Sept. 3, 1957 W. D. SCHMIDT 2,804,727

GRINDING MACHINE

Filed July 15, 1955

4 Sheets-Sheet 1

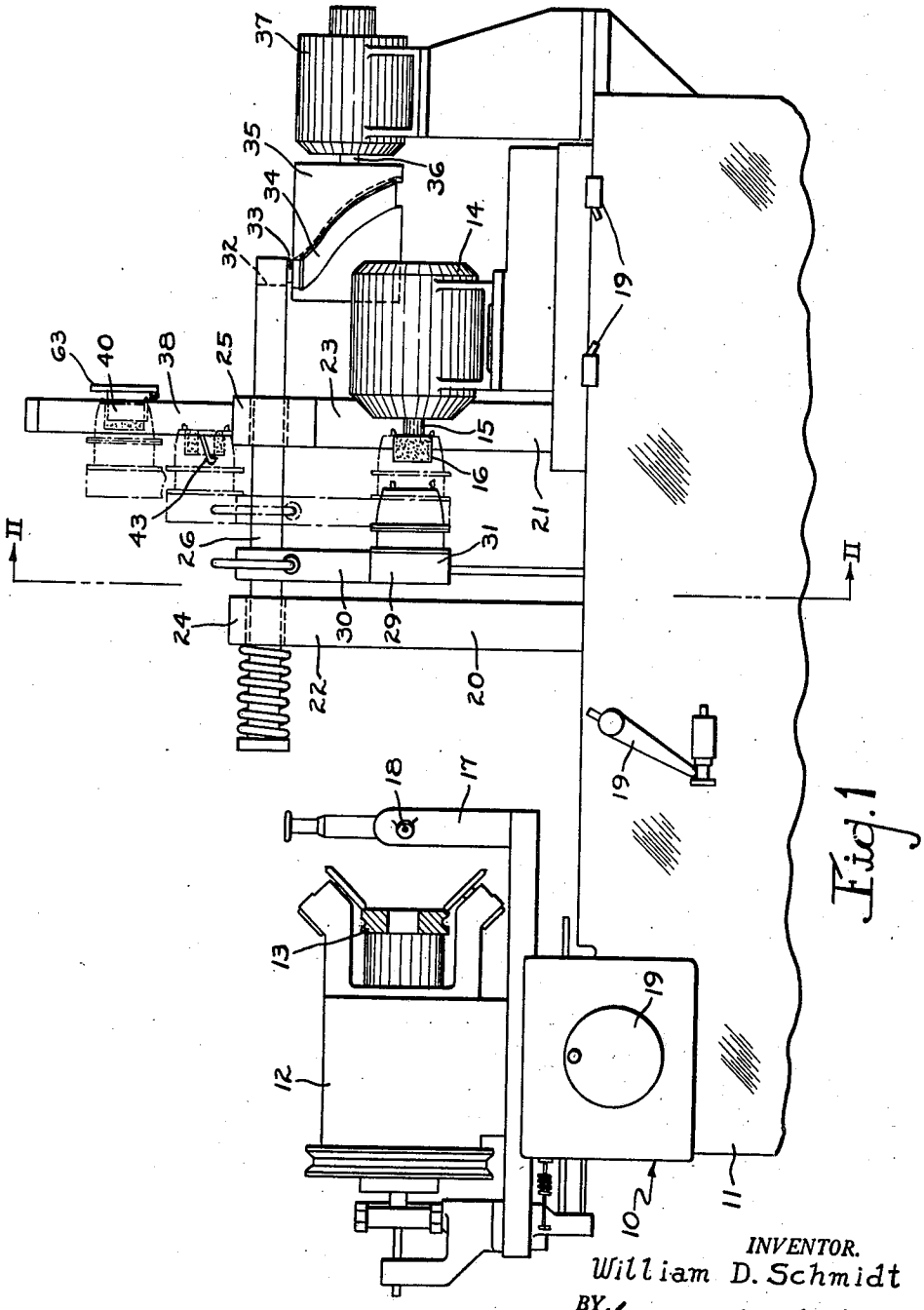


Fig. 1

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