Dec. 10, 1940. G. W. BINNS 2,224,423

PROCESS AND APPARATUS FOR FINISHING PREGROUND ARTICLES

Filed June 8, 1939 2 Sheets-Sheet 1

Fig. 1

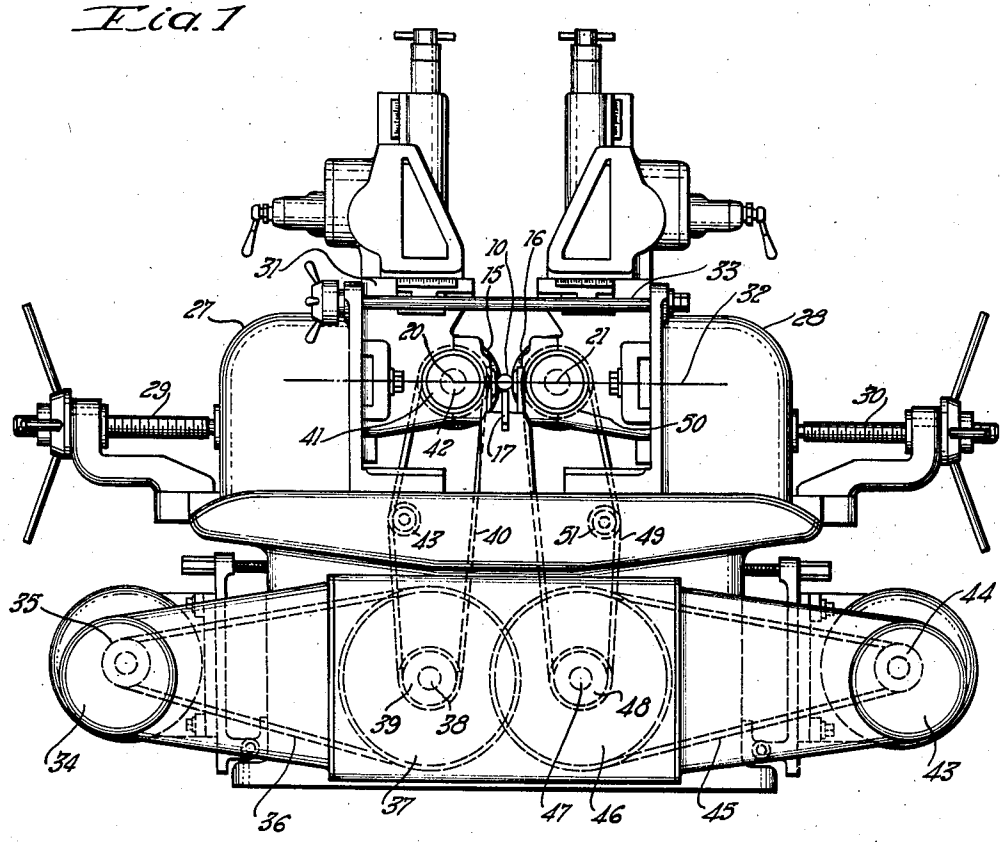
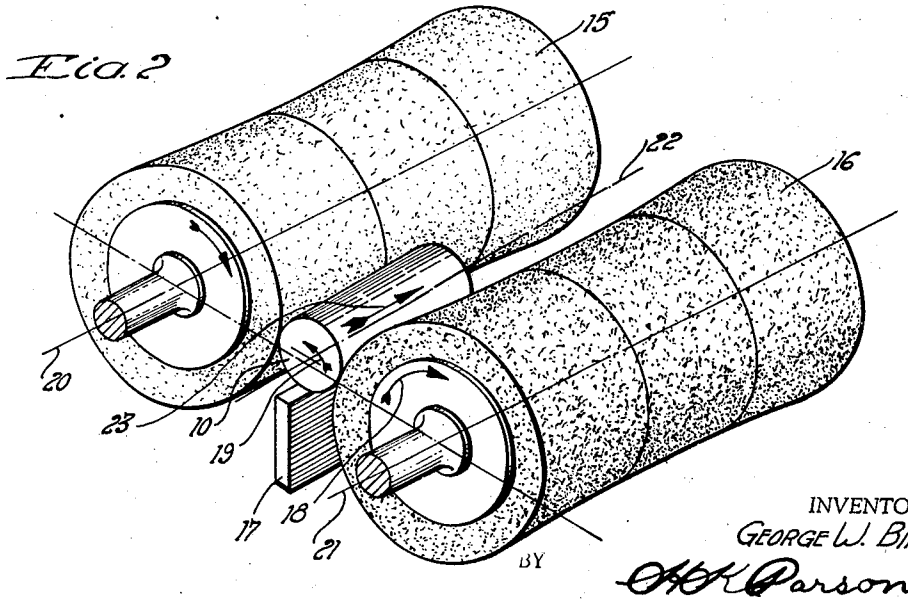


