March 2, 1937. L. E. TOPHAM ET AL 2,072,228

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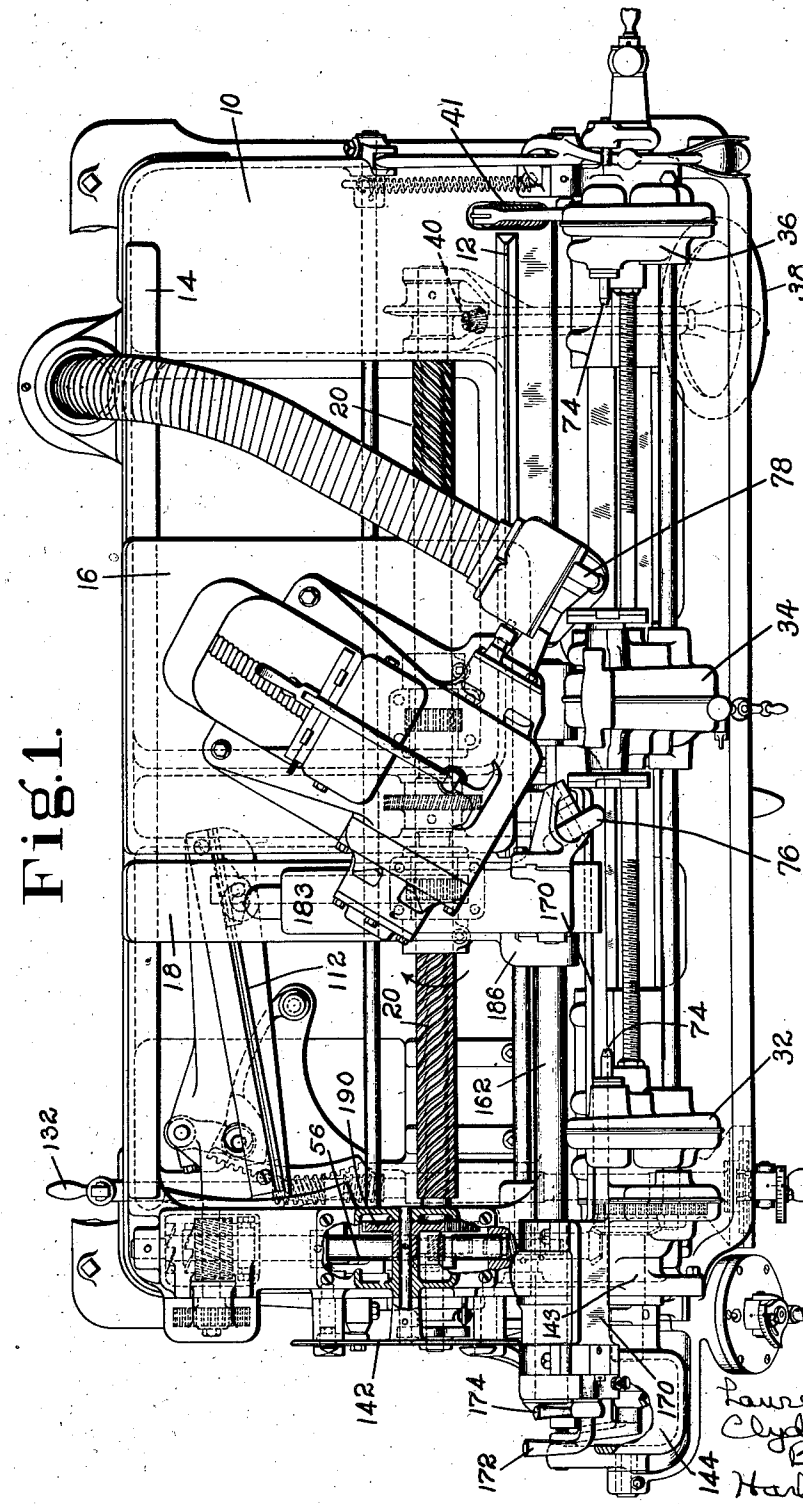


Fig. 1.

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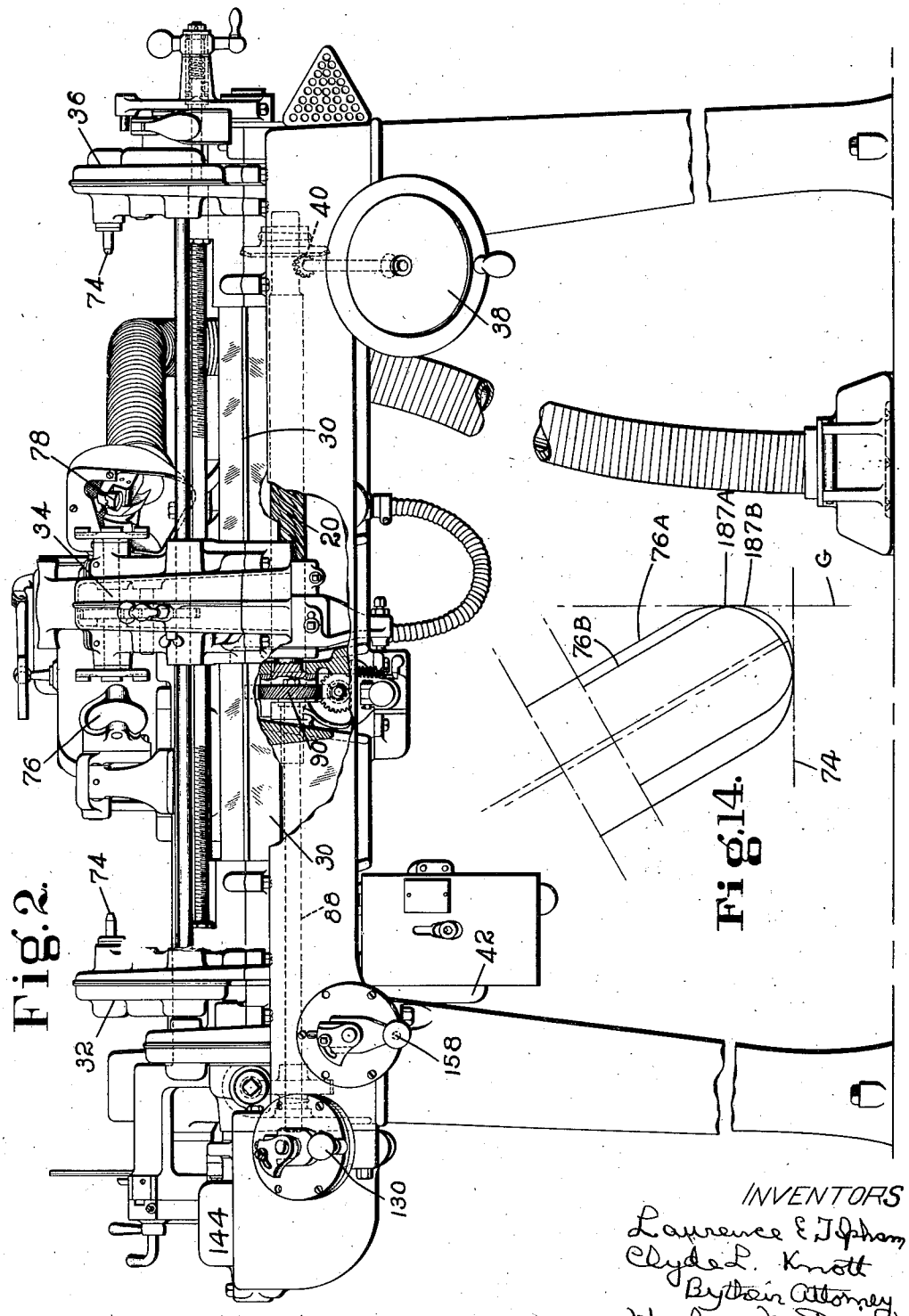


