United States Patent [19]

Hill

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[54] **DIGITAL READOUT METHOD AND APPARATUS**

[75] Inventor: **Richard D. Hill,** Glen Ellyn, Ill.

[73] Assignee: **A & A Engineering Company,** Franklin Park, Ill.

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[21] Appl. No.: **341,340**

[52] **U.S. Cl.**..... **51/5 D,** 51/165.75, 51/325

[51] **Int. Cl.**.. **B24b 49/02,** B24b 49/08, B24b 51/00

[58] **Field of Search**..... 51/281 R, 325, 5 D, 165 R, 51/165.75, 165.81, 165.87

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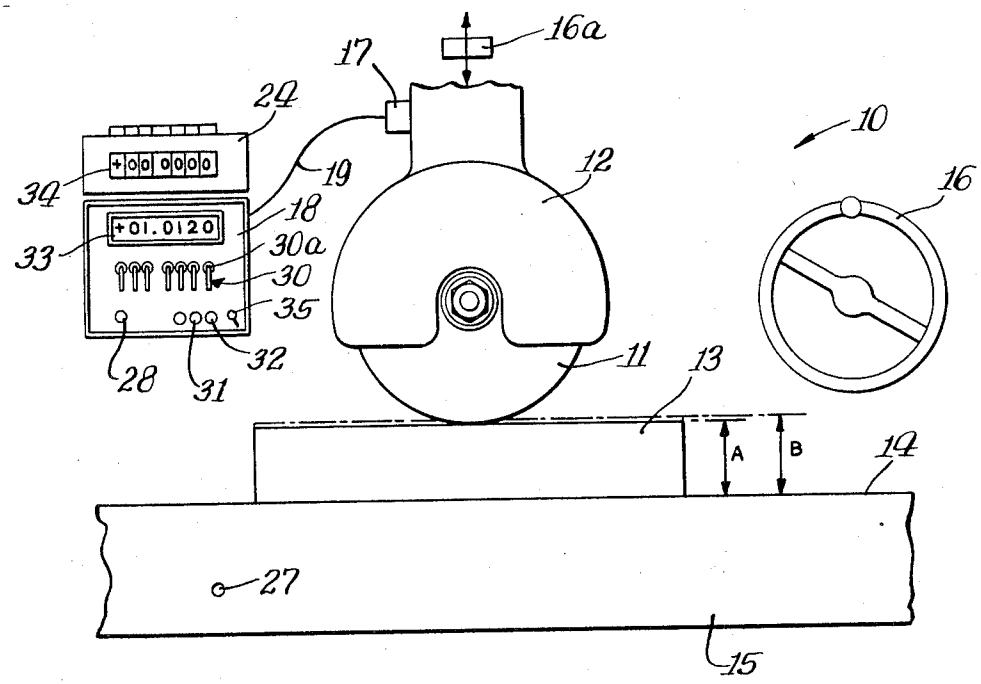
Primary Examiner—Donald G. Kelly

Attorney, Agent, or Firm—Hofgren, Wegner, Allen, Stellman & McCord

[57] **ABSTRACT**

A method and apparatus for grinding a plurality of workpieces, each to a preselected linear dimension, utilizing a digital readout means. Grinding of the workpieces is facilitated by providing on the readout display an indication of the linear dimension of the workpiece as it is being ground so that the grinding operation may be terminated when the readout indication agrees with the desired linear dimension of the workpiece. The grinding wheel may be repeatedly dressed and utilized for succeeding grinding operations while maintaining the readout arrangement for facilitated grinding of a large number of workpieces requiring one or more wheel dressing operations during the grinding operation. The method and apparatus may be utilized in connection with different types of grinding such as surface grinding, cylindrical grinding, etc.

29 Claims, 16 Drawing Figures



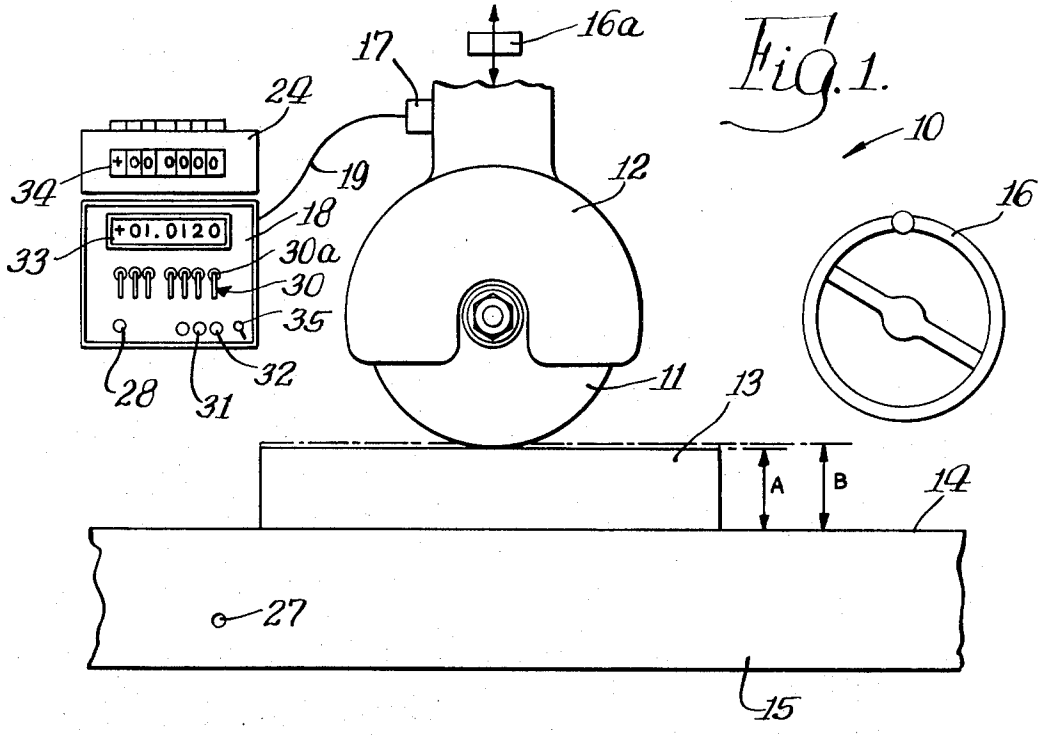

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Fig. 1.

