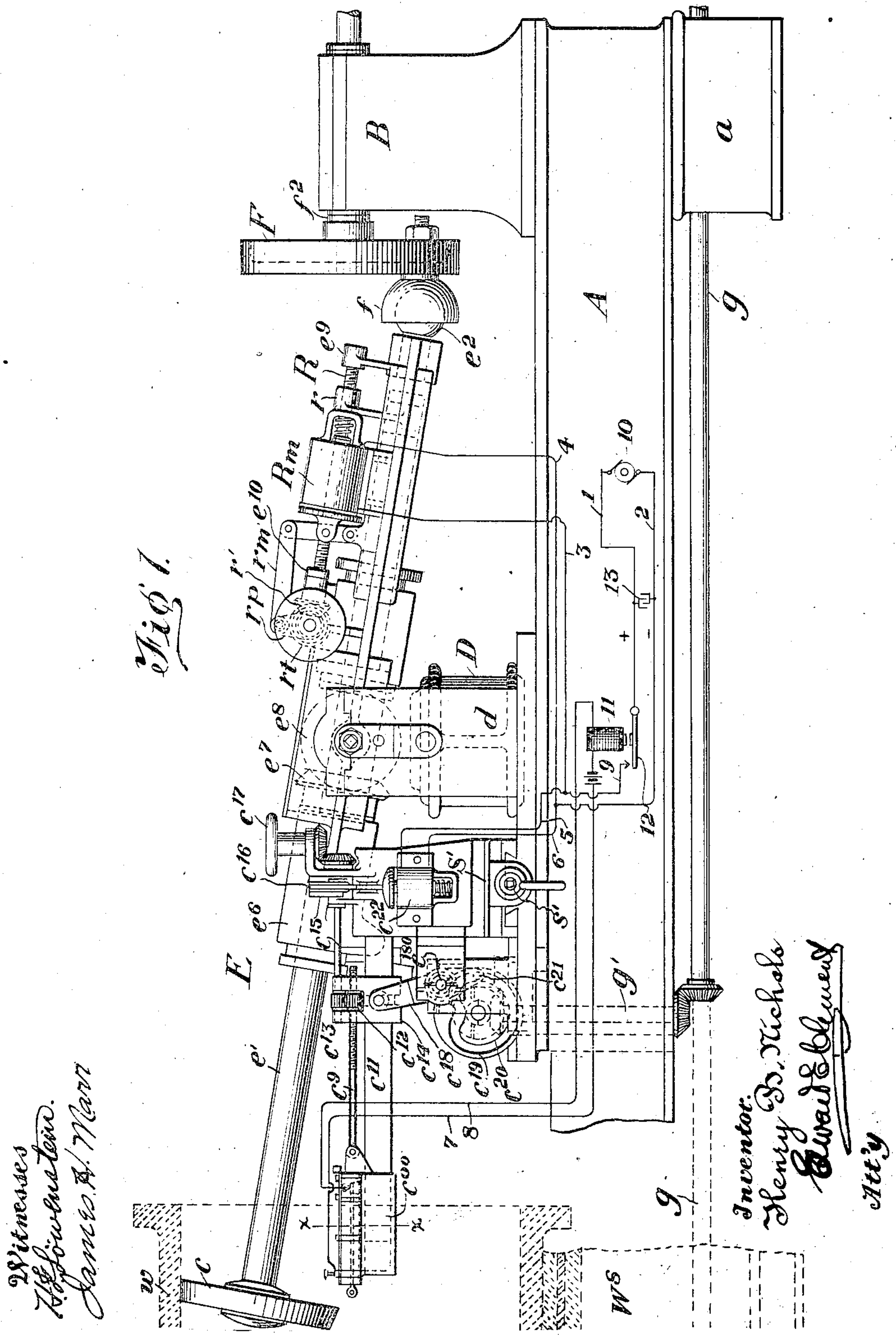
H. B. NICHOLS.

METHOD OF GRINDING AND SURFACING.

APPLICATION FILED AUG. 21, 1908.

960,188. Patented May 31, 1910.

