Sept. 3, 1946. B. E. LUBOSHEZ 2,407,206

METHOD AND APPARATUS FOR GRINDING AND POLISHING SURFACES

Filed June 23, 1944

Fig. 1.

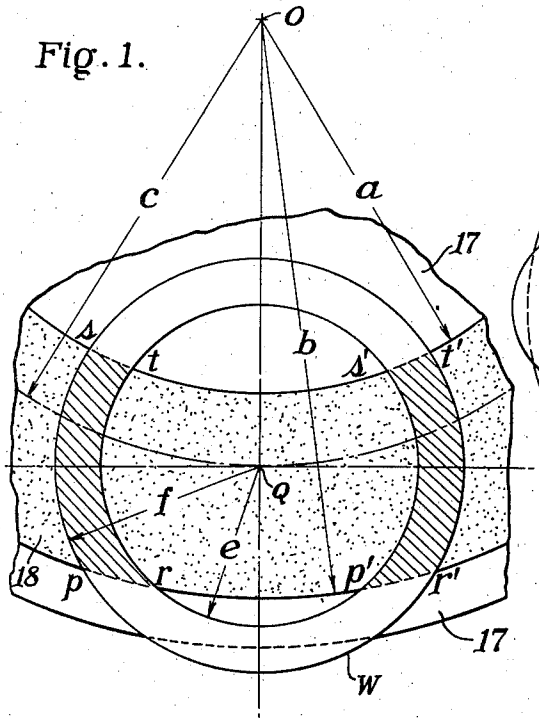


Fig. 2.

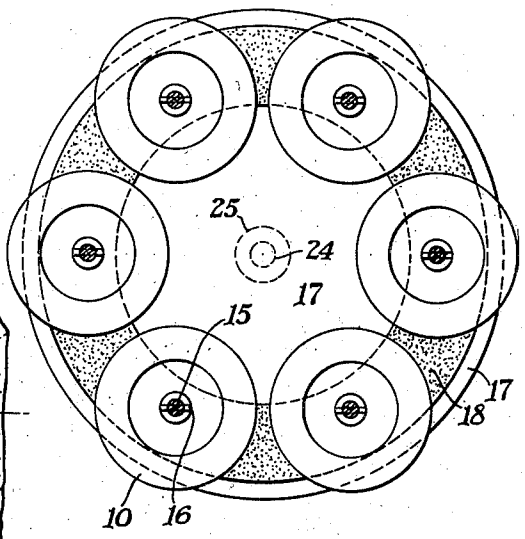


Fig. 3.

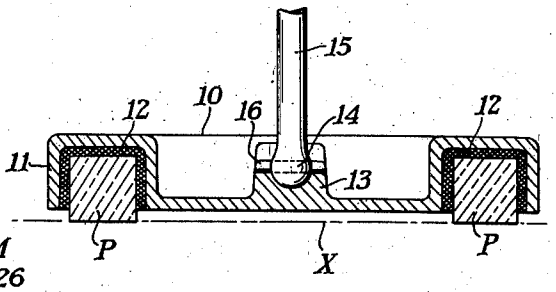
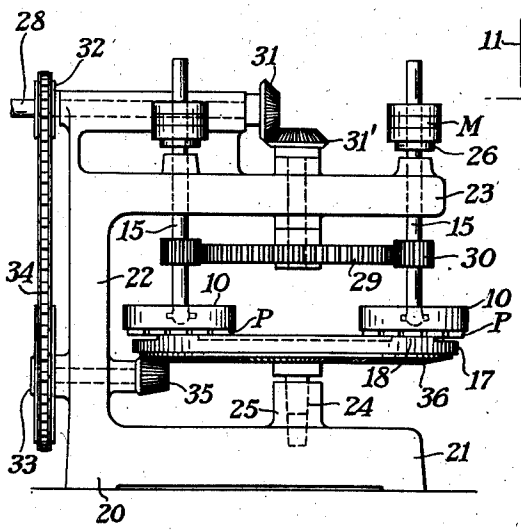


Fig. 4.



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METHOD AND APPARATUS FOR GRINDING AND POLISHING SURFACES

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Application June 23, 1944, Serial No. 541,679

9 Claims. (Cl. 51—131)

1

The present invention relates to grinding and polishing surfaces, and particularly to a method and apparatus by the use of which a flat surface can be obtained automatically with little or no individual adjustment by an operator.

In my copending patent application, Serial Number 537,410, filed May 26, 1944, I disclosed methods and apparatus for grinding and polishing surfaces under conditions of uniform wear at all points on the surface and at the same time obtaining a regime of uniform wear at all points on the tool. The latter condition was achieved partly through the agency of a separate compensating "shoe" working upon the tool.