Fig. 2



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Fig. 3

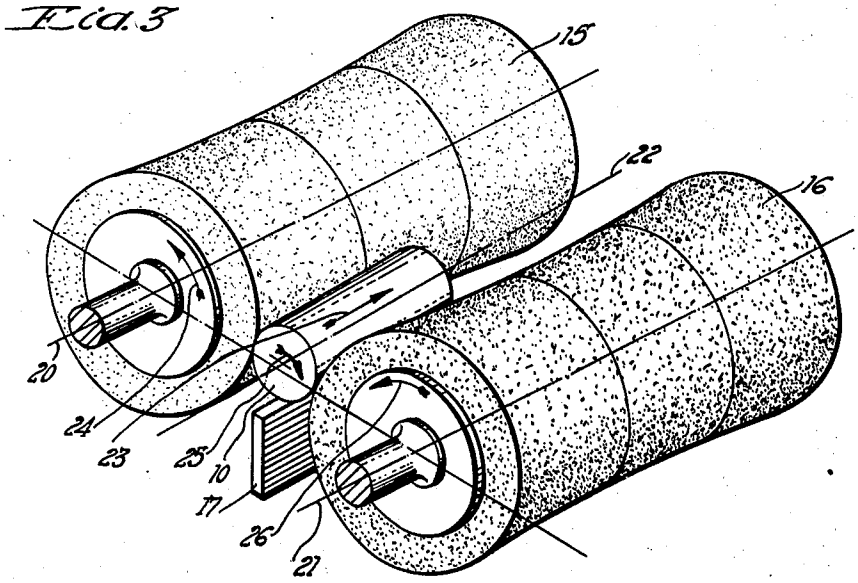


Fig. 5



Fig. 6



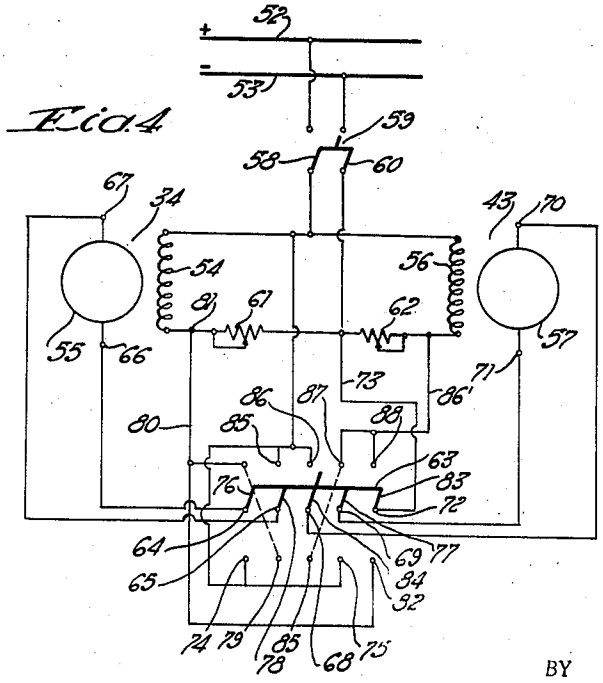
Fig. 7



Fig. 8



Fig. 4



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UNITED STATES PATENT OFFICE

2,224,423

PROCESS AND APPARATUS FOR FINISHING PREGROUND ARTICLES

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Application June 8, 1939, Serial No. 278,063

4 Claims. (Cl. 51—103)

When a work piece leaves a conventional grinding machine of either the center or centerless type, microscopic examination of the surface reveals that it has a definite texture or a nap which may be defined as fine lines extending circumferentially about the work and lying in cross sectional planes which are substantially perpendicular to the axis of work rotation. These lines, which are really grooves, are cut by the granulations on the surface of the wheel, and since the axis of the work was parallel to the axis of the grinding wheel during the grinding operation, these grooves lie in planes which are perpendicular to the axis of the work. It will thus be obvious that the surface is relatively rough and consists of alternate projections and hollows.

