April 26, 1938. A. G. BELDEN 2,115,678

GRINDING MACHINE

Filed Oct. 7, 1935 2 Sheets-Sheet 1

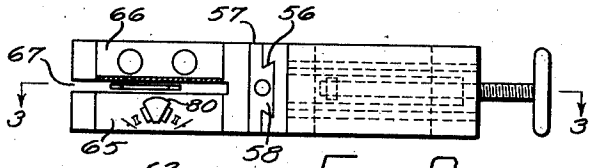


FIG. 2

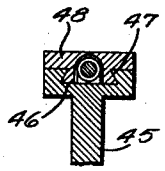


FIG. 4

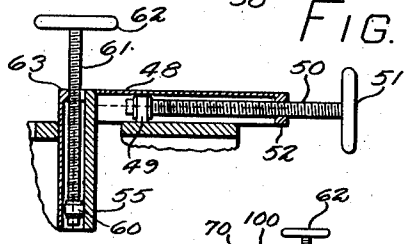


FIG. 3

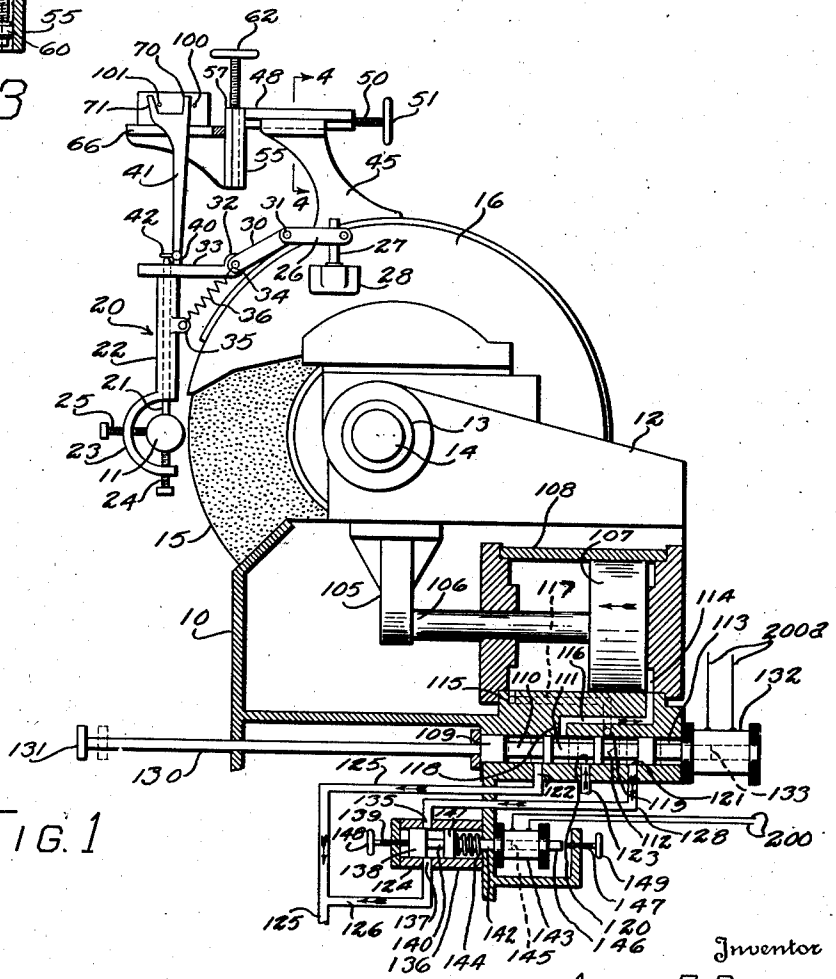


FIG. 1

Witness
John Lee Jr.