Fig. 2.

Fig. 14.

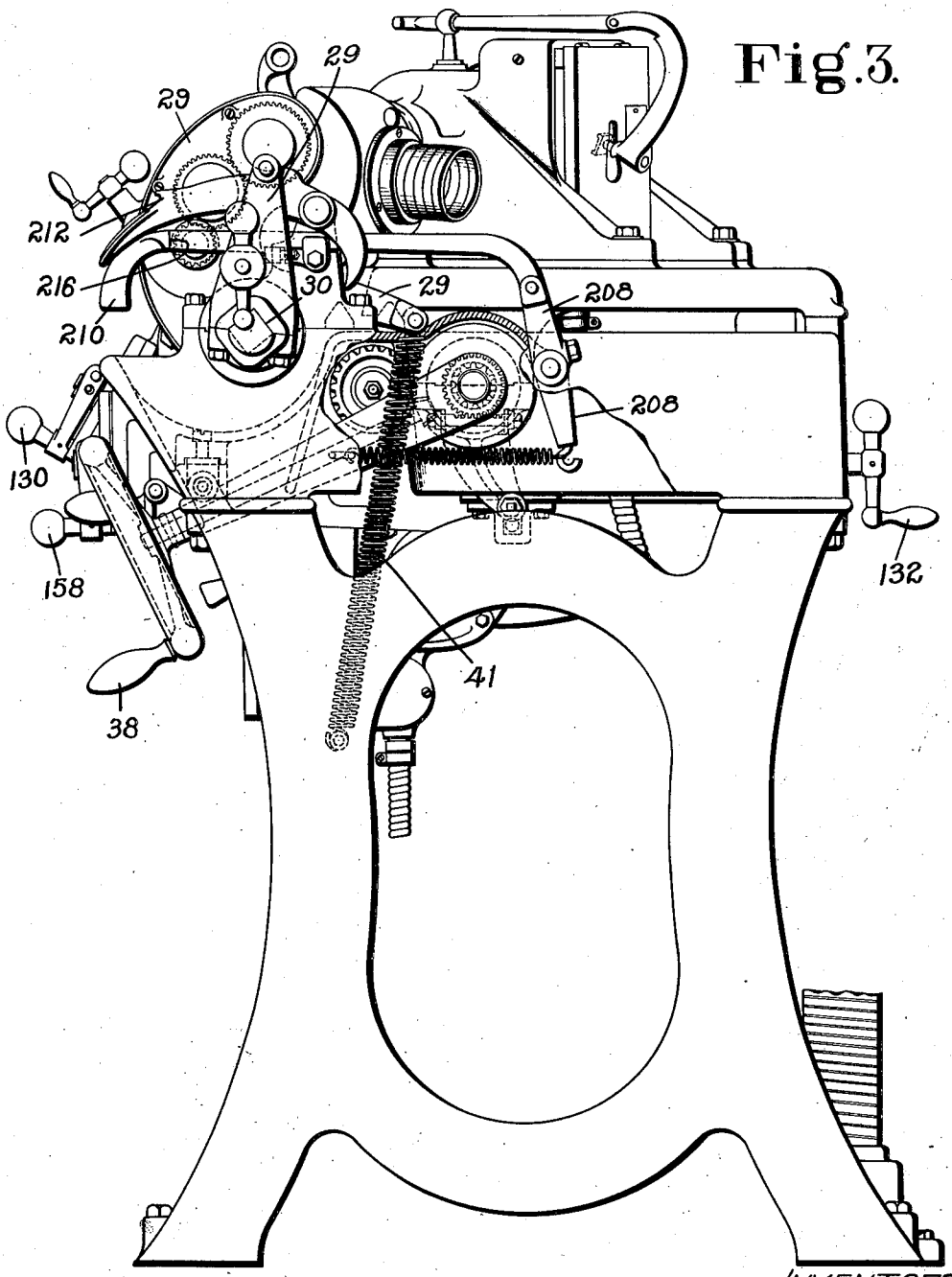
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Fig. 3.



