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Cary

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[45] Aug. 13, 1974

[54] **MACHINE FOR PRODUCING THIN SECTION SPECIMENS**

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[52] **U.S. Cl.** ..... **125/13 R,** 51/3, 51/166 MH

[51] **Int. Cl.** **B28d 1/04**

[58] **Field of Search** ..... 125/13, 13 SS, 14; 51/3, 51/166 MH, 168, 165.8

[56] **References Cited**

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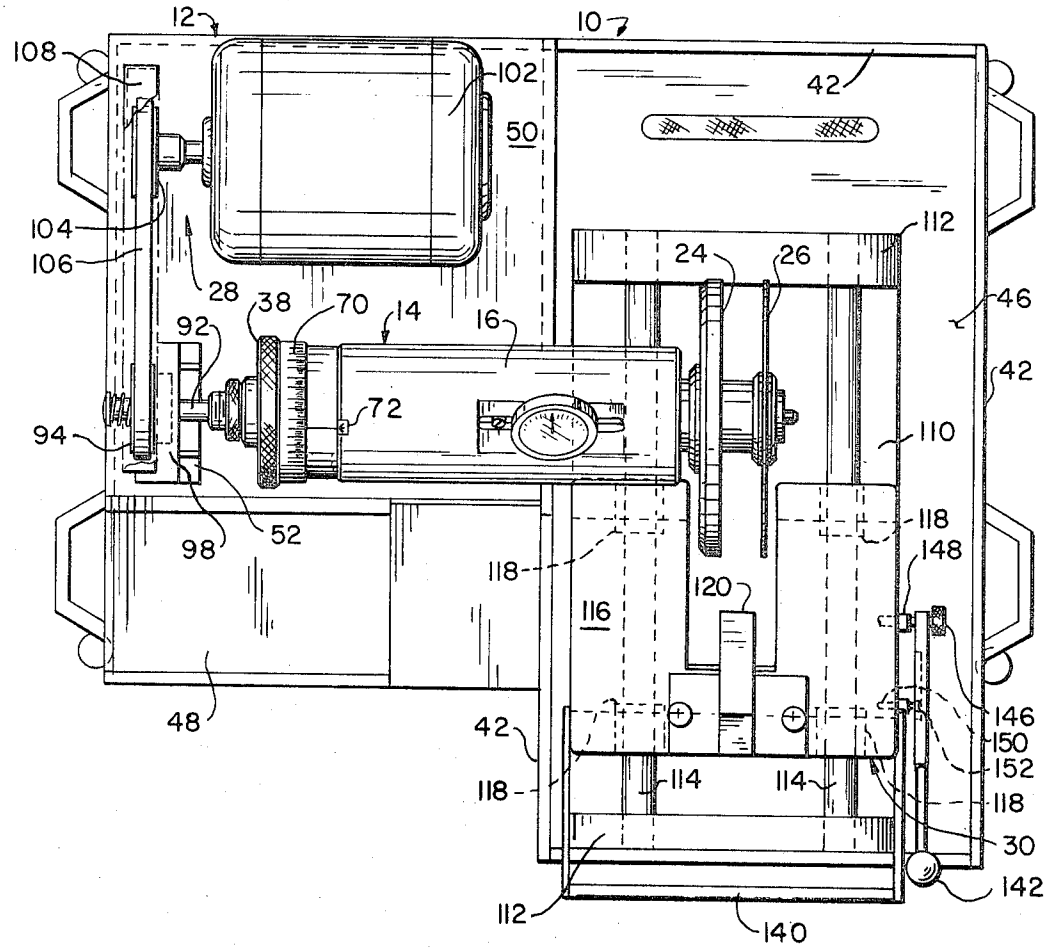
Primary Examiner—Harold D. Whitehead

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[57] **ABSTRACT**

A versatile apparatus for both cutting and grinding, lapping and polishing solid material to produce thin section specimens for analysis and quality control is disclosed herein and includes a support base upon which a quill assembly is mounted. The quill assembly is provided for imparting longitudinal movement to a power-driven rotationally movable spindle, grinding wheel, and cutting wheel, the latter two being connected with the spindle for rotational movement therewith. In this regard, the apparatus includes a differential screw and annular micrometer dial for effecting accurate longitudinal adjustment of the spindle. A sliding cross-plate is also mounted on the aforestated support base and is designed to be manually moved both toward and away from the grinding and cutting wheels. A specimen holder removably mounted on the sliding cross plate is designed to bring a pair of spaced apart specimens into contacting engagement with the wheels whereby one of the specimens will be in contacting engagement with a corresponding one of said wheels when the cross plate is moved toward the latter.