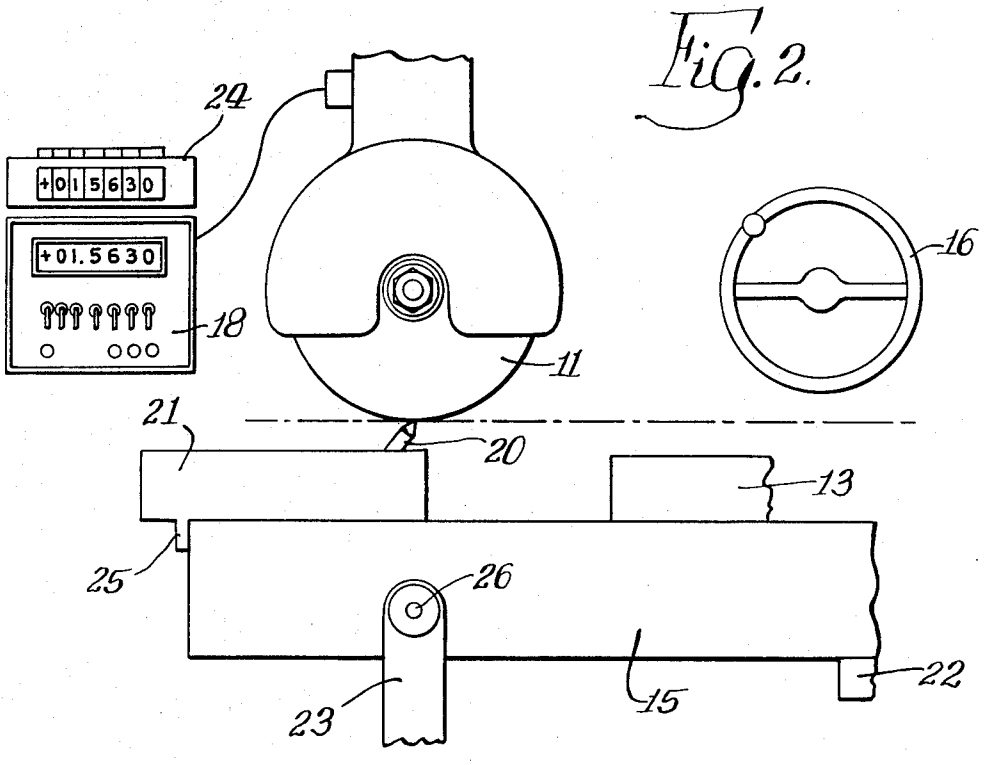
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Fig. 2.

Fig. 3.

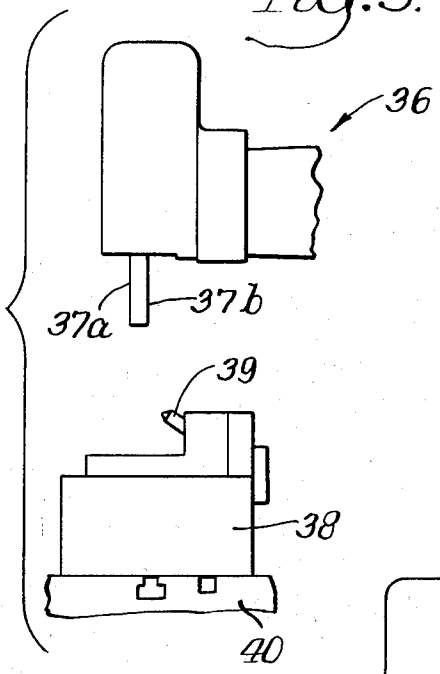


Fig. 4.

Fig. 5a.

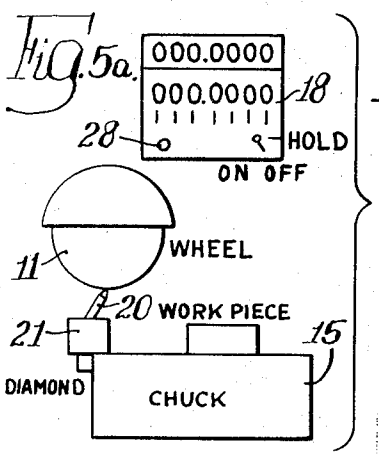


Fig. 5b.

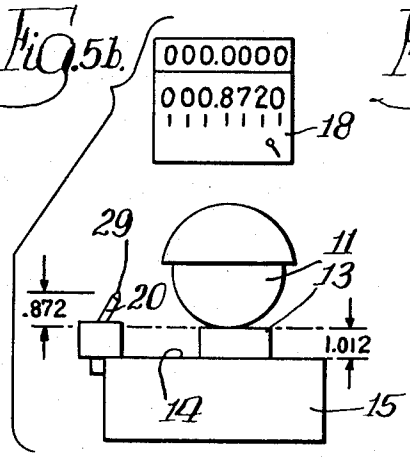


Fig. 5c.

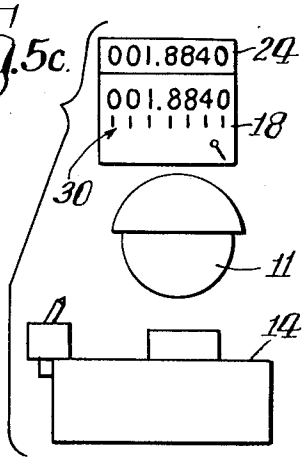


Fig. 5d.