If such a surface is subjected to wear the high points of the projections will naturally wear away first and also very quickly, whereby the practical diameter of the work is immediately reduced. If such parts are used in precision machinery a certain amount of play or looseness immediately develops.

One of the objects of this invention is to produce a finished surface on the work in which these projections have been reduced to a minimum by the time that the work has been reduced to its desired size.

Another object of this invention is to provide an improved process for finishing preground surfaces.

A further object of this invention is to provide one form of apparatus for performing the process described herein.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims without departing from or exceeding the spirit of the invention.

Referring to the drawings in which like reference numerals indicate like or similar parts:

Figure 1 is a front elevation of an apparatus for performing the process of this invention.

Figure 2 is a diagrammatic view illustrating one manner of performing the first step in the process of this invention.

Figure 3 is a diagrammatic view illustrating the second step in the process.

Figure 4 is a diagrammatic view of the electrical control circuit for the machine shown in Figure 1.

Figure 5 is a diagrammatic view illustrating the nature of the nap on a work piece produced by conventional grinding operations.

Figure 6 is a diagrammatic view illustrating the nap on a work piece after the first step of the process.

Figure 7 is a diagrammatic view of the nap produced by the second step of the process.

Figure 8 is a diagrammatic view illustrating the composite result of the process.

It is recognized in the grinding art that the finish produced by a conventional grinding operation is not sufficiently flat for parts which are to be used in the manufacture of precision machinery, requiring close fits, measurable in micro-inches. The grains of the abrasive members utilized in conventional grinding operations must be sufficiently large to remove the excess stock left for grinding purposes in a reasonably short time with the result that the final surface has what is termed grinding lines running circumferentially about the work.

The analysis of the surface shows that these lines are fine grooves with the result that the surface is composed of a series of alternate projections and depressions. It is the peaks of these projections which apparently wear away very quickly when the part is put to use producing the undesirable wear after very short usage.

After the projections have been somewhat flattened, the rate of wear is then very slow.

This invention deals with a process and apparatus for producing a surface which does not have such marked projections and depressions, thus eliminating the possibility of quick initial wear when the part is put to use.

Referring to Figure 5 of the drawings there is illustrated on a cylindrical work piece 10 the direction of the grindng lines 11 with respect to the axis of rotation 12 of the work which are produced by a conventional grinding operation.

It will be noted that these lines lie in planes which are substantially perpendicular to the axis of rotation and this is because the work is held substantially parallel to the axis of rotation of the grinding element. The first step of the process of this invention is to subject the work piece 10 in the condition shown in Figure 5 to an abrasive element which has a grain smaller than the original grinding element, as, for example, two or three times smaller, and maintaining the axis of the work at a small acute angle relative to the axis of the abrasive element while travers-

ing the work past the grinding element whereby a cross wiping effect is obtained which will produce grinding lines, such as those indicated by the reference numeral 13 in Figure 6. Because of the finer grain of the wheel used in this first step, the grinding lines produced will not be as deep as the original grinding lines and furthermore the tops of the original projections will be removed. It will thus be apparent that the net result is a flatter surface in that the distance between the top of the highest projection and the bottom of the deepest groove is reduced.

In the next step of the process the work piece is subjected to another abrasive element of still finer grain, such as two or three times smaller than the last, and the work is passed relative to this wheel in a plane, making an angle with the axis of the grinding wheel which is the opposite or negative of the first-named acute angle and which will produce grinding lines lying at the angle indicated by the lines 14 in Figure 7. This will tend to further reduce or flatten off the original projections without producing new grooves which would aggravate the situation. The composite results of these steps are shown in Figure 8.