Inventor
ALBERT G. BELDEN

By George Crompton Jr.
Attorney

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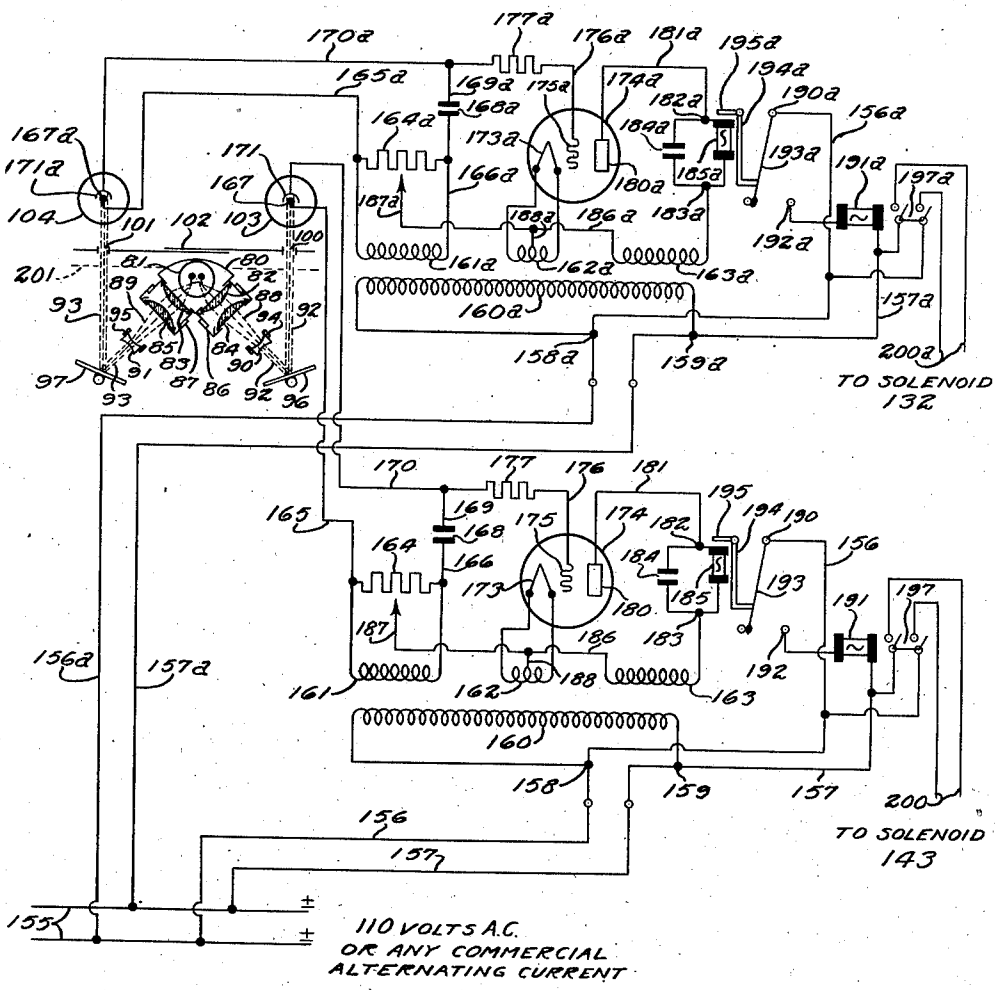


FIG. 5

Inventor
ALBERT G. BELDEN

Witness
John Leo A.

By George Crompton Jr.
Attorney

Patented Apr. 26, 1938

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UNITED STATES PATENT OFFICE

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GRINDING MACHINE

Albert G. Belden, Worcester, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application October 7, 1935, Serial No. 43,869

2 Claims. (Cl. 51—165)

The invention relates to grinding machines and with regard to its more specific features to a sizing mechanism therefor.

One object of the invention is to provide an electric sizing device whose sensitivity is not affected by arcing. Another object of the invention is to provide a sizing device capable of fine adjustment. Another object of the invention is to provide an efficient and sensitive cross feed and control thereof for a 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 indicated in the following claims.

