S. E. BOYNTON.

LAST LATHE.

APPLICATION FILED MAY 11, 1918.

1,362,185.

Patented Dec. 14, 1920.

11 SHEETS—SHEET 1.

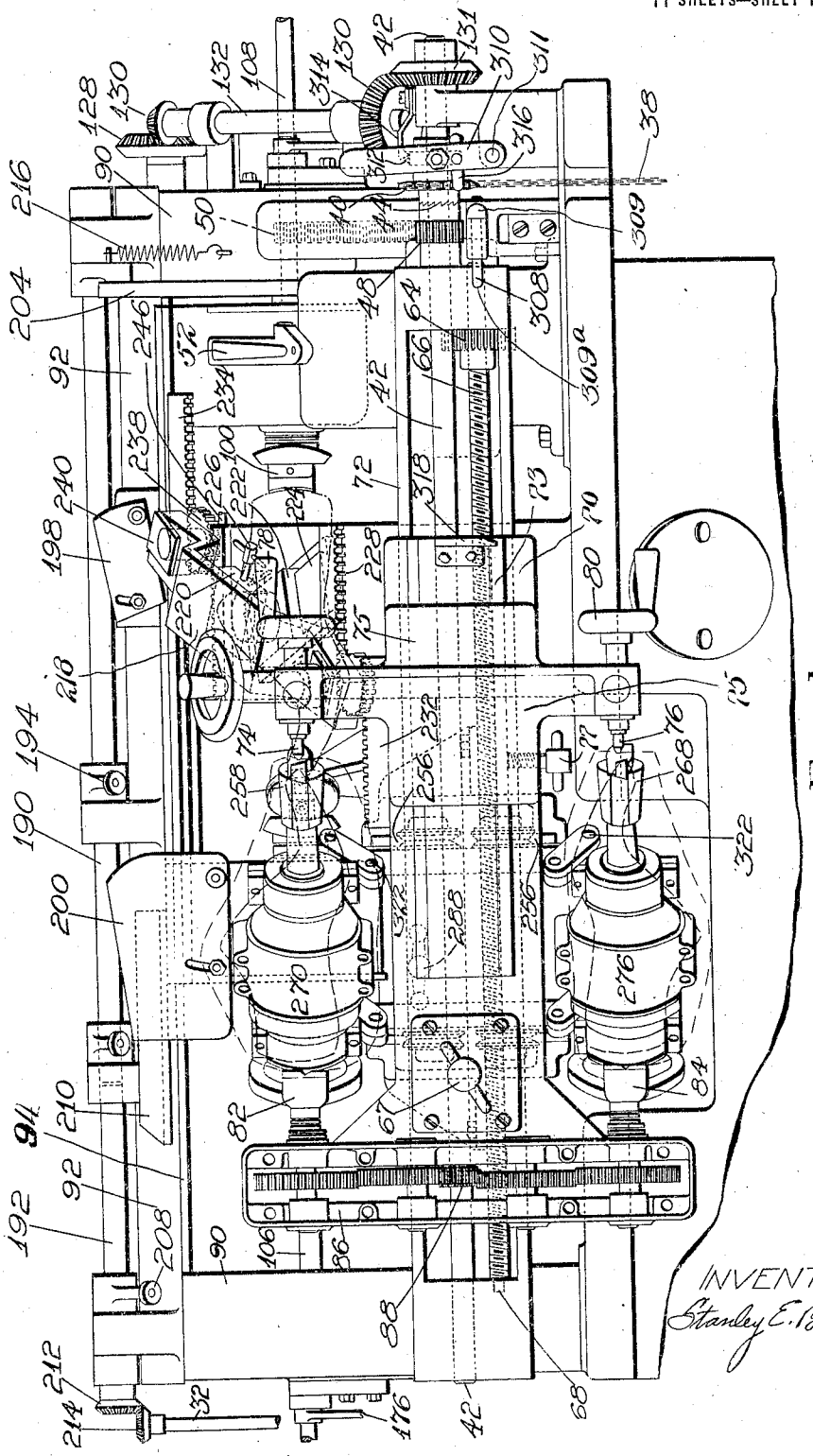


Fig. 1.

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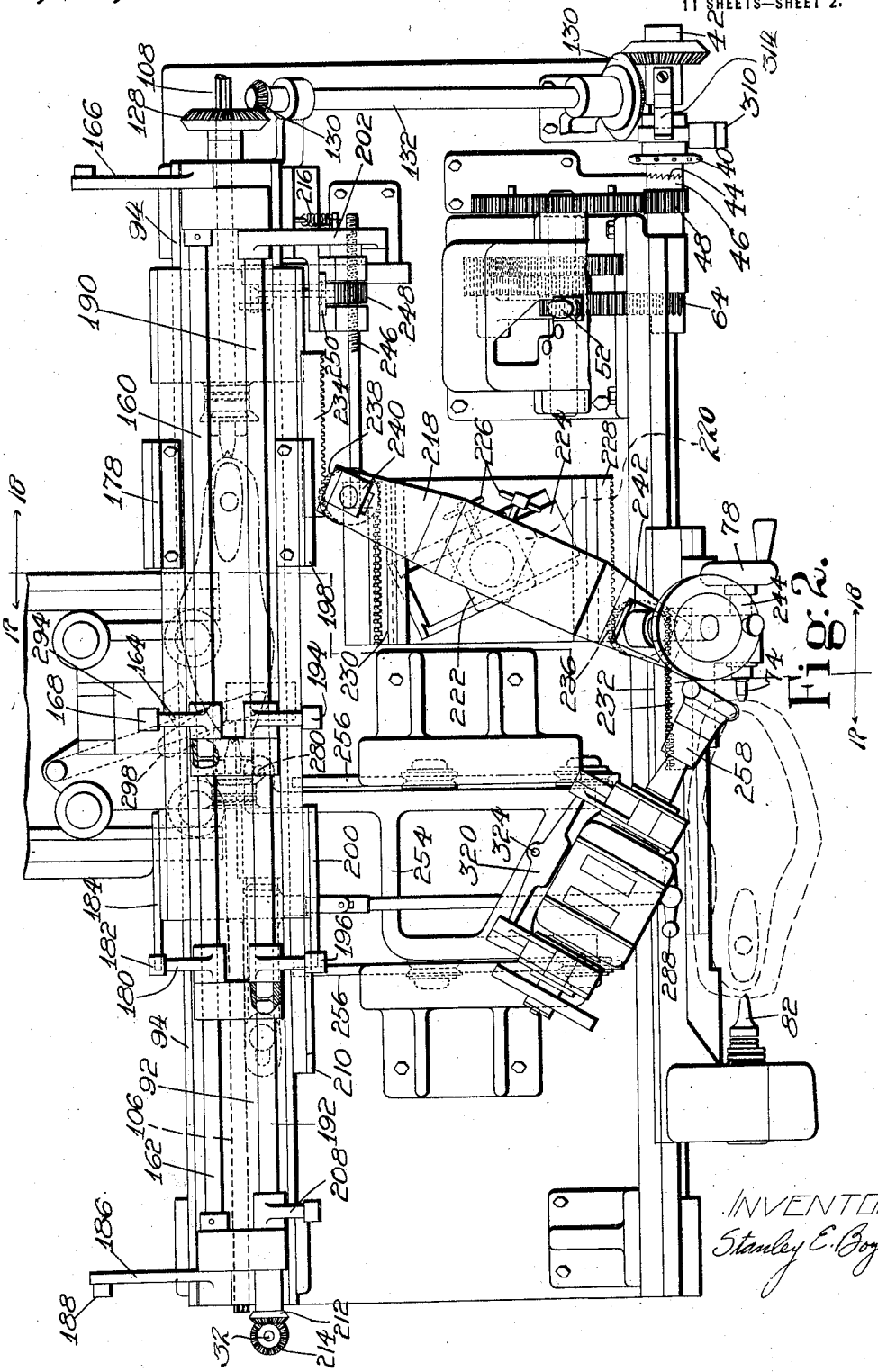


Fig. 2.

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Stanley E. Boynton

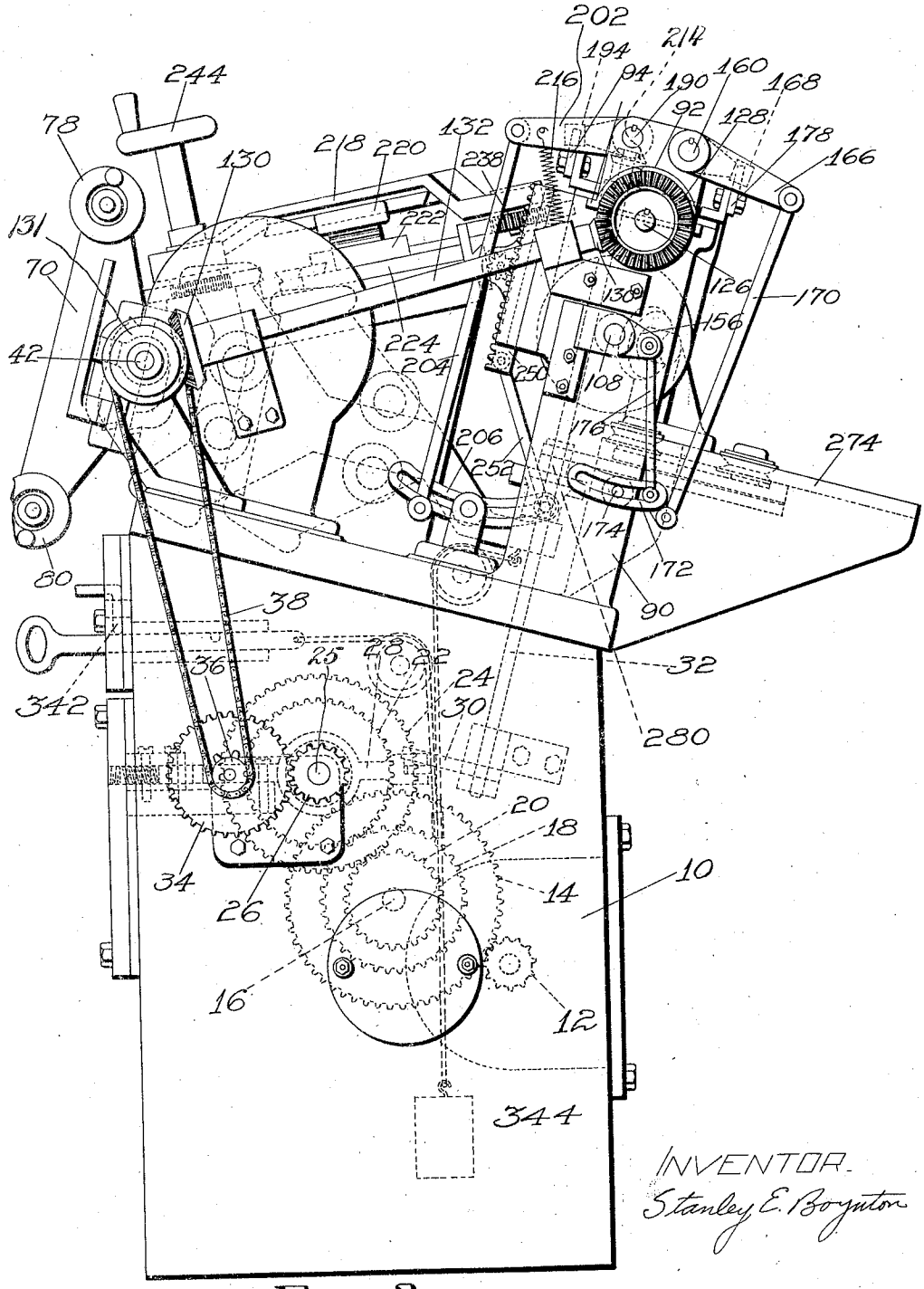
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11 SHEETS—SHEET 3.



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Fig. 3.