11 Claims, 6 Drawing Figures



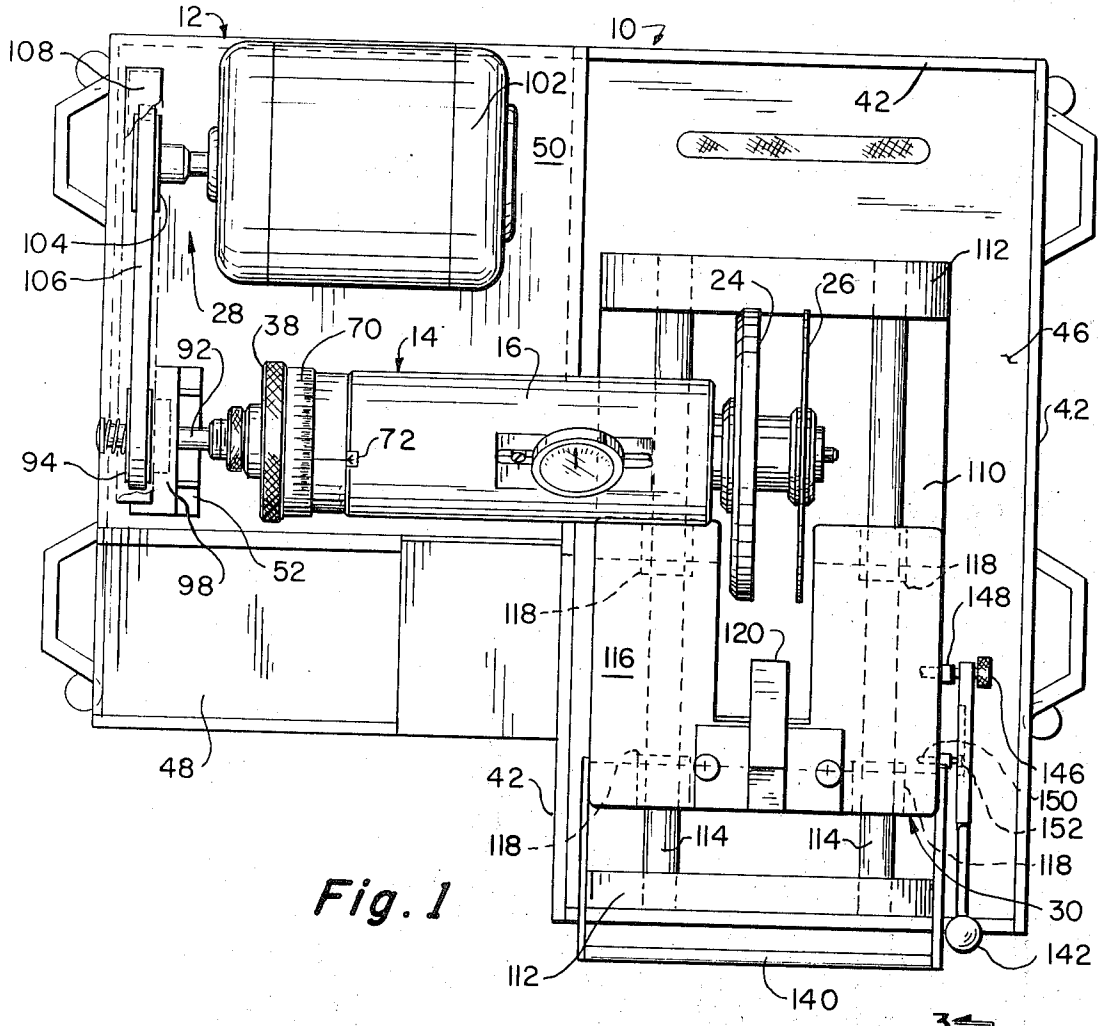

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Fig. 1

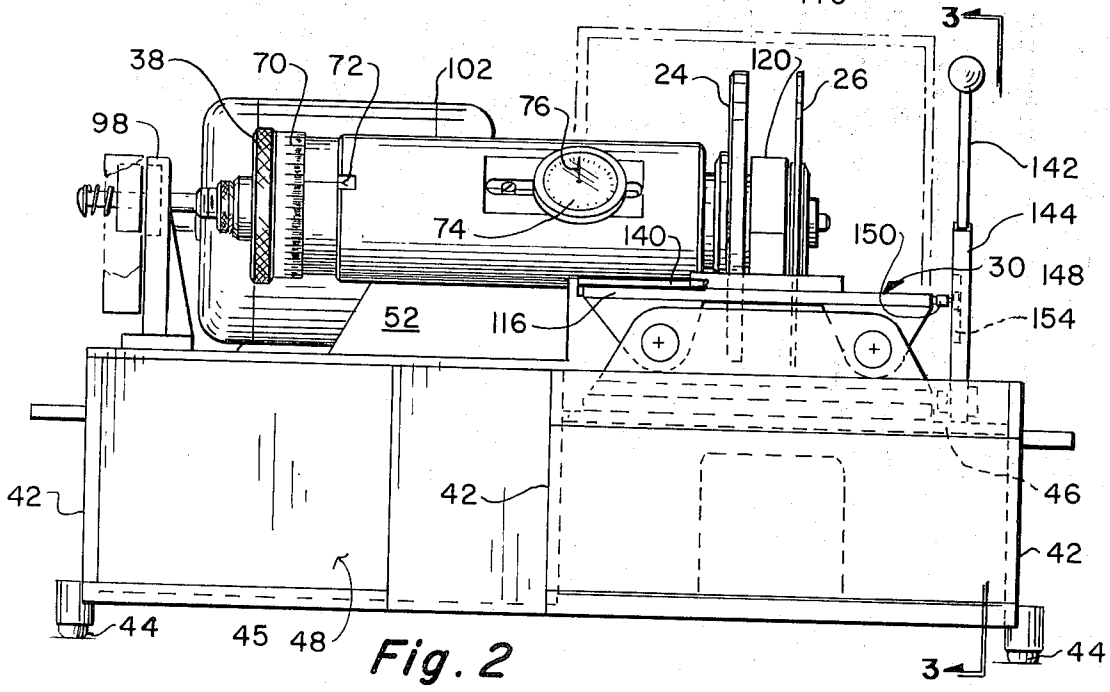

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Fig. 2

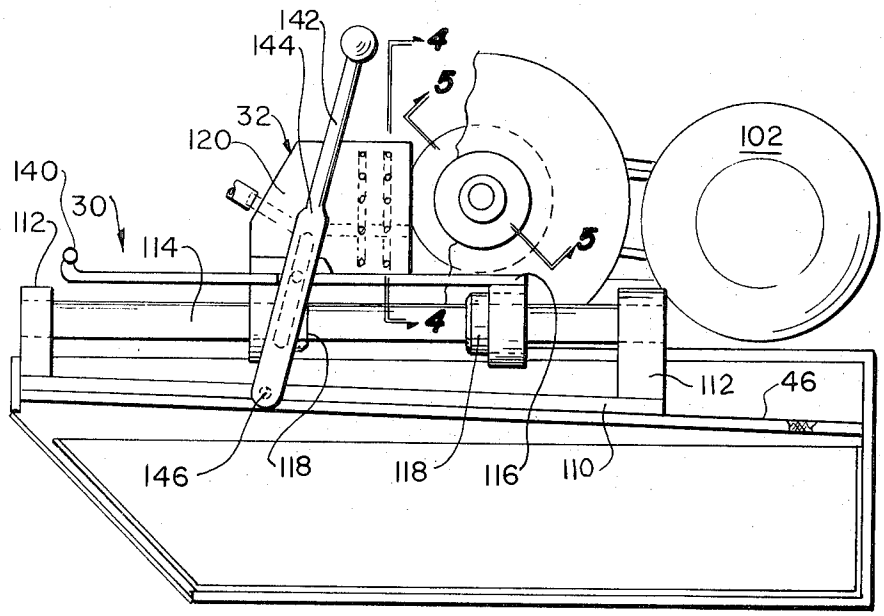


Fig. 3

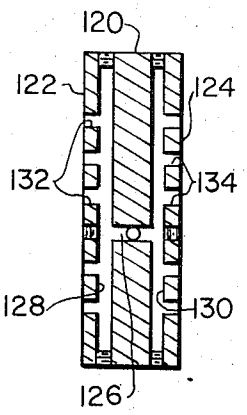


Fig. 4

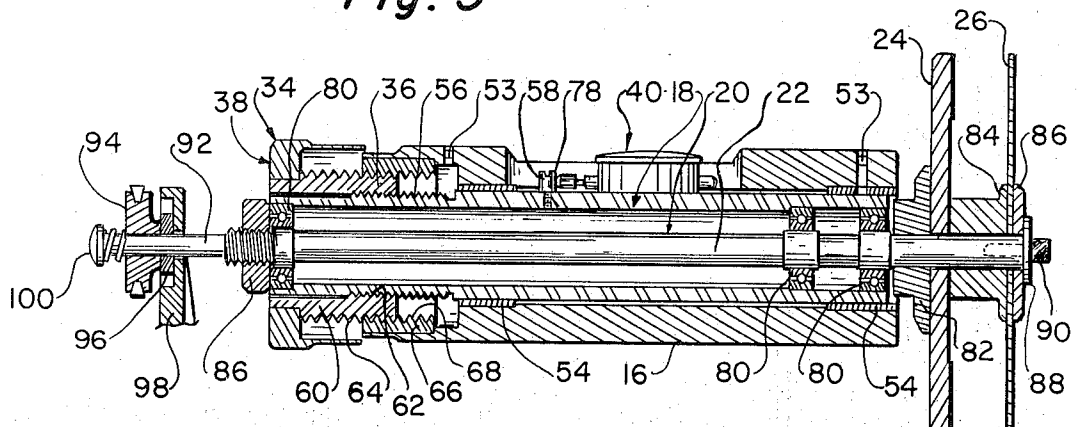


Fig. 5

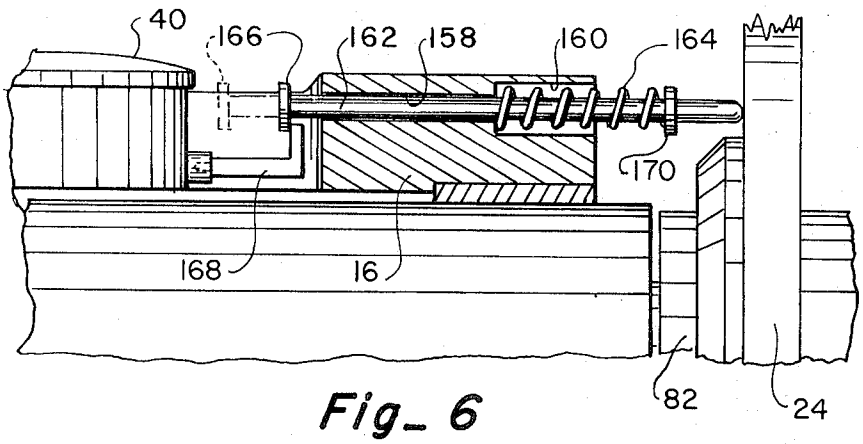


Fig. 6

MACHINE FOR PRODUCING THIN SECTION SPECIMENS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to an apparatus for producing objects of predetermined design and more particularly to an apparatus for producing thin section specimens.

2. Description of the Prior Art

To date, as well as in the past, machines are being utilized to process solid material for purposes of analysis, quality control and/or production of products. For example, in the processing of ore, thin section specimens are produced and used by mineralogists and geologists to determine the mineral content and grain structure of any given sample. In many cases, such specimens must possess certain physical characteristics which will render them useful. For example, they must be very thin, normally about 30 microns thick, and must be in a plane as nearly parallel to the surface of a glass slide as possible. It is usually very desirable that the surface of such specimens be as smooth as possible and polishing is often necessary to obtain this feature.

In the past, the conventional way of producing such specimens, as heretofore practiced, is to clamp the initial lump of material from which the specimen is to be taken in a large slabbing saw well known in the art and in wide use. A cut is taken through the lump of material to establish a flat surface, then the lump is reclamped and a second cut taken in order to provide a relatively thin section or slab having two roughly parallel faces. From this relatively thin slab, a specimen is cut that will suitably fit upon a glass slide.