In the accompanying drawings, in which is shown one of various possible embodiments of the mechanical features of the invention,

Fig. 1 is a view, partly in cross section and partly in elevation, showing the hydraulic actuating and control mechanism for the cross feed slide of a grinding machine, and illustrating also certain parts of the calipering mechanism in elevation,

Fig. 2 is a plan view of the calipering control,

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 2,

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 1,

Fig. 5 is a wiring diagram illustrating also certain details of the optical apparatus.

I provide a grinding machine including a machine base 10 having the usual ways, not shown, for the support of a work table, not shown, upon which work table is supported a headstock and a tailstock for the support and rotation of a work piece 11 which is to be exteriorly ground. The elements just referred to which are not shown herein are of well understood construction and any desired means for holding and rotating a work piece may be employed, whether such embodies means for longitudinally reciprocating the work piece or not.

Mounted on the usual cross feed slideways, not shown, is a cross slide 12 of any usual or desired form, which journals in journals 13 the spindle 14 of a grinding wheel 15. Surrounding the grinding wheel 15 is a wheel guard 16 which, according to this embodiment of the present invention, forms a support for the work calipering mechanism to be described.

I provide a work contacting calipering apparatus 20 which may take the form of that disclosed in the patent to Green No. 1,992,027, for example comprising a feeler rod 21 slidably mounted in a casing 22 to which is integrally attached an anvil 23 provided with an adjustable contacting screw 24 diametrically opposed to and aligned with the end of feeler rod 21, the anvil member 23 having also another adjustable contact screw 25 arranged to bear laterally upon the work and maintain the end of the feeler rod 21 and screw 24 in the desired location. In order to facilitate precise measurement with this calipering device it may be supported in any convenient manner so that the weight of the casing 22 and the parts assembled therewith are not supported by the feeler rod 21. To accomplish this there is provided a link 26 which may be clamped in any convenient position on a rod 27 uprising from a bracket 28 attached to the wheel guard 16; thus the parts of the calipering mechanism are located in fixed position relative to the grinding wheel and traverse of the work piece, if such is provided for, does not, in this preferred embodiment of the invention, alter the alignment of grinding wheel and calipering device. In case such traversing mechanism for the work table is provided the calipering mechanism is traversed relative to the work piece but due to its carefully balanced condition such traversing does not affect its operation and it is at all times measuring that part of the work which is being ground. However, it should be understood that the apparatus of the present invention is also particularly adapted for use in a grinding machine grinding by the so-called "plunge-cut" method, in which the wheel 15 is fed straight in against the work piece 11 and grinds to size without relative reciprocation between wheel and work or, in some cases, with only a slight relative reciprocatory motion which may be induced in the wheel spindle 14 itself.

Still referring to Fig. 1, a link 30 is pivotally and frictionally supported on the link 26 (which is rigidly secured to the rod 27) and the friction at pin 31 connecting links 26 and 30 is such that the link 30 may be moved about its pivot by the operator but will remain in the position in which it is set. Pivotally mounted on the end of link 30 by means of an enlarged portion 32 is a platform 33 which has attached to it the casing 22, and thus the casing 22 is supported. Connecting a pin 34 which joins the link 30 to the platform 33, and an ear 35 on the casing 22, is a spring 36 which maintains screws 24 and 25 in frictional contact with the work, thereby supporting the

caliper and providing a free sliding action of the feeler rod 21.

Upstanding from the platform 33 are a pair of journal bosses 40 pivotally supporting a shutter member 41 which is in the form of a bell crank lever having a short arm 42 in contact with the top of the feeler rod 21. From inspection of Fig. 1 it will be seen that the upper or operating end of the shutter 41 will move through a substantially greater distance than does the feeler rod 21 pursuant to reduction in size of the work piece. Thus the mechanism so far described constitutes a contacting feeler calipering device together with mechanical amplifying mechanism, and in so much as the shutter 41 is utilized to cut one or more beams of light it may be of very light construction and thus the mechanical apparatus of the calipering and control mechanism is subjected to very small strain which measurably increases its efficiency. One of the features of advantage of the present invention resides in the simplicity of the mechanical elements which, nevertheless being mechanical are highly reliable. Another feature of the invention associated with the foregoing is that adjustments for intermediate and final size may be made on the non-moving parts of the apparatus thus relieving the movable elements of the feeler mechanism from excessive load and back play or lost motion incidental to an adjusting mechanism; while the invention permits adequate fineness of adjustment through the use of substantial and rigid adjusting mechanism associated with the parts that are not directly moved by the feeler.