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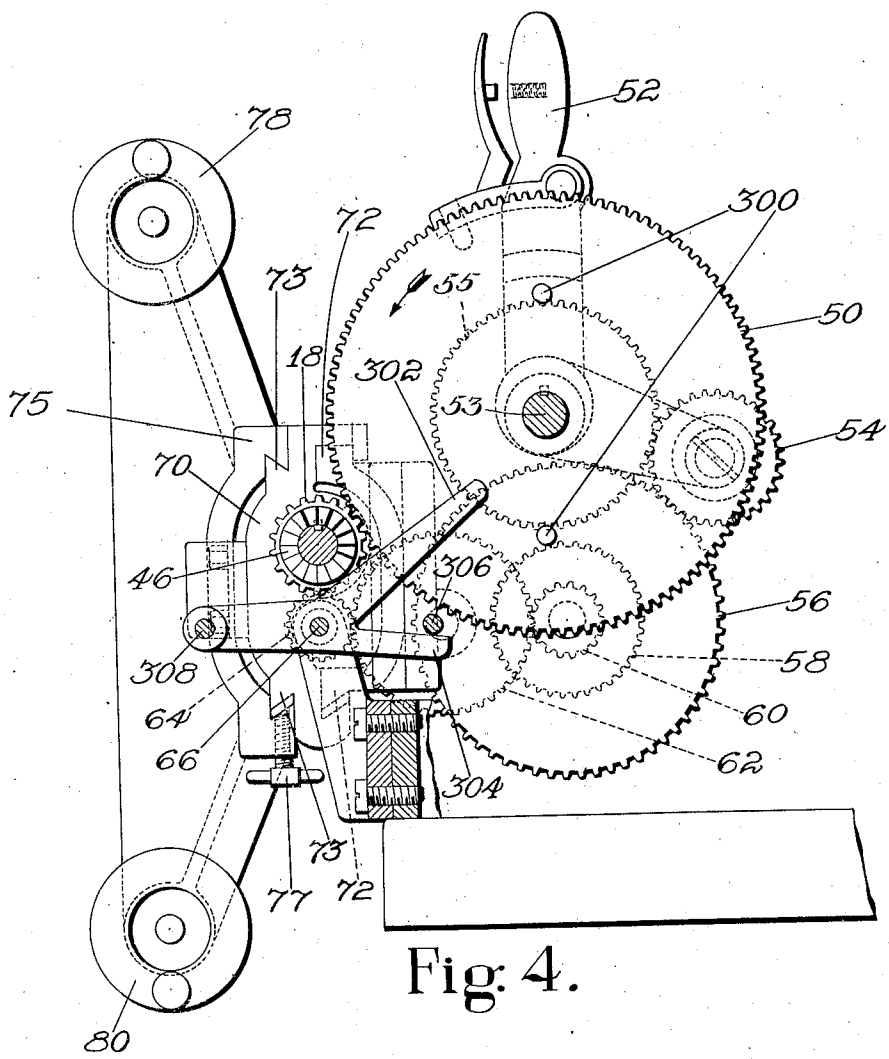


Fig. 4.

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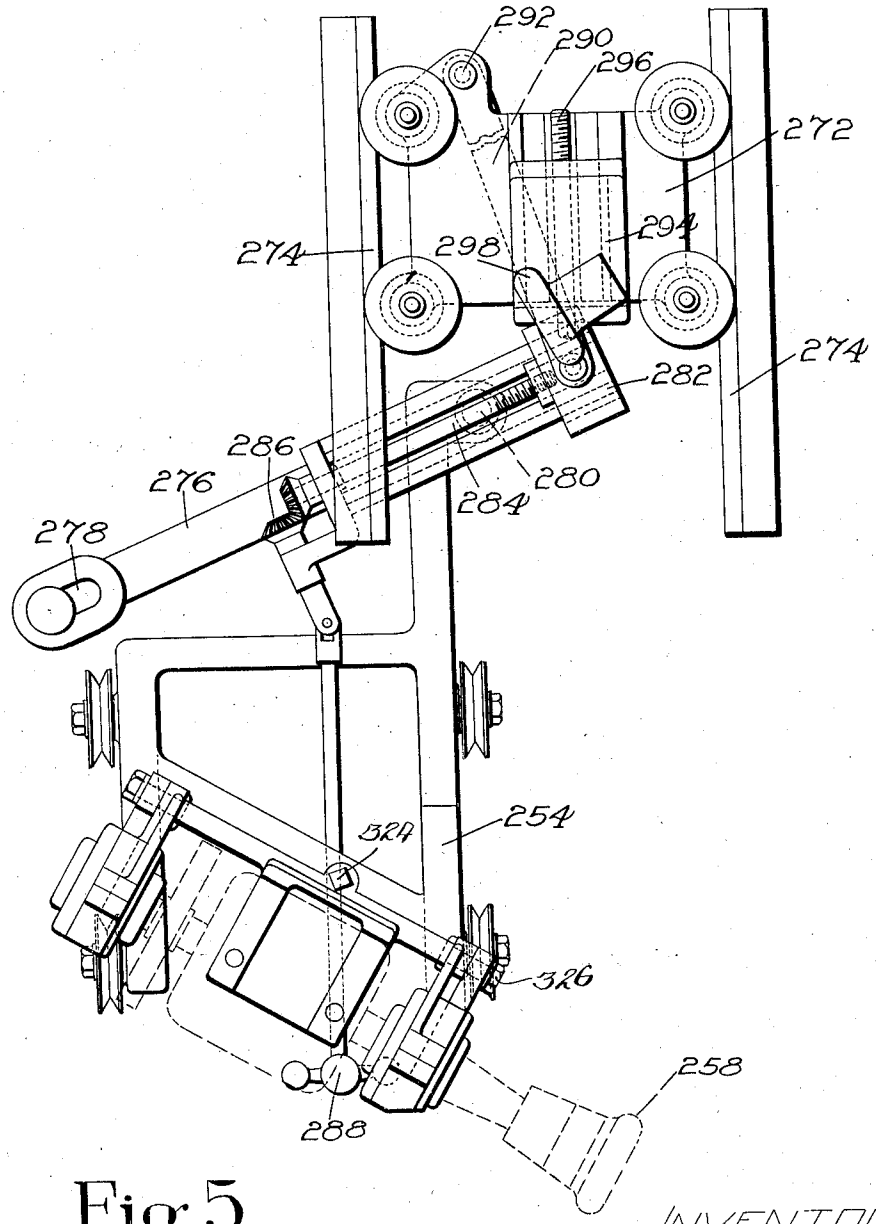


Fig. 5.

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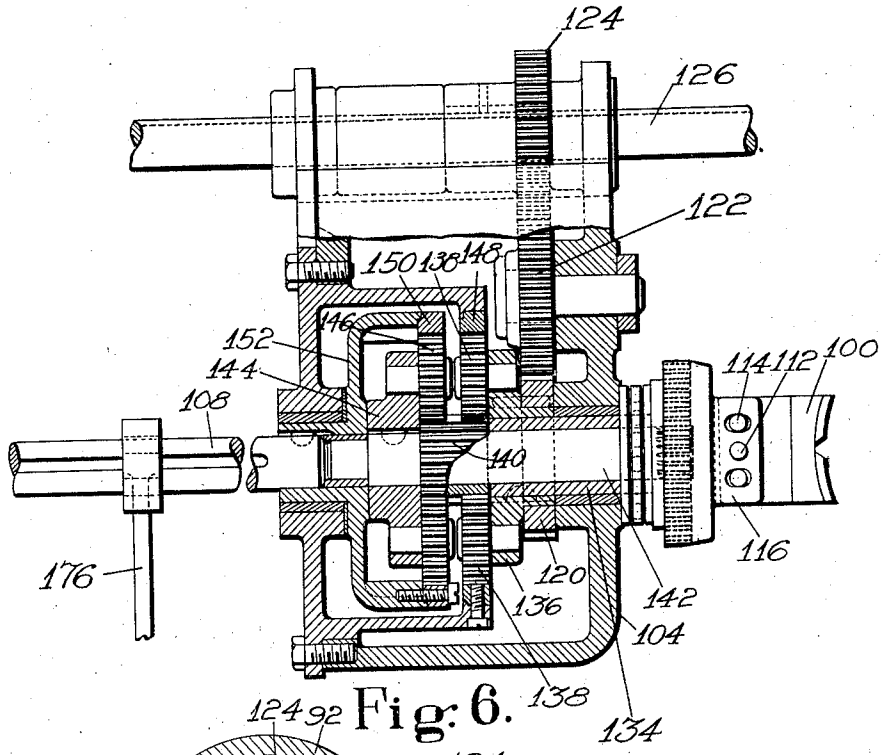


Fig: 6.

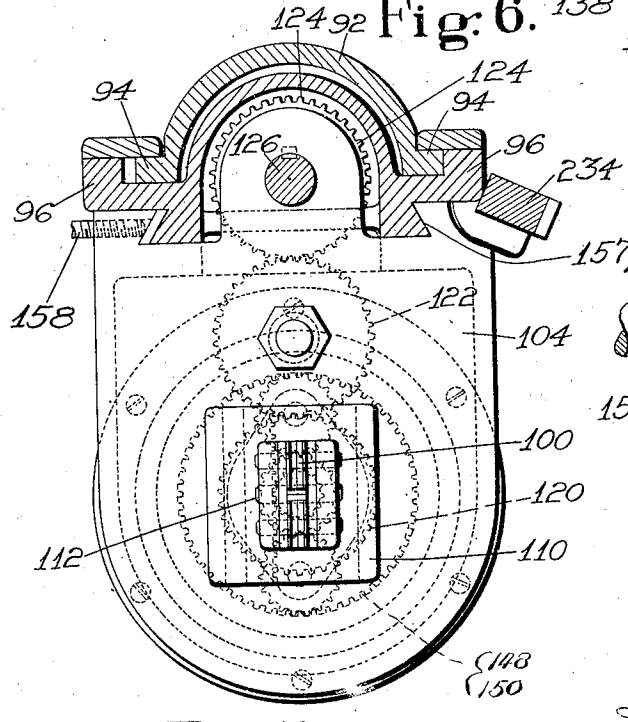


Fig: 7.

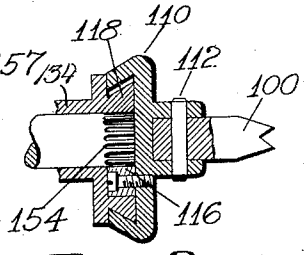


Fig: 8.

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APPLICATION FILED MAY 11, 1918.

1,362,185. **Patented Dec. 14, 1920.**

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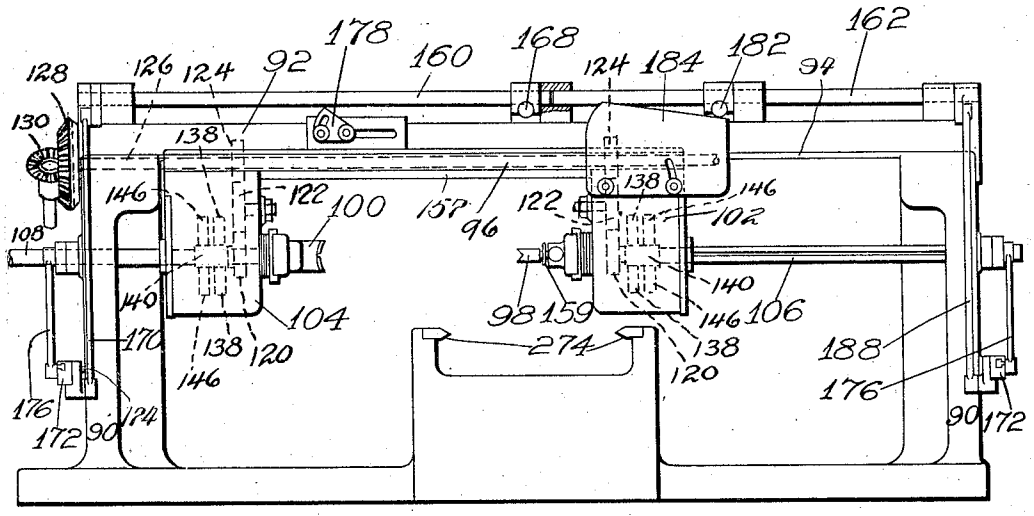


Fig. 9.

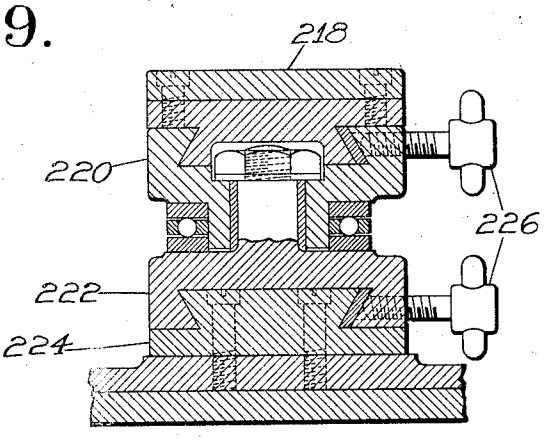


Fig. 10.