The process further includes in the first step the utilization of the finest grained wheel for rotating the work while grinding with the coarser grained wheel, and then in the second step of rotating the work with the coarser grained wheel while the finest grained wheel is doing the grinding. The work is moved relative to this pair of wheels in the same direction regardless of which wheel is doing the grinding.

The first step of the process is illustrated in Figure 2 in which the reference numeral 15 represents the coarser grained wheel and the reference numeral 16 represents the finer grained wheel. The work piece 10 is supported between these wheels on a work rest blade 17 and the wheel 16 is rotated in the direction of the arrow 18 at a relatively slow rate to effect rotation of the work in the direction of the arrow 19. The wheel 15 is rotated at a relatively fast rate to effect the grinding. The top of the work rest blade makes a slight acute angle to the plane determined by the axes 20 and 21 of the respective grinding wheels whereby the axis of travel 22 of the work is also inclined to this plane, thus producing the cross wiping effect connoted by the lines 13 in Figure 6. The inclination of the grinding wheels is such that the work is caused to travel automatically in the direction of the arrow 23.

The second step of the process is illustrated in Figure 3 and in this figure the coarser grained wheel 15 is rotated in the direction of the arrow 24 which is opposite to its direction of rotation shown in Figure 2, and its rate of rotation is relatively slow to effect rotation of the work in the direction of arrow 25, while the finer grained wheel 16 is rotated at a relatively fast rate and in the direction of arrow 26 to effect the grinding. Since the inclination of the wheels with respect to the surface of the work rest blade has not changed, the work will automatically feed in the same direction as indicated by the arrow 23.

It will thus be evident that an improved process has been provided for finishing preground parts which consists in subjecting the part to an abrasive element of a grain finer than the original elements which did the pregrinding, traversing the part relative to the abrasive element along a path angularly related with respect to the axis of the element and which is different from the angular relationship between the path of the work and the axis of the wheel in the pregrinding operation, whereby a cross wiping effect is produced; subjecting the part to a second abrasive element of a still finer grain, traversing the work relative to the last-named element along a path which is angularly related to the axis of rotation thereof and different from the angle in the first two cases whereby a second cross wiping effect is produced.

Considered more specifically, the process consists of presenting a work piece to a pair of grinding elements of different grains, rotating the work with the finer grained wheel and simultaneouly grinding the work with the coarser grained wheel; and then rotating the work with the coarser grained wheel and simultaneously grinding the work with the finer grained wheel.

As an example of an apparatus for performing the herein described process of finishing, a machine is shown in Figure 1 of the drawings comprising a bed 26 upon which is mounted a pair of adjustable supports 27 and 28. These supports are guided for movement relative to the bed 26 and may be adjusted by the screws 29 and 30 respectively. The support 27 carries a grinding wheel head 31 in which the grinding wheel 15 is rotatably journaled. The head 31 is attached to the support 27 for angular adjustment about the horizontal axis indicated by line 32, which passes through the longitudinal center of the grinding wheel axis 20.

The grinding wheel 16 is journaled at opposite ends in the head 33 which is attached to the support 28 for angular adjustment about the axis 32. A work rest blade 17 is supported on the bed 26 intermediate the wheels 15 and 16 and for illustrative purposes the top surface of this blade may be considered as lying in a horizontal plane.

Conventional means not illustrated may be utilized for raising or lowering this blade for changes in work size. The axes 20 and 21 and the work rest blade lie in parallel vertical planes but the axes 20 and 21 are angularly adjusted in their respective vertical planes about the horizontal axis 32 with the result that the plane determined thereby makes an acute angle with respect to a horizontal plane, and therefore, with respect to the top surface of the work rest blade. This provides the necessary cross wiping effect that is obtained on the work and it also determines the direction of feed of the work when inserted between the grinding wheels.

Since the work must, therefore, travel diagonally across the face of the wheels it will be apparent that in order to maintain the distance between the tangent points of the work with both wheels equal throughout the travel of the work the wheels must be trued to a slightly concave profile as viewed in plan. Since the mechanism for truing wheels in this manner is old and well known and forms no part of the present invention, it will not be described in detail here.