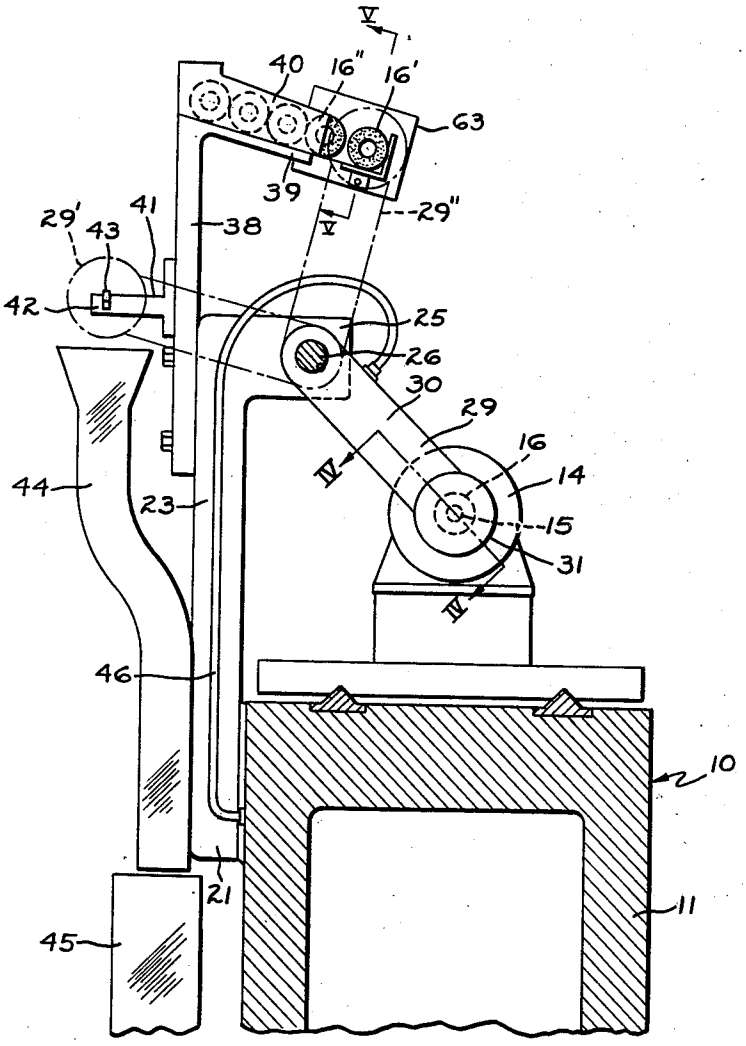


Fig. 2

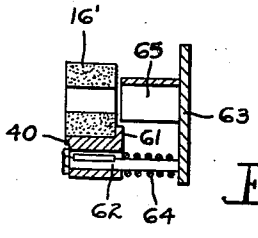


Fig. 5

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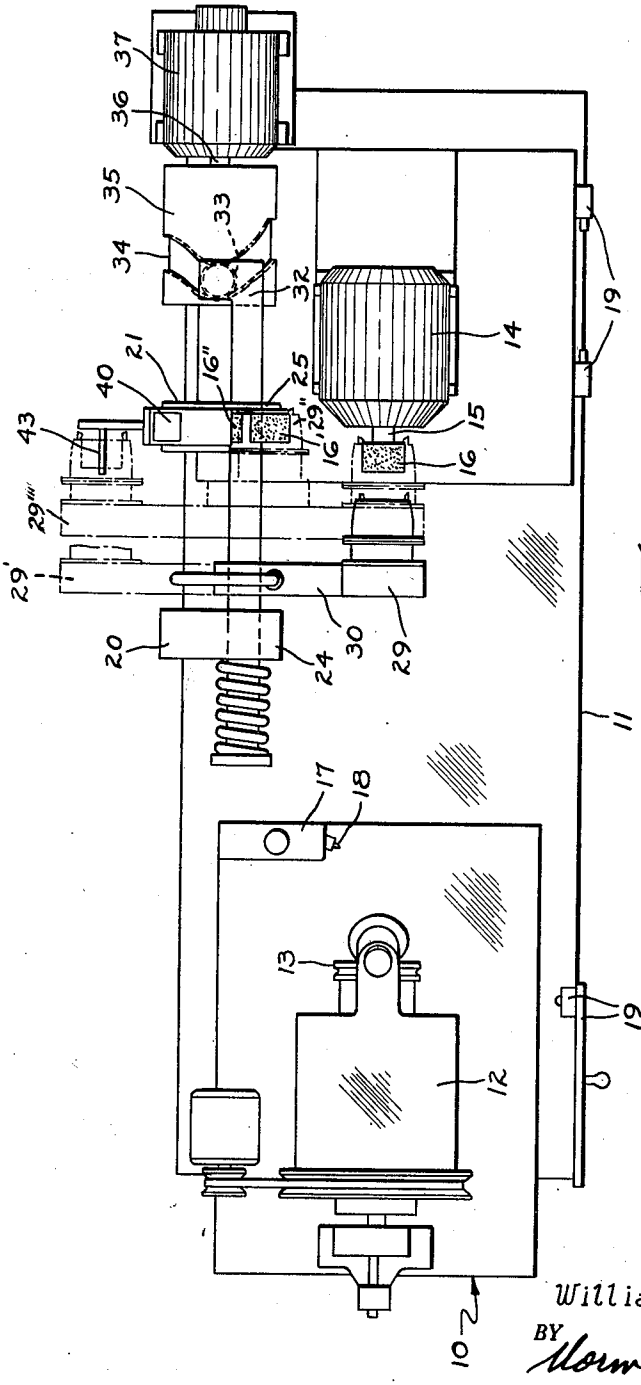