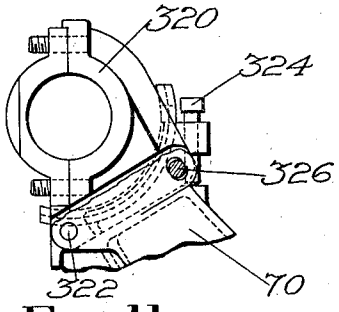


Fig. 11.

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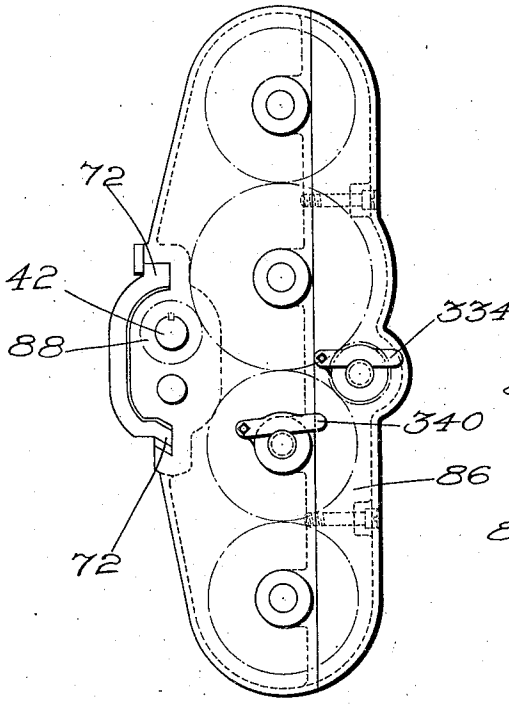


Fig.12.

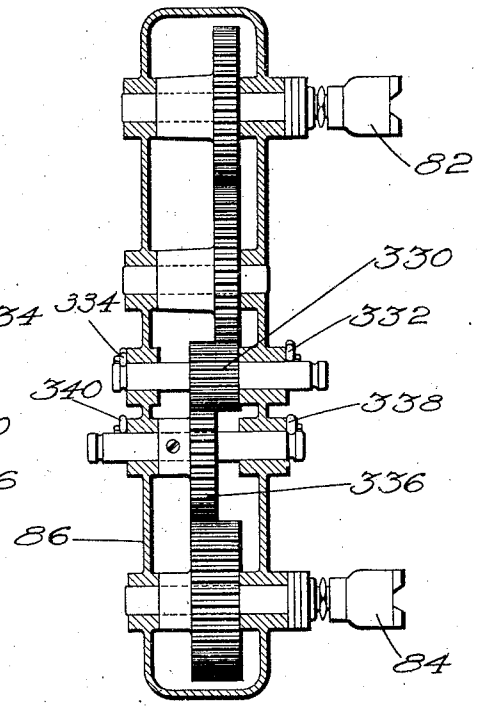


Fig.13.

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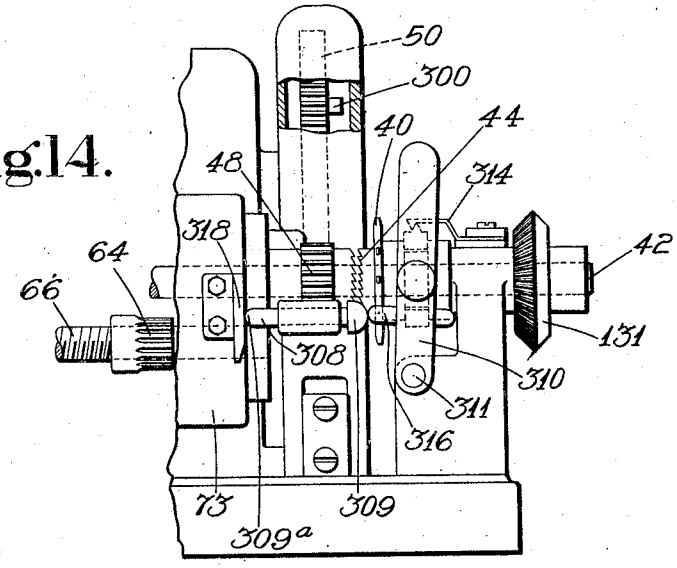
LAST LATHE.

APPLICATION FILED MAY 11, 1918.

1,362,185. Patented Dec. 14, 1920.

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Fig.14.



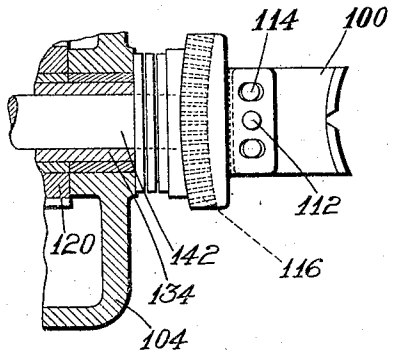


Fig.15.

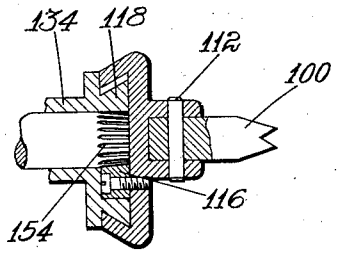


Fig.16.

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LAST LATHE.

APPLICATION FILED MAY 11, 1918.

1,362,185. **Patented Dec. 14, 1920.**

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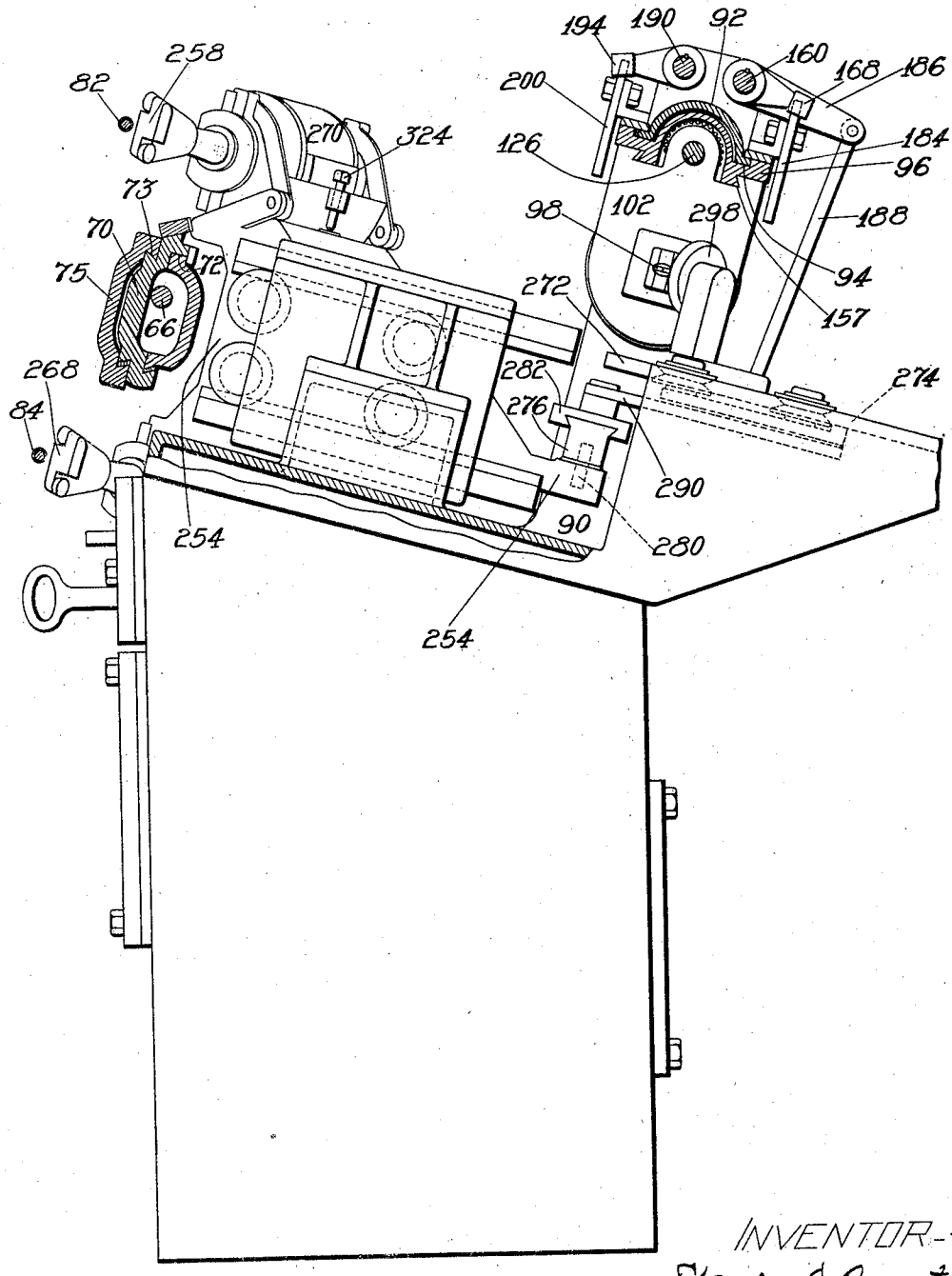


Fig.17.

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LAST LATHE.

APPLICATION FILED MAY 11, 1918.

1,362,185.

Patented Dec. 14, 1920.

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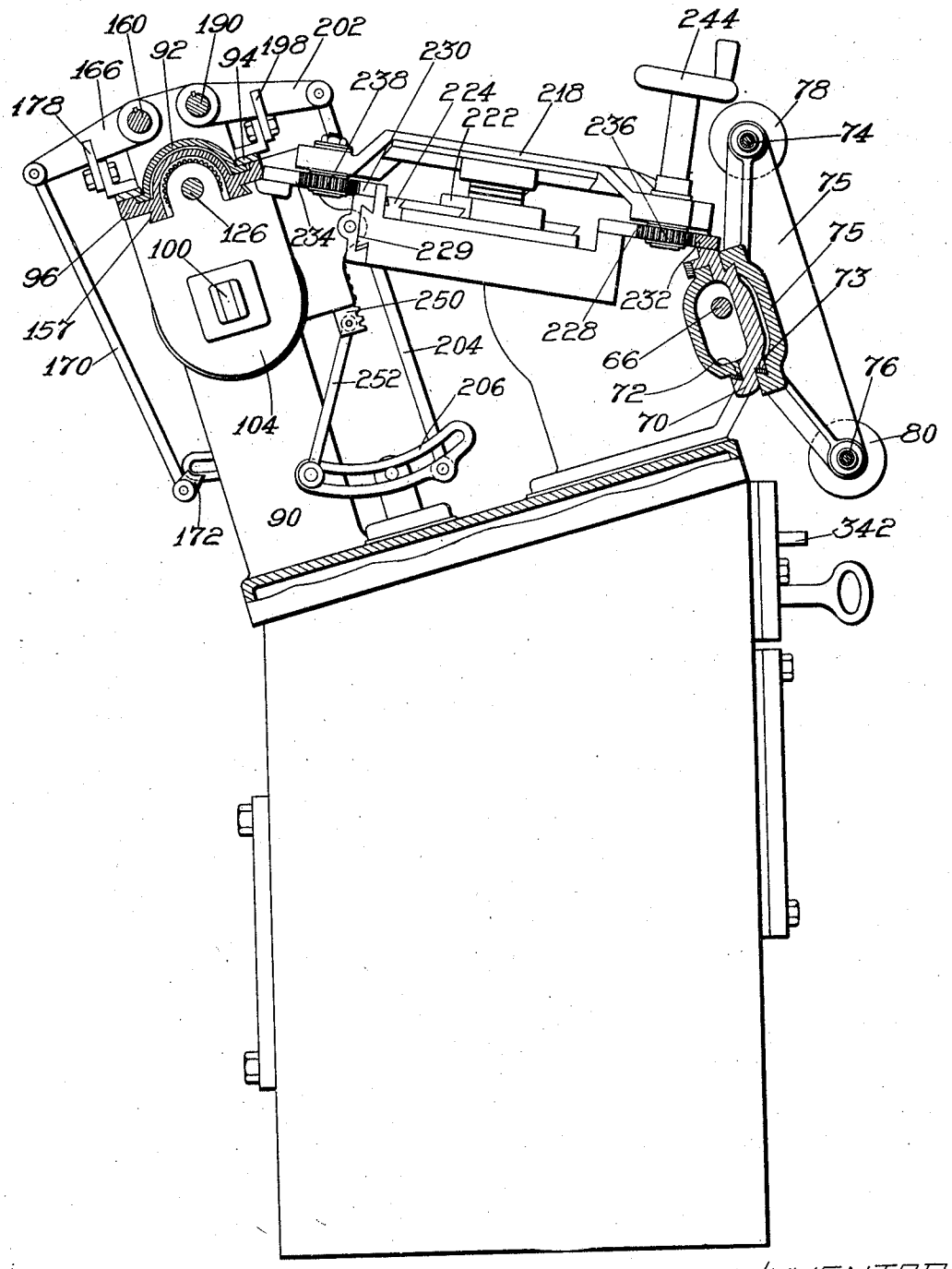


Fig.18.

