Aug. 27, 1940. R. A. COLE 2,213,024

OPTICAL SIZING APPARATUS

Original Filed Jan. 9, 1937 2 Sheets-Sheet 1

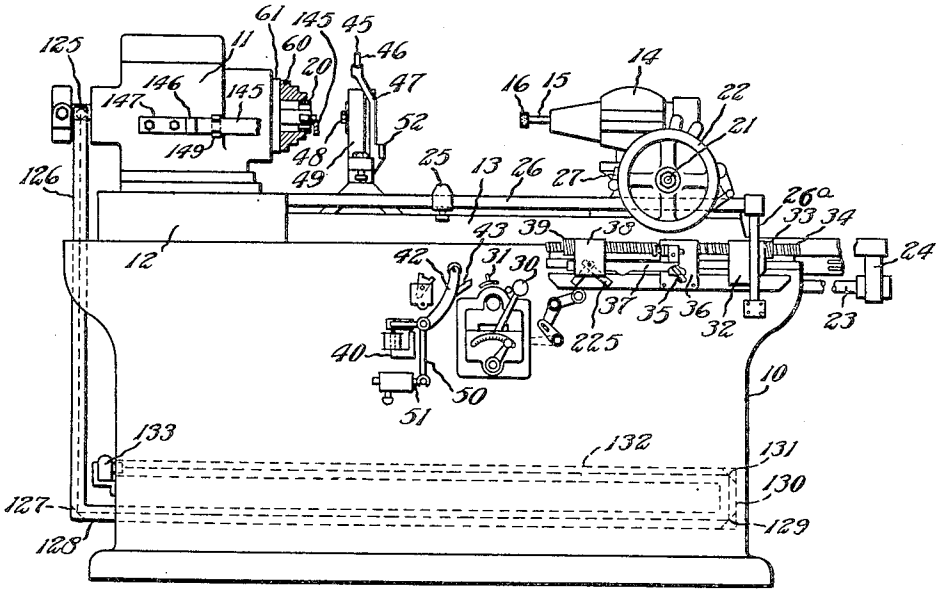


Fig. 1

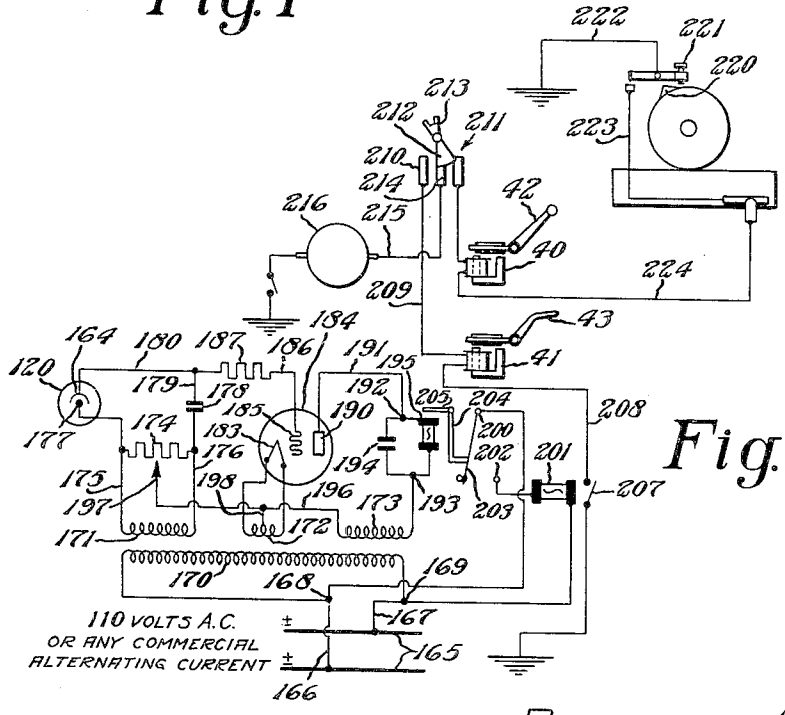


Fig. 2

Inventor

RAYMOND A. COLE

George Crompton Jr.