Fig. 3

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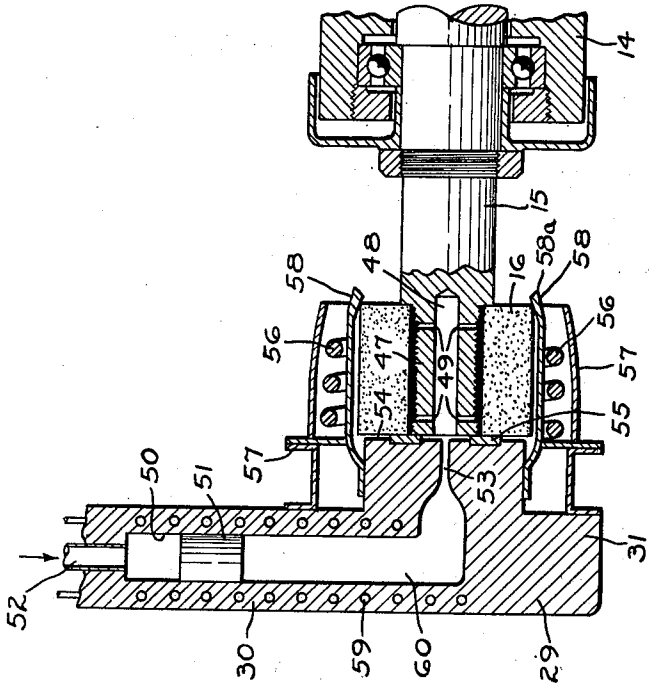


Fig. 4

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United States Patent Office

2,804,727

Patented Sept. 3, 1957

2,804,727

GRINDING MACHINE

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Application July 15, 1955, Serial No. 522,338

18 Claims. (Cl. 51—166)

This invention relates to a grinding machine and more particularly to apparatus for removing stock from a work piece by use of a rotating abrasive wheel.

In the art of grinding there have been many attempts to provide a machine which will be completely automatic. To some extent, this desire has been realized. However, there has been one stumbling-block in the path of progress toward the completely automatic, continously-operating grinding machine; this deterrent is related to the fact that the abrasive wheel wears out and must be replaced. The machine must be stopped and the wheel must be removed and replaced; the amount of time required to do this is completely unproductive and reduces the efficiency of the machine considerably. If the machine whose wheel is worn is part of a production line, the entire line may be held up during the replacement time. These and other difficulties experienced in the prior art have been obviated by the present invention in a novel manner.

It is therefore an outstanding object of the present invention to provide a grinding machine in which the changing of the abrasive wheel is completely automatic.

Another object of this invention is the provision of a grinding machine in which the abrasive wheel is attached to its spindle in a manner particularly adapted to automatic wheel changing.

It is a further object of the instant invention to provide a grinding machine having a wheel changing apparatus which operates in combination with a particular construction for attaching an abrasive wheel to its spindle to produce fully automatic wheel changing.

It is a still further object of the invention to provide a grinding machine including wheel-changing apparatus which may be used on such machines of conventional construction, that is rugged and dependable, which is simple and inexpensive to manufacture, and which requires a minimum of maintenance.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

The character of the invention, however, may be best understood by reference to certain of its structural forms, as illustrated by the accompanying drawings in which:

Figure 1 is a front elevational view of a grinding machine embodying the principles of the present invention,

Figure 2 is a sectional view of the machine taken on the line II—II of Figure 1,

Figure 3 is a plan view of the machine,

Figure 4 is an enlarged sectional view of the invention taken on the line IV—IV of Figure 2, and

Figure 5 is a sectional view taken on the line V—V of Figure 2.

Referring first to Figures 1, 2 and 3, which best show the general features of the invention, the grinding machine, designated generally by the reference numeral **10**, is shown as being of the internal type, although the invention is not to be considered as limited in application to

internal grinding machines. A base **11** is provided with a work head **12** mounted at one end of the upper surface thereof and holding a workpiece **13**. Suitable conventional means is provided for rotating the workpiece. A wheel head **14** is also mounted at the other end of the upper surface of the base. A driven shaft **15** extends from the wheel head toward the work head and a tubular abrasive wheel **16** is mounted on the shaft for rotation therewith. The portion of the shaft which enters the wheel is preferably formed with a reduced intermediate portion and is formed with a surface which is knurled or of a controlled roughness. A wheel dressing apparatus **17**, including a diamond **18**, is mounted at one side of the upper surface of the base between the two heads. Conventional means are provided for causing the wheel head and abrasive wheel to reciprocate relatively longitudinally of the base to separate the workpiece and the wheel and also, if desired, while the wheel overlaps the workpiece, for the removal of stock therefrom. Suitable conventional control means **19** is shown as being mounted on the base for adjusting and regulating these motions.