INVENTOR-
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By his Attorney,
Nelson W. Howard

UNITED STATES PATENT OFFICE.

STANLEY E. BOYNTON, OF ROCHESTER, NEW YORK, ASSIGNOR TO FITZ-EMPIRE DOUBLE PIVOT LAST COMPANY, OF AUBURN, MAINE, A CORPORATION OF MAINE.

LAST-LATHE.

1,362,185. Specification of Letters Patent. Patented Dec. 14, 1920.

Application filed May 11, 1918. Serial No. 234,012.

To all whom it may concern:

Be it known that I, STANLEY E. BOYNTON, a citizen of the United States, residing at Rochester, in the county of Monroe and State of New York, have invented certain Improvements in Last-Lathes, of which the following description, in connection with the accompanying drawings, is a specification, like reference characters on the drawings indicating like parts in the several figures.

This invention relates to pattern copying, or the production of objects having a systematic resemblance to a pattern used as a guide or templet, and is disclosed as embodied in a last lathe. Many of the principles and features of the invention are of broad application to the entire class of pattern copying machinery including the production of objects having less than three dimensions, such, for example, as patterns for soles, shoe uppers, clothing, etc., and accordingly I do not intend that all of the appended claims shall be limited in scope to pattern reproducing machinery of the last making or even of the three-dimensional type, and I have therefore in many of the claims used words and terms in a generic sense as applying to the broad class of machinery of the pattern reproducing type.

It is well-known that the ordinary width grading mechanism is unsatisfactory in that it causes a vertical distortion or bowing down of the sole profile of lasts wider than the model and vica versa. It has been proposed to correct this by shifting the model about one of its ends, in its own vertical plane, during the turning. This changes the position of the instantaneous axis of rotation of each model section at the time of its reproduction, and thus displaces the reproduced section in the last cut. For example, by raising the model in cutting from the toe to the ball, and lowering it again in cutting from the ball to the heel breast portion, the entire ball and instep part of the last cut will be raised relatively to the toe and heel, without affecting the actual "width" or room in the last.

A machine built as described has a defect due to the fact that it tips the model and that therefore the thin sections or differential elements which are successively reproduced are not strictly parallel. Such a machine bends the last produced instead of merely shifting plane laminæ in it differentially, and the distortion produced is sometimes objectionable.

The invention contemplates broadly the movement of the model or work or both, or the independent relative movement of the ends of both, transversely to a grading axis with relation to which a grading mechanism is arranged to magnify or reduce differential elements of the model. In the illustrated embodiment of the invention, the "ends" of the model and work lie in the direction of the grading axis, which is shown as a width grading axis, in relation to the particular problem discussed. In another aspect, my invention contemplates broadly the independent relative shifting between each model end and the corresponding block end during the last cutting, in the same or in different (and not necessarily opposite) directions. More broadly still, I contemplate altering arbitrarily, during the last cutting, the relation between the two relative movements one of which takes place between the model wheel and the entire model supporting means and the other of which takes place between the cutter and the entire work supporting means. The term "entire" signifies that the entire supporting means is concerned in the accomplishment of the function, though different parts of the supporting means, for example, the two model dogs, need not have exactly the same relation to the operation. I further contemplate that the alteration mentioned (which in the machine shown is produced by shifting the model ends) shall be controlled throughout the last cutting, and shall be performed at any desired constant or variable rates. A machine performing these functions or any of them embodies an important feature of the invention. I am thus enabled, for example, to move the ends of the moved body equally, and thus to insure rigid parallelism between the successively displaced and reproduced sections of the model and block.

This latter aspect of the invention may be regarded somewhat differently. The pattern copying lathe, as known before the present invention, consisted essentially of four principal instrumentalities, viz., a model wheel, a model holder, a tool and a work holder which might be considered as related each to a mechanical axis of rota-

tion, the relations between the mechanical axes of the cutter and block being governed by the distance between those of the model wheel and model, as determined by the contact between the model wheel and model. The present invention effects a profile control by rotating one of the principal instrumentalities bodily about its mechanical axis of rotation while in a displaced relation to that axis of rotation, the displacement being one of pure translation.

In another view of the matter, the model, for example, may be considered as having fixed within itself an axis of its own, the line joining the toe tip to the heel center, which is normally coincident with the mechanical axis of rotation. The present invention may be conceived as displacing this axis upon the mechanical axis, and rotating it about the mechanical axis while the model is rotating about the fixed model axis just as it would do if the two axes were coincident.

An important feature of the invention consists in effecting the shifting movement through a member so constructed as to move, in accomplishing the shifting, proportionally to the shift produced. This member is preferably controlled by a cam, and the development of a cam required for any desired function is therefore simple.

Another very important feature of the invention resides in a novel grading mechanism arranged to cause relative movement at any arbitrarily variable velocity between two carriages. An important feature of the mechanism consists in constructing it so that the points of attachment of the carriages to the lever move in straight lines instead of curves, so that entire uniformity in the grading ratio may be secured. Another important feature of the invention consists in means for varying the uniformity of this grading action at will, and in any desired manner. In the machine shown a differential gear mechanism is used, controlled preferably by a cam of arbitrary form. Here, again, I effect the irregular action desired by a member whose movement is rigidly proportional to the effect produced by it on the grading mechanism, so that the development of any required cam offers no great difficulty.

These and other features of the invention, comprising various combinations and arrangements of parts, will be better understood from the following description of an embodiment thereof in a last lathe shown in the accompanying drawings in which:

Figure 1 is a front elevation of the machine.

Fig. 2 is a plan of the machine.

Fig. 3 is an end elevation of the machine.

Fig. 4 is an end elevation of the driving mechanism.

Fig. 5 is a plan view of the cutter and model wheel carriages and width grading mechanism.

Fig. 6 is a sectional view of the dog shifting mechanism.

Fig. 7 is an end elevation of the dog shifting mechanism.

Fig. 8 is a detail of the dog shifting mechanism.

Fig. 9 is a rear elevation of the model carriage.

Fig. 10 is a detail of the grading mechanism.

Fig. 11 is a detail of the cutter suspension.

Figs. 12 and 13 are details of a gearing adapted to cut either a pair or two identical lasts.

Fig. 14 shows the clutch at the instant of disengagement.

Figs. 15 and 16 show a modification of the dog-shifting mechanism.

Figs. 17 and 18 are sectional views on the line 17—18 of Fig. 2.

An electric motor 10 has a gear 12 on its shaft engaging a gear 14 on a shaft 16. A pair of change gears 18, 20 are keyed to the shaft 16, meshing with gears 22, 24, respectively, splined on a shaft 25 and which are connected to a gear 26 keyed on the shaft 25 through a device 28 operated by an arm on a shaft 32, arranged to connect either pair of gears by means of the splines according to the orientation of the shaft 32. The gear 26 drives a gear 34 rigidly mounted with a sprocket 36 which is connected by a sprocket chain 38 with a sprocket 40 loose on a shaft 42. The sprocket 40 has clutch teeth at 44 engaging a sleeve 46 keyed on the shaft 42 which carries a gear 48. The shaft 42 extends throughout the length of the machine. The gear 48 engages a pinion 50 which through its keyed shaft 53 and a splined spur gear 55 also keyed on the shaft operates a system of change gears which are shiftable by the handle 52. This handle, as shown in Fig. 2, shifts sidewise the gears 54 and 55 to place the gear 54 in mesh with any one of the gears 56, 58 and 60, all keyed on their shaft, and the latter gear meshes with the gear 62 which drives a pinion 64 on a shaft 66 threaded throughout most of its length and which is mounted at its outer end in the main frame of the machine at 68. The screw 66, through a suitable split nut, not shown, but operated by a handle 67, engages a carriage 70 which slides upon guides 72 horizontally arranged on the front of the frame of the machine. The carriage 70 carries a guide 73 upon which slides a casting 75 in which are mounted, vertically one above the other, two dead centers 74 and 76 each arranged to engage the toe end of a last block, the centers being adjustable by the screws and handles at 78 and 80. The

casting 75 can thus be adjusted to accommodate lasts of widely varying lengths, the final clamping operation being performed by the handles 78 and 80. The screw 77 will clamp the casting 75 firmly upon the carriage 70. Horizontally axially alined with these centers are the corresponding live centers 82 and 84 rotatably mounted in the carriage 70 and driven by a system of gearing in the box 86 operated by a gear 88 splined on the shaft 42. The gears in the box 86 may be so arranged as to drive the live centers 82 and 84 in the same or opposite directions and will preferably be constructed to effect similar or dissimilar rotation of the live centers at will. This is accomplished by inserting into or removing from the connecting train an extra gear wheel, as is well known to workers in this art. See Figs. 12 and 13.

The rear side of the machine carries at each end a standard 90, these standards being connected by an arched beam 92 having horizontal guides 94 at its opposite sides, see Fig. 7. Upon these guides is the model carriage which comprises a slide 96 running on the guides 94 to which is suspended the model toe and heel dogs 98 and 100. These members are suspended in boxes 102 and 104, respectively, which contain gearing which will be described and from which project two long shafts 106 and 108, respectively. These shafts extend through bearings in the standards 90 and extend out beyond the ends of the machine. The dog operating mechanisms are both alike and the description of one will suffice, see Fig. 6. The dog 100 is pivotally mounted on a slide 110 at 112 and has two pins 114 playing in slots in the slide in order to permit a slight up and down swinging movement of the dog. The slide 110 has an internal rack 116 by means of which it can be moved up and down on a guideway 118. The dog 100 is driven through a sleeve 134 by a gear 120 which meshes with an idler gear 122 operated by a gear 124 which is splined on a shaft 126 having a bevel gear 128 at its end driven from the shaft 42 by means of the bevel gears 130 and the counter shaft 132. The gear 130 meshes with a bevel gear 131 keyed on the shaft 42 and the gearing is so proportioned that the model center 100 and the block centers rotate at the same speed. The guideway 118 is mounted integrally with the sleeve 134, which is keyed to the gear 120 and also to a collar 136 on which are mounted two pinions 138 in the same plane which engage a spur gear 140 loosely mounted upon the shaft 142. Keyed to the shaft 142 which is mounted rotatably in the spindle 134 is another collar 144 carrying two corresponding pinions 146 also engaging the spur gear 140. These two sets of idler pinions are surrounded by and mesh with two circular internal gears 148 and 150, respectively, the former of which is fixedly mounted upon the model carriage and the latter of which is carried by a spider 152 rotatably mounted in the carriage co-axially with the shaft 142. This spider is keyed to the shaft 108. The shaft 142 carries on its inner end a pinion 154 in mesh with the rack 116. When the gear 120 is causing the model center to rotate, the collar 136 is also carried around at the same angular velocity and the pinions 138 roll around on the gear 148, turning the gear 140 in consequence. The gear 140 reciprocally causes the pinions 146 to revolve and run around on the gear 150. This will cause the shaft 142 to rotate at the same angular velocity as the sleeve 134 and there will be no relative movement between the rack 116 and the pinion 154. If now, the shaft 108 be rotated slightly by means of the arm 156 splined on it and rotatably mounted on the standard 90, the spider 152 will be turned, carrying the gear 150 with it. The gear 150 will then operate the pinions 146 as levers, they being fulcrumed upon the gear 140, and will cause the shaft 142 to revolve or advance ahead of its former position, which will operate the rack and pinion mechanism at 116, thus moving the model center up or down, considered relatively to the model, as the case may be.

The model dogs 98, 100 are longitudinally adjusted to approximate position by a sliding movement between the slide 96 and the gear carrying casing 104. The slide and clamp screws permitting this movement are illustrated at 157, 158 in Fig. 7. One dog, shown as the toe dog in Fig. 9, is also longitudinally adustable relative to its carrier 110 by any convenient, preferably screw-operated means 159, (Fig. 9) as will be well understood by workers in this art.