Still referring to Fig. 1 attached to the upper side of the wheel guard 16 is a bracket 45 having, as better shown in Fig. 4, horizontal slideways 46 for the support of the dovetailed portion 47 of a slide 48. Referring now to Fig. 3, upstanding from the slideway 46 is a collar member 49 which positions a screw shaft 50 having a hand wheel 51 on the end thereof. The screw 50 passes through an internally threaded portion 52 of the slide 48. Thus the slide 48 is mounted for horizontal adjustment fore and aft upon the bracket 45.

Referring now to Figs. 1 and 2, the slide 48 has a depending slideway member 55 in which is a slideway 56 supporting a vertical slide 57 having a dovetailed portion 58 fitting in the slideway 56. A collar 60 attached to the depending portion 55 positions a screw shaft 61 having a hand wheel 62 for vertical adjustment, the screw shaft 61 passing through a threaded portion 63 in the vertical slide 57. Still referring to Fig. 2, attached to and projecting horizontally from the vertical slide 57 are a pair of platforms 65 and 66 separated by a slot 67.

The shutter 41 is located in the slot 67 between platforms 65 and 66. Referring now to Fig. 1, in this particular embodiment of the invention the shutter 41 has a pair of shutter arms 70 and 71, which successively uncover light beams, the first of which initiates a change in the grinding cycle and the second of which determines the grinding operation and is the final size control. The apparatus herein described may be readily set up for either the shutter arm 70 or 71 to control the final size but by way of a preferred example it may be considered that the arm 70 alters the grinding cycle while the arm 71 controls final size. Still referring to the upper part of Fig. 1, it will be observed that the slide 57 may be moved up and down without great effect upon the right-hand edge of the shutter arm 70, which is the edge which uncovers the light beam, while movement up and down of the slide 57 definitely alters the position at which the other light beam is uncovered by the shutter arm 71. On the other hand, the relative position of both shutter arms 70 and 71 may be adjusted by turning the hand wheel 51 and thus moving horizontally the slide 48, and such adjustment does not affect the interval between uncovering of the light beams. Further, it may be stated that movement of the slide 57 pursuant to turning of the hand wheel 62 does change the interval between uncovering of the light beams. These features are due to the provision for adjusting the platforms 65 and 66 in two dimensions, as well as to the shapes of the shutter arms 70 and 71, the right-hand edge of one of which is nearly if not quite vertical and the right-hand edge of the other of which is at all times substantially inclined to the vertical. By selecting the left-hand shutter arm 71 as that which controls final size the invention provides in effect a vernier mechanism, for coarse adjustments may be made with the hand wheel 51 and fine adjustments with the hand wheel 62.

A feature of the invention is the control of the grinding operation by uncovering successively a pair of beams of light which operate a photoelectric apparatus ultimately actuating solenoids to effect the desired control. Considering now the optical apparatus, its position and general characteristics are indicated in Fig. 2 while more details of construction are disclosed in Fig. 5. Referring to these figures, I provide a lamp box 80 in which is located an electric light bulb 81 which may be of the point of light type or of the ribbon filament type in order to produce a beam having as little stray light as is possible within practical limits. Box 80 has a pair of walls in which are inset semi-convex lenses 82 and 83 respectively. In front of the lenses 82 and 83 are semi-convex lenses 84 and 85 thus producing, as shown in Fig. 5, a pair of systems of condensing lenses. The outer lenses may be adjustable in telescoping supports 86, 87.

