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[54] **PROCESS FOR TRUING A DIAMOND WHEEL UTILIZING A MOLYBDENUM TOOL**

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[51] **Int. Cl.²** **B24B 53/06;** B24B 53/02

[58] **Field of Search** ...... 51/262 T, 281 R, 283, 309, 51/293; 125/11 CD

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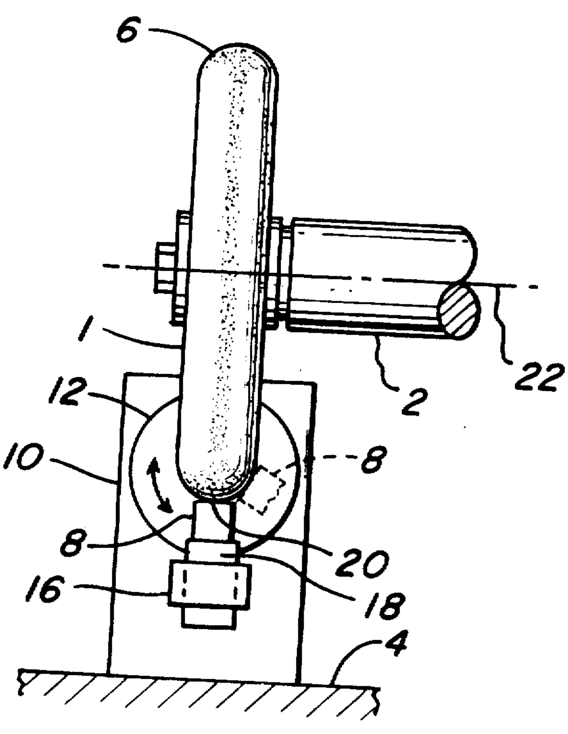
[57] **ABSTRACT**

A process for truing a resin bonded, diamond grinding wheel utilizing a molybdenum tool as the truing or dressing tool. The molybdenum tool is held in frictional contact with the peripheral work surface of the diamond grinding wheel as it rotates on a spindle, with the molybdenum tool either being stationary, or movable through a predetermined path to form a work surface of particular shape on the periphery of the diamond grinding wheel.