The mechanism for controlling the rate and direction of the rotation of the wheels will now be described.

The grinding wheel 15 is driven by a prime mover such as the electric motor 34 which has a drive pulley 35 connected by a belt 36 to a large pulley 37 fixed on shaft 38. The shaft 38 also carries a small pulley 39 which is connected by a belt 40 to pulley 41 integral with the

shaft 42 that supports the grinding wheel. An idler pulley 43 may be provided for removing the slack in belt 40 whenever the grinding wheel support is adjusted. It will be noted that the drive connections are such that if the electric motor drive pulley is rotated in a clockwise direction, it will effect clockwise rotation of the grinding wheel 15 which would correspond to the direction of rotation of this wheel illustrated in Figure 2.

The grinding wheel 16 is rotated by similar mechanism comprising the electric motor 43 having a drive pulley 44 which is connected by a belt 45 to a large pulley 46. The latter is attached to a shaft 47 which also carries a small pulley 48 connected by belt 49 to the grinding wheel pulley 50. An idler 51 is also provided for adjusting the tightness of the belt 49. It should also be noted that clockwise rotation of the motor pulley 44 will cause clockwise rotation of the grinding wheel 16 which corresponds to the direction of rotation of this wheel in Figure 2 of the drawings.

It will now be apparent that if both of the electric motors are rotated in a clockwise direction that the grinding wheels will be rotated in a direction to satisfy the conditions shown in Figure 2. As previously described, however, the wheel 16 must rotate at a slow rate relative to the rate of rotation of wheel 15. In the step shown in Figure 3, the direction of rotation of both wheels is changed, and in addition their rates of rotation are inversely changed with wheel 15 rotating at a slow rate and wheel 16 rotating at a fast rate.

An electrical control circuit for the electric motors has been provided as shown in Figure 4, which is so contrived that by the use of a single control element either condition of operation may be selected. In this figure the motors are assumed to be direct current motors which are supplied from the power mains 52 and 53. The field coil of the motor 34 is indicated by the reference numeral 54 and the armature by the reference numeral 55. The field coil of the motor 43 is indicated by the reference numeral 56 and the armature by the reference numeral 57. One end of each of the field coils are connected in parallel to the blade 58 of the cut-out switch 59. The other ends of these coils are connected to the blade 60 of switch 59 through separate variable resistances 61 and 62 respectively. It will be apparent that when the switch 59 is closed that current will flow continuously through the field coils of the two motors and in the same direction. Reversal of the motors is, therefore, effected by changing the direction of flow of the current in the armatures and the rate is varied by selectively cutting in or short circuiting the resistances 61 and 62.

All of this is selectively obtained by a single control member comprising a five-pole double throw switch 63. The poles 64 and 65 of this switch are connected to the brushes 66 and 67 respectively of the motor armature 55. The poles 68 and 69 are connected to brushes 70 and 71 of the motor armature 57. The pole 72 is connected by line 73 directly to the blade 60 of switch 59.

When the switch is thrown down, as viewed in Figure 4, the positive main 52 is connected to switch contacts 74, 75 and through switch blades 76 and 77 to armature brushes 66 and 71 of the respective motors whereby the current will flow through both motors in the same manner, thus causing the same direction of rotation which, for purposes of description, may be arbitrarily assumed to be in a clockwise direction. This will cause rotation of the grinding wheels in the respective directions indicated in Figure 2. The brush 67 of motor 34 is connected through switch blade 78 and contact 79 to branch line 80 which has one end 81 connected to the lower end of field coil 54 and the other end connected to the switch contact 82. The contact 82 is connected by switch blade 83 directly to the negative power main 53 whereby the variable resistance 61 is short-circuited with the result that the motor 34 will rotate at the faster rate.

The brush 70 of motor 43 is connected to switch blade 84 and contact 85 to line 86 which terminates at the lower end of field coil 56. Since no other outlet is provided, the current must flow through the resistance 62 to the negative main 53, thus causing the motor 43 to rotate at a slow rate.

It will now be apparent that when the switch is thrown down that both motors will be rotated in the same direction but one motor will be rotated at a fast rate and the other at a slow rate.