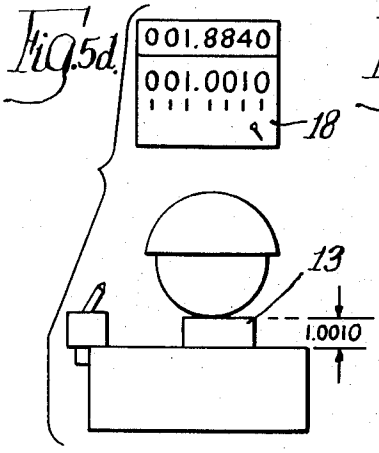


Fig. 5e.

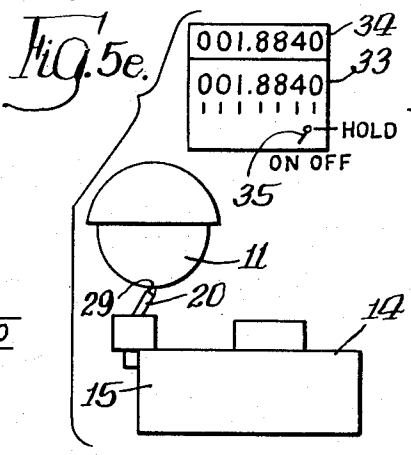


Fig. 5f.

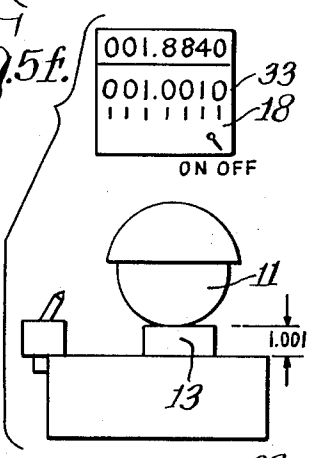


Fig. 6a.

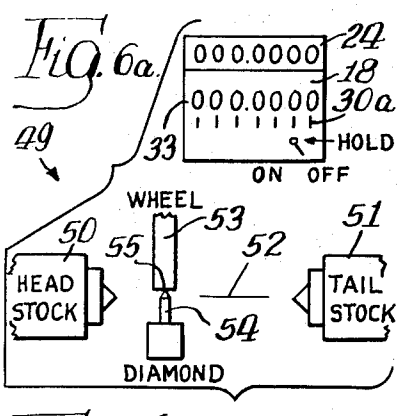


Fig. 6b.

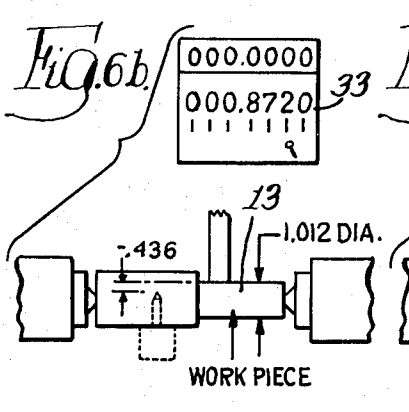


Fig. 6c.

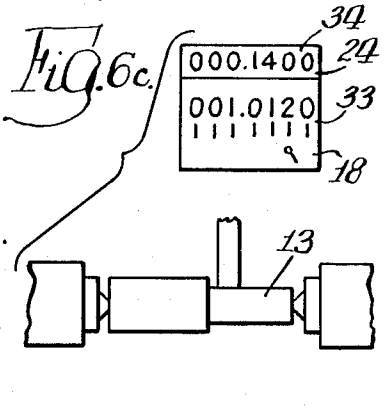


Fig. 6d.

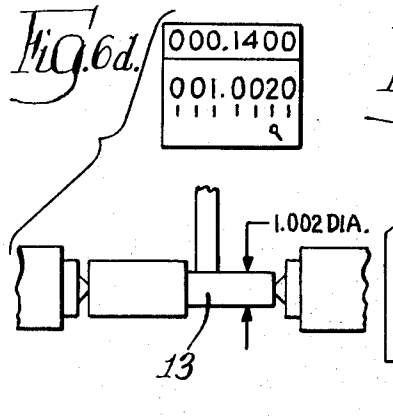


Fig. 6e.

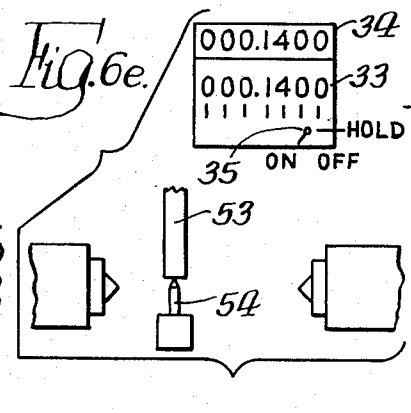
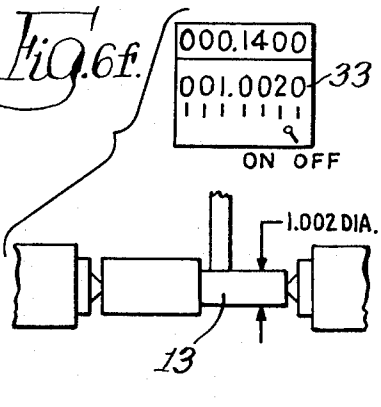


Fig. 6f.



DIGITAL READOUT METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to grinding methods and apparatuses, and in particular, to the grinding of workpieces to preselected accurate dimensions by grinding wheels.