4 SHEETS—SHEET 1.



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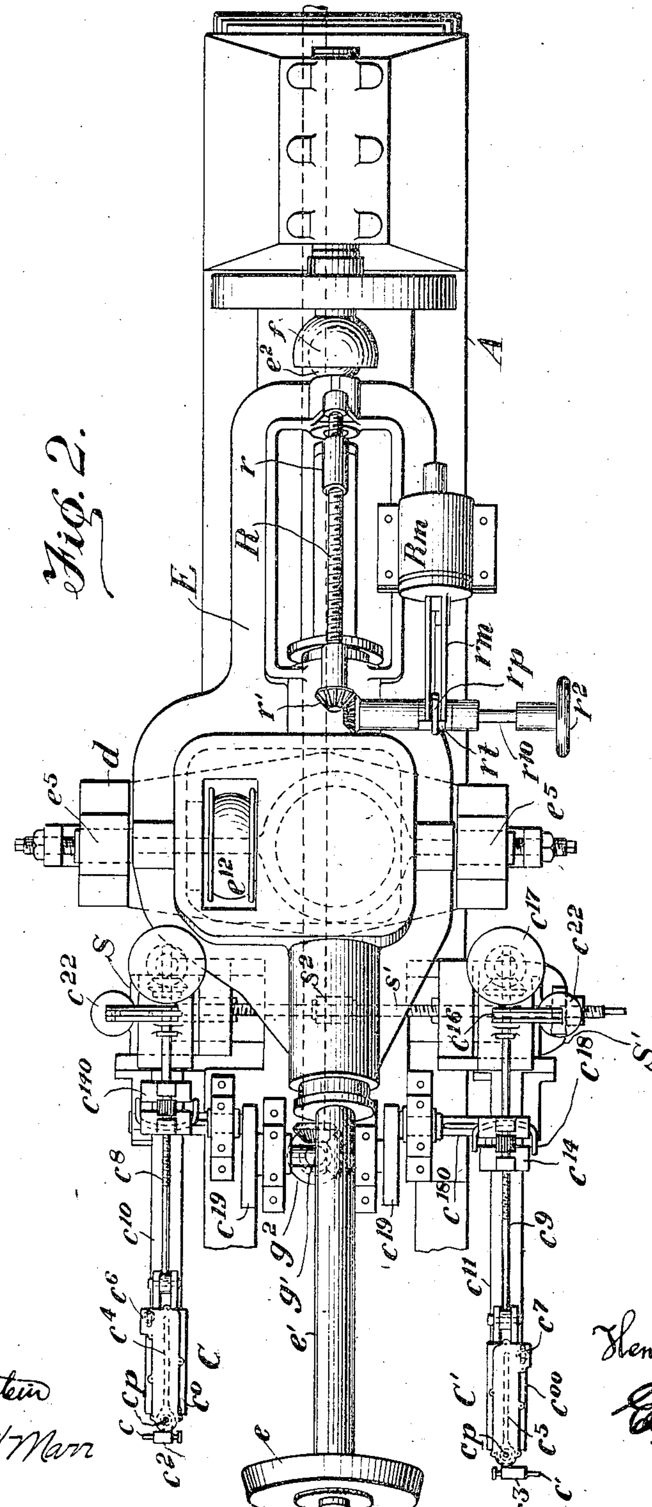
4 SHEETS—SHEET 2.

Fig. 2.



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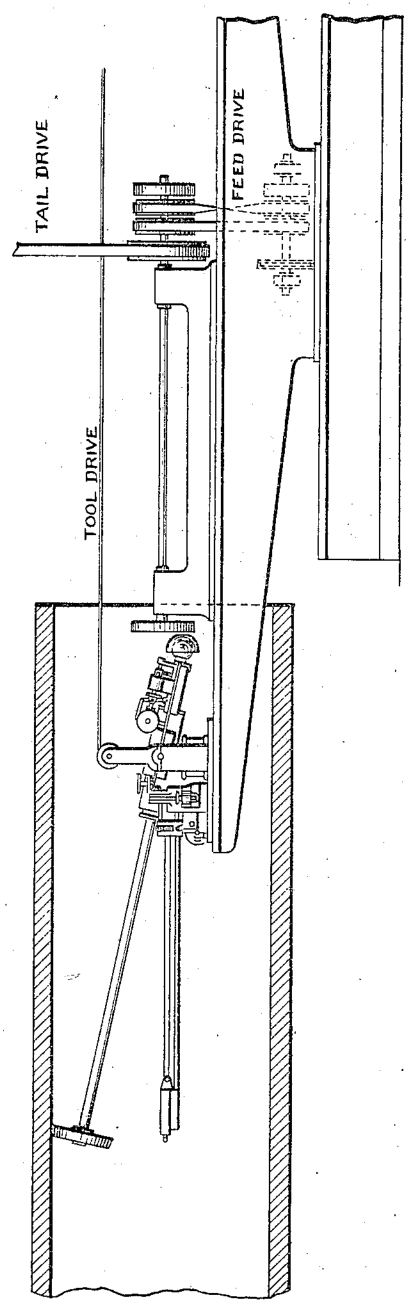