12 Claims, 5 Drawing Figures



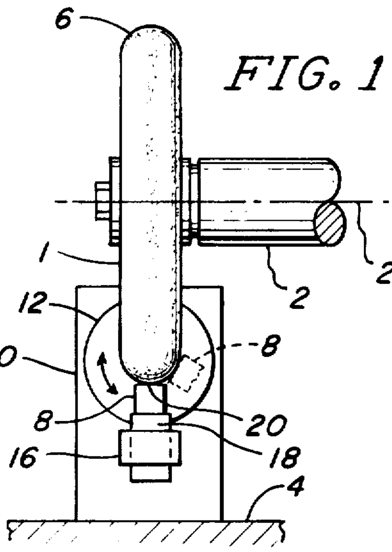


FIG. 1

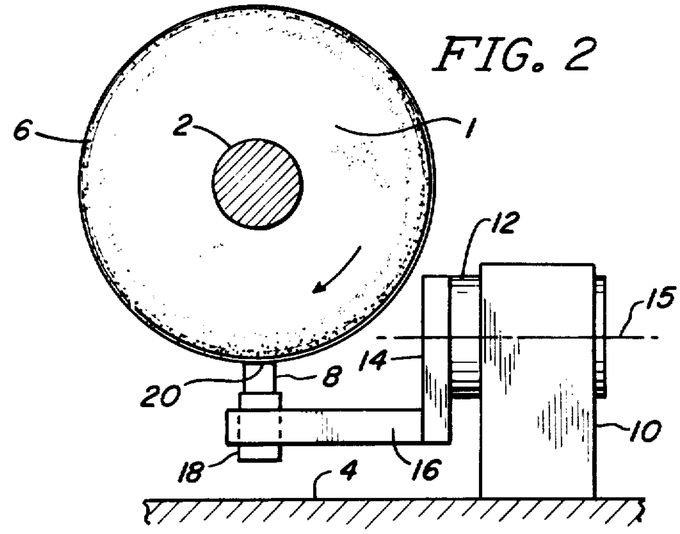


FIG. 2

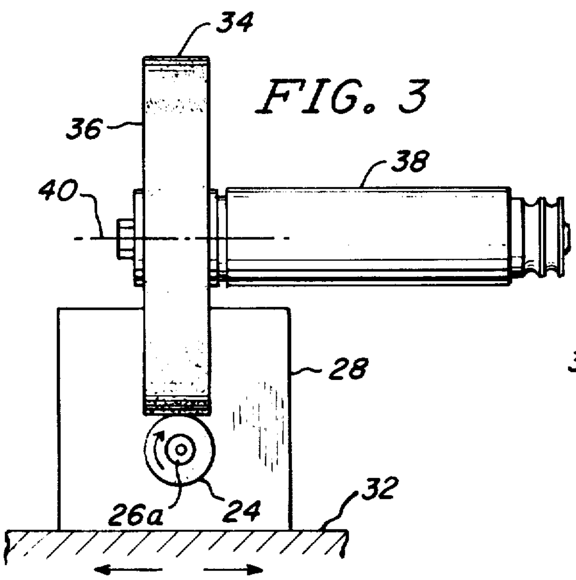


FIG. 3

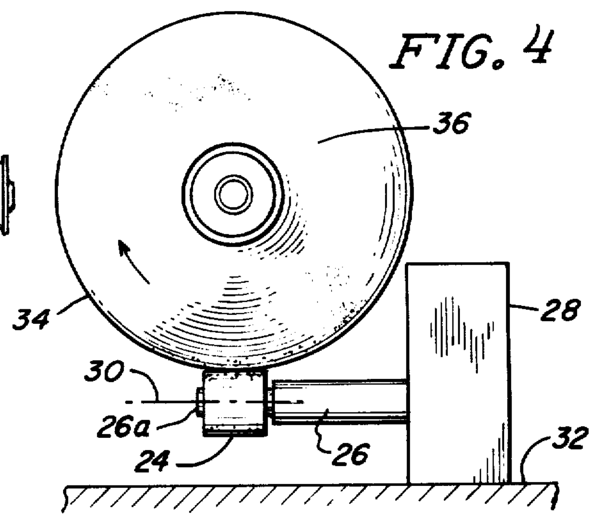


FIG. 4

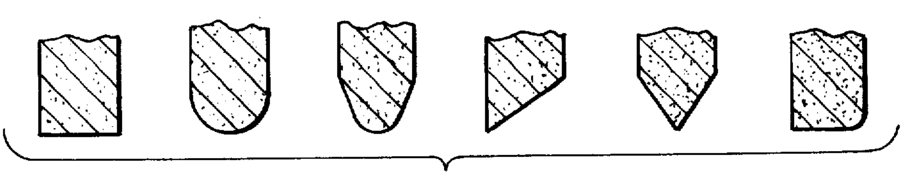


FIG. 5

PROCESS FOR TRUING A DIAMOND WHEEL UTILIZING A MOLYBDENUM TOOL

BACKGROUND OF THE INVENTION

For particular types of finishing and forming operations, diamond grinding wheels are used. For example, resin bonded, diamond grinding wheels are required where close tolerances and extremely smooth finishes are necessary, as in the forming of carbide and tungsten carbide tools. Diamond grinding wheels, like abrasive wheels of any kind, must be trued or dressed from time to time as they wear in order that they may accurately form fine finishes or precise contour or work pieces, such as tools. Precision grinding utilizing diamond wheels, as is done in making carbide tools, is becoming less and less popular because it is so difficult to establish and maintain the proper dress on diamond grinding wheels. The silicon carbide and aluminum oxide tools used in the past to dress diamond grinding wheels wear away so rapidly when held in frictional contact with a rotating diamond wheel during a dressing operation, that it is extremely difficult to accurately dress a diamond wheel with such tools. Even if sufficient material can eventually be removed from a diamond wheel using such tools in a dressing operation, the tremendous wear rate of such tools against a diamond wheel requires the use of excessive quantities of silicon carbide or aluminum oxide tools. Also, the heat and dust generated in using silicon carbide or aluminum oxide tools to dress diamond grinding wheels is highly undesirable.

I have discovered that the aforesaid difficulties can be overcome, and that the highly effective, accurate and economical dressing of a resin bonded, diamond grinding wheel can be accomplished using a molybdenum tool.

BRIEF SUMMARY OF THE INVENTION

The process of this invention for dressing or truing a resin bonded, diamond grinding wheel is particularly characterized by the use of a molybdenum dressing tool in such a way that an accurate surface of predetermined shape can be formed on a diamond grinding wheel with the generation of a minimum amount of heat and dust while wearing away a very minimum amount of the molybdenum tool in comparison with the use ratios of prior tools utilized for dressing diamond wheels.