Attorney

Aug. 27, 1940. R. A. COLE 2,213,024

OPTICAL SIZING APPARATUS

Original Filed Jan. 9, 1937 2 Sheets-Sheet 2

Fig. 3

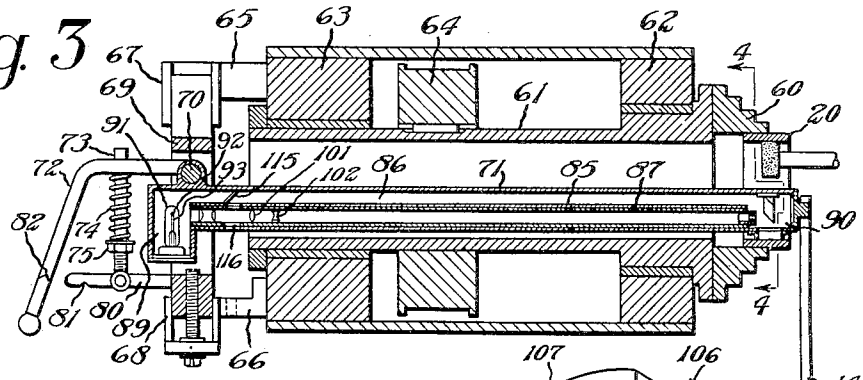
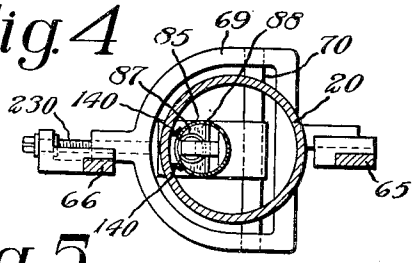


Fig. 4



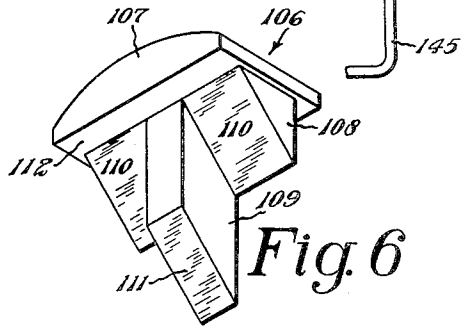


Fig. 6

Fig. 5

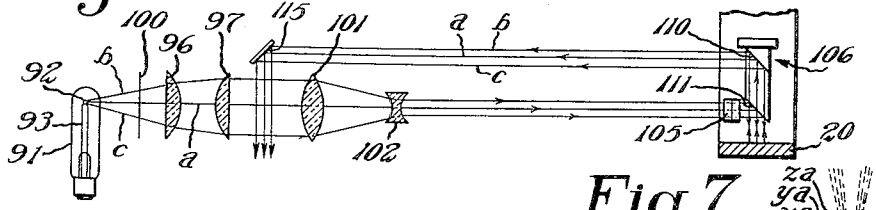


Fig. 7

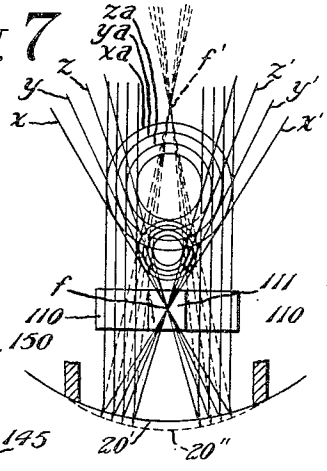
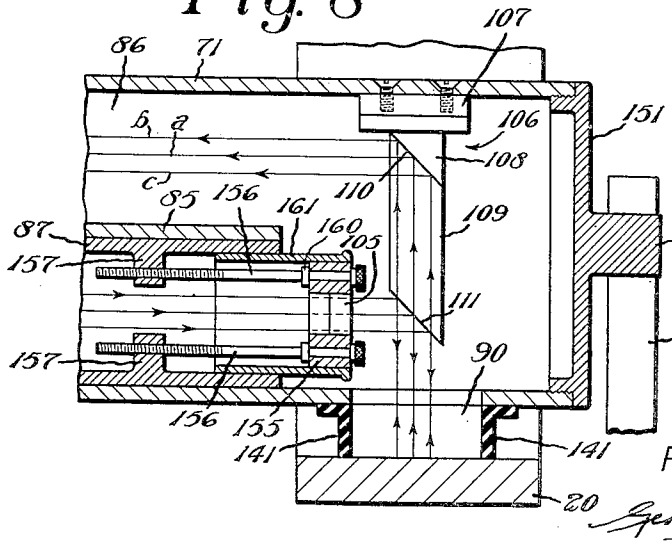


Fig. 8



Inventor

RAYMOND A. COLE

George Compton Tompkins

Attorney

Patented Aug. 27, 1940

2,213,024

UNITED STATES PATENT OFFICE

2,213,024

OPTICAL SIZING APPARATUS

Raymond A. Cole, Worcester, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Original application January 9, 1937, Serial No. 119,772. Divided and this application January 27, 1938, Serial No. 187,239

3 Claims. (Cl. 33—14)

The invention relates to internal grinding machines, and particularly to automatically actuating size controlling apparatus therefor.