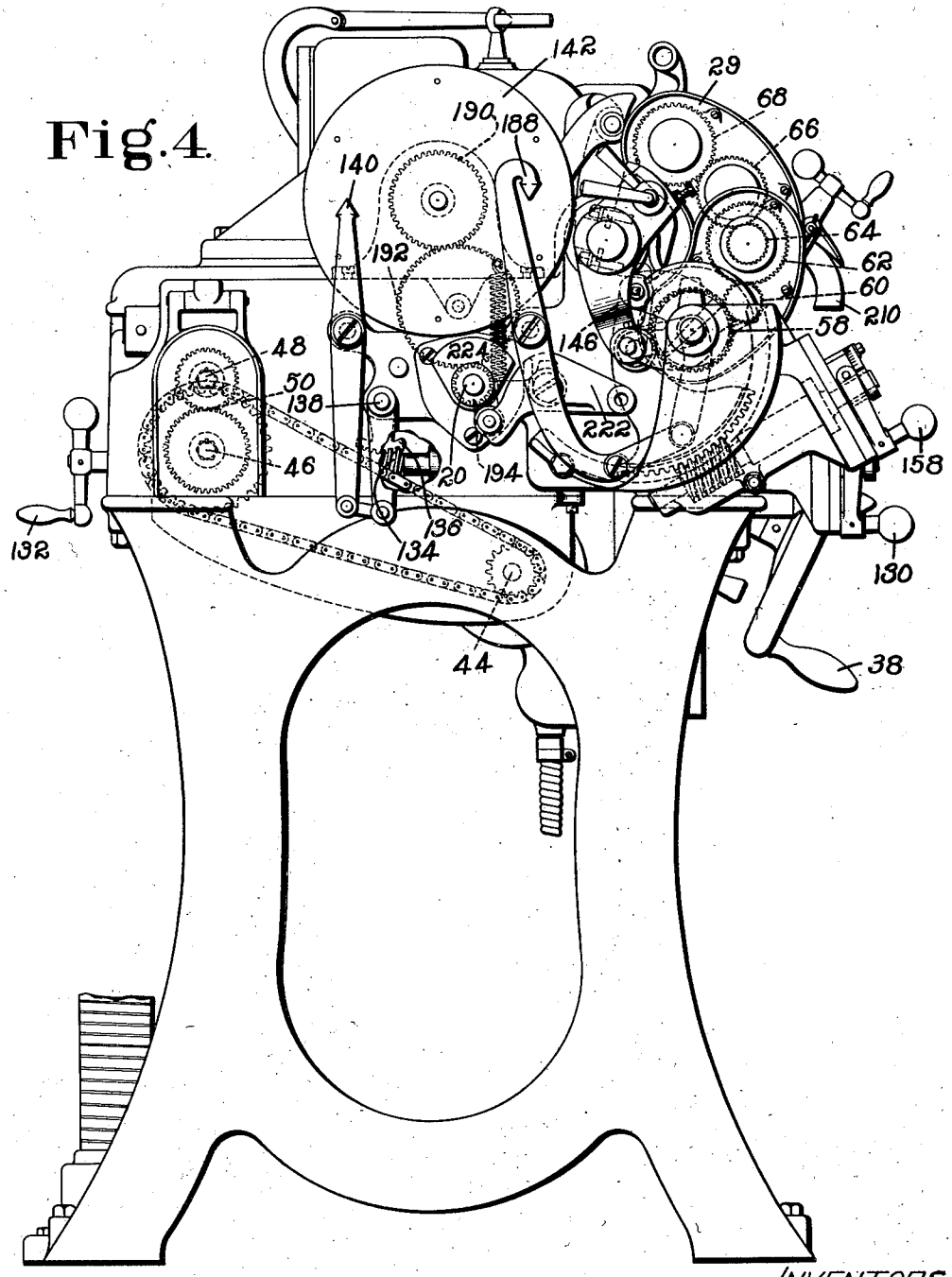
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Fig. 4.



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Fig.5.

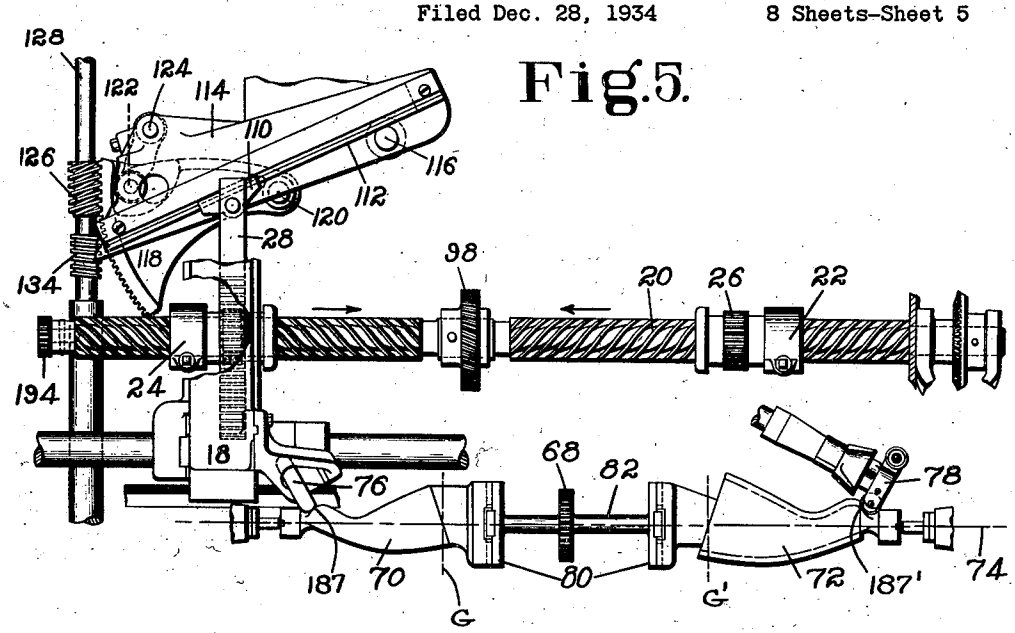


Fig.6.

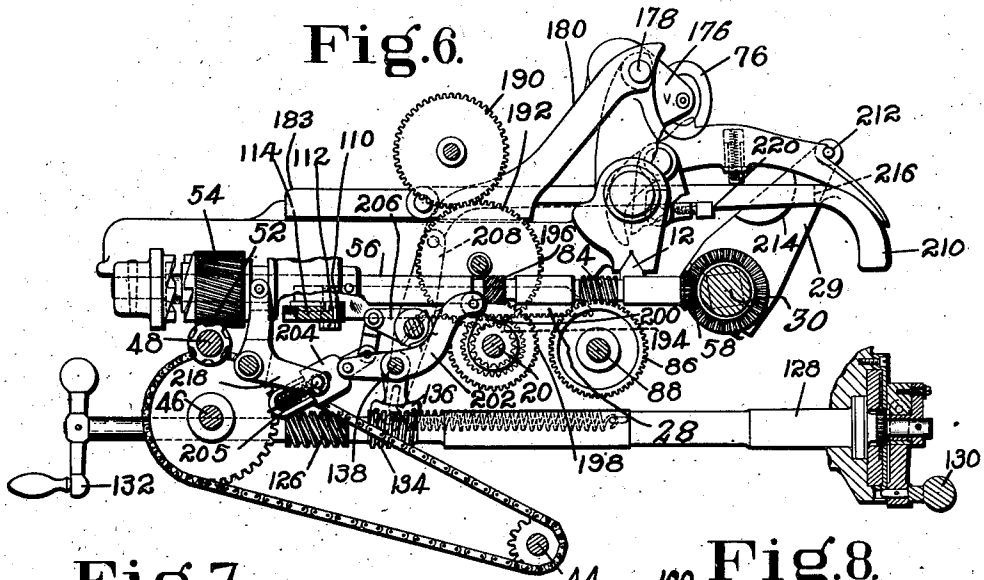


Fig.7.