The model carriage carrying frame work 92, at the back of the machine, has mounted in it a shaft 160 which extends longitudinally of it about half its length and another shaft 162 co-axial with the former shaft and extending the remainder of the length of the frame. The shaft 160 carries two arms 164 and 166. The arm 164 carries a roller 168 at its end and the arm 166 is connected to a link 170, which is connected to a slotted arm 172 pivoted at 174 on the standard 90 with a link 176 adustably connecting the arm 156 with its slot. The slot is so arranged that the link 176 can be adjusted either side of the pivot 174 so that the same movement of the link 170 can be made to cause movement in either direction as desired of the arm 156 and consequently of the model center 100. The shaft 160 is operated by a cam 178 of any desired size and shape, adjustably mounted upon the model carriage. This cam, therefore, will operate

the shaft 160 in any desired way as the turning of the last proceeds and will therefore cause any desired movement of the model center 100.

The shaft 162 has a corresponding arm 180 with a roller 182 operated by a cam 184 on the model carriage and an arm 186 connected to a link 188 which operates an entirely similar mechanism at the other end of the frame for controlling the other model center. The shafts 106 and 108, as stated, are splined in the members to which the arms 156 are attached so that as the model carriage moves back and forth the arms 156 which are mounted on the ends of the main machine frame may continue to control them. Mounted on the front of the model carriage supporting frame are two more shafts 190 and 192. The shaft 190 carries two operating arms with rollers 194 and 196, operated by cams 198, 200, mounted on the model carriage, and carries at its outside end an arm 202 connected to a link 204 engaging a pivoted slotted lever 206, the purpose of which will be later described. The shaft 192 has an arm and roller 208 which are operated by a cam 210 mounted on the model carriage like all the other cams. The shaft 192 carries a bevel gear 212, meshing with a bevel pinion 214, on the shaft 32 which operates the change speed device 30 when the proper point in the cutting has been reached, it being the custom to turn at a different rate of speed at the toe than at the shank and heel. The running back of the carriages to initial position is accomplished by the operator after loosening the split nut (operated by handle 67) and thereby disengaging the block carriage from the screw 66. This will disengage the cam 210 and the roller 208 and permit the roller 208 to return to lowest position with the first used pair of speed gears 18, 20, 22, 24 engaged. All of the arms on the shafts 160, 162 and 190, 192 may be held in their lowermost positions by suitable springs 216.

The model carriage and the block carriage are connected by a grading lever 218. This lever is slidably mounted upon a block 220 which is pivotally mounted upon another block 222 which in turn is slidably mounted on a slide 224 fixedly mounted on the main frame of the machine. These two blocks can be simultaneously moved along their slides to a suitable calibrated scale when the grading lever is parallel to the slide 224 which will occur when the carriages are in the position they occupy at the end of the cutting of the last. (Fig. 2 shows them at the beginning of the last cutting operation). When the blocks have been placed as desired, each one is clamped to its slide by the screws 226. The grading lever 218 is then free to turn about the pivotal axis of the two blocks and the two ends of it will move with velocities whose ratio depends upon the position of the pivotal axis of the blocks. Fixedly mounted upon the frame of the machine is a rack 228 and slidably mounted at 229 on the frame of the machine is another rack 230. Corresponding racks 232 and 234 are fixedly mounted upon the block carriage and model carriage, respectively. These racks mesh with pinions 236 and 238, respectively, which are pivotally mounted upon blocks 240 and 242 slidably mounted in two pairs of guides in the end of the grading lever. When the block carriage is driven by the screw 66 it will move the rack 232 over the pinion 236 which will rotate on the rack 228, thus causing the grading lever 218 to swing and causing a similar relative movement between the racks and pinion at its other end. This will cause the model carriage to move in the opposite direction to the block carriage at a velocity which is strictly proportional to that of the block carriage. Although the pinions slide in the grading lever, yet their distances from the center of rotation to the grading lever are always strictly proportional and depend upon the position of the pivotal centers of the blocks 240 and 242. A handle 244 is mounted upon the pinion 236 and enables the operator to move the carriages back and forth by hand when the split nut is disconnected from the screw 66.

The sliding rack 230 is moved back and forth by a threaded rod 246 the threaded portion of which is engaged by a pinion 248 mounted in the frame of the machine and operated by a rack 250, vertically moving in a slide on the main frame. The rack 250 is adjustably connected by a link 252 to the pivoted slotted arm 206, as will be easily understood, and is operated by the cams 198, 200, above described.

The cutter carriage 254 is mounted to move rectilinearly on guides 256 mounted in the main frame of the machine. These guides slope downwardly and backwardly at an angle, in the machine shown, of about 15°. The cutter carriage carries two cutting instrumentalities 258, 268, which are preferably mounted directly upon the shafts of independently operating motors 270, 276, the shafts forming an angle of about 30° with the line of centers of the blocks and the cutting instrumentalities being substantially pear-shaped or conical, with the large ends nearest the work.

The model wheel or guide carriage 272 is mounted to run on rectilinear guides or slideways 274 parallel to the cutter carriage guides 256 and likewise mounted on the frame of the machine. Both the cutter and model wheel carriages have roller bearings engaging the guides, as shown, and are linked together by any convenient width grading mechanism. I have shown a lever

276 having a pin and slot connection 278 with the main frame and pivoted to the cutter carriage at 280. This lever carries a sliding block 282 the position of which may be adjusted to a calibrated scale by the screw 284, gear mechanism 286 and handle 288, as desired. Pivoted to the block 282 is a link 290 the other end of which is pivoted to the model wheel carriage at 292. When the block 282 is adjusted with the pivotal center of the link directly over the center 280, the width produced by the machine will correspond to that of the model. When the block 282 is adjusted as shown in Fig. 5 the model wheel carriage will move faster than the cutter carriage and the last cut will consequently be narrower than the model, and vice versa. The model wheel carriage has a slide 294 adjustable by the screw 296 upon which is mounted the model wheel itself 298. This corresponds in shape with the finishing portion of the cutting instrumentality, but is sloped at an opposite angle as shown in Fig. 5, which places it at the same angle with the axis of the model, it being noticed that the model and block are pointed in opposite directions inasmuch as their carriages are moved in opposite directions.

The gear 50 carries a plurality of pins 300 which contact with a lever 302 at each revolution. This lever which is pivoted on the shaft 66 has an arm 304 which normally rests against the pin 306 and carries at its forward end a horizontally sliding pin 308 having rounded extremities 309 and 309ª. The movement of the pins 300 will therefore cause the pin 308 to be raised and then dropped again owing to the weight of the front portion of the lever 302, each time a pin 300 passes the rear end of the lever 302. A hand lever 310 pivotally mounted at 311 is arranged to shift the sliding sprocket collar 40 and has on its rear face a projection 312 which can be placed either side of a spring detent 314 to hold the clutch teeth 44 on the sprocket in either engaged or disengaged position relatively to the corresponding clutch teeth on the shaft 42. The lever 310 has a horizontally projecting arm 316, which, when the clutch is engaged, projects to the left in Fig. 1, to a position which does not intersect the vertical path of the end 309 when the pin 308 is in its Fig. 1 position, but projects enough to be struck by 309 when the pin 308 is slid to the right in Fig. 1. When the block carriage approaches its rightmost position and the cutting of the last is finished, a cam member 318 on the extreme right end of the block carriage will move into a position which is closer to the member 316 than the length of the member 308. The member 318 is somewhat above the lowest position of the member 308 and when the carriage has reached the position mentioned the next pin 300 which passes the lever 302 will raise the member 308 and force it to the right by contact of the end 309ª with the cam 318. As it continues to rise, it will jam (Fig. 14) between the members 318 and 316, and force the lever 310 to the right to disengage the clutch teeth at 44, thus stopping the operation of the machine. The pins 300 are so placed and the gearing is so timed that this disengagement will come at a time when the blocks have their normal vertical planes in the plane of the frame 70 so that the removal of the blocks and the insertion of new blocks will be facilitated.

The machine will be initially constructed so that the two block axes and the two cutter axes will be parallel to the plane of the sliding cutter carriage and so that the corresponding cutter and block axes will be at the same distance from this plane. This will insure proper working when cutting either right and left lasts at once or when cutting two rights or two lefts. An adjustment of the cutter axis toward and from the block axis may be necessary, owing to wear and adjustment of the cutters, and is provided as follows:

The motor which operates the cutter is clamped on a carriage 320, which is pivoted at 322 on an axis parallel to the axis of the cutter. A set screw 324 resting against a fixed part of the cutter carriage tilts the carriage 320 into the desired position to position the finishing cutters properly relatively to the block axis. The axis 322 is directly below the cutter axis, considered relatively to the plane of the cutter carriage, so that a shift of one-quarter inch or more parallel to this plane will not change the vertical distance of the cutter axis taken perpendicular to the plane of the cutter carriage by an amount great enough to cause inaccurate reproduction. The carriage 320 is then bolted to the cutter carriage frame by a bolt and slot connection at 326.

The model wheel center moves in a plane parallel to the guides 274 and passing through the axis of the model. A similar relation exists between the cutters and the block axes.

In Fig. 13 is shown an arrangement of gearing in the box 86 which will permit the turning of two lasts like the model or of a right and left. The extra gear 330 can be slid from one side of the casing to the other and locked by one of the latches 332 and 334. The next gear 336 can also be shifted and latched at 338 or 340. The gear 330 can thus be inserted into or removed from the train between the dogs 82 and 84.

The machine is provided with a suitable latch, as at 342, for holding the reciprocating carriages retracted when the work is being removed. A counter-weight 344 holds the carriages up to the work.

The plane containing the two block axes is preferably perpendicular to the planes in which the model wheel carriage and cutter carriage reciprocate and the line joining the two cutting instrumentalities is also perpendicular to this plane. The cutting instrumentalities and the model wheel directly and rectilinearly approach and recede from the blocks and the model, respectively. This avoids a difficulty inherent in machines heretofore used relative to the cutting of right and left lasts from the same model. The ordinary last lathe having a pendulum swing frame swinging in the arc of a circle about an axis at the top of the machine is unable to turn a right and left last which are exact "reflections" for the following reason:

When the cone of the model is rolling over the model wheel and is, for instance, above the center of the model wheel the cone of the block will occupy a generally similar position below the center of the cutter. These two positions make equal angles with a line having a fixed relation with and perpendicular to the swing frame. As the swing frame swings out to permit the tip of the cone to pass over the model wheel, this line changes its relation to the horizontal by the angular amount of swing, and consequently, the cone of the model and the cone of the block occupy different positions relative to the model wheel and cutter. In the language of the last lathe operator "one wraps around the model wheel more (or less) than the other does around the cutter". This causes a lateral dislocation of the tip of the cone in the block, and it is obvious that the lateral extent of these dislocations will vary throughout the length of the last since they depend upon the amount of the swing of the swing frame at the instants of reproduction. The result is an actual twist around the horizontal axis of the last. This difficulty is avoided by the present machine since there is no swing frame in the true sense of the word, the relative approach of the operating instrumentalities and the blocks and model being along strictly straight lines and there being therefore no possibility of different relations between them above and below the center of the cutters and model wheel, respectively.

The slidable rack 230 enables me to produce any arbitrarily desirable variation in the length grade. If the rack were motionless, the machine shown would grade with rigid accuracy, producing blocks which would be exactly proportional to the model in all longitudinal dimensions. By moving the rack during the turning, I am enabled to vary this uniformity of longitudinal grade in any desired way and am enabled to move the rack in any desired way by a proper shaping of the cams 198 and 200. The movement of the rack is exactly proportional to the irregularity in longitudinal movement of the model carriage produced by it, and the development of the cam is therefore simplified. Equal increments of movement of the rack 250 will produce equal increments of irregularity in the length grade at all times. This function is of peculiar value in the designing of new models, although this machine is not confined to model making. A new model is often ordered and defined by certain differences which it is desired that it shall have from an already existing model. Often these differences consist largely or entirely of changes in longitudinal proportions. The shoemaker may want the ball moved forward or backward slightly in the model he submits, or he may want a longer toe extension. Such models can be produced mechanically on my machine in a few minutes and at very slight expense, whereas it has been necessary to produce them by hand labor of skilled model makers which involves a considerable expense. I do not claim broadly the variation of length grading of a last as that is the invention of another, but I believe that I am the first to produce a machine in which irregular length grading of any desired variety can be produced at will. The cams 198, 200 can, of course, be so shaped that the machine will grade uniformly during any desired part of the cutting of the last and grade nonuniformly during the remaining part or parts of the cutting. If it were desired to extend the toe on a model submitted, the machine would be adjusted to grade from the toe tip to the ball and then to grade uniformly from the ball to the heel. Other uses of my novel length grading mechanism will be apparent without further description. The two cams 198, 200 are furnished merely for convenience in operation. A single cam, the length of the model, would do as well.