The present invention is an improvement on that disclosed in my above noted copending patent application. According to the present invention, conditions of uniform wear on all points of the work and tool are achieved by a very simple machine involving only rotational movements, or their equivalent, and no auxiliary apparatus. The present invention is intended primarily for the grinding and polishing of flat surfaces, such as the various faces of optical prisms and flat plates of small dimension (up to a few inches across), but the same is adapted for working small lenses of shallow curvature.

One object of the present invention is to provide a method of grinding and polishing surfaces under conditions of uniform wear on all parts of the surface being worked and/or on all parts of the tool being used so that no adjustment of parts is required by the operator during the operation and the procedure is thereby rendered automatic.

Another object of the present invention is to block the work in the form of an annulus, or ring, and bring it into surface contact with an arcuate or annular grinding surface in such a way that the surface to be finished is subjected to uniform wear at all points when the block of work is rotated.

And another object is to further dispose the block of work relative to the annular grinding surface so that the tool is subjected to uniform wear as well as the work as the latter is rotated.

And a further object is to provide an apparatus for carrying out this novel method and which apparatus is very simple and involves only rotational movements, or their equivalent, and no auxiliary apparatus.

And yet another object is to provide an apparatus which makes possible the production of a large volume of work with the use of a single grinding tool.

2

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its methods of operation, together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments when read in connection with the accompanying drawing in which,

Fig. 1 is an enlarged diagrammatic view showing an annular surface of work engaging a portion of an annular grinding surface, in accordance with the present invention, and used to prove that, with such a given disposition of the two parts, when the work is rotated about its center relative to the tool, all points on the work and/or all points on the tool are subject to uniform wear,

Fig. 2 is a diagrammatic plan view showing how the parts can be disposed so that a single tool can be utilized to grind six blocks of work,

Fig. 3 is a vertical section of a preferred embodiment of blocking tool used in the present apparatus, and

Fig. 4 is a side elevation, on a reduced scale, of a complete machine constructed in accordance with the present invention. For the sake of clarity and simplicity, only two blocks of work have been shown engaging the tool in diametrically disposed relationship on the tool, rather than six as shown in Fig. 3, but it is pointed out that the drive of the machine is capable of handling as many blocks of work as the circumference of the tool will allow.

Like reference charaters refer to corresponding parts throughout the drawing.

In accordance with the present invention, if the job at hand is to polish a given face on a plurality of elements, such as optical prisms, a number of the prisms or elements are mounted on a block in side by side relation in a circle so that the several surfaces to be ground and polished lie substantially in a common plane and form a substantially continuous annulus of work. As shown in Fig. 3, a suitable block 10 of the work may comprise a disk member having the edge deformed to provide a trough or prism seat 11 extending completely around the disk adjacent the periphery thereof and concentric with the center. If the elements to be worked are prisms, a plurality of them, two being shown in Fig. 3 at P, are mounted in side-by-side relation in the trough by means of cement, plaster of Paris, etc., 12 with the surface of each to be ground lying substantially in a common plane X which is spaced from the lower face

of the block. The blocking step can be accomplished in a well-known manner by first placing a quantity of the cement in the trough and, after placing the prisms therein, pressing the surfaces of the prism to be worked against a plane surface. When the elements of work are so mounted in the block, the surface of each to be finished join to form a substantially continuous surface of annular configuration which might be called an annulus of work.

The back of the block **10** is provided at its center with a boss **13** which constitutes a socket to receive the ball end **14** on a vertical spindle **15** which is adapted to be rotated in a manner later described. The ball **14** has a horizontal pin **16** extending therethrough which engages corresponding slots or openings in the socket so that the spindle can rotate the block **10** and at the same time the block is free to pivot relative thereto in one direction if necessary.

One or more of such "blocks" of work, or assembly of optical parts, is arranged to rotate rapidly and press upon a large flat annular tool **17**. In practice, the tool is a circular disk with a raised annular region **18** which constitutes the grinding surface. The block of work is mounted relative to the tool as diagrammatically shown in Fig. 1 wherein only an arcuate portion of the tool is shown engaged by one block of work. Considering only an arcuate portion of the tool engaged by one block, the grinding surface constitutes an elongated surface which is longer than it is wide and the width of which is less than the diameter of the annulus of work.