2. Description of the Prior Art

In grinding workpieces to desired final dimensions, a grinding wheel is conventionally brought against the surface of the workpiece and slowly fed into the surface until the workpiece has been ground to the desired final dimension. In order to determine when the grinding operation has reached the final desired point, the operator conventionally must mark down different dimensions and constantly calculate differences or sums in order to cause the workpiece to agree with the drawing showing the desired final linear dimension. In one method of grinding, the handwheel scale is marked with a colored line as a reference against linear dimension information obtained by the operator.

SUMMARY OF THE INVENTION

The present invention comprehends an improved method of and apparatus for grinding workpieces which substantially simplifies the grinding of the workpieces to final accurate desired dimensions. The apparatus includes digital readout means responsive to an encoder and transducer for indicating the position of the grinding wheel relative to the workpiece. A mechanical reference display is associated with the readout electronic display for storing numerical readout information for facilitating dressing of the wheel without affecting the continued facilitated grinding of successive workpieces by direct reading of the linear dimensions of the workpieces.

More specifically, the invention comprehends the improved method of grinding a plurality of workpieces each to a preselected linear dimension comprising the steps of disposing a reference portion of a first of the workpieces at a reference position whereby the surface of the first workpiece to be ground is spaced from the reference position a distance greater than the preselected linear dimension, disposing a dressing tool in a selected position relative to the reference position, providing a grinding wheel, engaging the grinding wheel with the dressing tool to dress the grinding wheel, providing a digital readout means presenting a display indicating the linear spacing of the grinding wheel from the reference position, causing the display to read zero upon completion of the dressing operation, moving the grinding wheel to grind a clean-up area in the surface, determining the linear dimension between the reference portion of the first workpiece and the clean-up area, providing a maintained indication of the sum of (a) the dimension displayed on the readout means repositioning the movement of the grinding wheel from the dressing position to the completed clean-up position and (b) the determined linear dimension of the first workpiece, causing the display to read said determined linear dimension moving the grinding wheel further against the workpiece toward the reference portion until the display reads the preselected linear dimension, and replacing the first workpiece seriatim with each of the other workpieces and grinding each workpiece by seriatim disposing the reference portion thereof at the reference position with the grinding wheel spaced therefrom a distance greater than the original linear dimension of that workpiece and moving the grinding wheel toward the reference position to grind the workpiece until the display again reads the preselected linear dimension.

The invention comprehends further the steps of redressing the grinding wheel prior to grinding all of the workpieces by redisposing the dressing tool in the selected position, returning the grinding wheel to the position wherein the display reading is identical to the maintained indication, holding the display reading while engaging the grinding wheel with the dressing tool to redress the grinding wheel, and returning the grinding wheel to grinding position while permitting the readout means to again change the display in accordance with the movement of the grinding wheel.

Still further, the invention comprehends providing apparatus for grinding such workpieces to the preselected linear dimensions including a grinding wheel, means for translating the grinding wheel, readout display means for providing a digital display of the spacing of a grinding wheel from a reference position, means for dressing the grinding wheel at a position having a preselected relationship to the reference position, and reference display means adjacent the display means for maintaining an indication of the linear dimension representing the preselected relationship.

The method and apparatus of the present invention are extremely simple and economical while yet providing the highly desirable features discussed above.

BRIEF DESCRIPTION OF THE DRAWING

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing wherein:

FIG. **1** is a fragmentary elevation of an apparatus embodying the invention for use in practicing the method of the invention;

FIG. **2** is a view similar to that of FIG. **1** illustrating a step of dressing the grinding wheel;

FIG. **3** is a side elevation of the grinding apparatus illustrating a side dressing operation therewith;

FIG. **4** is a side elevation similar to that of FIG. **3** but illustrating the arrangement for dressing either side of the grinding wheel;

FIGS. **5***a*–**5***f* are schematic elevations illustrating the method of the invention in connection with surface grinding; and

FIGS. **6***a*–**6***f* are similar schematic elevations illustrating the method of the invention in connection with cylindrical grinding.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the exemplary embodiment of the invention as disclosed in FIGS. **1, 2** and **5***a*–**5***f*, a surface grinder apparatus generally designated **10** is shown to comprise a grinding wheel **11** rotatably supported on a movable carrier **12** for vertical movement against a workpiece **13** carried on an upper surface **14** of a table **15.** Vertical movement of the wheel **11** is controlled by the operator through manipulation of a handwheel **16** and mechanism **16***a* in the normal manner, as will be obvious to those skilled in the art. The present invention is concerned with providing information to the operator to facilitate grinding of the workpiece accurately to a

desired linear dimension, such as Dimension A, with the workpiece being originally provided with a relatively larger linear dimension B, as shown in FIG. 1.

The vertical movement of the support 12 is sensed by a suitable encoder and transducer 17 well known to those skilled in the art, which may be connected to a conventional digital readout display device 18 by suitable wires 19 for providing an accurate readout of the vertical position of the grinding wheel 11.

As indicated briefly above, the invention further comprehends successively dressing wheel 11 as by means of a conventional diamond 20 mounted on a diamond holder 21 while permitting facilitated successive grindings of workpieces. For this purpose, table 15 is provided with conventional means 22 for effecting horizontal movement of the table when desired to bring the diamond 20 approximately under the center of the grinding wheel 11 to effect the desired dressing operation. A suitable conventional lock 23 may be provided in association with table 15 for locking the table in the wheel dressing position.

The invention further comprehends the provision of a mechanical reference display device 24 adjacent the digital readout display device 18 for storing a display for use in practicing the improved grinding method as will be discussed in greater detail herefollowing.