Fastened to the back of the base **11** are two supporting arms **20** and **21** having, respectively, vertical portions **22** and **23** and forwardly directed horizontal portions **24** and **25**. A control shaft **26** extends horizontally through the portions **24** and **25** and is also parallel to the common axis of the work head **12** and the wheel head **14**. Suitable bores are provided in the portions **24** and **25** of the supporting arms to hold the control shaft **26** for free longitudinal sliding and for rotation. A wheel-changing element **29** is located on the shaft between the supporting arms. The element consists of an arm **30** having at one end an operating head **31** and having the shaft **26** passing through the other end. The arm is keyed and fastened rigidly to the shaft so that it partakes exactly of any longitudinal or rotational movement to which the shaft is subjected. A flexible conduit **46** leaves the upper end of the arm **30** and enters the base **11**; this conduit encloses hydraulic and electrical lines as will be described. The details of construction of the wheel-changing element **29** are described more fully hereinafter. The shaft **26** extends a considerable distance beyond the supporting arm **21** and is provided at that end with an arm **32** extending at a right angle thereto, as is evident in Figure 1. The outer end of the arm **32** is provided with a downwardly-extending cam follower **33**. The follower rides in a three dimensional cam groove **34** formed in a cylindrical cam **35**. The cam is mounted on a shaft **36** driven at a very slow speed by a motor and gear reduction unit **37**. Thus, the cam controls the movement of the follower and is capable of moving it in all directions. The shaft **36** is mounted to be parallel to the shaft **26** on which the wheel-changing element is mounted and the shaft **15** on which the abrasive wheel is mounted. The groove **34** in the cam **35** varies from point to point in its position longitudinally of the shaft **36** and radially in its distance from that shaft.

A supporting post **38** is fastened at its lower end to the supporting arm **21** and extends vertically upwardly therefrom. At its upper end the post is formed with a downwardly and forwardly inclined arm **39** to which is fastened a new wheel dispensing chute **40** to supply new abrasive wheels **16'**, **16''**, etc. At the lower forward end of the chute **40** its side wall is opened and the bottom slotted so that an abrasive wheel may be removed axially in the direction of the work head **12**. A bracket **41** is fastened to the intermediate portion of the post **38**, the bracket having a horizontal arm **42** extending rearwardly. A sharply-barbed hook member **43** extends at a downwardly-inclined angle from the outer end of the arm in the direction of the work head. Underlying the hook

member 43 is the flared mouth of a chute 44 which is fastened to the supporting arm 21 and which has its lower end located over a receptacle 45 or the like.

In Figure 4 is shown the details of construction of the wheel-changing element 29. To begin with, it is well to note the particular manner in which the shaft 15 and the abrasive wheel 16 are associated. The shaft is provided with a slightly-reduced portion 47 having an axial bore 48 entering the free end. Radial passages 49 leave the bore and open onto the cylindrical surface of the reduced portion. The abrasive wheel 16 is formed with a circular cylindrical outer surface, a circular cylindrical bore having a diameter approximately the same as the reduced portion 47 of the shaft 15, and square ends; the length of the wheel is approximately the same as the length of the reduced portion of the shaft. Now, the arm 30 of the element is provided with a cylindrical chamber 50 having a slidable piston 51 contained therein. A conduit 52 opens into the upper portion of the chamber above the piston 51. The conduit leaves the arm 30 within the conduit 46 and enters the base 11 within which lie a conventional air pressure source and controls. At the lower end the chamber turns at a right angle and enters the head 31 and then tapers to a small bore 53 which, in turn, opens onto a plane face 54 which faces the wheel head 14 and lies at a right angle to the wheel axis. On the face 54 is fastened a seal 55 which is concentric with the small bore 53; this seal is capable of operation at fairly high temperatures without ill effects. Also concentric with the bore 53 is the coil 56 of a high-frequency induction heating apparatus of the conventional type, the details of which are not shown. The coil may be protected and supported by a frame 57 which is securely fastened by welding or the like to the remainder of the head 31 of the wheel-changing element 29. The frame 57 includes a curved hood with a minimum diameter beyond the outer end of the coil. Fastened to the head 31 and extending cantilever-fashion toward the wheel head and parallel to the axis of the bore 53 are fingers 58. In the preferred embodiment these fingers are four in number and are spaced equidistantly on a circle concentric with the bore 53. The free end of each finger is enlarged and provided with a point 58*a*; at least a part of the enlargement extends inwardly of the rest of the finger and is formed in a smooth curve. A heating coil 59 of the resistance type is formed internally of the walls of the element 29 and serves to keep in a molten state a body of cement 60 which is contained in the bore 50 under the piston 51. The cement or bond may be of a metallic type, such as type metal or other thermo-plastic substance, such as may be maintained in a semi-liquid state of such a consistency that it will normally not leak from the bore 53 onto the face 54. The cement must have a melting point well above the operating temperature of the wheel. The leads for the induction coil 56 and the heating coil 59 leave the arm 30 of the element 29 within the conduit 46 along with the hydraulic conduit 52.