I secure a very valuable result by means of my novel model dog shifting mechanism. It is well known that the width grader on the last lathe in ordinary use fails to operate satisfactorily in that it changes the sole profile of the lasts cut by means of it. The width grader automatically increases the dimensions on the model taken perpendicular to its axis of rotation and results, therefore, in bending down the sole profile of wide lasts and vice versa. This will be apparent when it is considered that the model is hung from its toe tip and the middle of the heel and that the bottom of the ball is farther from the axis of rotation than any other points of the sole of the last. This will result in the ball of the work being dropped farther than any other point by the width grader, which will result in bowing down the sole profile. This

systematic change in lasts as their width increases has no anatomical meaning whatever and causes the wide and narrow lasts to fit poorly. My novel model shifting mechanism permits the model to be displaced relatively to its axis by an arbitrary amount at any point in the cutting. Thus the perpendicular distances from points in the sole profile to the instantaneous axis of rotation can be made arbitrary at the instant at which the model wheel is passing over such points in the sole profile. Since the distances from the axis of rotation of the blocks to the corresponding points in the sole profile are equal to the before-mentioned distances multiplied by the width grading ratio, these distances in the blocks may therefore be made arbitrary and a last having any arbitrary sole profile may be produced from any model with any desired width grading ratio. For example, suppose that it is required to reproduce exactly, aside from length grading, the sole profile of the model. Let e' be the radius of a point of the model sole profile, referred to the initial, normal axis of rotation (through the toe tip and the middle of the heel). Then the model must be raised a distance x such that, if r is the width grading (magnification) ratio,

$$(e'-x)r=e'$$

and the cam must be designed to produce the proper quantity x for each point of the sole profile. Since r lies ordinarily between 0.9 and 1.2

$$\frac{r-1}{r}$$

will be a small fraction. It is readily seen to be the ratio of the increase in radius of the last cut to the increased radius itself. The quantity x is seen to be strictly proportional to the radius of the sole profile in the section being reproduced. It has been previously proposed to effect this arbitrary positioning of the model axis corresponding to the traverse of the model wheel over a desired point of the model by shifting one end of the model. By means of my invention, I am enabled to shift both ends of the model at once, thereby keeping its axis always parallel to itself. Thus in effect I am enabled to divide the last into thin differential slices all taken strictly parallel, and perpendicular to its main longitudinal axis and to shift these sections to an arbitrary position relative to the axis of rotation of the centers at the instant that these sections are being reproduced in the block. The rigid parallelism of these sections avoids a distortional difficulty which has been experienced in using machines that move one end of the model and therefore tilt it slightly by varying degrees during the reproduction.

It will be observed that equal increments of rotation of the shafts 206, 208 produce equal increments of transverse movement of the model dogs. The development of the controlling cams is thus made quite simple.

By moving both ends of the model in the same way, I am enabled rigorously to secure the effect of sawing the model into parallel laminæ, shifting these laminæ upon each other and reproducing the distorted model through the width grading ratio; or, stated in other language, I am able to reproduce the model in the ordinary way through the width grading ratio and shift a system of parallel laminæ in the block in order to acquire the sole profile desired. I can, of course, shift one end of the model alone according to the method previously proposed or can shift both ends of the model independently in the same or in opposite directions, if desired. The pivotal mounting at 112 allows a degree of freedom in case this operation is performed, insuring that the dogs will not get loose on the model as it tilts. I have shown also in Figs. 15 and 16 an alternative construction of rack 116 and pinion 154 in which the rack is curved on a radius substantially equal to the length of a model. This structure will facilitate the tilting operation, if it is desired to perform it.

The use of this mechanism will be apparent to those skilled in the art without extended description. For example, if a wide last is to be cut, the model may be raised gradually as the cutting proceeds from the toe to the ball, and then lowered as the cutting proceeds from the ball to the heel breast portion. This procedure will raise the ball of the wide last, and take out the exaggerated toe (and heel) spring which is produced by the ordinary unmodified width grading mechanism. The width grading and model shifting mechanisms are entirely independent and can be used singly but they will ordinarily be combined in ordinary work.

Having described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:—

1. In a pattern copying machine, means for rotating a model, and means for automatically shifting the model bodily relatively to the axis of rotation in order to alter the normal relations between reproduced differential elements.

2. In a last turning lathe, means for rotating a model, and means for automatically shifting the model bodily relatively to the axis of rotation, at an arbitrarily variable rate.

3. In a last turning lathe, means for ro-

tating a model, and means for automatically shifting the model bodily relatively to the axis of rotation, by predeterminedly variable amounts, the shifting movement having a substantially longer period than the rotational movement.

4. In a last lathe, guiding and cutting instrumentalities, model holding mechanism and block holding mechanism, constructed and arranged to revolve the model and block, and to present them to said instrumentalities respectively in similar relations, and means modifying the action of a holding mechanism for bodily shifting the entire object held by that mechanism relatively to its axis of rotation at a rate controllable during the cutting of a last.

5. In a pattern copying machine, guiding and cutting instrumentalities, model holding mechanism and block holding mechanism, constructed and arranged to revolve the model and block, and to present them to said instrumentalities respectively in similar relations, and a continuous control for a holding mechanism for bodily shifting the entire model relatively to its axis of rotation at a rate variable automatically during the cutting of a last.

6. In a last lathe, guiding and cutting instrumentalities, model holding mechanism and block holding mechanism, constructed and arranged to revolve the model and block, and to present them to said instrumentalities respectively in similar relations, and means for bodily shifting the model relatively to its axis of rotation at a rate variable during the uninterrupted cutting of a last.

7. In a last lathe, guiding and cutting instrumentalities, model holding mechanism and block holding mechanism, constructed and arranged to revolve the model and block, and to present them to said instrumentalities respectively in similar relations, and cam operated means for bodily shifting the model relatively to its axis of rotation automatically at a rate non-uniform during the cutting of a last.

8. In a last turning lathe, a model wheel, a cutter, a frame having centers for supporting and rotating a model and a block in operating relation to said wheel and cutter, the centers of one of said objects comprising toe and heel dog mechanism constructed and arranged to move the dogs relatively to the axis of rotation of said centers at a rate variable during the cutting of the last.

9. In a last turning lathe, a model wheel and cutter, carriages having centers for supporting and rotating a model and a block respectively, dogs movably mounted on said centers for supporting one of said objects, and connections between one of said carriages and said dogs for moving said dogs relatively to the axis of said centers at a rate controllable during the cutting of a last.

10. In a last turning lathe, a model wheel and cutter, carriages having centers for supporting and rotating a model and block respectively, dogs movably mounted on said centers for supporting one of said objects, and connections between one of said carriages and said dogs for moving said dogs relatively to the axis of said centers at a rate automatically controllable during the cutting of a last.

11. In a last turning lathe, a model wheel and cutter, carriages having centers for supporting and rotating a model and block respectively, dogs movably mounted on said centers for supporting one of said objects and connections between one of said carriages and said dogs, comprising means adjustably mounted on the carriage for moving said dogs relatively to the axis of the centers during the cutting of a last.

12. In a last turning lathe, model and work carriages, grading mechanism, centers for supporting and rotating a model and a block, dogs movably mounted on said centers for supporting one of said objects, and cam-operated means for moving said dogs relatively to the axis of said centers during the cutting and grading of a last while preserving the pantographic nature of the reproduction.

13. In a last turning lathe, a model wheel and cutter model and block rotating instrumentalities, comprising dogs for supporting one of said objects at both ends, and movable toward and away from the axis of rotation during the cutting of a last, the movement during one revolution being small as compared with the least dimension of that part of the object treated during a revolution.

14. In a last turning lathe, a model wheel and cutter, model and block rotating instrumentalities, comprising dogs for supporting one of said objects at both ends, and movable toward and away from the axis of rotation during the cutting of a last, at a rate variable during the cutting, in such manner that the movement toward and away extends over several revolutions of the object.

15. In a last turning lathe, a model wheel and cutter, model and block rotating instrumentalities, comprising dogs for supporting one of said objects at both ends, and movable toward and away from the axis of rotation during the cutting of a last, at a rate arbitrarily determinable at any point of the cutting.

16. In a last turning lathe, a model wheel and cutter model and block rotating instrumentalities comprising dogs for supporting

one of said objects at its extremities, and movable relatively to the axis of rotation in one direction, and later in the opposite direction, during the cutting of a last to alter the normal relation of progressively reproduced laminæ.

17. In a last turning lathe, a model wheel and cutter model and block rotating instrumentalities comprising dogs for supporting one of said objects at its extremities, and movable relatively to the axis of rotation in one direction, and later in the opposite direction, during the cutting of a last, at an automatically controllable rate.

18. In a pattern copying machine, the combination of a head-stock and tail-stock, heel and toe dogs respectively mounted on the spindles thereof, and means for shifting both of said dogs transversely to the spindles.

19. In a pattern copying machine, the combination of a head-stock and tail-stock, heel and toe dogs respectively mounted on the spindles thereof, and means for shifting both of said dogs relatively and perpendicularly to their respective spindles simultaneously.

20. In a last turning lathe, the combination of a head-stock and tail-stock, means for rotating their spindles simultaneously, heel and toe dogs respectively mounted on said spindles, and means for shifting both of said dogs simultaneously transversely to their respective spindles, said mechanism being constructed for movement of the said dogs relatively toward and from each other to engage lasts of varying lengths.

21. In a last turning lathe, the combination of a head-stock and a tail-stock, means for rotating the spindles of both of said stocks, heel and toe dogs respectively mounted on said spindles and a cam-operated mechanism for shifting said dogs laterally on their respective stocks, the displacements being all in the same direction over a substantial part of the last length.

22. In a machine of the class described, model holding instrumentalities, a work holding instrumentality, model and work traversing instrumentalities, and cam connections operated in longitudinal space relation to the production of the work for moving the model holding instrumentalities simultaneously equal amounts in the same direction relatively to the work holding instrumentality during the last cutting.

23. In a machine of the class described, a model contacting member, an instrumentality supporting a model for coöperation with said member, a work contacting member, an instrumentality for supporting the work for coöperation with said work contacting member, and means for laterally displacing one of said instrumentalities relatively to the other during the production of a piece of work, the displacements being all in the same direction during a substantial part in the cutting.

24. In a machine of the class described, a model holding means comprising dogs arranged to rotate the model, and means arranged in timed relation to the longitudinal production of the work controllable to shift the dogs laterally relatively to the axis of rotation in either the same or in opposite directions.

25. In a machine of the class described, a model holding means comprising dogs arranged to rotate the model, and a cam and connections arranged in timed relation to the longitudinal production of the work controllable to shift the dogs laterally relatively to the axis of rotation in either the same or in opposite directions in an arbitrarily predetermined manner.

26. In a machine of the class described, a work carriage, a tool carriage, a model carriage, and a guide carriage, the latter two governing the relation between the former two, and dog controlling means for moving the ends of the model transversely to the axis of the dogs independently relatively to the model carriage.

27. In a machine of the class described, a work carriage, a tool carrier, a model carriage and a guide carrier, the carriages having instrumentalities for holding and rotating work and model respectively, the reaction between the latter two governing the relation between the former two, and means operated in time relation to the longitudinal production of the work and controllable for moving the holding instrumentalities of one of the carriages translationally relatively to the carriage independently in either the same or in different directions.

28. In a last lathe, the combination of a head-stock and a tail-stock, heel and toe dogs respectively mounted on the spindles thereof, and means for shifting both of said dogs transversely to their respective spindles independently.

29. In a last turning lathe, a model wheel and cutter, carriages having centers for supporting and rotating a model and a block respectively, dogs movably mounted on said centers for supporting one of said objects, and connections between one of said carriages and said dogs for controllably moving said dogs relatively to the axis of said centers, the extremes of the movement being reached during different revolutions.

30. In a last turning lathe, a model wheel, a cutter, a frame having centers for supporting and rotating a model and a block in operating relation to said wheel and cutter, the centers of one of said objects comprising toe and heel dogs constructed and ar-

ranged to be moved relatively to the axis of rotation of said centers at rates variable during the cutting of the last.