Facilitated understanding of the novel grinding method embodied by the present invention may be had by reference to FIGS. 5*a*–5*f*. As illustrated, a first step in the grinding operation comprises placing the diamond holder 21 on table 15 in a preselected position thereon which permits repeated replacement thereof accurately in the same position. As shown, the diamond holder may include suitable dowels 25 for accurately positioning the holder at the end of table 15, in which position, it may be retained by magnetic chuck action of the table 15 in the normal manner. As illustrated in FIG. 5*a*, with the diamond 20 thus accurately positioned on the table, or chuck 15, the table is moved to the position wherein diamond 20 is approximately under the center of the grinding wheel 11. Table 15 is locked in this position by the lock means 23. Illustratively, lock means 23 may comprise a dowel 26 which is adapted to be received in a suitable registry opening 27 in table 15 in the dressing position of the apparatus. The grinding wheel is then dressed in the conventional manner by suitably bringing the wheel down against the diamond.

When the dressing of the wheel is completed, the readout display device is reset to zero by suitable manipulation of the "reset" button 28 thereof.

Table 15 is then moved, as shown in FIG. 5*b*, to position the workpiece 13 under the grinding wheel 11 and a clean-up spot is ground on the workpiece for purposes of taking an accurate measurement of the linear dimension such as the thickness of the workpiece illustrated as 1.012 inches in FIG. 5*b*. In grinding the clean-up spot, very light cuts are made so as to minimize any wear of the grinding wheel. At this point, the reading on the digital readout display device 18 is noted. The linear dimension of the workpiece is accurately determined as by conventional micrometer determination and these two figures are added together to provide an accurate indication of the exact distance from the tip 29 of the dressing tool diamond 20 to the upper surface 14 of table 15. Thus, for example, if the movement of the grinding wheel downwardly from the position of the diamond tip 29 is 0.872 inches, as shown in FIG. 5*b*, this dimension is added to the workpiece thickness dimension of 1.012 inches. The sum figure of 1.8840 inches is then entered into the mechanical reference display device 24, as shown in FIG. 5*c*. The digital readout display device is then reset mechanically by manipulating the unit digit switches 30 to the measured workpiece thickness, i.e., 1.012 inches with the grinding wheel maintained as shown in FIG. 5*b*. Thus set, the digital readout display device reads accurately the linear dimension from the table surface 14 to the bottom of the grinding wheel and, thus, when the wheel is advanced into the workpiece 13, as shown in FIG. 5*d*, the ground thickness dimension of the workpiece is constantly displayed on the digital readout display device 18. In other words, the display of the digital readout display device 18 now accurately indicates the size of the workpiece as it is being ground down to the final desired linear dimension. As further shown in FIG. 5*c*, the digital readout display device 18 indicates the spacing from reference surface 14 of the dressed surface of the grinding wheel 11 so that if, for example, the grinding wheel were backed off to the original dressed position of FIG. 5*a*, the reading would be accurately the spacing of the diamond dressing tool tip 20 from the reference plane 14.

Thus, there is no need for further calculations to be made by the operator in arriving at the final workpiece dimension. The linear dimension shown on the drawing from which the operator may be working indicates the reading of the digital readout display device 18 which corresponds to the completion of the grinding operation. To facilitate arriving at the final dimension, the digital readout display device 18 may include a selector control 31 providing an early warning such as when the readout dimension is within one-tenth or one-one hundredth of the final figure. Device 18 may include an indicator light 32 to provide an indication of the reaching of this proximity to the final desired dimension as indicated.

As indicated above, the invention comprehends the facilitated dressing of the grinding wheel from time to time in grinding a plurality of workpieces successively. Thus, as illustrated in FIG. 5*e*, the grinding wheel 11 may be brought back to the dressing diamond 20 which is accurately located on the chuck table 15 as described above. The wheel is then lowered until the digital readout display 33 corresponds to the display 34 on the mechanical reference display device. As indicated above, this corresponds to the position of the grinding wheel at the completion of the initial dressing operation. At this point, the hold switch 35 is actuated to lock the display 33 so that no change therein will occur notwithstanding a further lowering of the grinding wheel 11 into engagement with the diamond tool tip 29, as shown in FIG. 5*e*. It is assumed at this point that the grinding wheel will have worn down somewhat from the original dimension so that the wheel will have to be brought down slightly from the original position of FIG. 5*a* to effect the dressing operation. When the operator completes the dressing operation, he then reactivates the digital readout display device 18 by throwing the hold switch 35 to the "Off" position. As the diamond tip 29 is accurately located relative to the table surface 14 and this dimension is the dimension shown in the held display 34 and the now activated display 33, the system is again back to the same arrangement as it was

in FIG. 5*a* so that upon returning the grinding wheel **11** to overlie a subsequent workpiece **13,** the grinding of the workpiece may be effected in exactly the same manner as the grinding of the previous workpiece described relative to FIGS. 5*b*, 5*c* and 5*d*. Thus, by utilizing the hold means of the digital readout display device **18** during the dressing operation, no changes in the grinding operation need be effected so that any number of successive dressings of the wheel may be effected while yet permitting the operator to quickly and efficiently return to the grinding of the plurality of workpieces with the reaching of the desired linear dimension thereof being repeatedly indicated by the reaching of the desired figure in the digital readout display **33.** In effect, the holding of the display **33** comprises the provision of memory means in the apparatus as the display **33** effectively displays the distance from the bottom of the dressed grinding wheel to the table surface **14.**

When it is necessary to substitute or change the position of the dressing tool diamond **20,** the entire above discussed procedure is again effected including the establishment of the location of the diamond tool tip above the level of the table surface **14.** If the grinding wheel is changed, the steps shown in FIGS. 5*e* and 5*f* need merely be followed as this corresponds merely to a change in the diameter of the grinding wheel such as by wear on the grinding wheel.

