same relation to the grinding wheel. The mechanism as already described may be used for the abrading of cemented tungsten carbide and the present invention includes a method of forming an abrasive device adapted for the form grinding of cemented tungsten carbide.

My present invention includes an improved method of making diamond loaded abrasive articles especially adapted for the form grinding of cemented tungsten carbide articles or articles of other tough material. According to my method, a disc or wheel is provided and at least the outer periphery of the same is of a relatively soft metal or other material. Such periphery is form dressed or dressed to the desired contour and then my crushing roller, which is of complemental contour, is used to force diamond dust into such dressed periphery. The periphery of the wheel or disc or other article is of a material softer than that of my hardened and formed crusher roller and such periphery is dressed as by the diamond or another tool in holder 62.

When cemented tungsten carbide is to be form ground, a disc or wheel of brass or similar metal is mounted on the shaft 25 in place of the abrasive wheel shown. Such disc may be previously roughly dressed to the desired contour and if so, it is finished dressed by use of a cemented tungsten carbide tool or the like in the holder 62. Such tool, of course, will be operated through the pantograph means. When the brass or other disc is properly formed, the formed crusher roller is brought in against the edge of the disc and diamond dust placed on the edge of the brass disc.

This diamond dust is forced into the disc by the hardened and formed crusher roller. Thereafter cam 104 is shifted to permit of spring 114 carrying the crusher roller away from the brass disc and the latter is ready for use in the form grinding of cemented tungsten carbide. When the brass disc loses the detail of its form, it is necessary to cut away its periphery since while some diamond dust remains in its peripheral portion it may not be properly dressed. Its periphery is again formed and diamond dust spread thereon and forced therein by bringing the hardened, formed crusher roller thereagainst as previously described.

Having thus set forth the nature of my invention, what I claim is:

1. The method of making an abrasive article for the form grinding of cemented tungsten carbide and the like comprising mounting an abrasive wheel and a hardened roller on parallel axes, rotating said abrasive wheel at relatively high speed and while rotating the same accurately dressing its periphery to the exact inverse of the

contours desired in the finished article, then relatively moving said roller and abrasive wheel and bringing their peripheries into engagement and driving them at different speeds to have said abrasive wheel accurately grind into the periphery of said roller the exact contours desired in the finished article, relatively moving said abrasive wheel and roller to separate their peripheries, removing said abrasive wheel from its axis and mounting on said axis a second wheel having at least a periphery of softer metal, rotating said second wheel at relatively high speed and while so rotating the same accurately dressing its periphery to exactly the contours of the dressed abrasive wheel, spreading diamond dust on the formed periphery of said second wheel, and bringing the complementary formed peripheries of roller and second wheel into engagement and relatively rotating them and by the high unit pressure of the line contact between them embedding the diamond dust in the formed periphery of said second wheel by reason of the hardness of the periphery of the roller as compared with the hardness of the periphery of the second wheel.

2. The method of making an abrasive article for the form grinding of cemented tungsten carbide and the like comprising accurately dressing the periphery of an abrasive wheel to the exact inverse of the contour desired in the article to be ground, using such abrasive wheel to accurately grind into the periphery of a hard roller the exact

contours desired in a finished article, accurately dressing the periphery of a second wheel having at least a soft metal periphery to the exact contours of the dressed abrasive wheel, mounting said second wheel and said roller for rotation on parallel axes, spreading diamond dust on the periphery of said second wheel, and relatively rotating the formed second wheel and formed roller with their complementary peripheries in engagement whereby by the high unit pressure at the line of contact between them to embed the diamond dust in the formed softer metal periphery of said second wheel.

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