The specimen is then placed upon a lapping plate and one side is lapped to obtain a smooth, flat surface, the lapped surface being impregnated with a suitable bonding agent and then bonded to the glass slide. The specimen, now mounted upon the slide, goes through subsequent trimming, lapping, and polishing operations, in order to obtain the finished specimen. These subsequent operations, as heretofore practiced, have involved the use of various different machines or devices for each operation, for instance, a small slabbing saw for trimming, a lapping or grinding machine and a polishing machine. It should be readily apparent that the employment of these various differnt means involves a great deal of operator time and skill because the specimens are, for the most part, clamped, trimmed, fed, lapped or ground, and polished by hand. Skill on the part of the operator is very important because the operator must correct any errors induced in prior operations.

Since specimens are usually worked through the above-mentioned operations by hand and through different machines, the heretofore practiced process does not lend itself very well when the time it takes to produce such specimens is an important factor. In this regard, the required production of such specimens has been continuously increasing, due to increased research in various activities. Therefore, the required time to obtain the finished specimen and, hence, the analysis has become more important.

Many of the foregoing deficiencies have been overcome by a more recent apparatus which is disclosed in United States Letters Pat. No. 3,467,075 issued to Paul O. Cary, applicant of the present invention. More specifically, the Cary patent discloses a hand operated sectioning machine including a quill assembly which cooperates with a single thread movement control arrangement for longitudinally moving a power driven spindle in a controlled fashion. The spindle, in turn, rotatably drives either the specimen cutting blade adapted to provide thin specimen sections or a grinding wheel adapted to grind and polish the thin section or slab to final thickness. In this regard, the apparatus of the Cary patent also includes a cross slide supporting a single specimen vacuum chuck, both of which are adapted for manual movement transverse to the longitudinal movement of the spindle. In this manner, a single specimen can be affixed to the vacuum chuck and alternatively worked upon by either the cutter blade or grinding wheel.