Figure 5 shows the details of the new wheel dispensing chute 40. The chute is provided with a movable lower portion 61 which is slidably mounted on and keyed to a rod 62 extending horizontally from a panel 63 attached to the arm 39. A compression spring 64 causes the movable portion 61 to remain normally in line with the rest of the chute. An abutment 65 extends from the panel coaxially with the wheel 16', the size of the abutment being greater than the aperture through the wheel.

The operation of the grinding machine of the invention will now be clearly understood in view of the above description. The machine is operated in the usual manner during the removal of stock from the workpiece and the refinement of its surface. The workpiece 13 is revolved about its axis by the work head 12. The abrasive wheel 16 may reciprocate through the bore of the workpiece, if the operation is internal grinding, and is revolved on its shaft 15 by the wheel head 14. The wheel head is moved longitudinally along the upper surface of the base 11 by the controls within the base, which controls are evidenced externally by the control means 19. Although the reciprocation of the wheel head and the wheel is normally of very short amplitude, as determined by the longitudinal dimension of the workpiece, the wheel is, on occasion, withdrawn from the workpiece. Usually this is done only when the grinding cycle on a given workpiece is completed and the workpiece is to be replaced by a new one. During such a lengthened stroke or withdrawal of the wheel it is usual to dress the wheel by the act of causing it to pass adjacent the diamond 18 of the dressing apparatus 17. On such an occasion a small amount of the abrasive material is removed from the wheel. After a number of these dressing operations, the diameter of the wheel becomes considerably reduced; eventually it is so much reduced as to be useless. With the present invention, this condition of the wheel will be recognized by the controls of the machine and a wheel-changing cycle will be set in motion. First, the wheel head and the abrasive wheel are withdrawn from the workpiece and the dressing apparatus to the remote position shown in the drawings where it is available to receive treatment by the wheel-changing element 29. In a general way, the element removes the abrasive wheel from the shaft, discards it and replaces it with a new wheel. During the grinding cycle the motor gear-reduction unit 37 is not energized and the element rests in the general position indicated by dotted lines in Figures 2 and 3 and by the reference numeral 29'. When the machine controls have moved the wheel to the position shown in the drawings, the unit 37 is energized for rotation; the shaft 36 rotates the cam 35. The groove 34 moves the cam follower 33 vertically and longitudinally, depending upon its conformation at any point. As is evident in Figure 1, the follower 33 and the groove 34 of the cam are interengaged so that the follower rides in the groove irrespective of the turns the groove may take; the groove varies from one part to another in the distance that its surfaces reside from the axis of the shaft 36 in a radial direction and the distance in an axial direction that its center line resides from one end of the cam. The radial distance of the groove determines the vertical position of the follower, while axial distance determines its longitudinal position. When the contactor is moved vertically, it operates through the arm 32 to rotate the shaft 26; when the contactor is moved longitudinally of the wheel axis, it operates through the arm 32 to move the shaft 26 longitudinally in its bearings. The art of forming the cam 35 for a particular motion is well known in the art of mechanisms and it is not thought to be necessary to the present description to set forth its shape in greater detail.

The first portion of the wheel-changing cycle involves the rotation of the shaft 26 without longitudinal sliding to cause the element 29 to move from the rest position bearing the reference numeral 29' (Figure 3) to a second position in which the axis of the bore 53 is aligned with the axes of the wheel 16 and the shaft 15; this is the position of the element 29 which is shown in solid lines in Figures 1, 2 and 3. Next, the cam 34 causes the shaft to slide longitudinally without rotation. This carries the element 29 to the right in Figures 1 and 3 until the seal 55 on the face 54 strikes the outer radial surface of the wheel 16 and the end of the shaft 15. The apparatus at this portion of the cycle has the appearance indicated in Figure 4. The induction coil 56 surrounds the worn-out wheel 16. The coil is then energized and the shaft and wheel are quickly heated; this melts the cement holding the two together. The wheel may then be easily removed from the shaft. It should be noted that, as the coil 56 was moving into place over the wheel, the fingers 58 first struck the outer edge of the wheel and then slide longitu-