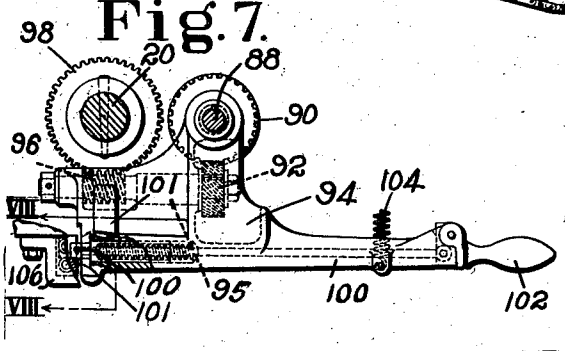
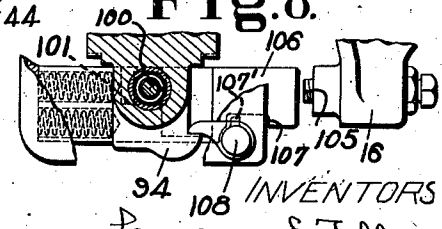


Fig.8.



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Fig.9.

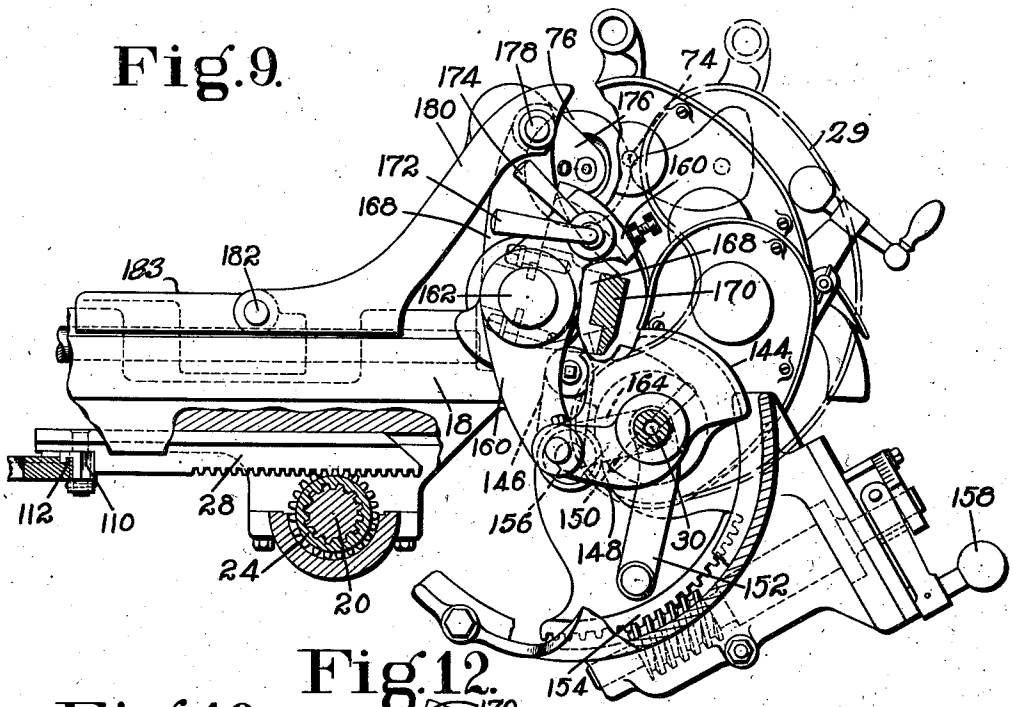


Fig.12.

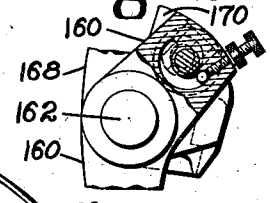
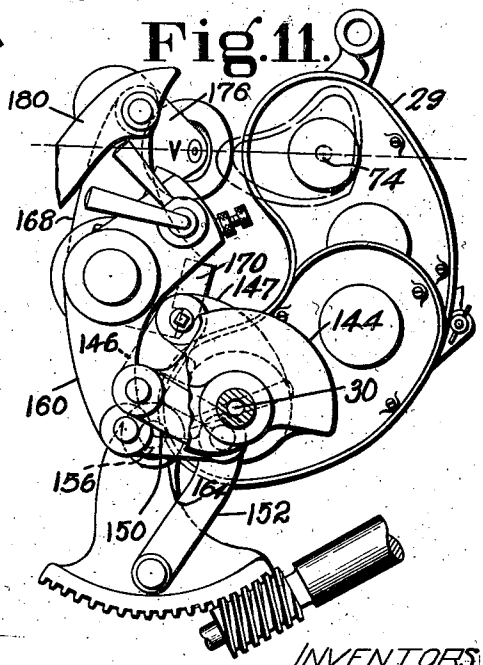


Fig.10.

Fig.11.