By the apparatus so far described a pair of converging light beams 88 and 89 are formed. These light beams are directed through concave lenses 90 and 91 to produce beams 92 and 93 of parallel or nearly parallel rays. In certain respects it is an advantage to avoid absolute parallelism as the beams of light may be desirably made very narrow indeed at the position where they are intercepted by the shutters 70 and 71 with resulting sensitivity of the apparatus. The concave lenses 90 and 91 may be adjustably mounted in brackets 94 and 95.

The beams 92 and 93 are converted into beams parallel to each other by means of mirrors 96 and 97 which may be angularly adjustable for the proper setting-up of the apparatus. The beams 92 and 93 thus reflected pass across the opening 67 and through orifices 100 and 101 in a diaphragm 102 which otherwise protects photoelectric cells 103 and 104. Fig. 1 shows the orifices 100 and 101 both uncovered but the apparatus should be adjusted so that both of these orifices shall be covered at the commencement of grinding, and when it is desired to change the feed the orifice 100 is uncovered by the shutter arm 70, and when the work piece comes to the final size the shutter arm 71 uncovers the orifice 101. It should be understood that by the phrase "uncover" I intend to indicate effective illumination of the photoelectric cells, for it is illumination by a given amount which causes their action

and it is their property of acting at a critical illumination which permits me to use them for accurate sizing of work pieces and although I prefer to make the beams 92 and 93 very narrow nevertheless I can achieve accurate sizing of work pieces although such beams of light may have, relatively speaking, substantial thickness.

In the preferred embodiment of the invention actuation of the photoelectric cell 103 causes cross feed movement between grinding wheel 15 and work piece 11 to cease, while actuation of the photo-electric cell 104 causes the cross feed slide 12 to retreat carrying the grinding wheel 15 definitely away from the work piece. Grinding between the first indication or electrical actuation and the final coming to size takes place owing to the pressures set up in the machine parts and such grinding, already known in connection with manually operated machines, has been termed "sparking out". The invention is shown embodied in an external cylindrical grinding machine, but may be embodied in other types of grinding machines, and the first actuation in some cases may be a slowing-down of the cross feed rather than an actual discontinuance of all movement. The mechanism of the present invention may be adjusted so as to bring the cross slide 12 to a stop at the first photoelectric actuation, or it may be adjusted so as to decrease the rate of cross feed rather than to stop it altogether.

In the preferred embodiment of the invention I use a hydraulic cross feeding mechanism which may be readily controlled by solenoids actuated by the photoelectric cells 103 and 104. Referring again to Fig. 1, depending from the cross slide 12 is a bracket 105 to which is attached a piston rod 106 having a piston 107 located in the cylinder 108. A slide valve 109 has reduced diameter portions 110, 111 and 112, which are separated by full diameter portions fitting a valve bore 113. A port 114 connects to the right-hand side of the cylinder 108 while a port 115 connects to the left-hand side thereof. A passage 116 connects the port 114 with a valve port 118, and a passage 117 connects the port 115 with a valve port 119. As shown in Fig. 1, the ports 118 and 119 are symmetrically located in the bore 113, one being slightly to the right of the center portion thereof, and the other an equal distance to the left.

The bore 113 also has ports 120, 121, and 122, the former being a fluid entrance port and connected to pipe 123 leading to a source of fluid under pressure, and the latter two being fluid exhaust ports, the port 121 being connected by pipe 128 to a valve 124, and the port 122 being connected by piping 125 direct to the exhaust. The valve 124 is connected by piping 126 to the piping 125 as clearly illustrated.

The slide valve 109 may be operated manually by means of a rod 130 having a handle 131 within convenient reach of the operator, and the slide valve 109 may be operated in one direction by means of a solenoid 132, as integrally formed with the slide valve 109 is a rod-like portion 133 which constitutes the core of the solenoid 132.