These basic advantages are achieved by utilizing a molybdenum tool which is of commercial grade, and preferably having a purity of at least 95 percent. The molybdenum tool may take various shapes, such as that of a cylinder, disc, bar, or pointed tip, and may be held in a fixed position or moved through a predetermined path as desired in frictional contact with the peripheral work surface of a rotating diamond wheel to accurately form a true work surface of desired contour on the diamond grinding wheel.

As a particularly beneficial aspect of my improved diamond wheel dressing process, thee molybdenum tool may be used to dress a resin bonded, diamond wheel while the diamond wheel remains mounted on its normal work spindle of a grinding machine, the work spindle being utilized to rotate the diamond wheel during the dressing operation. This is in contrast to previously used methods for dressing diamond wheels, in which the high wear ratio of prior dressing materials

has required the use of particularly large dressing tools and the mounting of the diamond grinding wheels on special dressing machines permitting access of the large dressing tools to the periphery of the diamond wheel.

These and other objects and advantages of my invention will become readily apparent as the following description is read in conjunction with the accompanying drawings wherein like reference numerals have been used to designate like elements throughout the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front elevation view in simplified form of a diamond grinding wheel and molybdenum tool positioned to utilize the truing process of this invention;

FIG. **2** is a side elevation view of the dressing tool and diamond wheel arrangement of FIG. **1**;

FIG. **3** is a front elevation view showing an alternative form and arrangement of a molybdenum dressing tool in accordance with my invention;

FIG. **4** is a side elevation view of the dressing tool and diamond wheel arrangement of FIG. **3**; and

FIG. **5** illustrates a variety of grinding wheel shapes which can be formed with the truing process of FIGS. **1** and **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, I have shown in FIGS. **1** and **2** one type of setup for a dressing operation on a grinding wheel utilizing a molybdenum tool. The grinding wheel **1** is shown mounted on a drive spindle **2** with which it can be rotated at a desired speed in carrying out a truing or dressing operation on the wheel. The grinding wheel will necessarily be a resin bonded, diamond grinding wheel, since this is the particular type of diamond wheel with which a molybdenum tool has proven to be particularly effective in a dressing operation. As is well known, such grinding wheels have diamond particles imbeded and held in a bonding agent in the form of a resin of some type. For example, the bonding resin may be Bakelite. Such wheels are to be distinguished from so-called metal bonded diamond wheels with which molybdenum tools of my improved dressing process have not been particularly effective. Although the spindle **2** on which grinding wheel **1** is mounted for the dressing operation may be a rotary spindle on any type of machine, including that of a special dressing machine, I have found that my molybdenum tool dressing process may advantageously be utilized to true a resin bonded, diamond grinding wheel while it is mounted on its normal work spindle of a grinding machine. Grinding machines of various types are well known, and therefore no such machine is illustrated in detail. It will suffice to say that work spindle **2** is rotatably supported on such a machine and is driven by a motor to operate within a predetermined speed range. The work bed of the grinding machine is indicated by reference numeral **4**.

The peripheral work surface **6** around the circumference of grinding wheel **1** is shown with an arcuate shape with a radius formed thereon, for illustrative purposes in FIGS. **1** and **2**. As is pointed out below, resin bonded, diamond grinding wheels having contours of various configurations on their peripheral surfaces may be dressed with the molybdenum tool process of this invention. For truing a diamond grinding wheel having such an arcuate peripheral work surface, a bar type molybdenum tool **8** is preferably utilized. Such an elongated, molybdenum bar formed from molybdenum bar stock of commercial grade and quality has been successfully used to dress a resin bonded, diamond grinding wheel. Although such commercial quality molybdenum would normally be over 99 percent pure, a molybdenum tool, in whatever form utilized in my dressing process, would provide satisfactory results if it were of at least 95 percent pure molybdenum. In the dressing setup shown in FIGS. **1** and **2**, molybdenum bar tool **8** is held in a dressing fixture **10** which may be advantageously secured in place on the work bed **4** of the grinding machine on which diamond wheel **1** is mounted for normal grinding operations. Tool support fixture **10** has a rotary head **12** with an upright member **14** affixed thereto for rotation about the rotary axis **15** of head **12**. Projecting forwardly from upright member **14** at substantially right angles thereto is a tool mounting arm **16** apertured at its outer end to receive a tool holding sleeve **18**. Molybdenum tool bar **8** is removably secured within sleeve **18** in the upright position shown in FIGS. **1** and **2**. Tool bar **8** is so mounted that its outer, flat tip portion **20** is in contact with the peripheral work surface **6** of diamond grinding wheel **1**.