Fig. 3.

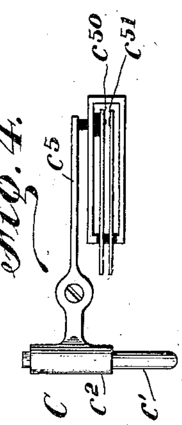

Fig. 4.

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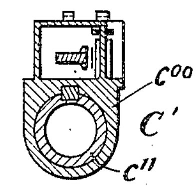
4 SHEETS—SHEET 4.

Fig. 5.



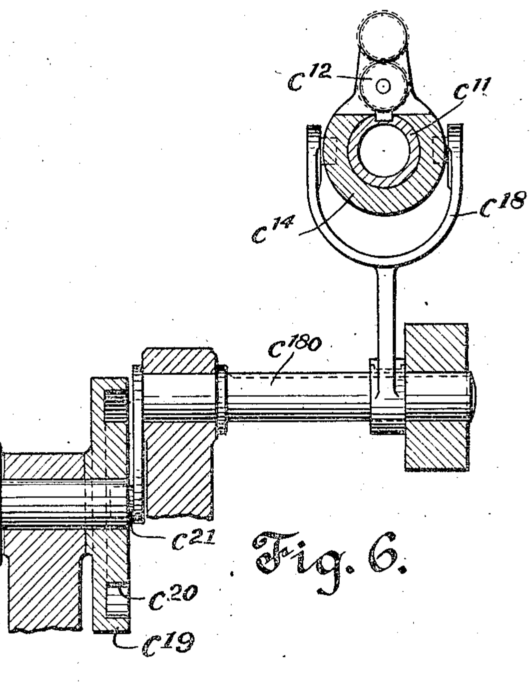


Fig. 6.

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UNITED STATES PATENT OFFICE.

HENRY B. NICHOLS, OF PHILADELPHIA, PENNSYLVANIA.

METHOD OF GRINDING AND SURFACING.

960,188. Specification of Letters Patent. Patented May 31, 1910.

Original application filed October 29, 1907, Serial No. 399,699. Divided and this application filed August 21, 1908. Serial No. 449,673.

To all whom it may concern:

Be it known that I, HENRY B. NICHOLS, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Methods of Grinding and Surfacing, of which the following is a specification, reference being had therein to the accompanying drawing.

My invention relates to methods of surfacing, and especially to the surfacing of hollow forms.

It has for its object the introduction of automatic control so as to compensate for variations in the material operated upon, irregularities in the machinery, or changes in the driving power, also for wear on the working parts.

The type of machine employed, or in fact the employment of a machine as such at all is immaterial. The only mechanical features indispensable to the practice of the method are some form of automatic calipering device and some form of compensation for the working tool or cutter, with a connection between the two. The device may be operated by hand, or it may be of the type of machines illustrated and claimed in my prior Patents Nos. 807,193 and 807,194, dated December 12, 1905, and 856,721 granted June 11, 1907. For a full understanding of the possibilities of the present invention, these patents should be read in connection with the present specification.

The distinctive and characteristic features of the inventions covered by my previous patents are, first, the work being held fixed while the cutting or grinding tool is given a double drive so as to produce a cutting motion and a feed motion, and second, the control of both the drives and especially the feed drive so as to permit of manual compensation for wear on the cutting or grinding head.