One object of the invention is to provide a sensitive photoelectric sizing apparatus for an internal grinding machine. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements and arrangements of parts, as will be exemplified in the structure to be hereinafter described, and the scope of the application of which will be pointed out in the following claims.

In the accompanying drawings illustrating one of many possible embodiments of the mechanical features of this invention,

Figure 1 is a front elevation of an internal grinding machine incorporating the invention;

Figure 2 is an electrical diagram;

Figure 3 is a horizontal axial sectional view of the optical apparatus for directing the rays against the work piece;

Figure 4 is a sectional view, taken on the line 4—4 of Figure 3;

Figure 5 is an optical diagram;

Figure 6 is a perspective view of one of the mirror instrumentalities which includes two reflecting surfaces;

Figure 7 is a further optical diagram in which the rays are projected into a single plane for purposes of illustration; and

Figure 8 is a fragmentary sectional view, on an enlarged scale, showing a portion of the optical apparatus.

Referring first to Figure 1, I provide an internal grinding machine which may be of the general type identified by the trade-mark "Size-Matic" and which, so far as some of its features are concerned, will be found described in United States Letters Patent No. 1,682,672 and No. 1,682,673 but, instead of relying on a predetermined advance beyond the dressing plane to control finished size of work pieces, I substitute the photoelectric apparatus herein particularly to be described. It should be understood, however, that I may embody the sizing apparatus more particularly described herein with any other type of internal grinding machine, for example that disclosed in McDonough Reissue Patent No. 16,141, using one of the gauges thereof to initiate a dressing operation.

Considering now the illustrative embodiment of the present invention, the machine includes a base 10, a work head 11 mounted on a bridge 12, and a carriage 13 mounted for reciprocatory movement on the base 10 under the bridge 12. The machine further includes a wheel head 14 mounted on a cross slide, not shown, which is mounted on the carriage 13 so that the wheel head 14 may be moved transversely of the direction of reciprocation of the carriage 13, that is to say substantially at right angles thereto. The wheel head 14 journals a spindle 15 upon which is mounted a small grinding wheel 16, and any suitable drive for the spindle 15 is provided. The ways supporting the carriage 13 guide the carriage 13 in the direction of the axis of the spindle 15 whereby the grinding wheel 16 may be advanced into a work piece 20, grind the work piece and thereafter withdraw to the position shown in Figure 1. The cross feed of the wheel head 14 on the carriage 13 is procured by rotation of a screw shaft 21 controlled by a hand wheel 22 and other mechanism more fully described in the patent to Taylor No. 1,682,673 referred to. The rectilinear movement of the carriage 13 may be procured by mechanical actuation or by fluid pressure actuation as, for example, by the use of hydraulic mechanism described in Heald and Guild Patent No. 1,582,468, which includes a cylinder-piston unit, not shown, actuating a piston rod 23 which is connected by a bracket 24 to the carriage 13. Automatic cross feed of the wheel head 14 is, as described in the Taylor patent referred to, achieved by a relative engagement of a cam 25 (adjustably fastened to a bar 26, one end of which is secured to the bridge 12 and the other end of which is secured by means of a bracket 26a to the base 10) with a roller, not shown, connected to a pawl 27. Pawl 27 actuates a ratchet wheel connected by reduction gearing to the screw shaft 21, all as is in detail illustrated in the Taylor patent referred to.

The control of the rectilinear movement of the carriage 13 may be achieved by fluid pressure controlling and reversing mechanism described in aforesaid Patent No. 1,582,468 to Heald and Guild, the reversing valve being controlled by a lever 30 which is interlocked with a reversing lever 31 so that when the lever 30 is to the right, the lever 31 is to the left, as shown in Figure 1, and vice versa. Suitable detents or load-and-fire devices are provided and the lever 30 controls a reversing valve to reverse the direction of motion of the carriage 13, as will be found described in the aforesaid patent to Heald and Guild, it being now well known to control the motion of a grinding carriage by the actuation of carriage

dogs on an interposed reversing lever, such as the lever 31. The carriage dogs which control the reversing lever 31, as shown in Figure 1, include a fixed dog 32 adjustably mounted as by means of worm 33 and worm rack 34 on the carriage 13 and a pivotally mounted dog 35 which is capable of lifting over the reversing lever 31 when the carriage is traversed to the left, but will engage the lever 31 when the carriage 13 is traversed to the right and when the lever 31 is between the dogs 32 and 35. The dog 35 is mounted on a sliding block 36 capabe of sliding with respect to the carriage 13 and controlled by a latch 37 which in turn is pivotally connected to a block 38 which is adjustably secured to the carriage 13 by means of a worm 39 and the worm rack 34.