With the slide valve in the position shown in full lines in Fig. 1, fluid under pressure is admitted from the piping 123 through the port 120 and past the reduced portion 111 to the port 118 and the fluid passes through passage 116 to the port 114 which is at the right-hand end of the cylinder 108 and therefore the fluid will urge the piston 107 to the left thus to move the cross slide 12 and carry the grinding wheel 15 towards and to reduce the diameter of the work piece 11. The parts are shown at the commencement of this operation in Fig. 1. While pressure fluid is moving the piston 107 to the left, fluid is being exhausted from the left-hand side of the cylinder 108 and it flows outwardly by way of port 115, passage 117, and port 119 past reduced diameter portion 112 and through piping 128 to valve 124 and thence by way of pipe 126 into pipe 125 which connects with the fluid sump or source of supply. When the valve 109 is moved to its right-hand position, as indicated in dotted lines in Fig. 1, the fluid under pressure from the pipe 123 and port 120 passes by way of reduced diameter portion 111 to port 119 and by passage 117 to port 115 and thus into the left-hand side of the cylinder 108. This causes movement of the piston 107 to the right thus carrying the grinding wheel 15 away from the work piece, and the fluid is forced out of the right-hand side of the cylinder 108, through port 114, passage 116, through port 118, past reduced diameter portion 110 to port 122 and by way of piping 125 to the sump.

It will be noted from the foregoing description that when the grinding wheel is traveling inwardly or to the left the exhaust fluid is passing through the valve 124, but when the grinding wheel is moving outwardly or to the right the exhaust fluid does not pass through the valve 124. The valve 124 is an adjustable metering valve and may be set to stop position; thus it controls the advance of the grinding wheel and procures a slow feed thereof and it is capable of being moved to a position to reduce the feed or to stop it altogether.

Considering now the construction of the valve 124 and referring to Fig. 1, the pipe 128 connects to a port 135 which opens into the side of a cylinder 136. Opposite the port 135 is a port 137 connecting with the pipe 126. A close fitting piston 138 is located in the bore of the cylinder 136 and its movement to the left is controlled by an adjustable stop screw 139. Connected to the piston 138 by means of a rod portion 140 is another piston member 141. Another rod 142 passes into a solenoid 143 and constitutes the core thereof. A spring 144 surrounds the core rod 142 and urges the piston 141 and therefore the other parts including the piston 138 to the left. The rod 142 is connected at 145 to a brass or other non-magnetic rod 146 which is in position to be engaged by a stop screw 147.

By properly setting the stop screw 139 as by means of a hand wheel 148 the normal condition of the valve 124 may be determined. By setting the stop screw 147 as by means of the hand wheel 149 the condition of the valve 124 may be adjusted for such part of the cycle as involves the energization of the solenoid 143.

According to the preferred embodiment of the present invention the machine has three main parts to a cycle of operation. There is first the infeed of the grinding wheel when the solenoid 143 is deenergized and the valve 124 is at its adjusted open or widest open position. Then follows the grinding cycle while the solenoid 143 is energized, the piston 138 being to the right and either restricting the flow of fluid through the valve 124 more than previously or else cutting it off altogether. Thirdly, there is the return of the grinding wheel to a retracted position which is not controlled by the valve 124 at all.

The change from the first to the second phase of the grinding cycle is determined by one indication from the sizing apparatus and the change

from the second to the third phase of the cycle is determined by a second indication of the sizing apparatus. As so far described the photoelectric cell 103 sets in motion the change from the first to the second phase and the photoelectric cell 104 sets in motion the change from the second to the third phase. The change from the third to the first phase might be effected in any manner but so far as the present embodiment is concerned may be effected by manual control, as a new work piece is to be introduced at this point, and the introduction of such work piece will deenergize the solenoids and the operator has ample time to shift the rod 130.