As will be seen hereinafter, the present invention among other features, provides a novel quill assembly and cooperating spindle control arrangement as well as the spindle, cross slide and specimen holding vacuum chuck. For example, longitudinal movement of the spindle is controlled by a Micrometer dial utilizing a differential screw arrangement rather than the single thread arrangement disclosed in the Cary patent. This, in turn, results in much finer movement control of the spindle without the disadvantages of extremely fine threads. One full turn of the micrometer dial results in a very small lateral movement of the wheel assembly and therefore a very small longitudinal movement of the spindle. Hence, very fine control over the amount of material being removed from the specimen section during either cutting or grinding can be achieved.

In addition, the present invention provides a visual dial indicator which accurately shows movement of the quill assembly, resulting in an accurate method of monitoring the amount of material being removed from the specimen section. Further, it has been found that the micrometer-quill assembly is less complicated and more economical to manufacture than the earlier quill assembly described in the Cary patent.

Another novel feature of the present invention over the Cary patent resides in the utilization of two specimen treating means such as a cutting blade and a grinding wheel mounted adjacent each other on one end of the same spindle. Hence, while one specimen may be trimmed into a thin section, a second specimen can be simultaneously held and brought into position for the subsequent grinding operation. In this regard, the present invention also provides a dual vacuum chuck adapted to support two specimens simultaneously. The dual vacuum chuck is mounted on a novel cross slide which straddles the two working wheels and hence is more stable during movement transverse to the wheels.

From the foregoing and, as will be more apparent hereinafter, the utilization of a micrometer including a differential screw, a quill-spindle arrangement including the simultaneous use of two specimen treating means and a visual dial indicator, and a dual vacuum chuck mounted on a cross slide which straddles the two specimen treating means results in a novel arrangement which is more versatile and efficient, and more practical and easier to operate than previous apparatus utilized for the same basic purpose. In this regard, other novel features of the present invention over tbe apparatus disclosed in the Cary patent as well as other apparatus of the prior art will become apparent hereinafter.

OBJECTS OF THE INVENTION

In accordance with the foregoing, an object of the present invention is to provide a novel apparatus for producing thin section specimens on a large scale production basis.

Another object of the present invention is to provide a novel apparatus for surfacing, trimming, grinding, lapping, and polishing thin section specimens.

Another object of the present invention is to provide a novel apparatus for producing and working on more than one specimen simultaneously.

Another object of the present invention is to provide an apparatus for producing thin section specimens including a novel arrangement for controlling the amount of movement of the various moving parts of the apparatus.

Another object of the present invention is to provide an apparatus for trimming or cutting one specimen and simultaneously holding a second previously trimmed specimen so that said second specimen can be immediately ground upon completion of the trimming.

Another object of the present invention is to provide an apparatus for producing thin section specimens including a novel specimen holding assembly especially suitable for simultaneously holding two specimens at one time.

Another object of the present invention is to provide a specimen holding assembly of the last mentioned type which is more stable during movement of the specimens than heretofore provided.

Another object of the present invention is to provide an improved apparatus for producing thin section specimens including improved means for accurately monitoring the amount of material being removed during operation of the apparatus.

Another object of the present invention is to provide a thin section specimen producing apparatus which is more versatile and efficient, more practical, and less complicated to operate than heretofore provided.

These and other objects and features of the present invention become apparent from the following descriptions.

DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. **1** is a plan view of the thin section specimen producing apparatus constructed in accordance with the present invention;

FIG. **2** is a front elevational view of the apparatus of FIG. **1**;

FIG. **3** is a right end elevational view of the apparatus of FIG. **1**;

FIG. **4** is a sectional view taken through the dual vacuum chuck along line **4—4** in FIG. **3**;

FIG. **5** is a sectional view taken generally along line **5—5** in FIG. **3**; and

FIG. **6** is a sectional view similar to FIG. **5** and showing a modified means for sensing longitudinal movement of the specimen treating means.

DETAILED DESCRIPTION

Turning now to the drawings, wherein like components are designated by like reference numerals throughout the various figures, a thin section specimen producing apparatus, constructed in accordance with the present invention, is illustrated and generally designated by the reference numeral **10.** As will be described in more detail hereinafter, apparatus **10** includes a support base **12** upon which a quill assembly **14** is mounted. As will also be seen hereinafter, the quill assembly **14** includes a housing **16** and a quill **18** (see FIG. **5**) mounted within the housing **16** for longitudinal, non-rotary movement relative thereto.

Mounted within quill **18** is a rotational system **20** (see FIG. **5**) including a spindle **22** adaptable to rotational movement and a pair of longitudinally spaced apart specimen treating members **24** and **26** mounted on the spindle adjacent one end thereof. As will be seen hereafter, the specimen treating members **24** and **26** will generally be a grinding wheel and cutting wheel, respectively, both of which are keyed for rotation with spindle **22.** In this regard, a power assembly **28** also mounted to support base **12** and positioned adjacent rotational system **20** is designed to transmit rotational power to the spindle **22.**

Apparatus **10** further includes a sliding cross plate arrangement (best illustrated in FIG. **3**) which is mounted on the support base and designed to be moved, preferably manually, both toward and away from the specimen treating members **24** and **26.** The specimen holder **32** is removably mounted on the sliding cross plate and designed to bring a pair of spaced apart specimens into contacting engagement with the spaced apart treating members **24** and **26.** Hence, while one specimen will be brought into contacting engagement with the cutting wheel **26,** a secnd specimen may be simultaneously held and brought into position for a subsequent grinding operation with grinding wheel **24.** This, of course, eliminates the alternate mounting of the grinding wheel and blade required in previous designs. In addition, this dual system, as will be seen hereinafter, allows the sliding cross plate to be positioned in a straddling fashion with respect to the two treating members, thereby providing a more stable sliding cross plate.

In another mode of operation where specimen treating means **24** is replaced with a cutting blade, it is then possible to treat simultaneously two specimens when the sliding cross plate is moved toward the rotational system. In this regard, as will be seen hereinafter, the specimen holder is comprised of a dual vacuum chuck arrangement adapted to hold more reliably both specimens in place.