Referring now to Figures 1 and 2, the machine further includes electromagnets 40 and 41, the former being mounted in front of the latter, and both being mounted on the front of the machine, as shown in Figure 1. These electromagnets control levers 42 and 43. The lever 42 is in the vertical plane of the latch 37. The lever 43 is in the vertical plane of the dog 35. When the lever 42 is lifted, the latch 37 will be raised, thus to allow the block 36 to slide, relatively, along the carriage 13, extending the reciprocatory traverse stroke of the grinding wheel 16 to pass it by a dressing diamond 45 which is at that time lowered into the path of travel of the wheel 16. Raising of the lever 43 causes the dog 35 to pass over the reversing lever 31 to extend the stroke of the carriage 13 to the right, thereby to cause the grinding action to cease, the carriage 13 being stopped in the withdrawn position by devices not shown herein. The dressing diamond 45 is mounted on an adjustable screw plug 46 which in turn is carried by a swinging member 47 mounted on a trunnion 48 provided by a suitable standard 49 rising from the stationary frame of the machine. When the lever arm 42 is moved, a downward extension 50 thereof moves a valve 51, thus making the pressure fluid active against the piston, not shown, which is connected by means of a link 52 to the member 47, so that when the electromagnet 40 is operated, the stroke of the grinding wheel 16 is extended and as it starts outwardly, the diamond 45 moves into its path, thereby to procure a dressing operation.

The foregoing instrumentalities are now well known in grinding machines, are described in the patents referred to and in others and embodied in many machines now on the market, and therefore I do not described the same in more detail. In the present embodiment of this invention, the grinding wheel 16 is advanced into the work piece 20 and grinds with a reciprocatory stroke just long enough to effect the grinding action and, after preliminary grinding has been achieved, the automatic dressing indicated is effected, whereupon the wheel 16 returns into the work piece for the final and finishing cuts. The wheel 16 is finally removed from the work piece by energization of magnet 41 which lifts the dog 35, and magnet 41 is controlled by the size controlling apparatus now particularly to be described. During the outward movement of the carriage 13 at the end of a grinding operation, compensation of the cross slide is achieved in a manner fully described in Taylor Patent No. 1,682,673 whereby the vertical plane of the cutting line of the grinding wheel on the work piece at finished size will bear substantially the same relation to the vertical plane of the dressing line throughout the grinding of a whole series of work pieces ground to the same size. Accordingly, the specific compensation mechanism of the Taylor patent need not be in detail described herein.

Referring now to Figure 1, the work piece 20 is held by means of a suitable chuck 60 which is mounted on the end of a work spindle 61. Referring now to Figure 3, the spindle 61 is journalled in journals 62 and 63 incorporated in the work head 11. Fastened to the spindle 61 is a pulley 64 by means of which the spindle 61 may be rotated by a belt drive, not shown. Extending rearwardly from the journal member 63 in the work head 11 are brackets 65 and 66. These brackets 65 and 66 have slideways 67 and 68, respectively, supporting a slide 69 which is shaped in the form of the capital letter D, as shown in Figure 4. Extending between the top and bottom of the slide 69, as shown in Figures 3 and 4, is a rock shaft 70 upon which is mounted an optical tube 71. Extending rearwardly from the optical tube 71 is an arm 72 through which extends a rod 73 having a spring 74 thereon which engages the arm. The spring 74, which is backed up by a nut 75, urges the arm and also the optical tube 71 in a clockwise direction, Figure 3. The front end of the rod 73 is supported by a resilient bar 80 having a notch 81 in a position to engage a detent 82 on the arm 72. The arm 72 may be used as a handle to swing the optical tube 71 in a counterclockwise direction and the detent 82 and the notch 81 will hold it there. This facilitates the introduction into and removal of work pieces from the chuck 60.