As indicated briefly above, the invention may be utilized with other types of grinding apparatus. As shown in FIGS. **3** and **4,** the invention may be utilized in connection with a side grinder generally designated **36.** Such machines are well known to those skilled in the art. Briefly, as shown in FIGS. **3** and **4,** side grinder **36** includes a grinding wheel **37** having sides **37***a* and **37***b*. As shown in FIG. **3,** diamond holder **38** may be utilized to hold a single dressing tool diamond **39** in position to grind wheel surface **37***b* in one position on the chuck **40.** Reversing the position of the holder **38** on the chuck may be effected for dressing the opposite surface **37***a*. As shown in FIG. **4,** a double tool dressing device generally designated **41** is shown to include a pair of dressing tool diamonds **42** and **43** having a spacing therebetween greater than the width of the grinding wheel **37** to accommodate the wheel therebetween. The tool holder **44** may be accurately mounted to the chuck **45.** The operation of the side grinder **36** in connection with the digital readout display device **18** and mechanical reference display device **24** is substantially identical to that of the surface grinder operation discussed above except for the horizontal translation of the grinding wheel rather than the vertical translation. Thus, the side of the grinding wheel **37** is first dressed and the display **33** is then set at zero. The tool holder **44** is then removed from chuck **45** and the workpiece placed against the back gauge **46.** A clean-up cut is then ground on the side of the workpiece and the linear dimension between the tip of the grinding tool and the surface **47** of the back gauge determined and placed in the mechanical reference display device **24.** The digital readout display device **18** is then reset as discussed above to display the determined linear dimension of the workpiece and grinding of the workpiece is then effected with the changing, ground linear dimension of the workpiece being shown at all times during the grinding operation by the display **33.**

Dressing of the wheel is effected in the same manner as in connection with the surface grinder discussed above. Thus, the tool diamond is again positioned on the chuck **45** by placement of the tool holder against the back gauge **46.** Cross slide **48** is actuated until the display **33** corresponds to the held display **34.** Display **33** is then held by operation of the hold switch **35** whereupon dressing of the wheel may be effected and grinding of the subsequent workpiece then effected by releasing the display **33** upon completion of the grinding operation. Thus, in connection with the side grinder **36,** the holding of the electronic display **33** is utilized in the same manner as in connection with the surface grinder to facilitate a continuous grinding operation of a plurality of workpieces wherein redressing of the grinding wheel is effected from time to time.

Still further, the present invention may be utilized in connection with a cylindrical grinder **49** such as schematically illustrated in FIGS. 6*a*–6*f*. Such cylindrical grinders are well known to those skilled in the art, and for purposes of the present invention, it need merely be understood that in such grinders, the workpiece **13** is held between a head stock **50** and a tail stock **51** which rotate coaxially about an axis **52** so that engagement of the grinding wheel **53** will effect a grinding of the outer cylindrical coaxial surface of the workpiece. Effectively, the same method of grinding as discussed above relative to the surface and side grinders is utilized in conjunction with such cylindrical grinders.

More specifically, the accurately located dressing tool diamond **54** is utilized to dress the grinding wheel **53** and upon completion of the dressing operation, display **33** is set at zero. As shown in FIG. 6*b*, a clean-up cut is then taken on the outer diameter of the workpiece. Assuming that the movement of the grinding wheel outwardly from the position of the diamond is 0.436 inches, the readout display **33** is arranged to show a figure twice this movement, or 0.8720 inches, to correspond to the diameter relationship rather than the radial relationship. Assuming that the accurately determined diameter of the cleaned-up portion of the workpiece is 1.012 inches, the difference between the measured diameter and the indicated display is then entered into the mechanical reference display device **24.** Thus, display **34** would read 0.1400 inches. The 0.1400 inch figure is that reading on the display **33** to which the operator must return in going back to the tip **55** of the diamond **54** in a subsequent grinding operation. At this time, the operator resets the digital readout display device **18** to show in display **33** the part size 1.012 inches. The workpiece is then ground down to a diameter slightly larger than the desired final diameter, as shown in FIG. 6*d* (assuming that the final diameter is 1.0000 inches). The ground diameter may be 1.0020 inches. As shown in FIG. 6*e*, grinding wheel **53** is then redressed by tool **54.** To effect the redressing operation within the scope of the invention, the operator moves the grinding wheel until display **33** corresponds with the held display **34,** which, as shown in FIG. 6*e*, comprises the reference figure 0.1400 inches. The hold switch **35** is then thrown to the "On" position and the grinding wheel dressed by tool **54** similarly as discussed with respect to the surface and side grinders above. Upon completion of the dressing operation, the hold switch **35** is thrown to the "Off" position, whereupon display **33** is released and the wheel is then brought back to the position wherein the display **33** again reads 1.0020 inches. At this point, the grinding wheel will be back accurately at the position of the rough cut of FIG.

6*d* and as the grinding wheel is now newly dressed, the finished grinding of the workpiece to the final 1.000 inch dimension may be effected by moving the grinding wheel until the display **33** reads the final desired linear dimension of 1.000 inch.

If the operator fails to dress the wheel before substantial wear of the wheel occurs, the wheel must be brought down further in order to obtain the desired ground size of the workpiece. Where this occurs, the operator may adjust the display devices **18** and **24** incrementally by means of the digit switch **30***a* controlling the last digit on the digital readout display device **18** and by suitably correspondingly manually adjusting the last digit of the mechanical reference display device **24**. This automatically maintains the relationship between the two display devices and the desired reference point for the dressing tool tip.

The present invention provides means for improved angle and radius dressing of wheels in providing high accuracy in the location of the wheels relative to the workpiece. The invention provides for improved facilitated working of workpieces such as in a grinding operation by simple digital readout means coordinated with means for holding the display thereof in correspondence with stored information in an associated mechanical reference display device. Thus, substantial economies in manufacturing, as in the grinding operations thereof, may be effected by the disclosed method and apparatus while yet they are extremely simple and economical.