When the switch is thrown up the positive main 52 is connected through contacts 85 and 86 and switch blades 78 and 84 to motor brushes 67 and 70, thus causing the armatures to rotate in an opposite direction which will cause rotation of the grinding wheels in the direction indicated in Figure 3.

This time, however, the motor brush 66 is connected through blade 76 to line 80, and since the contact 82 is open the return connection to the negative main 53 must be through the resistance 61 whereby the motor 34 will rotate at a slow rate.

The brush 71 of motor 43 is connected by the switch blade 73 to contact 87 and line 86 which also has a connection to the lower end of field coil 56, but the line 86 has a branch connection to switch contact 88 which this time is connected through switch blade 83 and line 73 directly to the negative power main 53 whereby the motor 43 will rotate at a fast rate. Thus, the use of a single selector element, the direction of rotation and the respective rates of rotation may be changed to select the condition shown in Figure 2, or the one shown in Figure 3.

There has thus been provided an improved process and apparatus for finishing cylindrical work pieces and in carrying out the process it will be obvious that a group of work pieces may be passed through the machine with the set-up shown in Figure 2 and then passed through the machine with the set-up shown in Figure 3, rather than performing the complete process on one work piece before starting the next one through.

Attention is also invited to the fact that the relative acute angularity of the wheel axes with respect to the surface of the blade need not be exactly the same. For instance, they can be made different to vary the rate of work feed in the different steps and this will also vary the angle of the cross wiping for the different steps.

What is claimed is:

1. In a grinding machine, the combination of a pair of opposed grinding wheels of different grains supported for rotation on parallel axes, a work rest blade supported intermediate said wheels, separate prime movers for driving said wheels, an electrical control circuit for said prime movers, including a reverse switch for simultaneously changing the direction of rotation of said wheels, separate electrical resistance means in said circuit for reducing the rate of rotation of each prime mover, and means controlled by the alter-

nate positions of said switch for alternately short-circuiting said resistance means whereby for one direction of rotation, the coarser grained wheel will run faster, and for the other direction of rotation the finer grained wheel will run faster.

2. A machine of the character described, including a work rest member adapted rotatably to support a work piece, a pair of abrading wheels disposed on opposite sides of the work rest for engagement laterally with a supported work piece, means rotatably mounting said wheels with their axes inclined as respects the potential work path as determined by the work rest, a first means operable to rotate one of said wheels in opposite directions and at a different speed in one direction of rotation from the speed in the other direction of rotation, a second means for effecting rotation of the other of said wheels in either direction and at inverse speeds as respects the corresponding directional speeds of the first wheel, whereby each of said wheels will function as an abrading member in one direction of rotation and a regulating member in the opposite direction of rotation.

3. A machine of the character described, including a work rest member adapted rotatably to support a work piece, a pair of abrading wheels disposed on opposite sides of the work rest for engagement laterally with a supported work piece, means rotatably mounting said wheels with their axes inclined in a common direction as respects the potential work path as determined by the work rest, a first means operable to rotate one of said wheels in opposite directions and at a different speed in one direction of rotation from the speed in the other direction of rotation, a second means for effecting rotation of the other of said wheels in either direction and at inverse speeds as respects the corresponding directional speeds of the first wheel, whereby each of said wheels will function as an abrading member in one direction of rotation and a regulating member in the opposite direction of rotation, and a unidirectional feeding movement of the work will be effected by the alternately employable regulating wheels.

4. A machine of the character described, including a work rest member adapted rotatably to support a work piece, a pair of abrading wheels disposed on opposite sides of the work rest for engagement laterally with a supported work piece, means rotatably mounting said wheels with their axes inclined as respects the potential work path as determined by the work rest, a first means operable to rotate one of said wheels in opposite directions and at a different speed in one direction of rotation from the speed in the other direction of rotation, a second means for effecting rotation of the other of said wheels in either direction and at inverse speeds as respects the corresponding directional speeds of the first wheel, whereby each of said wheels will function as an abrading member in one direction of rotation and a regulating member in the opposite direction of rotation, and a single control device for the respective actuators for jointly determining the direction and rate of actuation of the respective wheels.

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