dinally along the cylindrical surface of the wheel. The fingers are spread apart by the camming action of the wheel on the smoothly curved points of the fingers. When the seal **55** contacts the end of the wheel, the points of the fingers **58** have advanced well beyond the inner end of the wheel, as shown, and they come toward one another again. When the induction coil has loosened the wheel on the shaft, the shaft **26** is moved longitudinally without rotation, thus moving the element **29** axially away from the wheel to the position shown in solid lines in Figure 1. The loose wheel is grasped by the fingers **58** and is carried by the element. The shaft **26** is then rotated without longitudinal movement to the position shown in dotted lines in Figure 2 and indicated by the reference numeral **29'**. This is the rest position from which the element **29** started at the beginning of the wheel-changing cycle. The head **31** of the element, with the used wheel enclosed and carried thereby, is aligned with the hook member **43**. The shaft **26** is moved longitudinally without rotation, carrying the element **29** with it; eventually the outer end of the head **31** strikes the bracket **41** on which the hook member is mounted. The element is then in the position indicated in dotted lines and by the reference numeral **29'''** in Figure 3. As the element **29** moves axially to this position, the edge of the wheel strikes the inclined edge at the end of the hook member; the hook member is cammed upwardly so that, as the element advances, the hook member slides along the cylindrical surface of the wheel. Eventually, the barb of the hook member drops behind the edge of the wheel. The shaft **26** then moves longitudinally without rotation to return the element **29** to the rest position **29'**. During this last movement the barb of the hook member **43** catches behind the edge of the wheel and draws it from between the fingers **58**, the barb of the hook member presenting considerably more resistance to the movement of the wheel than the curved points of the fingers **58**. When the element **29** has reached the rest position **29'**, the wheel drops on the inclined top of **43**, slides down it, and drops into the chute **44** for transfer to the discard receptacle **45**. During this portion of the cycle, the old wheel has been removed from the shaft and has been discarded. At this point in the cycle, the element **29** has returned to the first or rest position **29'**.

Next, the shaft **26** rotates without longitudinal movement to the position indicated by dotted lines and reference numeral **29''** in Figure 2. In this position the axis of the head **31** of the element **29** is aligned with the lowermost new wheel **16'** in the chute **40**. The shaft **26** then moves longitudinally without rotation toward the chute. The ends of the fingers **58** touch the new wheel **16'** first, are spread outwardly, and begin to slide longitudinally along its cylindrical surface. Next, the curved shield of the supporting structure **57** pushes the movable portion **61** toward the panel **63** along the rod **62**, at the same time camming the next new wheel **16''** up the chute and out of the way. The wheel **16'** is caused to remain behind by the pin **65**. The longitudinal movement of the element **29** comes to a stop when the enlarged ends of the fingers **58** have passed the end of the wheel and the fingers have moved together to grasp the wheel. The shaft **26** then moves longitudinally (to the right in Figure 1) without rotation, carrying with it the element **29**, which now grasps the new wheel **16'** within its head **31**. The shaft then rotates without longitudinal motion so that the element **29** moves to the position shown in solid lines in Figure 1, 2 and 3, in alignment with the shaft **15**. Then, the shaft **26** moves longitudinally without rotation until the head **31** has passed over the reduced portion of the shaft carrying the new wheel **16'** onto the shaft until the motion of the wheel is stopped by the shoulder between the reduced portion and the main part of the shaft **15**. The element **29** proceeds still farther, if necessary until the seal **55** is firmly pressed against the outer radial end of the wheel. Referring to Figure 4, the hydraulic controls then increase the pressure above the piston **51** in the bore **50** so that the piston moves downwardly a short distance. The movement of the piston displaces a predetermined amount of molten cement from the bore **53**. The cement fills the bore **48** in the end of the shaft and flows radially outwardly through the passages **44** into the slight space between the reduced portion of the shaft and the inner bore of the wheel. The induction coil **56** is energized to cause the cement to permeate the abrasive material of the new wheel and to form a good bond between the wheel and shaft. After a satisfactory period has passed, the induction coil is deenergized and the wheel, shaft and cement are allowed to cool. After the cement has had an opportunity to cool, so that the wheel is firmly fixed to the shaft, the shaft **26** is moved longitudinally without rotation until the element **29** reaches the position shown in solid lines in Figures 1, 2 and 3. In withdrawal of the element from the wheel, the fingers **58** slide easily over the wheel without, of course, pulling sufficiently on the wheel to pull it from the shaft. The shaft **26** is then rotated without longitudinal movement until the wheel-changing element **29** moves to the rest position **29'** where it remains until the start of the next wheel-changing cycle. The new wheel then enters into the grinding operation.