The foregoing disclosure of specific embodiments is illustrative of the broad inventive concepts comprehended by the invention.

I claim:

1. The method of grinding a plurality of workpieces each to a preselected linear dimension, comprising the steps of:

disposing a reference portion of a first of said workpieces at a reference position whereby the surface of said first workpiece to be ground is spaced from said reference position a distance greater than said preselected linear dimension;

disposing a dressing tool in a selected position relative to said reference position;

providing a grinding wheel;

engaging the grinding wheel with the dressing tool to dress the grinding wheel;

providing a digital readout means presenting a display indicating the linear spacing of the grinding wheel from said reference position;

causing the display to read zero upon completion of the dressing operation;

moving the grinding wheel to grind a clean-up area on said surface;

determining the linear dimension between said reference portion of the first workpiece and said clean-up area;

providing a maintained indication of the sum of

a. the dimension displayed on the readout means representing the movement of the grinding wheel from the dressing position to the completed clean-up position, and

b. said determined linear dimension of the first workpiece;

causing the maintained indication to read said sum;

resetting the display to read said determined linear dimension;

moving the grinding wheel further against the workpiece toward said reference portion until the display reads said preselected linear dimension; and

replacing said first workpiece seriatim with each of the other workpieces and grinding each workpiece by seriatim disposing the reference portion thereof at said reference position with the grinding wheel spaced therefrom a distance greater than the original linear dimension of that workpiece and moving the grinding wheel toward the reference position to grind the workpiece until said display again reads said preselected linear dimension.

2. The method of grinding a plurality of workpieces each to a preselected linear dimension of claim **1** wherein said reference position comprises a horizontal table surface and said grinding wheel is moved vertically to surface grind the workpiece.

3. The method of grinding a plurality of workpieces each to a preselected linear dimension of claim **1** wherein said reference position comprises a vertical back gauge surface and said grinding wheel is moved horizontally to side grind the workpiece.

4. The method of grinding a plurality of workpieces each to a preselected linear dimension of claim **1** wherein said reference position comprises an axis of revolution of the workpiece, said workpiece is rotated about said axis and said grinding wheel is concurrently moved radially toward said axis to cylindrically grind the workpiece, said preselected linear dimension comprises the desired ground diameter of the workpiece, and said sum comprises twice (a) and (b) to represent a diametric linear dimension.

5. The method of grinding a plurality of workpieces each to a preselected linear dimension, comprising the steps of: disposing a reference portion of a first of said workpieces at a reference position whereby the surface of said first workpiece to be ground is spaced from said reference position a distance greater than said preselected linear dimension; disposing a dressing tool in a selected position relative to said reference position; providing a grinding wheel; engaging the grinding wheel with the dressing tool to dress the grinding wheel; providing a digital readout means presenting a display indicating the linear spacing of the grinding wheel from said reference position; causing the display to read zero upon completion of the dressing operation; moving the grinding wheel to grind a clean-up area on said surface; determining the linear dimension between said reference portion of the first workpiece and said clean-up area; providing a maintained indication of the sum of (a) the dimension displayed on the readout means representing the movement of the grinding wheel from the dressing position to the completed clean-up position, and (b) said determined linear dimension of the first workpiece; causing the maintained indication to read said sum; resetting the display to read said determined linear dimension; moving the grinding wheel against the workpiece toward said reference portion until the display reads said preselected linear dimension; replacing said first workpiece seriatim with each of a plurality of other workpieces and grinding each such other workpieces by seriatim disposing the reference portion thereof at said reference position with the grinding wheel spaced therefrom a distance greater than the original linear dimension of that work-

piece and moving the grinding wheel toward the reference position to grind the workpiece until said display again reads said preselected linear dimension; redressing the grinding wheel prior to grinding additional ones of said workpieces by redisposing the dressing tool in said selected position, returning the grinding wheel to the position wherein said display reading is identical to said maintained indication, holding the display reading while engaging the grinding wheel with the dressing tool to redress the grinding wheel, and returning the grinding wheel to grinding position while permitting the readout means to again change the display in accordance with the movement of the grinding wheel; and grinding each of said additional workpieces with the redressed grinding wheel by seriatim disposing the reference portion thereof at said reference position with the grinding wheel spaced therefrom a distance greater than the original linear dimension of that workpiece and moving the grinding wheel toward the reference position to grind the workpiece until said display again reads said preselected linear dimension.

6. The method of grinding a plurality of workpieces each to a preselected linear dimension of claim **5** wherein said reference position comprises a horizontal table surface and said grinding wheel is moved vertically to surface grind the workpiece.

7. The method of grinding a plurality of workpieces each to a preselected linear dimension of claim **5** wherein said reference position comprises a vertical back gauge surface and said grinding wheel is moved horizontally to side grind the workpiece.

8. The method of grinding a plurality of workpieces each to a preselected linear dimension of claim **5** wherein said reference position comprises an axis of revolution of the workpiece, said workpiece is rotated about said axis and said grinding wheel is concurrently moved radially toward said axis to cylindrically grind the workpiece, said preselected linear dimension comprises the desired ground diameter of the workpiece, and said sum comprises twice (a) and (b) to represent a diametric linear dimension.