It should be noted that either of the photoelectric cells 103 or 104 may be selected for initiating either change, as this is simply a matter of connection of two pairs of final circuit wires. Furthermore, the sizing apparatus may be adjusted so that the change from the first phase to the second phase occurs at the end of the movement which brings the grinding wheel against the work piece, or the change may be effected when the work piece is nearly to size so that the final cuts will be in the nature of a fine grinding operation. I prefer to adjust the valve 124 so that no advance of the grinding wheel will take place after the solenoid 143 is energized, the further reduction of the work piece being due to the strain or spring in the machine parts and the final cuts being what have been described as "dying out" cuts, or simply "sparking out". The sparking out method of grinding has been found to be particularly effective for the production of true cylindrical fine finish and accurate work. The calipering mechanism of the invention may be readily adjusted so that the difference between actuations of the two photoelectric cells is within the range of the amount of size reduction effected by a dying-out cut.

Referring now to Fig. 5, the photoelectric cell 103 is associated with amplifying and relay apparatus to energize the solenoid 143, while the photoelectric cell 104 is associated with identical apparatus to energize the solenoid 132. Any amplifying and/or relay apparatus may be used, and direct or alternating current may be employed in any of the circuits, as my invention is not confined to any particular electrical arrangement. For purposes of illustration, however, I have disclosed in Fig. 5 a set of circuits which may be employed.

Referring now to Fig. 5, a 110 volt A. C. line 155 has connected to it conductors 156 and 157 leading to the terminals 158 and 159 of a transformer primary 160. Similarly conductors 156a and 157a connect to terminals 158a and 159a of a transformer primary 160a. Three secondary coils 161, 162, and 163 are energized by the primary coil 160 and similarly secondary coils 161a, 162a and 163a are energized by the primary coil 160a. Non-inductive potentiometer resistances 164 and 164a are connected across the conductors 165 and 166 and 165a and 166a respectively of the coils 161 and 161a. Conductor 165 leads to the anode 167 of the photoelectric cell 103 and conductor 165a leads to the anode 167a of the photoelectric cell 104. Conductors 166 and 166a lead to condensers 168 and 168a which are connected by conductors 169 and 169a to conductors 170 and 170a which connect respectively to the cathodes 171 and 171a of the photoelectric cells 103 and 104.

The secondary coils 162 and 162a respectively energize filaments 173 and 173a of amplifying or triode tubes 174 and 174a. Grids 175 and 175a of the tubes 174 and 174a are connected by conductors 176 and 176a to non-inductive resistors 177 and 177a the other ends of which are connected to the conductors 170 and 170a respectively. Plates 180 and 180a in the tubes 174 and 174a respectively are connected to conductors 181 and 181a which conductors are connected to terminals 182 and 182a. The secondaries 163 and 163a have each of them one end thereof connected respectively to terminals 183 and 183a. Connected in parallel between terminals 182 and 183 are a condenser 184 and a sensitive relay coil 185, and connected in parallel between terminals 182a and 183a are a condenser 184a and a sensitive relay coil 185a. The other ends of the secondary coils 163 and 163a are connected to conductors 186 and 186a. Conductors 186 and 186a connect respectively to the movable elements 187 and 187a of potentiometers 164 and 164a and conductors 186 and 186a are also connected by leads 188 and 188a to the mid points of coils 162 and 162a. It will now be seen that a certain degree of illumination of photoelectric cell 103 causes energization of relay coil 185, while a certain degree of illumination of photoelectric cell 104 causes energization of relay coil 185a. The apparatus is adjustable by means of the potentiometers 187—164 and 187a—164a.

In so much as the energization of the relays 185 and 185a may be momentary I further have provided a relay to close and keep closed the final circuits upon any energization whatsoever of the sensitive relays. As shown in Fig. 5, conductor 156 also connects to a terminal 190 and conductor 156a connects to a terminal 190a. Conductor 157 connects to a relay coil 191 and conductor 157a connects to a relay coil 191a. The other ends of the relay coils 191 and 191a are connected to terminals 192 and 192a respectively.