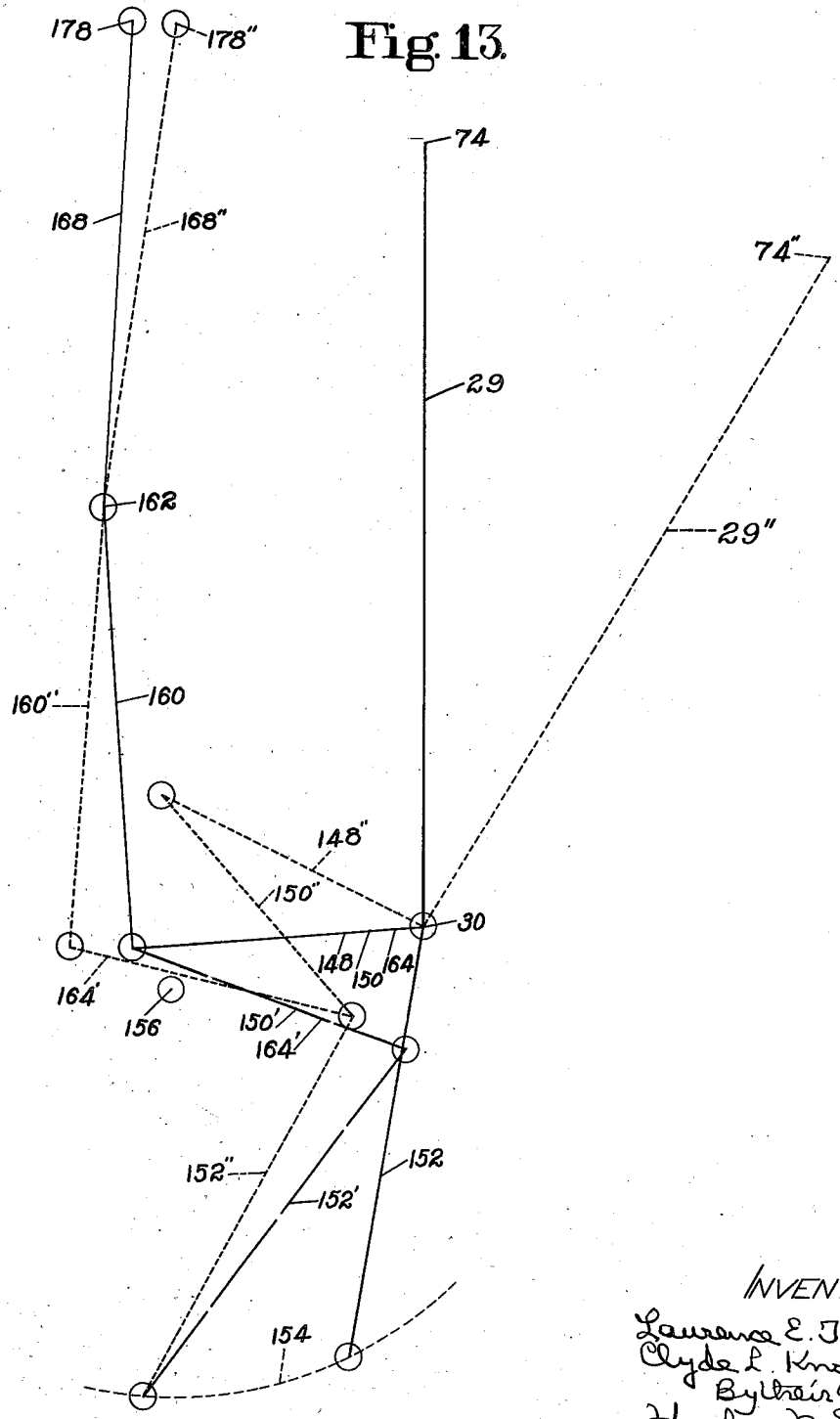
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Fig. 13.



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Fig. 16.

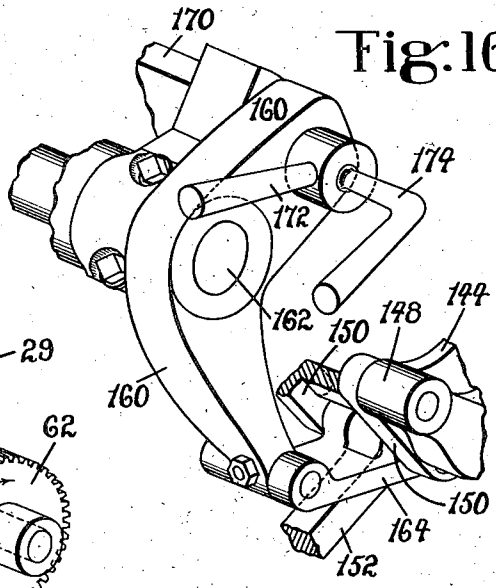


Fig. 15.

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2,072,228

UNITED STATES PATENT OFFICE

2,072,228

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Laurence E. Topham, Wenham, and Clyde L. Knott, Beverly, Mass., assignors to United Shoe Machinery Corporation, Paterson, N. J., a corporation of New Jersey

Application December 28, 1934, Serial No. 759,580

20 Claims. (Cl. 142—15)

This invention relates to copying lathes and is illustrated as embodied in a machine generally of the type shown in United States Letters Patent No. 1,713,792, granted May 21, 1929, upon an application of L. E. Topham.

In the machine shown in this patent the cutter and model wheel carriages are driven in opposite directions by a right- and left-hand threaded feed screw, and the length grading, which involves driving them at different speeds, is effected by providing a third carriage directly driven by one end of the screw and connected to the cutter or model wheel carriage by an ordinary length grading lever. The present invention simplifies and improves the length grading mechanism by driving the grading carriage directly from the feed screw by means of a differential gearing comprising a nut between the screw and the carriage, the nut itself being driven to modify the driving action of the screw. In the illustrated machine, this is effected by a rack which is driven by a slide moving along an angularly adjustable guide rib as the carriage moves along. Preferably the rotation of the nut is in the same direction as that of the screw which relieves the pressure between the screw, nut and carriage, thus avoiding danger of sticking and irregular motion.

The invention also provides an improved transverse or width grading mechanism in which the model wheel, which does the width grading, is mounted on a crank arm instead of a slide, which renders its grading movement less liable to irregularities. In the illustrated machine, a crank arm on the swing frame is connected to the model wheel crank by a chain of links the adjustment of one pivot in which modifies the action of the linkage to effect the desired transverse grade.

The invention is also characterized by a novel relationship between the model wheel, the cutter and the length grading centers of the machine whereby separate foreparts and heel parts may be accurately graded for over-all length irrespective of faulty proportional relations between the model wheel and the cutter. This will be more fully hereinafter explained.

These and other features of the invention comprising certain combinations and arrangements of parts will be apparent from the following description of a preferred embodiment of the invention shown in the drawings, in which

Fig. 1 is a plan view of the machine;

Fig. 2 is a view in front elevation;

Fig. 3 is a view in right-hand elevation;

Fig. 4 is a left-hand view in elevation of the same machine;

Fig. 5 is a detail of the length grading mechanism;

Fig. 6 is a detail of the driving mechanism;

Figs. 7 and 8 are details of the clutch;

Figs. 9, 10 and 11 are details of the width grading mechanism;

Fig. 12 is a detail of the stocking on device;

Fig. 13 is a diagram of the width grading mechanism;

Fig. 14 is a diagram showing the relation of different model wheels to the length grading operation; and

Figs. 15 and 16 are perspective views of the width grading mechanism.

The instant machine is generally similar in its construction to the machine shown in Letters Patent No. 1,713,792, hereinbefore referred to. Reference should be made to this patent for more exhaustive description of certain matters not so fully treated herein. In the following description, reference numerals in parentheses refer to analogous parts in the machine shown in the patent.