9. The method of grinding a plurality of workpieces each to a preselected linear dimension, comprising the steps of:

disposing a reference portion of a first of said workpieces at a reference position whereby the surface of said first workpiece to be ground is spaced from said reference position a distance greater than said preselected linear dimension;

disposing a dressing tool in a selected position relative to said reference position;

providing a grinding wheel;

engaging the grinding wheel with the dressing tool to dress the grinding wheel;

providing a digital readout means presenting a display indicating the linear spacing of the grinding wheel from said reference position;

causing the display to read zero upon completion of the dressing operation;

moving the grinding wheel to grind a clean-up area on said surface;

determining the linear dimension between said reference portion of the first workpiece and said clean-up area;

providing a maintained indication of the sum of

a. the dimension displayed on the readout means representing the movement of the grinding wheel from the dressing position to the completed clean-up position; and

b. said determined linear dimension of the first workpiece;

causing the maintained indication to read said sum;

resetting the display to read said determined linear dimension;

moving the grinding wheel further against the workpiece toward said reference portion until the display reads said preselected linear dimension;

replacing said first workpiece seriatim with each of a plurality of other workpieces and grinding each such other workpieces by seriatim disposing the reference portion thereof at said reference position with the grinding wheel spaced therefrom a distance greater than the original linear dimension of that workpiece and moving the grinding wheel toward the reference position to grind the workpiece until said display again reads said preselected linear dimension;

redressing the grinding wheel prior to grinding additional ones of said workpieces by redisposing the dressing tool adjacent said selected position, engaging the grinding wheel with the dressing tool to redress the grinding wheel, and upon completion of the redressing and prior to moving said grinding wheel from the final dressing position, adjusting the digital readout means display to indicate said sum; and

grinding each of said additional workpieces with the redressed grinding wheel by seriatim disposing the reference portion thereof at said reference position with the grinding wheel spaced therefrom a distance greater than the original linear dimension of that workpiece and moving the grinding wheel toward the reference position to grind the workpiece until said display again reads said preselected linear dimension.

10. The method of grinding a plurality of workpieces each to a preselected linear dimension of claim **9** wherein said reference position comprises a horizontal table surface and said grinding wheel is moved vertically to surface grind the workpiece.

11. The method of grinding a plurality of workpieces each to a preselected linear dimension of claim **9** wherein said reference position comprises a vertical back gauge surface and said grinding wheel is moved horizontally to side grind the workpiece.

12. The method of grinding a plurality of workpieces each to a preselected linear dimension of claim **9** wherein said reference position comprises an axis of revolution of the workpiece, said workpiece is rotated about said axis and said grinding wheel is concurrently moved radially toward said axis to cylindrically grind the workpiece, said preselected linear dimension comprises the desired ground diameter of the workpiece, and said sum comprises twice (a) and (b) to represent a diametric linear dimension.

13. Apparatus for grinding a plurality of workpieces each to a preselected linear dimension, comprising:

a grinding wheel;

means for translating the grinding wheel;

readout display means for providing a digital display of the spacing of a grinding wheel from a reference position;

means for holding the workpieces in a preselected disposition relative to said reference position;

fixed means for dressing the grinding wheel at a position having a preselected fixed relationship to said reference position; and

reference display means adjacent said display means for maintaining an indication of the linear dimension representing said fixed preselected relationship.

14. The grinding apparatus of claim **13** wherein said reference display means provides a display of the maintained linear dimension indication closely adjacent said digital display of the readout display means.

15. The grinding apparatus of claim **13** wherein said reference display means provides a display of the maintained linear dimension indication closely adjacent to and aligned with said digital display of the readout display means.

16. The grinding apparatus of claim **13** wherein said readout display means includes means for selectively holding the display indication notwithstanding translation of the grinding wheel.

17. The grinding apparatus of claim **13** wherein said readout display means includes means for warning of closely approaching the preselected linear dimension.

18. The grinding apparatus of claim **13** wherein the dressing means comprises means for dressing the sides of the grinding wheel.

19. Apparatus for grinding a plurality of workpieces each to a preselected linear dimension, comprising:

a grinding wheel;

means for translating the grinding wheel;

readout display means for providing a digital display of the spacing of a grinding wheel from a reference position;

means for holding the workpieces in a preselected disposition relative to said reference position;

means for dressing the grinding wheel at a fixed position about a fixed preselected relationship to said reference position;

reference display means adjacent said display means for maintaining an indication of the linear dimension representing said fixed preselected relationship; and

means for selectively locking said readout display means to maintain said digital display notwithstanding a movement of said wheel relative to said reference position.

20. The grinding apparatus of claim **19** wherein said reference display means provides a display of the maintained linear dimension indication closely adjacent said digital display of the readout display means.

21. The grinding apparatus of claim **19** wherein said reference display means provides a display of the maintained linear dimension indication closely adjacent to and aligned with said digital display of the readout display means.

22. The grinding apparatus of claim **19** wherein said readout display means includes means for warning of closely approaching the preselected linear dimension.

23. The grinding apparatus of claim **19** further including means independent of said reference display means for presetting said readout display means.

24. The grinding apparatus of claim **19** wherein the dressing means comprises means for dressing the sides of the grinding wheel.

25. Apparatus for grinding a plurality of workpieces each to a preselected linear dimension, comprising:

a grinding wheel;

means for translating the grinding wheel;

readout display means for providing a digital display of the spacing of a grinding wheel from a reference position;

means for holding the workpieces in a preselected disposition relative to said reference position;

fixed means for dressing the grinding wheel at a position having a preselected fixed relationship to said reference position;

reference display means adjacent said display means for maintaining an indication of the linear dimension representing said fixed preselected relationship; and

means independent of said reference display means for presetting said readout display means.

26. The grinding apparatus of claim **25** wherein said reference display means provides a display of the maintained linear dimension indication closely adjacent said digital display of the readout means.

27. The grinding apparatus of claim **25** wherein said reference display means provides a display of the maintained linear dimension indication closely adjacent to and aligned with said digital display of the readout display means.

28. The grinding apparatus of claim **25** wherein said readout display means includes means for warning of closely approaching the preselected linear dimension.

29. The grinding apparatus of claim **25** wherein the dressing means comprises means for dressing the sides of the grinding wheel.

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