A dressing operation is carried out on grinding wheel **1** using the aforesaid setup, by rotating grinding wheel **1** at a predetermined speed with work spindle **2**. Simultaneously, as wheel **1** is rotating, rotary head **12** of the tool fixture is rotated about axis **15** in a reciprocating fashion as indicated by the directional arrow in FIG. **1**, to thereby move the work tip **20** of molybdenum tool bar **8** back and forth in an arcuate path over the circumferential, peripheral edge surface **6** of grinding wheel **1** as it rotates. Tool bar **8** is moved generally transversely of the peripheral work surface **6** of grinding wheel **1** in a vertical plane which will normally be oriented at right angles with respect to the plane of grinding wheel **1**. The arcuate movement of molybdenum tool bar **8** over the entire peripheral work surface **6** of grinding wheel **1** is illustrated in FIG. **1** by showing tool bar **8** in phantom lines in one of the positions it will assume during the truing operation.

By moving molybdenum tool bar **8** back and forth through an arcuate path with its tip **20** in frictional contact with the peripheral work surface **6** of wheel **1** as it rotates, tool bar **8** will form a precise radius on the peripheral work surface **6** of wheel **1** to thereby provide the exact arcuate contour of predetermined radius required on peripheral work surface **6**. It is to be noted that with the dressing setup shown in FIGS. **1** and **2**, the rotational axis **22** of grinding wheel **1** extends substantially perpendicular to the plane of wheel **1**. For forming a predetermined radius on the peripheral work surface **6** of wheel **1**, molybdenum tool bar **8** is preferably mounted as shown in FIGS. **1** and **2** with its elongated support arm **16** extending at right angles to rotational axis **22** of grinding wheel **1**. Those skilled in the art will appreciate that tool bar **8** could be held stationary, or moved through various types of predetermined paths in order to true a flat or arcuate surface of particular contour on the peripheral work surface of a diamond grinding wheel. In FIG. **5** I have illustrated in cross section a number of radius and angled surfaces which can accurately be formed on a resin bonded, diamond grinding wheel using a molybdenum tool bar **8** mounted on a radius-angle dresser secured in place on a work bed **4** of a grinding machine so as to hold the molybdenum tool bar in proper position with respect to the peripheral work surface of the grinding wheel **1**. It will be appreciated that the dressing setup illustrated in FIGS. **1** and **2** is primarily intended for generating convex forms, such as radii and angles, singly or in combinations as illustrated in FIG. **5**, on the peripheral work surface of the grinding wheel.

In FIGS. **3** and **4** I have shown an alternative setup for a dressing operation utilizing a molybdenum tool **24** of cylindrical shape. Tool **24** is mounted on the forward end **26***a* of a drive spindle **26** rotatably supported on a fixture **28**. Drive spindle **26** is supported for rotational movement abouts its longitudinal axis **30**, and is driven by a motor not shown, as is rotary head **12** of tool support fixture **10** shown in FIGS. **1** and **2**. As is the case with respect to the dressing tool setup of FIGS. **1** and **2**, dressing tool mounting FIG. **28** is directly supported on the work bed **32** of a grinding machine of conventional design. Drive spindle **26** is so positioned that molybdenum tool cylinder **24** will be positioned as shown with its cylindrical peripheral surface in tangential line contact with the circular peripheral work surface **34** of a diamond grinding wheel **36**. Wheel **36** would also be a resin bonded, diamond grinding wheel of the type with which the molbdenum truing tools of this invention have proven to be particularly efficient and effective. Diamond grinding wheel **36** is shown mounted on a spindle **38** for rotation with the spindle about its longitudinal axis **40**. Although a special work spindle on a dressing machine could be utilized to support and rotate grinding wheel **36** during a truing operation, spindle **38** will preferably be the normal work spindle of a grinding machine on which diamond wheel **36** is normally mounted for grinding operations. Tool support fixture **28** is supported on the work bed **32** of the grinding machine at a position such that dressing tool **24** will be positioned as shown in frictional contact with the peripheral surface **34** of wheel **36**.