In order to control the amount of material removed from the specimens, the entire quill **18** is adjusted longitudinally which, in turn, adjusts the entire rotational system **20** including spindle **22** and specimen treating members **24** and **26** longitudinally. As will be seen hereinafter, this is achieved in a more accurate and less complicated fashion by the utilization of a novel quill movement control arrangement **34** including a differential screw arrangement **36,** an annular micrometer dial **38,** both of which cooperate with the quill **18** to provide longitudinal movement of the latter. By providing the novel arrangement of differential screw and micrometer dial, a much finer adjustment of the spindle and specimen treating members can be achieved. One full turn of the micrometer dial **38** results in a very precise control over the amount of material being removed from the thin section and achieves an increased degree of accuracy over the thickness of the finished product. In order to further enhance accuracy of spindle movement, apparatus **10** includes a visual dial indicator **40**

(see FIG. 5) which indicates the amount of movement of quill 18.

Turning now to the details of apparatus 10, attention is redirected to support base 12 which, as illustrated best in FIGS. 1 and 2, includes a plurality of vertically disposed support panels 42 suitably interconnected together and mounted on rubber feet 44, the latter being provided to compensate for any unevenness of surface and also to resist slippage. The support base 12 also includes a coolant drain floor 46 which comprises the front portion of the base and a control panel 48 and adjacent mounting deck 50 which together form the rear portion of base 12. The farious components comprising the support base 12 as well as many of those components mounted to the base are preferably welded together, but may be joined by any other suitable geans, including bolts. A flap door (not shown) may be provided on the front side of the base for allowing easy access to the area beneath drain floor 46. Such area contains a pull-out coolant tray and a recirculating cooling pump system.

Turning to FIGS. 1, 2 and 5, attention is now directed to quill assembly 14 which, as illustrated, includes cylindrical housing 16 which is mounted to deck 50 by a suitable mounting block 52. A plurality of openings 53 are provided through the housing for lubricating the components therein. Within each end of the quill housing are two sleeve bearings 54 which circumscribe quill 18, the latter being concentrically positioned within housing 16 so as to bear against the inner face of each sleeve bearing. The quill includes near its rearward or lefthand end, as viewed in FIG. 5, external threads 56 which, as will be seen hereinafter, cooperate with movement control arrangement 34 and particularly differential screw 36.

Quill 18 is prevented from rotational movement by an anvil stud 58 which screws into the outer diameter of the quill and fits in a longitudinal slot 78 cut into the quill housing, thereby alolowing longitudinal movement of the quill but preventing rotational movement thereof. As will be seen hereinafter, this anvil stud also transmits the longitudinal movement of the quill, and therefore longitudinal movement of the spindle, to dial indicator 40. Thus, the anvil stud serves a two fold purpose, i.e., to cooperate with the dial indicator 40 to give a read out on longitudinal spindle movement and also to prevent rotational movement of the quill, this arrangement being a notable advancement over the previously described Cary patent.

In accordance with the present invention, movement control arrangement 34 includes the aforestated differential screw 36 which, as will be seen hereinafter, provides extremely accurate longitudinal adjustment of the quill 18 and therefore, spindle 22. The differential screw 36 includes an annular member 60 which is internally threaded at 62 and externally threaded at 64, the external threads differing in pitch from the pitch of the internal threads. In fact, in accordance with a preferred embodiment of the present invention, the external threads 64 display a pitch of 28 while the internal threads 62 display a pitch of 36, thereby providing an external to internal pitch ratio of 7/9. As illustrated in FIG. 5, annular member 60 is positioned concentrically around quill 18 so that internal threads 62 are disposed in complementary threaded engagement with the external threads 56 of the latter.

Differential screw 36 further includes a second annular member 66 which is greater in diameter than annular member 60 and which qs suitably fixed to the inner surface of quill housing 16. Annular member 66 is internally threaded at 68, the internal threads being disposed in complementary threaded engagement with the external threads 64 of annular member 60. Micrometer dial 38 which, in essence, comprises part of differnetial screw 36 that is included in movement control arrangement 34, is annular in configuration. The micrometer dial is fixed to and circumscribes previously described annular member 60 for importing axial rotational movement to the latter in response to rotational movement of the micrometer dial. In this regard, as illustrated in FIG. 1 and FIG. 2, the micrometer dial includes numerous graduations 70 engraved around its circumference which are easily set in relation to a witness mark 72 (see FIG. 2), thus closely controlling longitudinal movement scale 74, as will be seen hereinafter.

From the foregoing, it should be readily apparent that by moving micrometer dial 38, and therefore annular member 60, extremely fine and accurate longitudinal movement of quill 18 is achieved. For example, by utilizing an external to internal thread pitch of 7/9 for annular member 60, the net movement of quill 18 in a working embodiment of the present invention has been found to be approximately 0.008 inches per revolution on micrometer dial 38. In this working embodiment, the dial 38 has 200 equal graduations resulting in a 0.00004 inch wheel travel per graduation. This also equals 1 micron in metric measurement. However, it is to be understood that the present invention is not limited to this specific arrangement but may be provided with either coarser or finer adjustment depending, of course, on the pitch arrangement of the differential screw.

It should be noted that because of the utilization of differential screw 36, an unlocking screw similar to that utilized in the aforedescribed Cary patent is not necessary in the present invention to secure quill 18 against longitudinal movement. This is primarily due to the inherent ability of the differential screw to hold its adjustment and, in actual use, the screw is constantly being operated to move the specimen treating members to be described ereinafter, into contacting engagement with a specimen in order to remove material. When the differential screw is used to move the quill forward, the screw threads back each other up at zero clearance and when reversing this procedure, back lash due to the normal clearance in the threads is eliminated by the use of an anti-backlash spring (compression spring) to be described hereinafter. This spring provides continuous urging or pulling of the wheel and differential screw assembly in a direction away from the specimen treating members to keep the thread clearances at zero and thereby eliminating backlash, thereby providing more accurate readings on the dial indicator.