The machine has a main frame 10 with longitudinal slideways 12 (12), 14 (16), on which slide a cutter carriage 16 (20), and a model wheel carriage 18 (18). These are driven by right- and left-hand threaded screws 20 (24), constructed as one integral member which turns as shown by the arrow in Fig. 1, and engages nuts 22, 24 mounted in the carriages 16 and 18, respectively. These nuts are provided with gear teeth 26 which engage racks, one of which, 28, is used for length grading purposes, as will be explained, and the other of which (not shown) engages the nut 22 and is used for setting it in order to adjust the machine when it is being built, remaining unaltered in position thereafter. The machine also has a swing frame 29 comprising the square pivot shaft 30 (48) which carries the dog and gearing housings 32 (72), 34 (52), 36 (74). The screw 20 is turnable by hand by means of the handle 38 and gearing 40, in order to traverse the carriages rapidly. The swing frame is pulled toward the model wheel by a spring 41.

The machine is driven by a motor 42 mounted under its left end, and driving a shaft 44 sprocket geared to a shaft 46. The shaft 46 is connected to a shaft 48 by a change gear 50 (Fig. 4). The shaft 48, by means of spiral gearing 52, drives the longitudinally slidable clutch member 54 on the shaft 56 (Fig. 6) which, by bevel gearing 58, 59 at its front end, drives the idler gear 60 (Figs. 4 and 15) which drives the dogs in the swing

frame by the gears 62, 64, 66, 68. The gear 59 is rotatable on the shaft 30. The model 70 and block 72 are mounted to face in opposite directions on the axis 74 in the swing frame, where they are traversed by the model wheel 76 and cutter 78 which both move toward the center of the machine when a block is being cut. The gearings in the boxes 32, 34, 36 are identical and are so designed that the rotation of the swing frame, per se, effects no alteration in the respective orientations of the model and model wheel center, and of the block and cutter center. This is explained in the patent referred to. The face plates 80 are mounted on the ends of a single spindle 82 on the axis 74 (56), thus preventing any discrepancies between the model and work piece due to looseness in the gearing, as explained in the patent referred to. The axes of the model wheel and cutter are placed at an angle of about 30° to the axis of the feed screw 20, as explained in United States Letters Patent No. 1,330,841, granted February 17, 1920, on the application of F. S. Buck, and the cutter head 78 is constructed substantially as shown in that patent.

The feed screw 20 is driven from the shaft 56 as follows. A spiral gear 84 on the shaft 56 (Fig. 6) drives the gear 86 on the shaft 88 which extends to the center of the machine, and there carries a spiral gear 90 (Fig. 7) meshing with a gear 92 in a housing 94 pivoted on the shaft 88. The gear 92 drives a shaft 95 with a spiral gear 96 on its rear end engaging the gear 98 which is pinned to the screw 20. The housing 94 latches, by means of a rod 100, over a slidable but normally fixed ledge 101 to hold the gears 96, 98 in mesh, the latch being operated by the handle 102. The housing 94 is urged upward by the spring 104 toward the position in which the gears 96, 98 are disengaged. As the carriage 16 nears the leftward extremity of its movement, a lug 105 on it (Fig. 8) strikes a sliding bar 106 and urges it to the left in Fig. 8 and toward the observer in Fig. 7. The bar 106 has a cut-out portion forming the ledge 101 and the end of the ledge is thus carried past the latch rod 100 permitting the spring 104 to disconnect the gears 96, 98. In case the operator has his hand on the handle 102 at this time, a lug 107 on the bar 106 strikes a pin 107' on a pawl shaft 108 which positively forces the housing 94 down into inoperative position (Fig. 8).

The gearing is so timed that one revolution of the screw 20 corresponds to one revolution of the model and block in the swing frame.

The length grading device is shown in Fig. 5. The pitch of the left-hand end of the screw 20 is greater than that of the right-hand end, so that the model wheel carriage normally travels faster than the cutter carriage. The machine is designed so that it grades down 6½ sizes under these conditions, the function of the length grader being to grade always up from the normal 6½ sizes down. The grade up is effected by moving the sliding rack 28 which turns the nut 24 counterclockwise as seen from the left end of the machine. In other words, the rack 28 turns the nut 24 in the same direction as that in which the screw 20 turns and relieves the pressure between the carriage 18 and the screw thread, instead of wedging the nut in tighter between them. This avoids sticking and irregular movement which might result from the latter procedure, in the case of grading down with the two screw ends alike.

The rack 28 is pulled toward the back of the machine by a block 110 which slides on an inclined guide 112 as the carriage 18 moves to the left, carrying the rack 28 with it. The guide 112 is mounted on a plate 114 pivoted at 116 on the frame 10 and is angularly adjusted by a segment 118 pivoted at 120 on the frame and linked to the plate 114 at 122, 124. The segment is adjusted by a worm 126 on a shaft 128 operated by handles 130, 132. When the guide 112 is parallel to the axis of the screw 20, the rack 28 does not operate and the grade is 4½ sizes down. When the guide 112 is swung to its extreme angular position (Fig. 5), corresponding to the smallest model wheel provided, the grade is 6 sizes up, the rack 28 then actually effecting a grade of 10½ sizes. A second worm 134 on the shaft 128 operates a small segment 136 on a shaft 138, which carries a pointer 140, the end of which can be read against a chart on a revolving chart plate 142, in case it be desired to effect continuous control of the grading factor as explained in the Topham patent referred to.

The width grading mechanism is shown in Figs. 9 to 11, and is diagrammatically shown in Fig. 13. The end of the shaft 30 is rounded to turn in its bearing 143 and carries a housing 144 rotatably mounted on it. Ordinarily this housing is held rigid with the shaft 30 by a link 146 extending between an arm 147 on the shaft and an arm 147½ on the housing. The housing 144 has another arm 148, which, together with the swing frame 29 and the link 146, forms a rigid bell crank. The end of the arm 148 is connected by a link 150 to the end of a link 152, the other end of which is pivoted to a segment 154, pivoted at 156 on the frame 10. This segment is angularly adjustable by the width grading handle 158. The junction of the links 150, 152 is connected to an arm 160 on a shaft 162 by a link 164. The links 150 and 164 and the arm 148 are of the same length. In Fig. 9 the axis 74 of the swing frame dogs, i. e., the turning axis of the model and block, is shown in alinement with the face of the model wheel 76. This is called the neutral position of the swing frame and of the model wheel. With this position, if the model grading handle 158 is set to zero, the design is such that the upper end of the link 152 is in line with the axis of the shaft 30 and the links 150 and 164 lie exactly behind the arm 148, the ends of the arms 148 and 160 being in line. The model wheel 76 is carried on an arm 168 which, with the arm 160, normally forms a rigid lever, as will be seen, and which is normally rotatively rigid with the shaft 162 when the machine is running, and the width grading is done by the movement of the shaft 162 and arm 168.