With work spindle **38** driving diamond grinding wheel **36** at a predetermined speed, molybdenum tool cylinder is simultaneously rotated in frictional contact with the peripheral work surface **34** of wheel **36**. The rotational axis **30** for cylindrical molybdenum tool **24** is disposed substantially at right angles to the rotational axis **40** of grinding wheel work spindle **38**. Thus, with molybdenum tool **24** being a right cylinder, as shown, it will true and form a substantially flat or straight surface on the circular periphery **34** of diamond grinding wheel **36**. In order to form an accurate, flat work surface over the entire periphery **34** of diamond grinding wheel **36**, molybdenum tool cylinder **24** may be reciprocated horizontally in a direction parallel to the rotational axis **40** of wheel **36**, as is indicated by the directional arrows in FIG. **3**. This may readily be accomplished by reciprocating the work bed **32** of the grinding machine on which tool fixture **28** is mounted, such work beds of grinding machines normally being reciprocal in a horizontal plane for the purpose of moving a work piece back and forth under a diamond grinding wheel during a finishing operation.

Although the dressing setup of FIGS. **3** and **4** shows an elongated, cylindrical molybdenum tool, I contemplate that a disc-type cylindrical segment of shorter length could also be used in such a setup. The elongated cylindrical tool **24** shown in FIGS. **3** and **4** has the advantage that it presents a substantial lenth of tool surface to the peripheral surface **34** of grinding wheel **36**, and therefore will not wear away as quickly as would a thin, disc-like dressing tool. Also, in addition to the bar and cylinder type molybdenum dressing tools disclosed in FIGS. **1** through **4**, I contemplate that other types and shapes of molybdenum tools could be used satisfactorily in dressing a resin bonded, diamond grinding wheel. For example, the tool could be a bar or rod with a pointed tip, or possibly even a flat plate against which the peripheral surface of a diamond grinding wheel would rotate during a truing operation.

I have found that particularly accurate dresing of resin bonded, diamond grinding wheels with a minimum of wear of the dressing tool can be accomplished utilizing a cold rolled molybdenum tool. The reason for improved performance with such a cold rolled molybdenum tool is not precisely known. However, different metallurgical properties, including grain dispersion and hardness are apparently achieved in a cold rolled molybdenum tool, in contrast to a hot worked molybdenum tool, which may account for the improved results when such a tool is used to dress a resin bonded, diamond wheel.

One of the most important advantages achieved by the use of a molybdenum tool as disclosed herein for dressing or truing a resin bonded, diamond grinding wheel is the low wear ratio of the tool with respect to the grinding wheel. Silicon carbide and aluminum oxide tools which have traditionally been used for dressing diamond grinding wheels of both resin bonded, and metal bonded types, have had wear ratios of as high as 100 to 1. That is to say, 100 times as much of such dressing tools wears away during a dressing operation, as does the resin bonded, diamond wheel. Molybdenum dressing tools used in truing operations as disclosed herein have shown a very minimal wear ratio of the tool to the grinding wheel of only about 2 to 1. This small amount of wear of the molybdenum tool in comparison with that of higher tools utilized for dressing resin bonded, diamond wheels, also explains to a large degree the minimum amount of dust and heat generated during a truing operation utilizing a moybdenum tool. Silicon carbide tools, for example, wear away so rapidly when used for dressing a diamond grinding wheel, that a tremendous amount of dust and heat is generated. This is highly undesirable for obvious reasons, and special vacuum pickup devices must be utilized to remove the dust during the dressing operation. Utilizing a molybdenum dressing tool on a resin bonded, diamond grinding wheel, I have found that the temperatures generated are so low that either the grinding wheel or the molybdenum dressing tool can safely be touched by hand immediately after a truing operation has been completed. Neither the grinding wheel itself, or the molybdenum tool reach a temperature in excess of 200° F during a truing operation.