Still referring to Figure 3, the tube 71 has a central partition 85. On one side of this partition 85 is a camera chamber 86 for the passage of light. On the other side of the partition is a tube 87 forming another camera chamber for the passage of light. The tube 87 is supported by a plurality of partitions 88 which, as shown in Figure 4, surround the tube 87 and extend between it and the inside of the tube 71. At the ends of the tube 71 are right angle extensions 89 and 90, respectively. In the right angle chamber 89 and firmly fastened in place is a lamp 91 having a point source of illumination 92. The lamp 91 is an incandescent electric lamp, the filaments 93 of which are dark, all light being given from the point 92. The point 92 is located in the axis of the tube 87. In the tube 87 are suitably fastened a pair of condensing lenses 96 and 97. These are lenses which have substantially spherical surfaces to refract the light in two dimensions to direct the rays toward a true focus. In front of them and mounted in the tube 87 is a color filter 100 to eliminate all rays excepting those of one color, in order that diffusion of light by refraction of the different wave lengths at different angles will be avoided to a sufficient extent. In the tube 87 is also a condensing lens 101 which may be of the same general type as lenses 96 and 97, but in the present illustrative embodiment of the invention it is shown as a double convex lens whereas the lenses 96 and 97 are single convex lenses. Referring now to Figure 5, three rays of light will be traced, these being designated *a*, *b* and *c*. The ray *a* is the central ray and the rays *b* and *c* are marginal rays. The ray *a* passes through all three lenses 96, 97 and 101 and also the color filter 100 without being deviated from its straight line course. It next passes through a double concave lens 102, also suitably fastened in the tube 87, without being diverted from its straight line course. The rays *b* and *c*, however, were altered from their path of divergence by the

lenses 96 and 97, being brought into parallelism with the ray *a* between the lenses 97 and 101. The lens 101 brought the rays *b* and *c* toward a focus. Considering the light now as a beam, it started out as a diverging beam from the source of light 92, as every luminous body sends rays in all directions. The lamp 91 should have its glass painted black excepting in the very small circle sufficient to send forth enough light to cover the face of the lens 96. The lenses 96 and 97 produced a beam with parallel rays. The lens 101 brought this beam towards a focus. Before it came to a focus, this beam passed through the double concave lens 102 which changed it into a beam of parallel rays again. The reason for condensing the beam that existed between the lenses 97 and 101, thereafter to cause it to reassume the form of a beam with parallel rays, is in order to intensify the light, or stating this in another way, in order to collect as many rays as possible to form a strong beam of light. The beam in the tube 87 is a beam all the rays of which are substantially in parallelism. It will be recognized that this is a condition the complete attainment of which is not possible but by providing a point source of light, triple condensing lenses and a double concave lens, this desired condition is achieved for the practical purposes of this invention. The beam after the lens 102 may also be described as a beam the focus of which is at infinite distance from the lens 102.

Referring now to Figures 3, 5 and 8, at the front or right-hand end of the tube 87 is a double convex lens 105 of characteristics quite different from the lenses 96, 97 and 101. This lens 105 is a cylindrical lens; that is to say, its outline is that of a parallelogram when seen from above, as in Figures 3 and 5. However, when seen from in front, it looks like the lens 101. This lens 105 causes the rays to converge in a vertical plane but not in a horizontal plane. In my apparatus the lens 105 is complementary to the cylindrical work piece surface in that the effect of the two when the work piece is at the desired size, is to produce a final parallel ray beam.