The swing frame being in the neutral position, as above stated, the crank arm 148 and its connection to the link 150 are fixed in position. The other end of the link 150 is connected by the link 164 to the arm 160. The links 150 and 164 being equal in length to the crank arm 148, the junction of the link 164 and the crank arm 160 will be coaxial with the end of the crank arm 148 and any adjustment of the handle 158 and segment 154 will merely swing the junction of the links 150 and 164 up and down without moving the arm 160, so that adjustment of the width grader when the swing frame is in neutral position affects nothing else in the machine.

When the width grader is set at zero, the junction of the links 150 and 164 is permanently coaxial with the shaft 30, and movement of the swing frame merely rocks these links around the axis of the shaft 30, the junction of the link 164 to the arm 160 remaining fixed. It should be

borne in mind that it is the movement of the junction between the links 152 and 164 which causes movement of the arm 160 through the link 164. If this junction is coaxial with the axis 30, the arm 160 is held motionless at all times; but when the segment 154 is set elsewhere than in zero position, rocking the swing frame rocks the upper end of the link 152 (dotted lines, Fig. 13) which causes a rocking of the shaft 162 and consequent grading movement of the model wheel 76.

This will be clearer from an inspection of Fig. 13, which is a diagram. The full line 74—30 represents the swing frame 29 in neutral position. The arm 148 and links 150, 164 are shown by a single full line, and the full line 152 shows the link 152 when the grader is set neutral. The dash line 152' shows the link set to grade up 6 sizes, and the dash line marked 150, 164 shows these links under these circumstances, the swing frame and arm 160 being in neutral position. The dotted line 30—74'' shows the swing frame swung out, and the other dotted lines marked with double primed numerals show the parts in the positions they then take. The distance 176—176'' corresponds to the grading movement of the model wheel, though not exactly equal to it.

Figs. 15 and 16 show the width grading mechanism in perspective. There are actually two arms 148 on the housing 144, and the link 150 is formed as a yoke at its ends to cooperate with the two arms 148 and to embrace the end of the link 164 which is also split at both ends to embrace the end of the link 152 and the end of the arm 160. The housing 144 is pivoted at its outer end in a frame bearing 30' in line with the axis of the shaft 30, as well as on the shaft 30 itself, as stated. Thus the entire construction is balanced against twisting stresses.

The connection of the model wheel 76 to the shaft 162 is effected as follows. The shaft 162 is really rotatably mounted in the arm 160 and carries a square-edged bar 170 rigidly fastened, and parallel, to itself. The left end of the bar 170 is connected to the arm 160 by an eccentric 172 and clamp 174, so that the bar 170 and shaft 162 can be rotatably adjusted relatively to the arm 160. The model wheel 76 is hung in a casting 176 which is mounted on an arm 180 pivoted at 182 to a slide 183 running along the top of the model wheel carriage 18, and the casting 176 is also pivoted at 178 in the member 168 which is arranged to slide along the square-edged bar 170 as a guide. The adjustment of the bar 170 on the arm 160 thus carries the arm 168 with the bar 170. The member 168 is mounted on the shaft 162 and bar 170 between two lugs forming a yoke 186 (Fig. 1) which are integral with the model wheel carriage 18, and is thus slid along the shaft 162 and bar 170 by the movement of that carriage. When the arm 160 is rocked the bar 170 and member 168 are rocked with it and the model wheel 76 is given a movement which is nearly horizontal owing to the connection 180, and this movement of the model wheel effects the width grade. The design is such that the grading movement keeps the model wheel center substantially in a line joining its neutral grading position with the axis 74 of the model. The advantage of this structure is discussed in the above-mentioned Patent No. 1,713,792. The purpose of the adjustment at 172, 174 is to adjust the model wheel face to a position in front of its neutral position. Such adjustment makes the cutter cut that much too high all around the block, which operation is called "stocking on" or "wooding up." This operation is not the same thing as pantographic width grading because the amount added is the same everywhere. It might be called arithmetical as distinguished from the ordinary pantographic width grading, and it is commonly provided for in machines of this character.

Fig. 9 shows the parts as they are when the width grader is set at the zero or neutral position (see also Fig. 13, full lines). Fig. 10 shows the situation when the swing frame is in neutral position and the width grading mechanism has been set to grade up (see also Fig. 13, full lines 29, 148, and dash lines 150', 164'). The link 152 has thus been displaced to the left and the right ends of the coincident links 150, 164 have been dropped off from the axis 30. Fig. 11 shows the parts as the swing frame is swung out from its neutral position, the grader being still set to grade up. The left end of the link 150 is raised by the arm 148, pulling the link 152 to the left. This pushes the link 164 to the left and pushes the arm 160 to the left, moving the model wheel to the right (dotted lines in Fig. 13).

In order to effect perfect grading the ratio of the cutter thickness to that of the model wheel should be the length grading factor and the ratio of their diameters should equal the width grading factor. To this end I have provided eight interchangeable assemblies 176—76, the model wheels in which have various diameters and thicknesses to correspond with various grading problems. The different castings 176 are so designed that they all hold the front faces of their model wheels in the same positions, so that an interchange does not change the adjustment of the machine.

The design of the assemblies 176—76 is peculiar in another respect. In prior attempts to cut last foreparts and heel parts separately the length grading has given considerable trouble. The instant machine has been so constructed that the pivot between the rack 28 and the slide block 110 travels in a line which passes through the pivot 116, so that when the carriage 18 has traveled so far to the right (Fig. 5) that these two pivots are collinear, adjustment of the length grading segment 118 will cause no movement of the rack 28 and nut 24. With the parts in this position, the leading edge 187 of the model wheel will come into the line G (Fig. 5) and the corresponding point 187' of the cutter will come into the line G', each of which locations is called the length grading center for that side of the machine. These lines correspond to the location of the hinge pin, for example, or some other point in the joint end of the last part having a predetermined geometrical relation to the last part surface, and the movements of the points 187, 187' up over the toe ends of the model and block and thence to the lines G, G' represent exactly the model length and the graded last part length, respectively. If the machine were so built that the front points of the model wheel and cutter come simultaneously to the lines G, G' the length of the block would be cut wrong by the graded value of the error in the radius of the circular front face of the model wheel, because the model wheel travels that far in coming up over the end of the model. The set of model wheels provided are dimensioned for accurate grading at intervals of 1½ sizes, and each wheel is used to grade ½ size up and down from the size for which it is dimensioned, so that in grading a complete line of last parts or lasts, the width grading is a little wrong in two-thirds of the cases, but the over-all lengths, the dimension in which discrepancies are most strongly ob-

jected to, will all be correct owing to the above-described arrangement.