As shown in Fig. 1, the block of work is mounted above the tool so that the annulus of work extends across the width of the grinding surface, and there are two arcuate areas of contact (*prts*) and (*p'r't's'*) between the grinding surface and the annulus of work which are oppositely disposed on the annulus of work or disposed circumferentially of the grinding surface. In Fig. 1, the entire blocking tool is not shown, but only a ring W is shown representing the annulus of work in order to point out what disposition of the work and grinding surface is required to obtain uniform wear on the tool and work in accordance with the present invention. The shaded areas (*prts*) and (*p'r't's'*) represent the areas of the work and tool which are mutually in contact, and it is assumed that the whole area of the annulus of work W represents the surface being ground or polished. This condition can only be approximately realized in practice, but in any case, whatever errors are introduced affect the wear on the tool and not the wear on the work.

Consider the case when the annulus of work W is rotated about its center Q when the tool **17** is stationary, or the work is rotated sufficiently rapidly so that if the tool is rotated slowly, for the purpose hereinafter set forth, the motion of the grinding surface can be neglected. Under these conditions, it is clear that the wear at all points on the annulus W will be constant provided that all arcs concentric with the center Q of the annulus in the areas of mutual contact, such as (*ps*), (*rt*), (*p's'*), and (*r't'*) are of constant length, since these arcs represent the amount of grinding surface **18** that any point on the annulus W passes over. Consequently the annulus of work and the grinding surface are so mounted relative to one another that this specified condition exists. Since the tool **17** is stationary, or its angular speed compared to that of W is negligible, only the possibility of unequal wear along radial lines on W need be considered and wear along the circumferential lines would in any case average out.

The wear upon the grinding surface **18** along circles having **0** as a center need not be uniform since any such differences average out. However, any differences in wear in a radial direction cannot average out and must be considered in order to obtain uniform wear on the tool as well as on the work. In this case, the condition for uniform wear on the tool is that all ends of the arcuate areas of mutual contact such as (*pr*), (*st*), (*p'r'*), and (*s't'*) divided by their respective distances from the center **0** of the tool must be constant, i. e. $(pr) \div (b) = (st) \div (a)$. The annulus of work W and the grinding surface **11** are arranged relative to one another so that these specified relations exist.

So far, it has been assumed that the pressure is applied between the grinding surface **18** and the annulus of work W in a uniform manner, and this is only possible if pressure is applied over the center of gravity of the shaded areas (*prts*) and (*p'r't's'*) in the diagram. This application of pressure is obtained in the present instance by applying pressure to the block of work through the spindle **15** to the ball-and-socket joint **13, 14**, which is located at the center of the block.

Three conditions must, therefore, be realized in order to attain uniform wearing conditions on both the tool and the work, and the parts of the present apparatus are so dimensioned and relatively arranged as to make these conditions existant. For example:

$$(ps) = (rt) = (p's') = (r't')$$

$$\frac{(pr)}{(b)} = \frac{st}{(a)} = \frac{(p'r')}{(b)} = \frac{s't'}{(a)}$$

Q is the center of gravity of the shaded areas (*prts*) and (*p'r't's'*).

These conditions are easily attainable in practice by empirical trial. The following proportions (referring to Fig. 1) are given by way of example as fulfilling all the requirements and permitting the use of six spindle and block assemblies on one annular grinding surface,

$(a) = 9.1$
$(b) = 14.1$
$(c) = 11$
$(d) = 4$
$(f) = 5$

While theoretically, conditions of uniform wear on the work and tool depend on the grinding surface being stationary, in practical operation it is not feasible to keep the grinding surface stationary because the grinding action thereon by the work would be repetitive and arcuate grooves would be worn therein. It is, therefore, necessary, from a practical standpoint, to move the grinding surface relative to the work in order, not only to make the wear thereon nonrepetitive, but also in order to distribute the abrasive uniformly. If the tool is rotated very slowly, say one-half R. P. M., or very slow relative to the rotation of the work, there will be insufficient grinding action on the work due to such movement to upset the specified conditions of uniform wear on the parts and the life of the tool will be greatly increased due to the fact that the grinding action of the work on the tool will be rendered nonrepetitive.

The present invention is conducive to greatly increased production per machine, or per grinding tool. In Fig. 2 I have shown how six blocks **10** of work may be simultaneously ground and

polished on a single tool 17 having an annular grinding surface 18. In a practical form of the machine, six vertical power driven spindles are arranged above a rotatable turn-table in the manner similar to a multiple-spindle vertical drill press. The number of blocks of work which can be handled by a single tool is limited only by the relative diameters of the block and the annular grinding surface.