One of the significant problems directly related to the high temperatures generated in dressing diamond wheels with aluminum oxide or silicon carbide tools is burning and glazing of the peripheral surface of the resin bonded, diamond wheels during the truing operation. The high temperatures encountered with such tools cause the resin bonding elements to melt and glaze over and around the diamond particles on the periphery of the grinding wheel. As a result, a final dressing operation utilizing a separate abrasive is frequently required to open up the peripheral surface of a resin bonded, diamond grinding wheel to expose the tips of diamond particles after a truing operation utilizing a silicon carbide or aluminum oxide tool. The molybdenum truing tool of this invention produces a more open face initially on the peripheral surface of a resin bonded, diamond wheel with good exposure of diamond particles. There is no need for a final, additional dressing operation utilizing a special abrasive after the molybdenum tool truing process, since the temperatures generated in the use of a molybdenum tool against a resin bonded diamond wheel are not high enough to melt and glaze the resin bonding material. The high temperatures, glazing of the bonding agents, and high wear ratios with resulting dust generation, make it very difficult to obtain the necessary accurate contours on diamond wheels required for precision grinding operations utilizing such wheels. As a result, much more accurate, finer finishes can be achieved on work pieces, and particularly on carbide and tungsten carbide tools, using a molybdenum dressed, resin bonded diamond wheel. For example, I have been able to achieve finishes with tolerances as close as 2 micro inches with a resin bonded, diamond grinding wheel dressed with a molybdenum tool. This is in contrast to the finishes of 15 to 20 micro inches achievable in the past with conventionally dressed resin bonded, diamond wheels.

Another particularly significant benefit realized from the use of molybdenum dressing tools to true resin bonded, diamond grinding wheels is that the truing operation can be carried out with the diamond grinding wheel mounted on its work spindle of a grinding machine. The tremendously high wear rate of silicon carbide and aluminum oxide tools used in the past to dress diamond grinding wheels has required the use of particularly large tools in the nature of bars or cylinders of such dressing materials. Such dressing tools are so large, that they cannot be mounted in a fixture and positioned in working relation to a grinding wheel with the grinding wheel mounted on its work spindle on an ordinary grinding machine. Traditionally, the grinding wheel has been removed from its work spindle and mounted on the spindle of a special dressing machine utilizing a relatively large aluminum oxide or silicon carbide tool, such as a very large diameter silicon carbide disc or cylinder. Because of the extremely high wear rate of such prior dressing materials, it is simply impractical to attempt to use the small tools in the nature of small discs or bars, which will be required to achieve access to the periphery of a diamond grinding wheel mounted on its normal work spindle. Such small tools as those illustrated in FIGS. **1** through **4** in the nature of tool bars or cylinders not over several inches long or several inches in diameter would simply wear away so quickly if made from silicon carbide or aluminum oxide and used to dress a diamond wheel, that the tools would have to be replaced repeatedly without actually removing any significant amount of material from the periphery of the diamond wheel. The minimum wear ratio of tool to diamond wheel on the order of 2 to 1 achieved with my molybdenum tools overcomes these problems, and permits a very small molybdenum tool to be used to dress a resin bonded diamond grinding wheel with the wheel mounted on its normal work spindle. Thus, the grinding wheel does not have to be removed from its machine and placed on a special drive spindle of a truing machine to carry out a truing operation. As will be appreciated by those skilled in the art, this necessarily improves the accuracy which can be achieved in the form dressing of a diamond grinding wheel utilizing a molybdenum tool with the grinding wheel mounted on its work spindle. If the grinding wheel has to be transferred from one spindle to another in the course of a truing operation, accuracy in the truing operation will necessarily be lost because of unavoidable differences in tolerances between the work spindle of a grinding machine and the special drive spindle of a dressing machine on which the wheel would be mounted during a dressing operation. The relatively low wear ratio of a molybdenum tool with respect to a resin bonded, diamond wheel permits a relatively small molybdenum tool such as those shown in FIGS. **1** through **4** to accomplish the dressing operation with the diamond wheel rotating on its normal work spindle of a grinding machine. A small molybdenum tool can readily be mounted in conventional radius-angle dressing devices such as those shown in FIGS. **1** through **4**, and positioned in working relation to the peripheral surface of a grinding wheel with the tool dressing fixture mounted on the work bed of the grinding machine. As noted above, it would be impossible to achieve access to the peripheral surface of a grinding wheel mounted on its normal work spindle if a large tool had to be used in the dressing operation, as is the case with previously utilized silicon carbide and aluminum oxide tools.

When a dressing operation is carried out in the preferred manner with the grinding wheel mounted on its work spindle, the wheel will be rotated during the dressing operation within a predetermined speed range available on the grinding machine. Normally, the speed range availability on conventional grinding machines is between 5000 and 5500 surface feet per minute. Satisfactory truing results have been achieved using a molybdenum tool held in frictional contact with the work surface of a grinding wheel rotating within such a speed range. However, improved results in the form of particularly accurate finishes and minimum wear of the molybdenum tool have been achieved with the grinding wheel operating at slower speeds within a range of from 600 to 700 surface feet per minute. Such lower speed ranges for the grinding wheel work spindle are available only on certain types of grinding machines utilized for special forming operations.