The characteristic features of the present invention are, first, holding the work or material operated upon in a relatively fixed position, while giving a double motion or drive to the cutting means; second, automatically following or calipering the condition of the cut as it progresses; and third, automatically controlling the further removal of material through this continuous measuring or calipering process. The present method is particularly suited to such work as the interior surfacing of tubular articles, such as engine cylinders, pieces of ordnance, and the like; but it may also be applied to irregular surfaces, by making small changes in the apparatus with which it is practiced.

The present application is a division of my earlier application Serial No. 399,699, filed October 29, 1907.

In order to convey a full understanding of my invention, I shall describe herein a complete automatic machine with which the method may be practiced. It is to be clearly understood, however, that the method is not limited to this machine, but as I have stated may be practiced with either hand or power actuated tools, in combinations of extreme simplicity.

In the accompanying drawings, forming a part hereof, Figure 1 is a side elevation of a machine embodying my present invention. Fig. 2 is a plan view thereof. Fig. 3 is a side elevation of a similar machine mounted on a cantaliver bed for surfacing large hollow forms. Fig. 4 is a detail of one of the calipers showing a modified form of contacts. Fig. 5 is a transverse section through one of the calipers, and Fig. 6 is a detail thereof with parts in section.

Referring to the drawings, and particularly to Figs. 1 and 2, A represents the bed of the machine, which may be mounted upon pedestals a, or may be built as a cantaliver structure like that shown in Fig. 3. The form shown in Figs. 1 and 2, however, is especially adapted and intended for use with pieces of work that can be fed, so that the machine may remain fixed. Owing to the limited space available within the sight of a Patent Office drawing, I have not been able to show all the connections in Fig. 1, and I have been forced to break away and foreshorten portions of the bed and of the work support, as well as the working parts such as the spindle and the calipers. In practice these latter parts would be of relatively greater length than they appear in Figs. 1 and 2.

Upon the bed A I mount the tool support or turret D, and the tail-stock B. Upon the tool support is mounted a swivel yoke d, carrying the frame E by means of trunnions e^5, which together with the central pintle or swivel mounting of the yoke, give the frame E universal motion over the bed. The frame carries bearings for the tool spindle e', upon the end of which is the cutting head or grinding wheel e. It will be understood that this head e may represent and be replaced by any desired cutting tool.

Specifically the present machine is a grinder, but the automatic calipering and other valuable features should not be limited in the scope of their application. The spindle e' is driven by means of a pulley e^{12} transmitting rotary motion to the spindle through bevel gears e^7 and e^8, the gear e^7 being splined on the spindle to permit longitudinal adjustment thereof. Along the rear end of the frame I provide a longitudinal feed screw R, carrying the feed nut r, and having its ends journaled in bearings e^9 and e^{10}. The forward end is connected through miter-gears to the transverse feed shaft r^{10}, which carries a ratchet rt and a hand wheel r^2. The ratchet is controlled by a pawl rp, connected to the armature and plunger of a solenoid Rm. Each time the solenoid is energized its armature is drawn over and by means of the link rm the pawl rp is caused to follow, stepping around the spindle r^{10}, thereby turning the feed screw R, which draws up the nut r so as to step the cutting head e forward. In grinding this feed is especially required to compensate for the decrease in diameter of the wheel e as it wears.

The tail of the frame E is provided with a ball e^2 fitting in a socket f attached eccentrically to the face plate F on the driven tail spindle f^2. This spindle as well as the main feed screw g is turned through suitable belts and pulleys or equivalent connections, as fully illustrated and described in my prior patents. As the ratio of speeds of the tool spindle e', the tail spindle f^2, and the feed screw or spindle g are all variable and determinable for any particular work by mere changes in the sizes of the belt wheels or gears, I have thought it unnecessary to illustrate or describe the latter in detail especially as it is fully set forth in the patents referred to.

Just forward of the tool support D I mount a pair of transverse slides consisting of blocks S and S' dovetailed onto the bed or frame. On each of these blocks is carried a forwardly projecting slide or arm, and upon these slides or arms I mount the automatic calipers C and C' which form a very important and in fact essential feature of the present invention. The slide carried by block S is marked c^{10}; while that carried by the block S' is marked c^{11}. The caliper C has a head c^2 pivoted at cp on its carriage c^0, and provided with a projecting arm c^4 which coöperates with a fixed and insulated contact point c^6 in the control of an electric circuit, one side of which is connected to the frame of the machine and the other to the insulated point c^6. The carriage c^0 is pivotally connected to the feed screw c^8, which passes back over the slide to a small pair of gears carried in a slide block c^{140}.