Pendulum contactors 193 and 193a are adapted to connect terminals 190—192 on the one hand and 190a—192a on the other hand. These pendulum contactors are arranged to be operated by long arms 194 and 194a of armatures 195 and 195a actuated by the coils 185 and 185a.

Energization of the relay coils 191 and 191a respectively, even momentary energization thereof, causes the closing of knife switches 197 and 197a. These are double knife switches and one set of terminals thereof is connected by shunt leads to the 110 volt A. C. wires 156, 157, and 156a, 157a respectively, while the other terminals of these knife switches 197 and 197a connect to lines 200 and 200a which respectively lead to the solenoids 143 and 132.

The pendulum contactors 193 and 193a may be of spring steel so that normally they lie in the position shown in Fig. 5 but a slight force will throw them into contacting position. The photoelectric cell cathodes 171 and 171a are preferably sensitive caesium plated cathodes and a certain definite amount of light on either of them will cause enough current to flow in either of the relay coils 185 and 185a to close the circuit by contactor 193 or 193a. By producing narrow beams of light 92 and 93 and providing sensitive double relay apparatus one element of which is a current measuring relay, I am enabled accurately to size the work.

In order to set up the machine, a work piece 11 ground to the desired size by means of hand gauges is placed in the machine centers and the calipering device is located in position and the main switches are closed. The hand wheel 62 is

now turned until the orifice 101 appears about the middle of the shutter 71 in a vertical direction. The screws 24 and 25 may now be turned until the shutter 71 is just covering the orifice 101. Before this is done the screw 50 should be placed about in its mid position. Now the hand wheel 51 may be turned until the solenoid 132 is energized.

The machine is now ready to operate and an oversized work piece 11 placed in position will be automatically ground to size in the manner already indicated. When the operator wishes to start a particular grinding operation he draws the head 131 of the rod 130 forwardly. Many other manners of adjusting the machine and many varied cycles of operation may be adopted.

The electrical apparatus may be conveniently located at any part of the machine and takes very small space. The cross feeding mechanism involves a simple valve and a cylinder and piston unit together with a control valve. Thus the apparatus is simple and by controlling fluid pressure apparatus through a solenoid which is in turn controlled by relays, amplifying apparatus and a photoelectric cell, I achieve a readily adjustable and simple control for a grinding machine. The apparatus also has the advantages of an actual contact gauge without placing a pressure on the contacts due to cumbersome operating apparatus associated therewith, as the shutter 41 may weigh less than an ounce.

In some cases in order to make the apparatus more sensitive I may optionally add a diaphragm with very small holes therein as indicated in dotted lines in Fig. 5 by the numeral 201.

It will thus be seen that there has been provided by this invention an apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As various possible embodiments might be made of the mechanical features 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 a grinding machine, a pair of photoelectric cells, means for creating a pair of light beams directed towards said photoelectric cells, a shutter arm, a pair of shutters on said arm, the sides of the shutters being inclined to each other so that the distance between such sides in one plane varies with the position in a plane normal to the first plane, adjustment means to vary the increment between cutting of the beams by the shutters, a pair of controls to alter the grinding operation respectively from a coarse to a fine grinding operation and from a fine grinding operation to cessation of grinding, and devices connected to be actuated by the photoelectric cells respectively to actuate said controls respectively.

2. A work calipering device for grinding machines and the like comprising a gauge device including a pair of elements positioned to engage a round work piece at different points, one of said elements being movable, a lever, a connection between the lever and the movable element to move the lever as the work piece changes in size through grinding, a pair of shutter surfaces on the lever at an angle to each other, means for creating a pair of light beams, orifices towards which the beams are directed, photoelectric cells behind the orifices, the shutter surfaces being movable across the orifices, adjustment means for the orifices to move them substantially parallel to the margin of one of the shutter surfaces whereby because of the angular relation of said shutter surfaces the increment between uncovering of the orifices will be altered, and instrumentalities actuated by the photoelectric cells to control a grinding operation.

ALBERT G. BELDEN.