Considering further Figures 3 and 4, to the inside of the tube 71 I fasten a mirror fixture 106 comprising a base portion 107 which may be screwed to the tube 71 and a glass wedge 108 secured thereto which has integrally connected thereto a non-rectangular parallelopiped 109 of glass. The wedge 108 and the parallelopiped 109 have reflecting surfaces 110 and 111 which form dihedral angles with the flat surface 112 of the base 107 of 135°. Surfaces 110 and 111 may be silvered surfaces. Light from the lens 105 is directed onto the surface 111 and thereby is turned at right angles into the plane of revolution of the work piece. This light is reflected and some of it is reflected by the surfaces 110 into a pair of beams, all the rays of which are parallel, passing through the camera chamber 86. In the camera chamber 86 and at 135° to the axis thereof is a mirror 115 in line with holes 116 in the wall 85, tube 87 and tube 71. From the mirror 115, the light passes to various other mirrors and finally to a photoelectric cell 120. But beams with parallel rays, i. e. with focal length at infinity, leave the mirror 110 only when the work piece 20 is at predetermined finished size, as will now be explained in connection with Figure 7, which is an illustration of the light rays in projection. Since the projection plane of Figure 7 is not identical with the diagrammatic view of Figure 5, the rays *a*, *b* and *c* cannot be identified. However, rays *x*, *y*, *z*, *x'*, *y'* and *z'* are identified in Figure 7, and these rays represent rays actually approaching the work piece 20 toward the finished surface 20' thereof between said surface and the mirror 111; beyond the mirror 111 they are shown in their image positions, that is to say with their incident paths projected backwards. Construction circles *xa*, *ya* and *za* are drawn in Figure 7 tangent to rays *x*, *y*, *z*, *x'*, *y'* and *z'*. It will be seen that upon reflection from the surface 20', rays *x*, *y*, *z*, *x'*, *y'* and *z'* are tangent to the other sides of the circles *xa*, *ya* and *za*. The reflected paths of these rays are parallel to each other. However, with the work piece surface at 20'', the rays *x*, *y*, *z*, *x'*, *y'* and *z'*, upon reflection, assume the positions indicated by the dotted lines. These rays are not in parallelism and the reflected beam comes to a focus *f'*. The beam has a focal length which has a small finite value, in inches. After passing the focal point *f'*, the rays are absorbed in the walls of the various tubes through which they pass. In order to produce a reflected beam whose rays are in parallelism from a beam the rays of which are in parallelism, lens 105 and the mirror 111 are placed in the relative positions shown to produce converging rays *x*, *y*, *z*, *x'*, *y'* and *z'* having focal point *f* in the mirror 111 relative to the circle of the work piece, as shown in Figure 7, and it is sufficient that the lens 105 be of a convexity and index of refraction to bring the rays to this focal point. As the focal point *f* has a definite geometrical relation, shown in Figure 7, to the circle 20' of the finished work piece, this relation is destroyed for any other size of work piece, such as is represented by the circle 20'', and therefore only when the work piece is at a given finished size will the rays be reflected from the surface thereof as a parallel beam with focal length infinity. The mirror 111 intercepts a part of this parallel beam but the two side portions thereof are picked up by the mirrors 110, 110 and sent along the tube 71 in the camera chamber 86. As is shown in Figure 7, a large cross-sectional area of the original beam is directed toward the mirrors 110, 110.

The walls of the camera chamber 86 as well as the interior wall of the tube 87 are painted with a dull black paint, such as any paint having a carbon pigment without a glossy surface, so that all rays which strike these walls will be, as much as possible, absorbed. After leaving the mirror 115, the rays of the beam of light or parallel beams of light are reflected by a mirror 125 whose position is indicated in Figure 1 and which is placed at an angle of 45° to the horizontal so that the light will be reflected downwardly in a vertical direction. The mirror 125 is at the top of a tube 126 which is held by the machine base 10, as shown in Figure 1. The interior wall of the tube 126 is likewise painted with a dull black pigment paint. At the bottom of the tube 126 is a mirror 127 at the junction of this tube 126 with a tube 128. Tube 128 extends along the entire length of the machine base and at the right-hand end thereof is a mirror 129 which is also at the bottom of a tube 130. At the top of the tube 130 is a mirror 131 which is also at the right-hand end of a tube 132. At the left-hand end of the tube 132 is located the casing 133 that holds the photoelectric cell 120. The mirrors 129 and 131 are at 45° angles, as shown in Figure 1, so that light is directed from the tube 126 into the tube 130 and then axially into the tube 132. Tubes 128, 130 and 132 are likewise painted black inside.

Only a beam or beams of light of very great focal length can pass along these tubes, as otherwise the light is absorbed by the walls of the tubes. Furthermore, it will be noted that the central part of the beam has been cut out by a second reflection from the mirror surface 111. Therefore, the central axial ray does not pass along the tubes at any time, and consequently only at the moment when the focal length of the light beam is substantially infinity will any light at all reach the photoelectric cell 120.

Referring now to Figure 4 and 8, the extension 90 is formed by horizontal upper and lower walls 140 which are of a hard material such as hardened steel and bear against the inside of the work piece 20. Extension 90 also has side walls 141 which are preferably of rubber. The steel walls 140 bear against the work piece and determine the position of the tube 71 which is urged in a clockwise direction, Figure 3 by the spring 74. These walls 140 together with the walls 141 keep cooling water out of the extension 90, at least to a very considerable extent. The walls 141, however, will readily deform slightly to conform to the different curvatures of the work piece during grinding. It will be appreciated that the relative change in size of the work piece, as indicated in Figure 7, is grossly exaggerated, to the end that the principles of the invention may be made readily apparent. In order to prevent the tube 71 from vibrating as the work piece 20 is revolved, I provide a support 145 which, as shown in Figure 1, may be hinged at 146 to a bracket 147 that is bolted to the work head 11. This support 145 is in the form of a bent arm which may be swung into and out of position, being held in operative position by means of spring clamps 149. This support 145 rests under a cylindrical boss 150 integral with a screw cover 151 which closes the right-hand end of the tube 71.