The caliper C' has the head c^3 pivoted at c' with an arm c^5, and an insulated contact point c^7. Its carriage c^{00} is pivoted on the end of the feed screw c^9, passing to the small gear c^{12} in the slide block c^{14}. The parts appertaining to the two individual calipers are identical, and further description will therefore be directed only to those shown in Figs. 1, 5 and 6, and belonging to the caliper C'. It will be observed that the slide block c^{14} carries the two pinions c^{12} and c^{13}, the latter being splined on a transverse spindle c^{15} connected to the ratchet c^{16} and through miter gears to the hand wheel c^{17}. The splining is necessary because the block c^{14} is thrown back and forward once for each complete rotation of the tail plate F, that is to say for each rotation of the tool around the surface of the work. This is accomplished by means of a lever c^{18} pivoted at c^{180} in a bearing carried on the main frame. The upper end of this lever is bifurcated as indicated especially in Fig. 2, the prongs or arms having inwardly extending pins which take into vertical slots in the block c^{14}. The bifurcated arm is splined onto the transverse rock-shaft c^{180} which constitutes the pivot element of the lever. This is to permit transverse adjustment of the blocks and slides as a unit, as will presently appear. The lower arm of the lever extends down within the bearings and carries a pin c^{21} which travels in a cam slot formed in the face of a constantly rotating wheel c^{19}. The slot is shown at c^{20} in Fig. 1, and is regular or circular throughout the greater part of its length so as to produce no motion radially of the pin c^{21}, but at one portion the slot takes an inward dip so as to throw the pin in and throw the lever arm back so as to draw back the block c^{14} and with it the carriage c^{00} with its caliper C'. The cam is set so that this dip and withdrawal will take place immediately after the cutting head e has passed the spot touched by the point c' of the caliper. In short, this entire rigging of slide and cam is intended to momentarily insert the caliper into the path of the cutting head and then to withdraw and keep the same out of the line of the cutting head until the latter has passed the spot to be touched by point c' of the caliper. It will be understood of course, that the two cams governing the two calipers C and C' are set with their dips 180 degrees apart, for obvious reasons. If there are more than two calipers they would be set at corresponding angles, so that each caliper in turn would be inserted into and withdrawn from the path of the cutting head. The cam wheels are constantly driven by means of miter gears connected to a vertical spindle g', off the main feed screw g.

I have stated that the blocks S and S', which carry all of the caliper parts, are mounted upon transverse slides. These blocks are adjusted by means of a right and left hand screw shaft s and s' provided with collars and turning in a fixed bearing s^2 against which the collars abut. The shaft is turned to set up the blocks by means of a wrench. This transverse adjustment is obviously necessary as a concomitant of the radial adjustment of the socket f, so as to enable the machine to be used and readily adjusted to bore or grind forms of different diameters.

In Fig. 1 I have indicated a piece of work W, supposed to be slidably mounted on a fixed support Ws, and controlled for feed purposes by the main screw g. This is sufficient to indicate the necessary provisions and connections to be made in practice. The calipers have their contacts included in a circuit 7—8, which also includes a battery 9 and a relay 11. This relay has an armature 12 which has a pair of contacts controlling the circuit 1—2 taking current from a generator 10, and bridged by capacity 13 for the purpose of taking up spark. One branch 3—4 of this circuit goes to the solenoid Rm, and another branch 5—6 goes to each of the solenoids c^{22}. Closure of the caliper contacts on either side results in energization of the relay 11, closure of the circuit 1—2—3—4—5—6, and the passage of working current through the solenoids Rm and c^{22}. These solenoids all pull up their arms simultaneously, each works its ratchet, and the cutting head with both the calipers is thereby stepped forward a small fraction of an inch. It should be noted that this feed is by relatively small divisions of the face of the wheel e, so that a slight inequality or wear at the front cutting edge of the wheel effects the calipers and is then corrected after the feed before the rear edge of the wheel is reached. By this means the accuracy of my machine as a grinder is rendered much greater that that of the regular boring tools, although the latter if equipped with my system of calipers would give better results than without it.