It should be pointed out that there are some very important advantages to be obtained by the use of the concept of cementing the wheel to the shaft, aside from the obvious fact that it makes possible wheel changing according to the present invention. The fact that the radial end surface of the abrasive wheel is square and flush with the end surface of the shaft makes it particularly useful in an internal grinding machine of the plug gaging type shown and described, for instance, in the patent application of Schmidt et al., Serial Number 415,048, filed March 9, 1954. Because of the absence of protruding nuts and the like from the end of the wheel-shaft combination, the plug is able to follow more closely the movements of the wheel so that the gaging accuracy is increased. With the old style of fastening the wheel to the shaft, the wheel was carried with a rather loose fit on the reduced portion of the shaft and clamped in place between the shoulder on the shaft and the nut; this meant that the wheel was actually held only by friction at each end with little or no support between the ends. The same thing is true where the wheel is held on the shank of a bolt threaded into the end of the shaft; the wheel is clamped between the bolt head and the end of the shaft. With the wheel-mounting concept of the invention, the wheel is held by the fastening of the entire internal bore surface to the shaft. It would appear, then, that the ability to resist the torque and radial forces to which a grinding wheel is subjected during working has been increased greatly and experiment has proved this to be true. Furthermore, there is no danger of crushing the wheel as is present with the old construction. In some cases in the prior art, the bolt head has been hidden in an end recess or countersink on the wheel. This makes the wheel more expensive to manufacture and also reduces the amount of reduction of diameter, due to wear or to dressing, that is permissible before the wheel must be discarded. No counterbore or the like is necessary or proper in the present construction and the wheel is of a simple, inexpensive tubular form. The use of the applicant's technique permits the wheel to be reduced to a minimum useful diameter with a given workpiece and its removal and re-use with a workpiece having a smaller bore. Furthermore, the technique of cementing the wheel to shaft permits the use of a larger shaft with less deflection under load, since none of the wheel bulk is rendered useless by counterbores; in this connection, it should be pointed out that the applicant's mounting system permits a thinner final wall thickness of the abrasive "tube" without breakage.

Although a specific means has been shown for introducing cement or bond between the new wheel and the shaft, the method of introduction is not critical. For

instance, instead of supplying the cement in molten form from within the element 29, it could be supplied by coating the bore of each new abrasive wheel with a coating of cement. It is probable that the shaft will remain coated with cement after each worn wheel is removed and when the coated wheel and coated shaft are brought together, heated and allowed to cool, the bond should be excellent.

It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such as properly come within the scope claimed.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent is:

1. A grinding machine comprising a wheel head, a shaft extending from the head, an abrasive wheel mounted on the shaft, the shaft having a passage terminating in the space between the wheel and the shaft, thermoplastic cement interposed between the wheel and shaft to hold them together, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operations, means for heating the cement to loosen the wheel on the shaft, means for removing and discarding the wheel, means for placing a new wheel on the shaft, and means for forcing liquid cement into the said passage in the shaft for cementing a new wheel to the shaft.

2. A grinding machine comprising a wheel head, a cylindrical shaft extending from the head, a cylindrical tubular abrasive wheel mounted on the shaft, the shaft having a passage terminating in the space between the wheel and the shaft, cement present in a thin annular space between the wheel and shaft to hold them together, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operations, means for heating the cement to loosen the wheel on the shaft, means for removing and discarding the wheel, means for placing a new wheel on the shaft, and means for forcing liquid cement into the said passage in the shaft for cementing a new wheel to the shaft.

3. A grinding machine comprising a wheel head, a shaft extending from the head, an abrasive wheel mounted on the shaft, cement interposed between the wheel and shaft to hold them together, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operations, a wheel-changing element movable toward and away from the wheel and shaft, the said element including a high frequency induction coil for heating the cement to loosen the wheel on the shaft, means for removing and discarding the wheel, and means for cementing a new wheel to the shaft.

4. A grinding machine comprising a wheel head, a shaft extending from the head, an abrasive wheel mounted on the shaft, cement interposed between the wheel and shaft to hold them together, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operations, a wheel-changing element movable parallel to the shaft axis and movable in planes transverse to the shaft axis, the element including means for heating the cement to loosen the wheel on the shaft, means for removing and discarding the wheel, and means for cementing a new wheel to the shaft.

5. A grinding machine comprising a wheel head, a cylindrical shaft extending from the head, a cylindrical tubular abrasive wheel mounted on the shaft, cement present in a thin annular space between the wheel and shaft to hold them together, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operations, a wheel-changing element movable parallel to the shaft axis and movable in planes transverse to the shaft axis, the element including a high frequency induction coil for heating the cement to loosen the wheel on the shaft, means for removing and discarding the wheel, and means for cementing a new wheel to the shaft.

6. A grinding machine having its abrasive wheel cemented to its shaft comprising a wheel-changing element movable toward and away from the wheel, the said element including a heating coil for melting the cement, means for removing and discarding a worn wheel, means for placing a new wheel on the shaft, and means for introducing cement between the new wheel and the shaft.