31. In a last turning lathe, a model wheel, a cutter, a frame having centers for supporting and rotating a model and a block in operating relation to said wheel and cutter, the centers of one of said objects comprising toe and heel dogs constructed and arranged to be moved relatively to the axis of rotation of said centers at rates automatically variable during the cutting of the last.

32. In a last turning lathe, a model wheel, a cutter, a frame having centers for supporting and rotating a model and a block in operating relation to said wheel and cutter, the centers of one of said objects comprising toe and heel dogs constructed and arranged to be moved relatively to the axis of rotation of said centers at rates automatically variable according to an arbitrarily predetermined law during the cutting of the last.

33. In a machine of the class described, a carriage having dogs arranged to engage the ends of a model, the carriage being arranged to move in the direction of the length of the model, means for rotating the dogs, means for shifting the dogs relatively to the axis of rotation, a member on the main frame for governing the shifting means, and means on the carriage to operate the member as the carriage moves.

34. In a machine of the class described, a carriage having means for engaging a last like body, comprising dogs engaging the ends thereof, means for rotating the dogs, means for shifting the dogs relatively to the axis of rotation, and a member for operating the shifting means having connection with the fixed frame of the machine.

35. In a machine of the class described, a carriage comprising dogs for engaging and rotating a body, means for shifting a dog relatively to its axis of rotation comprising a crank arm mounted on the frame of the machine and a cam carried by the carriage for operating the crank arm.

36. In a machine of the class described, a carriage comprising dogs arranged to hold and rotate the model, means for shifting a dog transversely to its axis of rotation comprising a member mounted on the carriage, a member mounted at a fixed station on the frame of the machine and having sliding engagement with the member mounted on the carriage, and a cam mounted on the carriage for operating the member mounted at the fixed station.

37. In a machine of the class described, a carriage having means for engaging a work-like body, comprising dogs engaging the ends thereof, means for rotating the dogs, means for shifting the dogs relatively to the axis of rotation, and a member for operating the shifting means constructed and arranged to produce equal increments of shifting movement corresponding to equal increments of its own movement.

38. In a machine of the class described, work holding and rotating dogs, a dog operating mechanism comprising a slideway, a slide carrying a dog, means for rotating the slideway and slide, means for shifting the slide on the slideway comprising a shaft, a gear on the slideway, a gear on the shaft, a gear engaged by both of the previously mentioned gears, two gears separately engaged by the two first-mentioned gears, respectively, and means for relatively shifting the two last-mentioned gears whereby the slide may be shifted on the slideway as they both rotate.

39. In a machine of the class described, work holding and rotating dogs, a dog operating mechanism comprising a slideway, a dog carrying slide on the slideway, an operating member for the slide, similarly moving gear mechanism to which said way and slide are respectively geared, other gears to which the way and slide are connected respectively, and means for relatively shifting the other gears whereby relative movement between the slide and slideway may be produced.

40. In a machine of the class described, work holding and rotating dogs, a dog operating mechanism comprising a slideway, a dog carrying slide on the slideway, an operating member for the slide, the operating member and the slideway both carrying similar idler gears, a gear meshing with the idler gears, a pair of gears meshing with the idlers respectively, and means for relatively shifting the gears of the pair whereby relative rotational movement is produced between the operating member and the slideway.

41. In a machine of the class described, work holding and rotating dogs, a dog operating mechanism comprising a slideway, a dog carrying slide on the slideway, an operating member for shifting the slide on the slideway, said member being concentric with the spindle of the rotary slideway, a differential idler gear mechanism connecting the spindle and the operating member to provide for differential rotational movement of the spindle and the operating member.

42. In a machine of the class described, work holding and rotating dogs, a dog operating mechanism comprising a spindle carrying a slideway, a dog carrying slide on the slideway, an operating member for the slide concentric with the spindle, and gearing for giving a differential rotational

movement to the member and spindle for shifting the dog relatively to the spindle during rotation thereof.

43. In a machine of the class described, work holding and rotating dogs, a dog operating mechanism comprising a spindle carrying a slideway, a dog carrying slide movable transversely of the axis of rotation of the spindle upon the slideway, an operating member for the slide concentric with the spindle, idler gears mounted integrally with the spindle and operating member, both engaging two gear mechanisms, the parts of one of said mechanisms engaged by the idler gears respectively being relatively fixed, the parts of the other gear mechanism engaged by said idler gears respectively being relatively movable, and a member mounted on the frame of the machine having a connection with one of said last-named parts for operating the same.

44. In a machine of the class described, a work holding carriage, a tool holding carriage, a model holding carriage, and a guide holding carriage, means for producing relative vibratory movement between the members of each pair of carriages, comprising two parallel rectilinear slides.

45. In a machine of the class described, two traversing carriages, one on the model side and one on the work side respectively, a power mechanism for effecting the rotation of the model and the work carried by the carriages comprising a member timed to pass a fixed point in timed relation to an arbitrary orientation of the model and work, and means operated by the member and one of the carriages to disconnect the power mechanism from the carriages whereby the work will always be stopped in the same position.

46. In a machine of the class described, traversing carriages for holding and rotating the model and work respectively, a power mechanism for effecting the rotation having a member timed to pass a fixed point in timed relation to a desired orientation of the work, a throwout for the power mechanism alined with one of the carriages, a member interposed between the throwout and the said carriage by the said timed member each time it reaches the fixed point whereby movement may be transmitted from the carriage to the throwout when the carriage reaches the end of its traverse.

47. In a pattern copying machine, a carriage on the model side, a carriage on the work side, and a grading lever connecting them having a pivot between its points of connection to the carriages.

48. In a machine of the class described, a carriage on the model side, a carriage on the work side, and a grading lever connecting them, having a fixed pivot between its points of connection to the carriages.

49. In a machine of the class described, a carriage on the model side, a carriage on the work side, and a grading lever connecting them having an adjustable pivot between its points of connection to the carriages.

50. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grading lever connecting them, the points of connection on the lever moving in straight lines in space as the lever swings.

51. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grading lever connected at its ends with the carriages, the points of connection moving rectilinearly on the lever as the lever swings.

52. In a pattern copying machine, a carriage on the model side, a carriage on the work side, a grading lever connected with the carriages, the points of connection on the lever moving on the lever at velocities whose ratio is equal to the grading ratio.

53. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grading lever connected with the carriages, the points of connection on the lever moving on the lever in opposite directions at velocities whose ratio is equal to the grading ratio.

54. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grading lever having slots, and members having a uniform relation to the carriages respectively and working in the slots as the lever swings.

55. In a pattern copying machine, a carriage on the model side, a carriage on the work side, a grading lever pivoted between its ends having slots, and members having a uniform relation to the carriages respectively and working in the slots as the lever swings.

56. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grading lever pivoted between its ends and having slots in its ends, and members having a uniform relation to the carriages respectively and working in the slots as the lever swings.

57. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grading lever, and pivots on the lever through which it has connection with the carriages, said pivots sliding longitudinally in the lever and moving rectilinearly in space as the lever swings.

58. In a machine of the class described, a carriage on the model side, a carriage on the work side, a gear mechanism between each carriage and main frame, and means for operating the gear mechanisms at velocities having an arbitrary ratio constant during the cutting of the last.

59. In a pattern copying machine, two carriages, a grading mechanism connecting them so as to produce a velocity ratio between them which is uniform during the cutting of a last, and means for inhibiting the uniformity of the grading action by predeterminedly arbitrary amounts.

60. In a machine of the class described, two carriages, a grading mechanism connecting them so as to produce a velocity ratio between them which is uniform during the cutting of a last, and means operated in time relation to the movement of the carriages for inhibiting the uniformity of the grading action by predeterminedly arbitrary amounts.

61. In a machine of the class described, two carriages, a grading mechanism connecting them so as to produce a velocity ratio between them which is uniform during the cutting of a last, and means operated by the movement of a carriage for inhibiting the uniformity of the grading action by predeterminedly arbitrary amounts.

62. In a machine of the class described, two carriages, a grading mechanism connecting them so as to produce a velocity ratio between them which is uniform during the cutting of a last, and means for inhibiting the uniformity of the grading action by predeterminedly arbitrary amounts, comprising a member on a carriage and a member on the frame controlled by the former member and connected to the grading mechanism.

63. In a machine of the class described, two carriages, a grading mechanism connecting them so as to produce a velocity ratio between them which is uniform during the cutting of a last, and means for inhibiting the uniformity of the grading action by predeterminedly arbitrary amounts comprising a member arranged along the line of travel of a carriage and continuously controlled by the carriage.

64. In a machine of the class described, a carriage on the model side, a carriage on the work side, gear mechanisms between the carriages and main frame, respectively, and means for operating the gear mechanisms at velocities having an entirely arbitrarily variable ratio during the cutting of the last.

65. In a machine of the class described, a carriage on the model side and a carriage on the work side, gear mechanisms between the carriages and the main frame, respectively, and means for operating the gear mechanisms comprising a lever connected to both.

66. In a machine of the class described, a carriage on the model side and a carriage on the work side, gear mechanisms between the carriages and the main frame, respectively, and means for operating the gear mechanisms comprising a lever having a fixed fulcrum connected to both.

67. In a machine of the class described, a carriage on the model side and a carriage on the work side, gear mechanisms between the carriages and the main frame, respectively, and means for operating the gear mechanisms comprising a lever having a fulcrum fixed in space and connected to both.

68. In a machine of the class described, two carriages, grading mechanism for relatively moving them comprising a rack on a carriage, a rack on the frame, a pinion meshing with both racks, and means for driving the pinion to cause movement of the carriage.

69. In a machine of the class described, a carriage on the model side, a carriage on the work side, grading mechanism for relatively moving them comprising rack and pinion mechanisms between the carriages and the main frame, respectively, and means for driving both rack and pinion mechanisms at an arbitrary velocity ratio which is constant during the cutting of a last.

70. In a machine of the class described, a carriage on the model side, a carriage on the work side, grading mechanism for relatively moving them comprising a lever, rack and pinion mechanisms between the carriages respectively and the lever, and means for driving both rack and pinion mechanisms at an arbitrary velocity ratio which is variable during the cutting of the last.

71. In a machine of the class described, a carriage on the model side, a carriage on the work side, rack and pinion mechanisms between the carriages, respectively, and the main frame for effecting a relative grading movement between the carriages, and means for driving both rack and pinion mechanisms at an arbitrary velocity ratio which is automatically variable during the cutting of the last.

72. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grade bar for causing relative movement between the carriages, rack and pinion mechanisms between the carriages respectively and the grade bar, and means for driving both rack and pinion mechanisms at an arbitrary velocity ratio which is variable during the cutting of the last.

73. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grading mechanism for effecting relative movement between carriages, comprising rack and pinion mechanisms between the carriages and the main frame respectively for driving both rack and pinion mechanisms at a velocity ratio which is arbitrarily automatically and variable during the cutting of the last.

74. In a machine of the class described, a carriage on the model side and a carriage on the work side arranged for parallel movement, grading mechanism comprising rack

and pinion mechanisms between the carriages respectively and means for driving both rack and pinion mechanisms at an arbitrarily variable velocity ratio controlled by the movement of a carriage during the cutting of the last.

75. In a machine of the class described, a carriage on the model side and a carriage on the work side arranged for movement in opposite directions, grading mechanism comprising rack and pinion mechanisms between the carriages respectively and the main frame, means for driving both rack and pinion mechanisms at an arbitrarily variable velocity ratio, and a cam for controlling the velocity ratio.

76. In a machine of the class described, a carriage on the model side and a carriage on the work side arranged for relative movement, a grade bar for causing a relative grading movement of the carriages, a rack and pinion connecting each carriage and the grade bar, and means for driving the pinions at an arbitrary velocity ratio constant during the last cutting.

77. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grading mechanism constructed and arranged to drive the carriages in opposite directions comprising a rack and pinion connecting each carriage and the frame, and means for driving the pinions at an arbitrary velocity ratio variable during the last cutting.

78. In a machine of the class described, a carriage on the model side, a carriage on the work side, a grading mechanism arranged to produce relative movement of the carriages and comprising a rack and pinion between each carriage and the frame, and means for driving the pinions at an arbitrary velocity ratio variable during the last cutting and controlled by the movement of the carriage.

79. In a machine of the class described, a carriage on the model side and a carriage on the work side arranged to be driven in opposite directions, a grading mechanism comprising a rack and pinion connecting each carriage and the frame, means for driving the pinions at an arbitrary velocity ratio variable during the last cutting, and a cam for controlling the variable velocity ratio.