In Fig. 4 I have shown one embodiment of a complete machine for carrying out the present invention. For purposes of clarity, in this machine only two blocks of work have been shown diametrically disposed on the annular grinding tool, although it will be readily appreciated that the same drive could be used for the six spindle machine illustrated in Fig. 2. The machine comprises a frame 20 including a base 21, an upright 22, and an arm 23 extending from the upright 22 in vertical spaced relation with the base 21. A tool 17 having an annular flat grinding surface 18 is rotatably mounted on the base 21 by having a conical post 24, extending from the bottom thereof, engaging a conical bearing 25 on the base.

Rotatably and slidably mounted in bearings in the arm 23 are a pair of vertical spindles 15 on the lower ends of which blocks 10 of work are connected in the manner shown in Fig. 3. The blocks of work are like that illustrated in Fig. 3 and one of each is disposed relative to the grinding surface in the relationship shown in Fig. 1. Each block of work 10 is pressed against the annular grinding surface by weights M slidably mounted on the top of the spindle and supported thereon by a flange 26 fixed to the spindle.

For rapidly rotating the blocks of work and very slowly rotating the annular grinding surface the following drive may be provided. The power driven shaft 28 is connected to a relatively large and centrally located spur gear 29 through bevel gears 31 and 31'. This large spur gear is in turn in mesh with a small pinion 30 fixed to each of the spindles 15, the pinions being long enough to permit the spindles to be raised and lowered without disengaging the gears. If the drive shaft 28 is rotated at 10 R. P. M. then the gearing shown to the blocks of work will permit said blocks to be rotated at approximately 60 R. P. M. which is the conventional grinding or polishing speed.

For obtaining a very slow rotation of the annular grinding surface to prevent nonrepetitive grinding action thereon the following drive therefor may be provided. A small sprocket 32 is fixed to the drive shaft 28 to the left of the upright 22 and is connected to a larger sprocket 33 by a chain 34. The sprocket 33 drives a small bevel gear 35 which meshes with a large bevel gear 36 formed on, or fastened to, the under side of the tool 17. With this drive, it is possible to obtain a ½ R. P. M. of the tool with a 10 R. P. M. of the driving shaft, and which speed is slow enough so as not to upset the specified conditions of uniform wear on the work and grinding surface, but is sufficient to prevent a nonrepetitive grinding action on the grinding surface.

As will be apparent from an inspection of Fig. 1, if only one or two blocks of work are to be used the grinding surface need not be a complete annulus but need only be an arcuate section sufficiently long to extend clear across the block, or blocks, of work to be surfaced. In this case the grinding surface would then be oscillated about its center beneath the work rather than being given a complete rotational movement.

It is believed that it will be obvious to those skilled in the art that the present method and apparatus for grinding and polishing, by virtue of the conditions of uniform wear on the work and/or on tool obtainable by the use thereof, is conducive to automatic operation and does away with the need of skilled operators. No adjustments of the tool and/or work by the operator is necessary, and which adjustments have been required with conventional grinding and polishing procedures and have demanded an experienced operator, due to the prevailing conditions of uniform wear. The only thing which might require an operator would be the periodic application of an abrasive and/or lubricant to the work, and even this step can be automatically accomplished by existing systems. In addition, the present invention greatly increases the output of each machine, because the novel method of blocking the work, along with the novel disposition of the block of work and tool, makes it possible for a single tool to accommodate a plurality of blocks rather than only one or two.

While I have shown and described certain specific embodiments of my invention, I am aware that many modifications thereof are possible. My invention, therefore, is not to be limited to the precise details and construction shown and described but is intended to cover all modifications coming within the scope of the appended claims.

Having thus described my invention, what I claim is new and desire to secure by Letters Patent of the United States is:

1. The method of abrading a surface on a plurality of members under a condition of uniform wear on all surfaces by the use of a grinding tool having a grinding surface which is longer than it is wide, and comprising the steps of blocking the members so that the surfaces thereof to be worked form a substantially continuous and plane surface in the form of an annulus, the inner diameter of which is greater than the width of said grinding tool; disposing the said annulus of work relative to the tool so that when the two are brought into surface contact the annulus of work will extend across the width of the tool and will have two oppositely disposed arcuate areas in contact therewith at any instant, the disposition of the annulus relative to the tool also being such that the lengths of all arcs concentric with the center of said annulus in said arcuate areas are of equal length; forcing the tool and annulus of work together in such a way that the pressure per unit area is equal over the areas of the two in contact; and rotating said annulus of work about its own center relative to the tool.