The lenses 96, 97, 101 and 102 may be cemented in place in the tube 87 because once the light beam in the tube 87 has been brought to a condition of focal length infinity, there is no further occasion for adjustment. However, in order that this condition may be achieved in each new piece of apparatus despite unavoidable variations in manufacturing operations, the lamp 91 is preferably made adjustable in a direction parallel with the axis of the tube 87. This adjustment may be achieved in any suitable manner, not herein indicated, as by the use of holding screws extending into slots.

It is, however, desirable that the apparatus be adjustable so that it may be used to grind work pieces to different internal diameters. Accordingly the lens 105 is adjustable in the tube 87 by means of the construction shown in Figure 8. The lens 105 is cemented to a metal annulus 155 through which pass a pair of adjusting screws 156 with knurled heads, these screws 156 extending also into threaded bores in integral lugs 157 located in the inside of the tube 87. Screws 156 are rotatable in the annulus 155 but are axially immovable relative thereto, as by the provision of collars 160 press fitted onto the screws 156. The annulus 155 is secured to the inside of the telescoping tube 161. By turning the screws 156 substantially together, the tube 161 may be moved axially in the tube 87. However, the relative angular position of the tubes 87 and 161 is unchanged and, therefore, the relative angular position of the lens 105 is not disturbed by the adjustment. The adjustment moves the center of the lens 105 towards and away from the surface 111 and, therefore, adjusts the focal line of the crossing beam relative to the surface of the work piece towards which the beam is directed.

Considering now one electric circuit which may respond to light impinging upon the cathode 164 of the photoelectric cell 120, and referring to Figure 2, a 110 volt A. C. line 165 has connected to it conductors 166 and 167 leading to terminals 168 and 169 of a transformer primary 170. Three secondary coils 171, 172 and 173 are energized by the primary coil 170. A non-inductive potentiometer resistance 174 is connected across conductors 175 and 176 of the coil 171. Conductor 175 leads to the anode 177 of the photoelectric cell 120. Conductor 176 leads to a condenser 178 which is connected by conductor 179 to conductor 180 which connects to cathode 164 of the photoelectric cell 120.

Secondary coil 172 energizes filament 183 of an amplifying or triode tube 184. A grid 185 of the tube 184 is connected by a conductor 186 to a non-inductive resistor 187, the other end of which is connected to the conductor 180. A plate 190 in the tube 184 is connected to a conductor 191 which is connected to a terminal 192. The secondary 173 has one end thereof connected to a terminal 193. Connected in parallel by the terminals 192 and 193 are a condenser 194 and a sensitive relay coil 195. The other end of the secondary coil 173 is connected to a conductor 196 which connects to the movable element 197 of potentiometer 174. Conductor 196 is also connected by a lead 198 to the mid point of coil 172. It will now be seen that a certain degree of illumination of the photoelectric cell cathode 164 causes energization of relay coil 195 and the apparatus is adjustable by means of the potentiometer 174—197.

In so much as the energization of the relay 195 may be momentary, I have further provided a relay to close and keep closed the final circuits upon any energization whatsoever of the sensitive relays. As shown in Figure 2, the conductor 166 also connects to a terminal 200. Conductor 167 connects to a relay coil 201. The other end of the relay coil 201 is connected to a terminal 202. A pendulum contactor 203 is adapted to connect terminals 200 and 202 and this contactor is arranged to be operated by a long arm 204 of an armature 205 actuated by the coil 195. Therefore, energization of the relay coil 195, even momentarily, closes a knife switch 207 electromagnetically operated by the coil 201. Knife switch 207 connects a conductor 208 to ground. The conductor 208 is connected to one terminal of the electromagnet 41, the other terminal of which is connected by a conductor 209 to one bar 210 of a switch 211 which will be found described in the Taylor patent referred to and which is provided for the purpose of preventing continuous dressing of the grinding wheel. When the grinding wheel has taken the final and finishing strokes on the work piece, a contact plate 212 of the movable element 213 of the switch 211 connects a bar 214 with the bar 210, thus to connect the conductor 209 to a conductor 215 connecting to a generator 216, the other terminal of which is ground, as shown in Figure 2. This generator 216 is a direct current generator but in certain cases the alternating current lines 165 may be substituted for the generator 216.