As stated hereinabove, apparatus 10 also includes an indicator 40 provided for sensing and accurately visually indicating the relative amount of longitudinal movement of quill 18. To accomplish this, indicator 40 includes a scale 74 and indicating means 76 and a sensor disposed in contacting engagement with the previously described anvil stud 58. Since the anvil stud 58 is attached to the quill 18, movement of the quill 18 is

transmitted through the stud **58** to the sensor and, in turn, to the indicating means **76.**

Attention is now directed to rotation system **20** which, as stated above, includes spindle **22.** As illustrated in FIG. **5,** the spindle **22** is rotatably journaled inside quill **18** and runs in a plurality of ball bearings **80.** The spindle has a pair of longitudinally spaced mounting flange spacers **82** and **84** and a threaded thrust coller **86,** both acting to retain the spindle longitudinally and to preload the bearings **80** in order to eliminate spindle end shake. The thrust collar **86** is threadably engaged with the spindle and provides a manner of adjusting the amount of bearing preload. In addition, the mounting flanges **82** and **84** provide suitable surfaces for respectively mounting specimen treating members **24** and **26.** In this regard, the treating members are retained in the flanges by a washer **88** and screw **90.**

Extending from the spindle **22** out of the quill **18** is a drive rod **92** which preferably displays a square cross-section. The drive rod engages a square hole in a pulley **94** which is rotatably journaled in a ball bearing **96** so that the pulley is free to turn, but longitudinally retained. Ball bearings **96** is mounted in a housing **98** which is suitably mounted on deck **50.** Hence, it should be clear that, since pulley **94** engages the square drive rod with a square hole, a means is provided for the pulley to transmit rotary power to the spindle **22** and at the same time allowing the spindle to be longitudinally moved in relation to the pulley. It should also be clear that, by rotating the pulley and therefore the spindle, the mounting flanges and therefore specimen treating members **24** and **26** are rotated. It should be noted that the anti-backlash spring providing the aforedescribed function is positioned around the free end of drive rod **92** between pulley **94** and a flange element **100** fixed to the end of the drive rod.

Returning to FIGS. **1** and **2,** attention is re-directed to power assembly **28** which, as illustrated, includes a suitable drive motor **102** mounted to deck **50.** The drive motor includes a pulley **104** and a V-belt **106** between pulleys **94** and **104** to provide a transfer of power. A belt guard **108** may be provided for safety considerations.

As illustrated in FIGS. **1** to **3,** the sliding cross plate assembly **30** is mounted on the coolant drain floor **46** and includes a cross slide base **110.** At each end of base **110** are positioned shaft mounting blocks **112** in which are mounted two parallel shafts **114.** A cross slide plate **116** is mounted upon shafts **114** utilizing ball bushings **118** for linear movement. Hence, the slide plate **116** is capable of sliding along the length of the shafts under a very small amount of applied pressure.

In accordance with another feature of the present invention, a dual vacuum chuck **120** is mounted upon the cross slide plate **116,** the opposite faces **122** and **124** of which are employed to hold microscope slides to which have been mounted suitable specimens. As illustrated best in FIG. **4,** a vacuum is supplied to the chuck from a conventional source (not shown) through a suitable conduit (not shown) and thereafter by a center port or passage **126** provided centrally in the chuck. The center port **126** is, in turn, in communication with two main parts or passages **128** and **130,** each of the latter being in respective communication with a plurality of surface ports or passages **132** and **134** extending, respectively, to opposite faces **122** and **124.** While the dual vacuum chuck is a preferred arrangement for supporting two specimens, it is to be understood that the present invention is not limited to this particular arrangement.

From the foregoing, it should be noted that the cross slide plate **116** straddles the specimen treating member **24,** which as states hereinabove can be a grinding plate, and specimen treating member **26,** which can be a cutting blade, for providing a more stable arrangement. In addition, the cross slide plate allows for the use of the dual vacuum chuck.

The cross slide assembly can also be used for mounting attachments such as, for example, a rock vise, a collect attachment for holding rock cores or a polishing holder. In addition, the cutting blade can be removed and the grinding plate can be used for hand lapping or the grinding plate can be replaced with polishing plates for final polishing operations with very fine polishing abrasures, compounds, and the like. Removal of the cutting blade enables the grinding or polishing plates to be easily used from the front during this handwork. The above hand grinding is usually done after having a flat surface on the rock which is held in the rock vise or collet attachment and prior to bonding the rock to a glass microscope slide. The polishing is done usually after the thin section has been ground to final thickness. It should be pointed out, however, that lapping and polishing can also be done with the specimen held by the vacuum chuck or other type of specimen holders.

Referring to FIGS. **1** to **3,** it is to be noted that a handle **140** is provided for hand feeding the cross plate towards the specimen treating members **24** and **26** during operation of apparatus **10.** An auxiliary fine feeding lever **142** is provided for more closely controlled feeding of the cross slide plate and greater leverage. In this regard, the lever **142** includes a lever block **144** which is pivotally mounted at its lower end to the cross slide base by a pivot screw **146** and a spacer block **148.** Pivot screw **146** threads into the cross slide base. The hole in the spacer **148** and the lever block **144** are clearance holes. Hence, it should be obvious that the lever **142** can be moved in an arc.

Attached to the cross slide **116** is a stud **150** on which is mounted a ball bearing **152.** The ball bearing **152** engages a slot **154** milled in block **144.** The width of slot **154** closely fits the diameter of ball bearing **152.** It can be seen that, when the feed lever **142** is removed in its arc, motion is transmitted from the lever block **144** to the cross slide plate **116** by means of the slot **154** and ball bearings **152,** the movement of the cross slide being parallel to the axis of shafts **114.**

The apparatus of this invention may also include a spray coolant system (not shown) since spraying lengthens the life of the cutting mechanism by facilitating its work. Spraying also enhances the finished product. Such a spraying system would be similar to that shown in the aforestated Cary patent.