2. The method of abrading a surface on a plurality of members by the use of a grinding tool having an arcuate plane grinding surface which is longer than it is wide and under conditions of uniform wear on all surfaces being ground and on the surface of the tool, and comprising the steps of blocking the members so that the surfaces thereof to be worked form a substantially continuous and plane surface in the form of an annulus, the inner diameter of which is greater than the width of said grinding surface; disposing said annulus of work relative to the tool so that when the two are brought into surface contact the annulus of work will extend across the width of the grinding surface and will have two

oppositely disposed arcuate areas in contact therewith at any instant, the disposition of the annulus relative to the tool also being such that the lengths of all arcs concentric with the center of said annulus in said arcuate areas are of equal length, and the ratio of the width of each end of said arcuate areas to the radius of the grinding surface to that end will be equal to one another; forcing the tool and annulus of work and said grinding surface together in such a way that the pressure per unit area is equal over the arcuate areas of the two in contact; and rotating said annulus of work about its own center relative to the grinding surface.

3. The method according to claim 2, and including the step of continuously rotating the grinding surface about its center relative to the annulus of work at a very slow speed relative to the speed of rotation of the annulus of work in order to provide a nonrepetitive grinding action on the grinding surface by the work.

4. A grinding and polishing apparatus comprising in combination a tool having a grinding surface which is longer than it is wide; a blocking member adapted for blocking a plurality of elements in side by side relation with the surface of each element to be worked lying substantially in a common plane and constituting a substantially continuous annular surface the inner diameter of which is greater than the width of the grinding surface; means for mounting said blocking member relative to said tool so that said annular surface extends across the width of said grinding surface and is adapted to contact the same in two oppositely disposed arcuate areas each and every arc thereof which is concentric with the center of said annular surface being of equal length; means for applying a pressure to the blocking member to force said annular surface against said grinding surface, said means disposed so that the pressure per unit area between the grinding surface and said annular surface is equal over the entire areas of the two in contact at any instant; and means for rotating said blocking member relative to said tool about an axis which is at the center of said annular surface.

5. An apparatus according to claim 4, in which the grinding surface of the tool is arcuate in shape, and in which the block is further so disposed that the ratio of the width of each end of said arcuate areas of contact to the radius of the grinding surface to said respective ends is equal one to the other, whereby a uniform wear is obtained on the tool as well as on the surfaces being abraded.

6. An apparatus according to claim 4, in which the grinding surface of the tool is arcuate in shape, and in which the block is further so disposed that the ratio of the width of each end of said arcuate areas of contact to the radius of the grinding surface to said respective ends is equal one to the other, whereby a uniform wear is obtained on the tool as well as on the surfaces being abraded; and means for moving said tool so that the grinding surface rotates very slowly about its center in order that the grinding action on said surface by the work will be nonrepetitive, the speed of movement of said surface relative to the speed of the work being small enough so that the conditions of equal wear on the surface and work due to the disposition of the two is not upset.

7. A grinding and polishing apparatus comprising in combination a tool having an annular grinding surface of substantially large diameter; a plurality of blocking members, each adapted for blocking a plurality of elements in side by side relation with the surface of each element to be worked lying substantially in a common plane and constituting a substantially continuous annular surface the inner diameter of which is greater than the width of the grinding surface; means for mounting said blocking members in circumferentially spaced relation about said grinding surface so that the annular surface of work on each extends across the width of said grinding surface and is adapted to contact the same in two oppositely disposed arcuate areas each and every arc thereof which is concentric with the center of said annular surface being of equal length and so that the ratio of the width of each end of said arcuate areas of contact to the radius of the grinding surface to said respective ends is equal one to the other; means of applying pressure to the blocking members so that the pressure per unit area between the grinding surface and said annular surfaces is equal over the entire areas of contact at any instant; and means for rotating each of said blocking members relative to said grinding surface about an axis which is the center of the annular surface mounted thereon.

8. An apparatus according to claim 7 in which each blocking member comprises a disc provided on one face with a circular recess concentric with the periphery of the disc and in which the elements to be ground are adapted to be seated in side by side relation with the surface of each to be ground extending beyond the face of the disc and lying substantially in a common plane and thereby form a substantially continuous surface to be worked which is annular in shape.

9. A blocking member for blocking a plurality of elements, a plane surface of each of which is to be abraded, an comprising a disc having a face lying in a plane; said face provided with an annular recess concentric with the center of said disc and in which a plurality of elements to be abraded are adapted to be fixedly mounted in side-by-side and substantially abutting relation with the surface of each element to be abraded lying substantially in a common plane, said surfaces jointly constituting a substantially continuous surface of annular configuration; and a socket fixed to the center of the face of said disc opposite that face provided with said recess and adapted to receive a ball end on a pressure transmitting and driving spindle, whereby the pressure per unit area between the surface of the work blocked on said disc and a grinding plane will be equal over the entire area of contact between the work and grinding surface.

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