80. In a machine of the class described, a carriage on the model side and a carriage on the work side arranged for relative movement, a rack on each carriage, corresponding racks on the fixed frame of the machine, a grade bar and a pinion meshing with each pair of racks and operated by the grade bar, means for moving the pinions at an arbitrary constant velocity ratio, and independent means for shifting a rack whereby a non-uniform relative movement of the carriages is produced.

81. In a machine of the class described, a carriage on the model side and a carriage on the work side arranged for relative parallel movement, a rack on each carriage, corresponding racks on the fixed frame of the machine, a grade bar and a pinion connected with the grade bar and meshing with each pair of racks, means for shifting the grade bar to move the pinions at an arbitrary constant velocity ratio, and independent means for shifting a rack, controlled by movement of a carriage, whereby a non-uniform relative movement of the carriages is produced.

82. In a machine of the class described, a carriage on the model side and a carriage on the work side arranged for parallel movement in opposite directions, a rack on each carriage, corresponding racks on the fixed frame of the machine, a pinion meshing with each pair of racks, means comprising a grade bar for moving the pinions at an arbitrary constant velocity ratio, and a cam for operating a rack to vary the ratio where desired.

83. In a machine of the class described, a carriage on the model side, a carriage on the work side, means for relatively moving the carriages at an arbitrary velocity ratio, and means for varying the ratio comprising a member constructed and arranged to produce equal increments of variation by equal increments in its own movement.

84. In a machine of the class described, a carriage on the work side, a carriage on the model side, a rack mounted on each carriage, two corresponding racks mounted on the frame of the machine, two pinions meshing with the pairs of racks respectively, a connection between the pinions whereby one operates the other, and means for shifting one of the racks whereby the effect of the pinions and connection in producing relative movement between the carriages is modified.

85. In a machine of the class described, a carriage on the work side, a carriage on the model side, a rack mounted on each carriage, two corresponding racks mounted on the frame of the machine, two pinions meshing with the pairs of racks respectively, a connection between the pinions whereby one operates the other, and means for shifting one of the racks whereby the effect of the pinions and connection in producing relative movement between the carriages is arbitrarily modified.

86. In a machine of the class described, a carriage on the work side, a carriage on the model side, a rack mounted on each carriage, two corresponding racks mounted on the frame of the machine, two pinions engaging the pairs of racks respectively, a lever fulcrumed on the frame joining the pinions whereby a movement of one car-

riage will cause a corresponding movement of the other through the lever and pinions and racks, and means for shifting independently one of the racks, operated by longitudinal movement of the carriage.

87. In a machine of the class described, a carriage on the work side, a carriage on the model side, a rack mounted on each carriage, two corresponding racks mounted on the frame of the machine, two pinions engaging the pairs of racks respectively, a lever fulcrumed on the frame and joining the pinions whereby a movement of one carriage will cause a corresponding movement of the other through the lever and pinions and racks, and means for independently moving one of the racks, operated by a cam on the carriage.

88. In a machine of the class described, a carriage on the work side, a carriage on the model side, a grading connection between said carriages constructed and arranged to move them in opposite directions in space at an arbitrary velocity ratio.

89. In a machine of the class described, instrumentalities for holding a model, instrumentalities for holding a block, guiding and cutting instrumentalities for coöperating with them respectively, and means for producing movement of the instrumentalities of one only of the first or second mentioned groups independent of the movement incident to ordinary reproduction and grading action, whereby arbitrarily systematic variations from pantographic reproduction are effected.

90. In a machine of the class described, instrumentalities for holding a model, instrumentalities for holding a block, mechanism for contacting with the model and block and for reproducing the model in the block in successive parallel sections comprising grading mechanism, and means for effecting relative movements parallel to the planes of the successive sections between the model holding instrumentalities and the block holding instrumentalities, independent of movements incident to geometric reproduction.

91. In a machine of the class described, instrumentalities for holding a model, instrumentalities for holding a block, a model guide and a cutter, means for producing relative movements of approach and separation between the model instrumentalities and guide and between the block instrumentalities and cutter in order to effect pantographic reproduction of the model in the block, and means for arbitrarily altering during the cutting of a last the relation between these relative movements whereby pantographic reproduction is inhibited.

92. In a pattern copying machine, two moving carriages, and mechanism connecting them constructed and arranged to produce a relative velocity ratio which is arbitrarily and predeterminedly variable during the cutting of the last.

93. In a machine of the class described, a carriage on the model side, a carriage on the work side, and mechanism connecting the carriages constructed and arranged to produce relative movement between them at a relative velocity ratio predeterminedly variable in any desired manner during the cutting of the last.

94. In a machine of the class described, a carriage on the model side, a carriage on the work side, and a differential gear mechanism constructed and arranged to produce relative movement between the carriages at a velocity variable during the cutting of the last in any predetermined manner.

95. In a last turning lathe, the combination of a head-stock and a tail-stock, a shaft for rotating the spindles of said stocks, said shaft being parallel to the guides of said stocks, and gearing transmitting motion from said shaft to said spindles, said gearing comprising rotatable parts parallel to said shaft, one of which parts is attached to said shaft, and the other of which parts is attached to the corresponding spindle.

96. In a last turning lathe, the combination of a head-stock and a tail-stock, a shaft for rotating the spindles of said stocks, said shaft being parallel to the guides of said stocks, and gearing transmitting motion from said shaft to said spindles, said gearing comprising rotatable parts parallel to said shaft, one of which parts is attached to said shaft, and the other of which parts is attached to the corresponding spindle, and means for advancing and retracting one of said stocks toward and from its companion stock.

97. In a machine of the class described, model and work carriages comprising centers for holding model and work respectively, means for shifting both centers of one set transversely to their axis of rotation, and means for driving one of the said centers constructed and arranged to permit adjusting the said center to accommodate objects of different lengths.

98. In a machine of the class described, model and work carriages comprising centers for holding model and work respectively, means for shifting both centers of one set transversely to their axis of rotation, and means for driving one of the said centers, the other center being constructed and arranged for adjustment in order to accommodate objects of varying lengths.

99. In a machine of the class described, model and work carriages comprising centers for holding model and work respectively, means for shifting both centers of one set transversely to their axis of rotation, and means for driving both of the said centers constructed and arranged to permit rela-

tive adjustment of the said centers to accommodate objects of different lengths.

100. In a last turning lathe, means for rotating a model, and means for automatically shifting the model bodily relatively to the axis of rotation, the amount of shift during one revolution of the model being small as compared with any dimension of the portion of the model treated during the revolution.

101. In a machine of the class described, a head stock, a tail stock, means for rotating the spindles of both stocks, heel and toe dogs mounted respectively on the spindles, and a cam and connections for shifting the dogs on their respective spindles.

102. That improvement in the art of manufacturing lasts which comprises revolving the last block on a fixed axis and bodily shifting the model relatively to its axis of revolution a distance proportional to the radius of that portion of the profile of the sole of the model which is being operated upon by the model wheel.

103. That improvement in the art of manufacturing lasts which comprises revolving the last block on a fixed axis, revolving a model, and bodily shifting the model relatively to its axis of revolution a distance proportional to the radius of that portion of a longitudinal profile of the model which is being operated upon by the model wheel and proportional to the ratio of the change in the width of the model to the last itself.

104. That improvement in the art of manufacturing lasts which comprises bodily shifting the model relatively to its axis of revolution a distance proportional to the radius of that portion of the profile of the sole of the last which is being operated upon by the model wheel, said distance being also a function of the ratio of width grade.

105. In a last turning lathe, the combination of means for revolving the last block on a fixed axis, means for revolving a model, and means for bodily shifting the model relatively to its axis of revolution a distance proportional to the radius of that portion of the profile of the sole of the model which is being operated upon by the model wheel.

106. In a last turning lathe, the combination of means for revolving the last block on a fixed axis, means for revolving a model, and means for bodily shifting the model relatively to its axis of revolution a distance proportional to the radius of that portion of the profile of the sole of the model which is being operated upon by the model wheel and also dependent upon the ratio of change in width of the last.

107. In a last turning lathe, the combination of means for rotating a model, and means for bodily shifting the model relatively to its axis of revolution a distance proportional to the radius of that portion of the profile of the sole of the last which is being operated upon by the model wheel, said distance being proportional to the ratio of the change in the width of the model considered relatively to the last.

108. In a pattern copying machine, a grading mechanism for magnifying or reducing differential elements of the model in relation to a grading axis and means for relatively bodily displacing the model and work transverse to said axis.

109. In a pattern copying machine, a grading mechanism for magnifying or reducing differential elements of the model in relation to a grading axis and means comprising a cam tending to displace the model bodily transverse to the grading axis.

110. In a pattern copying machine, a grading mechanism for magnifying or reducing differential elements of the model in relation to a grading axis, and a cam and connections tending to relatively shift the model and work transverse to said axis.

111. In a pattern copying machine, a grading mechanism for magnifying or reducing differential elements of the model in relation to a grading axis, and a cam and connections tending to bodily shift the model transverse to the grading axis, according to any predetermined law.

112. In a pattern copying machine, a grading mechanism for magnifying or reducing differential elements of the model in relation to the grading axis, and a cam and connections for independently shifting the model ends transverse to the axis in accordance with any predetermined law.

113. In a pattern copying machine, four principal instrumentalities, viz., a model wheel, a model holder, a cutter and a block holder, four mechanical axes to which these instrumentalities are respectively related, the distance between the cutter and block holder axes being controlled by the distance between the model wheel and model holder axes as determined by contact between the peripheries of the model wheel and a model held in the holder, and means for bodily rotating one of said principal instrumentalities, displaced by a movement of pure translation from its normal position relatively to its mechanical axis, about said mechanical axis, the displacement being substantially constant during a revolution of the said instrumentality.

114. In a pattern copying machine, four principal instrumentalities, viz., a model wheel, a model holder, a cutter and a block holder, four mechanical axes to which these instrumentalities are respectively related, the distance between the cutter and block holder axes being controlled by the distance between the model wheel and model holder axes as determined by contact between the

peripheries of the model wheel and a model held in the holder, and means for translating and bodily rotating one of said principal instrumentalities, respectively, from and about its mechanical axis, the displacement being substantially constant during a revolution of the said instrumentality.

115. In a pattern copying machine, four principal instrumentalities, viz., a model wheel, a model holder, a cutter and a block holder, four mechanical axes to which these instrumentalities are respectively related, the distance between the cutter and block holder axes being controlled by the distance between the model wheel and model holder axes as determined by contact between the peripheries of the model wheel and a model held in the holder, and a cam and connections for bodily rotating one of said principal instrumentalities, translated from its normal position relatively to its mechanical axis, about said mechanical axis, the translation being substantially constant during a revolution of the said instrumentality.

116. In a pattern copying machine, four principal instrumentalities, viz., a model wheel, a model holder, a cutter and a block holder, four mechanical axes to which these instrumentalities are respectively related, the distance between the cutter and block holder axes being controlled by the distance between the model wheel and model holder axes as determined by contact between the peripheries of the model wheel and a model held in the holder, and a cam and connections for translating and bodily rotating one of said principal instrumentalities, respectively, from and about its mechanical axis, the translation being substantially constant during a revolution of the said instrumentality, and the rotation period being equal to that of the model about its own longitudinal axis.

117. In a pattern copying machine, four principal instrumentalities, viz., a model wheel, a model holder, a cutter and a block holder, four mechanical axes to which these instrumentalities are respectively related, the distance between the cutter and block holder axes being controlled by the distance between the model wheel and model holder axes as determined by contact between the peripheries of the model wheel and a model held in the holder, and a cam and connections for bodily rotating one of said holders, translated from its normal position relatively to its mechanical axis, about said mechanical axis, said cam being developed as a function of the longitudinal position in the work of the point being reproduced, the translation, as determined by said cam, being substantially constant during a revolution of the said instrumentality.

118. In a pattern copying machine, four principal instrumentalities, viz., a model wheel, a model holder, a cutter and a block holder, four mechanical axes to which these instrumentalities are respectively related, the distance between the cutter and block holder axes being controlled by the distance between the model wheel and model holder axes as determined by contact between the peripheries of the model wheel and a model held in the holder, and a cam and connections for bodily rotating one of said holders, translated from its normal position relatively to its mechanical axis, about said mechanical axis, the translation being substantially constant during a revolution of the said instrumentality, and the rotation time being equal to that of the model around its own longitudinal axis.

In testimony whereof I have signed my name to this specification.

STANLEY E. BOYNTON.