7. A grinding machine having its abrasive wheel cemented to its shaft comprising a wheel-changing element movable toward and away from the wheel, the said element including a high frequency heating coil for melting the cement, means for removing and discarding a worn wheel, means for placing a new wheel on the shaft, and means for introducing cement between the new wheel and the shaft.

8. A grinding machine having its abrasive wheel cemented to its shaft comprising a wheel-changing element movable parallel to the shaft axis and also movable in planes transverse to the shaft axis, the element including a high frequency induction heating coil for melting the cement, means for removing and discarding a worn wheel, means for placing a new wheel on the shaft, and means for introducing cement between the new wheel and the shaft.

9. A grinding machine having its abrasive wheel cemented to its shaft comprising a wheel-changing element having an elongated arm, the arm being mounted for rotational movement about an axis passing through one end thereof and parallel to the shaft axis and being mounted for linear motion toward and away from the shaft along lines parallel to the shaft axis, a head at the other end of the arm, said head including an induction heating coil for melting the cement, said head also including fingers for removing and discarding a worn wheel and for placing a new wheel on the shaft, and means for introducing cement between the new wheel and the shaft.

10. A grinding machine as set forth in claim 9 in which a hook member is provided for removing a worn wheel from the fingers and a chute is provided for loading a new wheel in the head for placement on the shaft.

11. A grinding machine comprising a wheel head, a cantilever shaft extending from the head and having a knurled portion, a tubular abrasive wheel mounted on the knurled portion of the shaft, cement constituting the only means for holding the wheel on the shaft, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operation, a bore entering the free end of the shaft axially thereof, and passages leaving the bore and opening on the outer surface of the shaft to permit cement to be forced between the shaft and the wheel.

12. A grinding machine comprising a wheel head, a shaft extending from the head, a tubular abrasive wheel mounted on the shaft, cement constituting the only means for holding the wheel on the shaft, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operation, heating means for melting the cement holding a worn wheel on the shaft, a device having fingers for grasping the worn wheel and withdrawing it axially while the cement is molten, the said device being also adapted for placing a new wheel on the shaft, the said heating means serving to heat the new wheel, shaft and cement to produce a good bond therebetween.

13. A grinding machine comprising a wheel head, a shaft extending from the head, an abrasive wheel mounted on the shaft, cement interposed between the wheel and shaft to hold them together, the cement having a melting

point well above the normal temperatures to which the wheel will be raised during normal grinding operations, a cement-feeding passage extending through the shaft into the space between the wheel and shaft, a wheel-changing element movable parallel to the shaft axis, the element including means for heating the cement to loosen the wheel on the shaft, means for removing and discarding the wheel, and means for cementing a new wheel to the shaft.

14. A grinding machine comprising a wheel head, a shaft extending from the head, an abrasive wheel mounted on the shaft, cement interposed between the wheel and shaft to hold them together, the cement having a melting point well above the normal temperature to which the wheel will be raised during normal grinding operations, a wheel-changing element movable parallel to the shaft axis, the element including means for heating the cement to loosen the wheel on the shaft, means for removing and discarding the wheel, means for placing a new wheel on the shaft, and means for cementing a new wheel to the shaft.

15. A grinding machine comprising a wheel head, a shaft extending from the head, an abrasive wheel mounted on the shaft, cement interposed between the wheel and shaft to hold them together, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operation, a wheel-changing element movable parallel to the shaft axis, the element including means for enveloping the wheel and heating the cement to loosen the wheel on the shaft, means for removing and discarding the wheel, and means for cementing a new wheel to the shaft.

16. A grinding machine comprising a wheel head, a shaft extending from the head, an abrasive wheel mounted on the shaft, cement interposed between the wheel and shaft to hold them together, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operations, a wheel-changing element movable toward and away from

the shaft and wheel, the element including means for enveloping the wheel and heating the cement to loosen the wheel on the shaft, means for removing and discarding the wheel, means for placing a new wheel on the shaft and means for cementing a new wheel to the shaft.

17. A grinding machine comprising a wheel head, a serrated shaft extending from the head, a tubular abrasive wheel mounted on the shaft, cement constituting the only means for holding the wheel on the shaft, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operation, a passage formed entering the free end of the shaft and terminating on the outer surface of the shaft to permit cement to be forced between the shaft and wheel.

18. A grinding machine comprising a wheel head, a serrated shaft extending from the head, a tubular abrasive wheel mounted on the shaft, cement constituting the only means for holding the wheel on the shaft, the cement having a melting point well above the normal temperatures to which the wheel will be raised during normal grinding operation, the wheel having a circular cylindrical outer surface, a circular cylindrical bore and plane ends lying at right angles to the axis of the wheel, a passage being formed entering the free end of the shaft and terminating on the outer surface of the shaft to permit cement to be forced between the shaft and wheel.

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