The operation of my machine will now be sufficiently clear. The adjustments are made for the diameter desired and the operation of the longitudinal feed screw g or its equivalent brings the work and the cutting tool together. As the cut progresses, the caliper points (which may advantageously be of hard steel with iridium tips) are pushed along in the same plane with the cutting edge of the wheel. As the latter wears, the cut becomes slightly lighter, and a very slight variation pushes the pin c or c' inward, swinging the long lever c^4 or c^5 until it touches the contact c^6 or c^7, either one of these serving to close its branch of the circuit 7—8, and energize the relay 11 to close the circuit 1—2—3—4—5—6 and energize the solenoids so as to feed the wheel forward and the calipers with it. Since the wheels work on an angle this forward feed of course compensates for wear. The only case where this is reversed is in outside grinding, as shown in my former patents, when of course the wheel would be secured on the spindle in a position the reverse of that shown in Fig. 1 herein. The ratchets would also be reversed so that all the parts would feed backward instead of forward. In straight line or plane work, the tail socket s must reciprocate straight up and down, the calipers must be brought in so as to be within the diameter of the wheel, and the latter will then swing in a vertical arc, grinding parallel surfaces on its opposite faces simultaneously if desired. This feature is of value in heavy plate work, and where the plates are fixed in place, and cannot be moved, as on a ship, the feed screws should move the body of the machine with relation thereto in order to carry the tool over the face of the work. The simplest way to reciprocate the tail of the frame E up and down is to make a cam slot in the face plate F on the tail spindle, set the ball or an equivalent pin e^2 in said slot and lock the turret D against horizontal rotation. Obviously somewhat similar provision might be made for moving the cutting head horizontally instead of vertically, and with the foregoing remarks the necessary changes will be obvious to those skilled in the art.

Referring now to Fig. 3, it will be seen that I have shown the machine mounted on a cantaliver bed, so as to indicate its applicability to large tubular work.

In Fig. 4 I show a form of inclosed contact, which may be advantageously used on the calipers and will exclude dust, oil, etc. The lever of the caliper works the inclosed contact springs by means of the insulating stud shown.

I have thus described one embodiment, and have suggested other embodiments of my invention. It is quite obvious that numerous changes and modifications may be made in the apparatus or in the method of its employment. I reserve the right to make such changes myself, and regard them as well within the scope of my claims and of my invention so long as they do not involve departures from the essential features and principles stated herein. As already pointed out, my method has particular reference to automatic calipering, and while it can be practiced with the apparatus described, it can also be practiced very well with others, some of the simplest forms of apparatus being applicable to hand tools such as a double-tilted lever with the caliper at one end and the hand-actuated tool associated with it, the whole attention of the workman being given to the drive and the cut regulating itself.

Having thus described my invention what I claim and desire to secure by Letters Patent is—

1. In surfacing, the method of compensating for wear of the tool, and of maintaining a constant cut at all times, which comprises the following steps: (1) causing the continuous removal of material from the surface to be reduced while progressing from one portion thereof to another; (2) gaging the depth of each portion of the cut, or the amount of the material removed at periodic intervals alternating with the advance and recession of the cutting means; (3) automatically determining the position and cutting effect of the tool during each period according to the gage indication for the preceding period, substantially as described.

2. The method of accurately surfacing, and of compensating for wear in the surfacing tool, which comprises the following steps: (1) effecting a progressive cut or removal of the material in recurring periodic cycles covering related portions of the surface; (2) gaging the depth of the cut for each cycle; and (3) automatically regulating the position of the tool and the consequent cut for the next cycle in accordance with the gage indications of the preceding cycle, substantially as described.

3. The method of accurate grinding, by compensating for wear of the grinding tool surface, which comprises the following steps: (1) causing the grinding surface to pass over advancing portions of the work at periodic intervals; (2) calipering the depth of the cut at alternating intervals; and (3) regulating the position of the grinding surface and thereby the depth of the cut for each succeeding interval according to the gage indication for the preceding interval, these operations being continuous in their recurrence from the beginning to the end of the cut, so as to maintain the same constant for a single manual setting of the grinding tool, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

HENRY B. NICHOLS.

Witnesses:
GEO. B. TAYLOR,
JAMES COREA.