In FIG. **6** is shown a modification of the structure illustrated in FIG. **5.** FIG. **6** depicts a different means for sensing longitudinal movement of the specimen treating means particularly the grindind wheel **24.** As shown in FIG. **6,** the housing **16** has a longitudinally extending opening **158** formed through a portion thereof. One end **160** of said opening **158** is formed with an increased diameter. A sensor rod **162** is mounted for reciprocal movement within the opening **158** and is biased toward the adjacent face of the grinding wheel **24**

by a compression spring 164. The sensor rod 162 has a head or flange 166 formed on one end thereof and is disposed to abuttingly engage an L-shaped member 168. The L-shaped member 168 is suitably connected to the dial indicator 40 from which may be ascertained the amount of longitudinal movement of the grinding wheel 24. As shown, the sensor rod 162 also includes a flange or boss 170 formed adjacent the other end thereof and against which is seated one end of the compression spring 164. The end of the rod 162 in contact with the wheel 24 is preferably arcuate or rounded in configuration. The left end of the sensor rod 162 and its flange 166 is shown in dotted lines for a position associated with a retraction of the grinding wheel 24. It will be appreciated that longitudinal movement of the cutting blade 26 will likewise be ascertained in the same manner since the grinding wheel 24 and cutting blade 26 are held in rigid spaced-apart relationship by suitable mounting thereof upon the spindle 22.

The operation of the machine is as follows: In place of the dual vacuum chuck 120, a vise (not illustrated) may be mounted on the cross slide. With the machine set up rocks can be cut into slabs by feeding them past the saw blade. In this case, the handle 142 is used in order to feed the rocks smoothly and so the operator can easily control the rate of feed. As many rock slabs as necessary can be run through this first surface operation.

After all the rocks have been slabbed, the first surfaces are lapped flat and then respectively bonded to glass microscope slides. The vise is removed and the dual vacuum chuck 120 is mounted on the cross slide plate 116.

Referring to FIGS. 2 and 4, a blank glass microscope slide is fixed to the left side 122 of the specimen holder 32 and a glass slide with a specimen mounted thereon is fixed to the right side 124. The quill 18 is adjusted longitudinally to position the specimen treating means 24, which in this case is a grinding wheel, and treating means 26, which is a cutting blade, so there is more clearance between the treating face of the grinding wheel 24 and the left side 122 of the specimen holder than there is between the right side 124 of the specimen holder and the inside cutting edge of the blade 26.

The power assembly 28 is energized by suitable control means (not shown) for transmitting rotational power to the spindle 22 and therefore specimen treating members 24 and 26. Thereafter, the sliding cross plate, specimen holder and specimens are moved toward the specimen treating means. However, only the mounted specimen is brought into contacting engagement with the blade 26 since the other side of the specimen holder 32 holds only a blank side and because of the increased clearance existing between the left side 122 and its corresponding grinding wheel 24. The sliding cross plate and specimen holder is advanced past the cutting edge of the blade 26 leaving a relatively thin section of specimen material remaining on the glass slide. The sliding cross plate is then moved away from the specimen treating means to clear the trimmed specimen.

The blank microscope olide (which is used to close off the opening formed within the vacuum chuck) is then removed from the left side of the specimen holder (as viewed in FIG. 1) and replaced by the blank upon which is mounted the thin section specimen just trimmed. A second mounted specimen is fixed to the right side of the specimen holder and the trimming operation is repeated thus producing a second trimmed thin section specimen. While trimming the second specimen, the first one, on the opposite side 122 of the specimen holder, is not touched by treagiting means 24 in view of the aforementioned greater clearance on that side. However, immediately after the second section is trimmed the quill 18 and, therefore, the grinding wheel 24, is adjusted longitudinally to bring the treating face of the grinding wheel 24 into contacting engagement with the thin section on the left side of the specimen holder. Thus, the grinding operation may now proceed. During grinding, the sliding cross plate is moved back and forth thus passing the thin section across the treating face of the grinding wheel 24 and at the same time the quill 18 and therefore the grinding wheel 24 is moved gradually against the thin section specimen in order to grind it to a final thickness. It is well to note that while the grinding wheel 24 is being advanced toward its corresponding thin section specimen, the blade 26 is continually moving away from its corresponding specimen thereby eliminating serrating or scarring the previously trimmed section. When the first thin section specimen has been finished ground the quill 18 and specimen treating means 24 and 26 are repositioned for trimming another mounted specimen. The finished thin section is removed from the holder 32 and replaced by the trimmed section from the right side of the specimen holder, another mounted specimen is fixed to the right side 124 and the whol above sequence of operations is repeated (alternating between trimming the mounted specimens and grinding the thin sections). It can be seen that small numbers of finished thin sections can be obtained quickly using the above procedure. However, when specimens are sectioned in large numbers it is understood that they can be produced by setting the machine for the trimming operation and running all specimens through the trimming operation and then proceed to grind all specimens in a separate grinding operation. It will be understood that if the specimen treating means 24 and 26 comprise two cutting blades, then mounted specimens can be trimmed on both sides of the specimen holder 32 simultaneously during one operation.

In view of the foregoing, it will be readily appreciated that a novel and versatile machine for producing thin section specimens has been described. The machine of this invention includes a novel quill assembly and cooperating spindle control arrangement as well as a spindle, cross slide and specimen holding vacuum chuck. Accurate longitudinal movement of the spindle is maintained at all times through the use of a differential screw arrangement in lieu of extremely fine threads. A plurality of specimens may be treated simultaneously with the machine of this invention thereby increasing the rate of production and decreasing the cost for producing each specimen. On the other hand, if only a few specimens are required, it can be quickly done because the dual vacuum chuck with the grinding wheel and the cutting blade can be utilized without having to set the machine up for either the grinding or sawing operation.

It is to be understood that this invention is not limited to the exact embodiment of the machine described and shown which is merely by way of illustration and not limitation, as various other forms and modifications will be apparent to those skilled in the art.

I claim:

1. A machine for producing thin section specimens comprising:

a. a support base;

b. a quill housing mounted on said base;

c. a quill mounted within said housing for longitudinal, non-rotary movement relative thereto;

d. a rotational system mounted within said quill, said system having a spindle adaptable to rotational movement, and a pair of longitudinally spaced-apart specimen treating means mounted on said spindle adjacent one end thereof;

e. a power means mounted on said support base adjacent said rotational system and designed to transmit rotational power to said spindle;

f. a sliding cross slide plate mounted on said support base and designed to be moved both toward and away from the specimen treating means of said rotational system;

g. a specimen holder removably mounted on said cross slide plate and designed to bring a pair of spaced-apart specimens into contacting engagement with said spaced-apart treating means whereby one of said specimens will be in contacting engagement with a corresponding one of said treating means when said cross slide plate is moved toward said rotational system;

h. means for effecting accurate longitudinal adjustment of said spindle, said means comprising a differential screw, said screw having internally and externally threaded portions, the lead of said externally threaded portion being different than the lead of said internally threaded portion, and including (i) an annular micrometer dial, (ii) said quill housing having fixed internal threads, the internal threads of said quill housing being disposed in complemental engagement with the external threads of said differential screw, and (iii) a portion of said quill including an externally threaded portion, the external threads of said quill being disposed in complemental engagement with the internal threads of said differential screw; and

i. means for sensing and accurately indicating the relative amount of longitudinal movement of said spindle, said means including (i) a first part secured to said quill housing and including an indicating member and a scale means, and (ii) a second part one portion of which is disposed to transmit longitudinal movement of said specimen treating means to the indicating means of said first part.