The easier, less expensive and more accurate truing of resin bonded, diamond grinding wheels possible with the use of molybdenum tools as described herein with the grinding wheel mounted on its normal work spindle, will make the forming of carbide and tungsten carbide tools by means of diamond grinding wheels much more feasible and attractive to tool makers. Presently, machinists avoid making carbide tools because it is so difficult to maintain and control the proper dress on diamond grinding wheels required for the finishing of carbide tools and work pieces of any kind. This is considered to be a significant benefit, since carbide tools wear so much better and last so much longer than steel tools.

Although I have described my improved dressing process for resin bonded, diamond wheels with respect to particular molybdenum tools and tool setups, I anticipate that various changes may be made in the size, shape, and arrangement of molybdenum dressing tools without departing from the spirit and scope of this invention as defined by the following claims:

What is claimed is:

1. A process for truing a resin bonded, diamond grinding wheel comprising:

rotating a resin bonded, diamond grinding wheel about a rotational axis extending substantially normal to the plane of the wheel; and

simultaneously holding a molybdenum tool in frictional contact with the peripheral work surface of said grinding wheel while it rotates.

2. A diamond grinding wheel truing process as defined in claim **1** wherein:

said molybdenum tool is commercial quality molybdenum of at least 95 percent purity.

3. A diamond grinding wheel truing process as defined in claim **1** wherein:

said molybdenum tool is cold rolled molybdenum.

4. A diamond grinding wheel truing process as defined in claim **1** wherein:

said diamond grinding wheel is mounted on its normal work spindle of a grinding machine during said truing operation, with said molybdenum tool being moved into frictional contact with the peripheral work surface of said grinding wheel as it rotates on its work spindle; and

moving said molybdenum tool back and forth through an arcuate path over the circumferential, peripheral edge surface of said grinding wheel transversely of said edge surface in a plane angularly oriented with respect to the plane of said grinding wheel as said grinding wheel rotates on said work spindle, thereby forming an arcuate peripheral work surface around the circumference of said grinding wheel.

5. A diamond grinding wheel truing process as defined in claim **4** wherein:

said molybdenum tool is in the form of a bar having a tip held in contact with the peripheral edge surface of said grinding wheel as said bar is moved back and forth through said arcuate path with said grinding wheel rotating on its work spindle.

6. A process for truing a resin bonded, diamond grinding wheel comprising:

rotating a resin bonded, diamond grinding wheel with a work spindle of a grinding machine on which said diamond grinding wheel is normally mounted for grinding operations; and

simultaneously holding a molybdenum dressing tool in frictional engagement with the circumferential, peripheral work surface of the grinding wheel while it is rotating.

7. A diamond grinding wheel truing process as defined in claim **6** wherein:

said diamond grinding wheel is rotated at a speed of between 600 and 700 surface feet per minute during said truing process.

8. A diamond grinding wheel truing process as defined in claim **6** wherein:

said molybdenum tool is in the form of a cylindrical member which is rotated about its longitudinal axis during said truing process with its cylindrical peripheral surface in tangential line contact with the circular peripheral work surface of said grinding wheel as it rotates.

9. A diamond grinding wheel truing process as defined in claim **8** wherein:

said cylindrical, molybdenum tool is mounted for rotational movement on a spindle having its longitudinal, rotational axis disposed substantially at right angles to the rotational axis of said grinding wheel work spindle.

10. A diamond grinding wheel truing process as defined in claim **6** wherein:

said molybdenum tool is moved back and forth through an arcuate path over the circular, peripheral surface of said grinding wheel transversely of said surface in a plane angularly oriented with respect to the plane of said grinding wheel as said grinding wheel rotates on said work spindle, thereby forming an arcuate, peripheral work surface on the circular periphery of said grinding wheel.

11. A diamond grinding wheel truing process as defined in claim **9** wherein:

said cylindrical, molybdenum tool is moved back and forth in a traversing stroke across the entire peripheral width of the grinding wheel in a direction parallel to the rotational axis of the grinding wheel as it rotates.

12. A diamond grinding wheel truing process as defined in claim **6** wherein:

said diamond grinding wheel is rotated at a speed of between 5000 and 5500 surface feet per minute during said truing process.

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