Briefly recapitulating the action of the machine, the operator, after having placed an un-

ground work piece 20 in the chuck 60, moves the lever 72 to swing the right-hand end of the tube 71 toward the work piece until the upper and lower walls 140 of the extension 90 contact the work piece. Having secured the cover 151 in place, the operator swings the support 145 into the position shown in Figure 3 where the tube 71 and all other parts are duly supported against vibration. The operator then causes the work piece 20 to be revolved in the usual manner and, moving the main control lever 30 to the left, causes the grinding wheel 16 to enter the work piece to start the grinding operation. Thereafter, automatically, as described in the Taylor patent referred to, a dressing operation takes place whenever a cam 220 operated by the cross feed engages a lever 221 connecting a conductor 222 which is grounded to a conductor 223 which is connected by way of conductor 224 to the electromagnet 40. As the carriage 13 moves to carry the wheel 16 to be dressed by the diamond 45, an arm 225 carried by the block 38 engages the movable element 213 of the switch 211 and deenergizes the magnet 40 which prevents further dressing until a new work piece is placed in the machine. Thereafter the final and finishing cuts are taken until such time as the rays of light from the point source 92 are, upon reflection from the work piece, of such great focal length that they ultimately reach the cathode 164 of the photoelectric cell 120 whereupon, as already described, circuits are closed which cause energization of the magnet 41 which trips the reversing dog 35, causing the carriage 13 to move to the right to the position shown in Figure 1, removing the grinding wheel 16 from the work piece.

By the provision of the various tubes described, the light is caused to travel a long distance to the photoelectric cell 120 which makes the apparatus extremely sensitive. The gauging device is spring-pressed against a surface of the work piece and, furthermore, is located in fixed position in a vertical plane by the supporting member 145. The entire apparatus can be adjusted by moving the D shaped slide 69 in the ways 65, 66, as by means of adjusting screw 230.

This is a division of my copending application Serial No. 119,772 filed January 9, 1937, now Patent No. 2,121,729.

It will thus be seen that there has been provided by this invention apparatus and a method in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In apparatus for determining the size of the cylindrical bore of an article which cylindrical bore has a reflecting surface, a source of light, means to condense the rays thereof to form a substantially parallel ray beam, means to converge the parallel ray beam in a single plane of its axis only, a first mirror positioned in the beam to direct the rays thereof on to the cylindrical bore, a second mirror arranged to receive the beam after reflection from the surface of the bore, the position of said converging means in the beam being such that the convergence of the rays is in a plane at right angles to the axis of the bore, the convergence being such that the work piece reflects substantially parallel rays when and only when the cylindrical bore is of a predetermined size, and means including a photoelectric cell positioned to receive the beam after reflection from the second mirror and said cell being optically spaced from the second mirror a distance such that the cell receives only substantially parallel rays.

2. In apparatus for determining the size of the cylindrical bore of an article which cylindrical bore has a reflecting surface, a source of light, means to condense the rays thereof to form a substantially parallel ray beam, means to converge the parallel ray beam in a single plane of its axis only, a mirror positioned in the beam to direct the rays thereof on to the cylindrical bore, the position of said converging means in the beam being such that the convergence of the rays is in a plane at right angles to the axis of the bore, the convergence being such that the work piece reflects substantially parallel rays when and only when the cylindrical bore is of a predetermined size, and means including a photoelectric cell positioned to receive the beam after reflection from the work piece and said cell being optically spaced from the work piece a distance such that the cell receives only substantially parallel rays.

3. In apparatus as claimed in claim 2 the combination with the parts and features therein specified of a housing containing the elements other than the cell specified in said claim and a member on said housing contacting the bore of the work piece whereby accurately to position the elements with respect to said bore.

RAYMOND A. COLE.

CERTIFICATE OF CORRECTION.

Patent No. 2,213,024. August 27, 1940.

RAYMOND A. COLE.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, first column, line 52, strike out the words "and a method"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 24th day of June, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

CERTIFICATE OF CORRECTION.

Patent No. 2,213,024. August 27, 1940.

RAYMOND A. COLE.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, first column, line 52, strike out the words "and a method"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 24th day of June, A. D. 1941.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)