2. A machine as described in claim 1 above in which said specimen holder includes a pair of spaced-apart surfaces disposed generally parallel one to the other, each surface including one or more means, each of said means constructed to receive one specimen.

3. A machine as described in claim 2 above in which a portion of each spaced-apart surface of said specimen holder, upon movement of said cross slide plate toward the specimen treating means, is disposed intermediate said specimen treating means.

4. A machine as described in claim 3 above in which one of said specimen treating means includes a cutter blade and the other one of said specimen treating means includes a surface grinder.

5. A machine as described in claim 4 above in which each of the means of the spaced-apart surfaces of said specimen holder is constructed to be disposed in fluid communication with a source of vacuum pressure, and means to provide a vacuum pressure to each of said means whereby, upon positioning of specimens on said means and furnishing vacuum pressure to said specimen holder, said specimens will be held upon said specimen holder.

6. In a machine for producing thin section specimens, said machine including a support base, a quill housing mounted on said base, a quill mounted within said housing for longitudinal, non-rotary movement relative thereto, and a rotational system mounted in said quill and including a spindle adapted for rotational movement within said quill, the improvement comprising:

a. a pair of longitudinally spaced-apart specimen treating means mounted on said spindle adjacent one end thereof;

b. a sliding cross slide plate mounted on said support base and designed to be moved both toward and away from said specimen treating means;

c. a specimen holder removably mounted on said cross slide plate and designed to bring one or more specimens into contacting engagement with said specimen treating means; and

d. means for effecting accurate longitudinal movement of said spindle, said means comprising a differential screw having a first annular member with internally and externally threaded portions, the lead of said externally threaded portion being different than the lead of said internally threaded portion and a second member with an internally threaded portion, the internal threads of said second member being disposed in complimental engagement with the external threads of said first member, and a portion of said quill being externally threaded, the external threads of said quill being disposed in complimental engagement with the internal threads of said first member, and said differential screw also including an annular dial means mounted for rotational movement with said first member.

7. In a machine for producing thin section specimens, said machine including a support base, a quill housing mounted on said base, a quill mounted within said housing for longitudinal, non-rotary movement relative thereto, and a rotational system mounted in said quill and including a spindle adapted for rotational movement within said quill, the improvement comprising:

a. a pair of longitudinally spaced-apart specimen treating means mounted on said spindle adjacent one end thereof;

b. a sliding cross slide plate mounted on said support base and designed to be moved both toward and away from said specimen treating means;

c. a specimen holder removably mounted on said cross slide plate and designed to bring one or more specimens into contacting engagement with said specimen treating means; and

d. means for effecting accurate longitudinal movement of said spindle, said means comprising a differential screw having a first annular member with internally and externally threaded portions, the lead of said externally threaded portion being different from the lead of said internally threaded portion, a portion of said gull housing being internally threaded, the internal threads of said quill housing being disposed in complemental engagement with the external threads of said first member, and a

portion of said quill being externally threaded, the external threads of said quill being disposed in complemental engagement with the internal threads of said first member, and said differential screw also including an annular dial means mounted for rotational movement with said first member.

8. In a machine as described in claim **6** above in which said second member is mounted on said quill housing.

9. In a machine as described in claim **6** above including means for sensing and indicating the relative amount of longitudinal movement of said spindle, said means including a first part secured to said quill housing and including an indicating member and a scale member, and a second part one portion of which is disposed to transmit longitudinal movement of said spindle to the indicating means of said first part.

10. In a machine as described in claim **6** above including means for sensing and indicating the relative amount of longitudinal movement of the specimen treating means, said means including a first part secured to said quill housing and including an indicating member and a scale member, and a second part comprising a sensor rod mounted within said quill housing for reciprocal movement relative thereto, said sensor rod being biased in a direction toward an adjacent surface of said specimen treating means, said sensor rod having a portion thereof disposed in motion transmitting engagement with the indicating means of said first part whereby longitudinal movement of said specimen treating means may be transmitted to the indicating member of said first part.

11. A machine for producing thin section specimens comprising:

a. a support base;

b. a quill housing mounted on said base;

c. a quill mounted within said housing for longitudinal, non-rotary movement relative thereto;

d. a rotational system mounted within said quill, said system having a spindle adaptable to rotational movement, and a pair of longitudinally spaced-apart specimen treating means mounted on said spindle adjacent one end thereof;

e. a power means mounted on said support base adjacent said rotational system and designed to transmit rotational power to said spindle;

f. a sliding cross slide plate mounted on said support base and designed to be moved both toward and away from the specimen treating means of said rotational system;

g. a specimen holder removably mounted on said cross-slide plate and designed to bring one or more specimens into contacting engagement with said specimen treating means when said cross slide plate is moved toward said rotational system;

h. means for effecting accurate longitudinal adjustment of said spindle, said means comprising a differential screw, said screw having internally and externally threaded portions, the lead of said externally threaded portion being different than the lead of said internally threaded portion, and including (i) an annular micrometer dial, (ii) said quill housing having fixed internal threads, the internal threads of said quill housing being disposed in complemental engagement with the external threads of said differential screw, and (iii) a portion of said quill including an externally threaded portion, the external threads of said quill being disposed in complemental engagement with the internal threads of said differential screw; and

i. means for sensing and accurately indicating the relative amount of longitudinal movement of said spindle, said means including (i) a first part secured to said quill housing and including an indicating member and a scale means, and (ii) a second part one portion of which is disposed to transmit longitudinal movement of said specimen treating means to the indicating means of said first part.

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