This is illustrated in Fig. 14, which shows two wheels 76A and 76B representing the extreme members of the line of wheels provided. These wheels are both shown in neutral position with their front faces on the axis 74 of the model, and with their leading points 187A and 187B on the length grading center line G.

The grading mechanisms of the illustrated machine have been constructed to effect geometric grading, in accordance with the method described in United States Letters Patent No. 1,948,547, granted February 27, 1934, upon an application of L. E. Topham. The handle 130 (Fig. 6), for example, is set into any one of three holes in the dial plate over which it turns, and the dimensions of the parts shown in Figs. 5 and 9 to 11 are so designed that movement of the handle from one hole to the next effects a ½ size change on a grade of about 3% per size.

A pivoted width grade indicator 183 is linked to the segment 154, and reads on the chart plate 182. This chart plate is rotated by gears 190, 192, 194, the latter of which is on the end of the screw shaft 20.

An automatic stop (Fig. 6) has also been provided to stop the rotation of the model and block at the same place in their cycle. See Fig. 6. A gear 196 on the shaft 56 operates a gear 198 which is loosely mounted on the screw shaft 20. This gear 198 is integral with a cam 200 which has a hump in it arranged to rock a lever 202 pivoted on the shaft 138. The rear end of the lever is pivoted to a slotted bar 204 which carries a spring-pressed pivot pin 205 in its slot. The front end of the bar 204 is linked to an arm 206 on a spring-pulled lever 208 connected to a handle 210.

When the operator desires to stop the machine he pulls the swing frame out until it latches at 212. A lug 214 on the frame then engages a lug 216 on the handle 210 and pulls it out to a position somewhat short of that shown in Fig. 6. This tilts the member 204 into such a position that the next time the cam hump 200 passes under the end of the lever 202, the member 204 will be given a further movement counterclockwise and will operate the bell-crank lever 218, which is connected to the pin 205, to disconnect the clutch 54. This will always take place at the same point of the rotation cycle of the model and block. In case the operator desires to stop them where they are at any instant, he pulls the handle 210 way out to the Fig. 6 position, so that it latches at 220, and this movement alone throws the member 204 sufficiently to disconnect the clutch.

As explained in the first Topham patent above mentioned, it is sometimes desirable to impose an entirely arbitrary width grading cycle on the work as, for example, when holding the bottom unchanged in grading the AA and AAA widths. This is accomplished (Fig. 4) in the instant machine by disconnecting the link 146 between the swing frame and the housing 144 and connecting it between the housing 144 and the end of a lever 222, the other end of which runs on a suitably shaped cam 224 on the end of the screw 20. The cam 224 then controls the movement of the arm 160 and the width grading cycle.

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

1. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and driving mechanism for effecting relative traversing movements between them in pairs, said driving mechanism comprising a differential gear device, one member of said device determining the relative traversing movement of one said pair, and the other member of said device determining the relative traversing movement of the other said pair.

2. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and driving mechanism for effecting relative traversing movements between them in pairs, said driving mechanism comprising a screw associated with each carrier, a nut mounted on each screw and rotationally but not translationally mounted in the carrier, and means for effecting relative rotations at different speeds between the nuts and their screws.

3. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and driving mechanism for effecting relative traversing movements between them in pairs, said driving mechanism comprising a screw associated with each carrier, a nut mounted on each screw and rotationally but not translationally mounted in the carrier, means for normally effecting relative rotations at the same angular velocities between the nuts and their respective screws, and means for effecting a differential relative rotation between the nuts and their respective screws to render the said angular velocities unequal.

4. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, driving mechanism for effecting relative traversing movements between them in pairs, said driving mechanism comprising a screw, a nut associated with each of the carriers and mounted on the screw, and means for continuously rotating the screw and one of the nuts.

5. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, driving mechanism for effecting relative traversing movements between them in pairs, said driving mechanism comprising a main driving gear member, and a differential gear member operatively located between the main driving gear member and one of the carriers.

6. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, driving mechanism for effecting relative traversing movements between them in pairs, said driving mechanism comprising a rotating screw, a nut operatively located between the screw and one of the carriers, and means for differentially rotating the nut during the rotation of the screw.

7. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, driving mechanism for effecting relative traversing movements between them in pairs, said driving mechanism comprising a rotating screw, a nut operatively located between the screw and one of the carriers, and means for rotating the nut during the rotation of the screw, said means being controlled by the movement of the nut along the rotating screw.

8. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, driving mechanism for effecting relative traversing movements between them in pairs, said driving mechanism comprising a rotating screw, a nut operatively located between the screw and one of the carriers, and means for rotating the nut during the rotation of the screw, said means comprising an angularly adjustable slide, a rack

progressively movable by the slide as the nut is moved along the screw, and pinion teeth on the nut engaging the rack.

9. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and driving mechanism for effecting relative traversing movements between them in pairs comprising a rotating screw having threads of different leads on its ends, and two nuts mounted one on each end of the screw, and having driving relation with the carriers, respectively, whereby one carrier is normally driven faster than the other.

10. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and driving mechanism for effecting relative traversing movements between them in pairs comprising a rotating screw having threads of different leads on its ends, two nuts mounted one on each end of the screw and having driving relation with the carriers, respectively, whereby one carrier is normally driven faster than the other, one of said nuts having a toothed periphery, and a rack driven by the movement of that nut along the screw for turning the nut as the nut moves along the screw.

11. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and driving mechanism for effecting relative traversing movements between them in pairs comprising a rotating screw having threads of two different leads on its ends, two nuts mounted one on each end of the screw and having driving relation with the carriers, respectively, whereby one carrier is normally driven faster than the other, one of said nuts having a toothed periphery, and a rack driven by the movement of that nut along the screw for turning the nut as the nut moves along the screw, said turning movement of the nut being in the same direction as the turning movement of the screw, whereby pressure between the nut and the screw, on one side, and the carrier with which the nut is associated, on the other side, is relieved.

12. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and driving mechanism for effecting relative traversing movements between them in pairs comprising a rotating screw having threads of different leads on its ends, two nuts mounted one on each end of the screw and having driving relation with the carriers, respectively, whereby one carrier is normally driven faster than the other, one of said nuts having a toothed periphery, a rack driven by the movement of that nut along the screw for turning the nut as the nut moves along the screw, an angularly adjustable segment, a slideway mounted on the segment, and a slide block on the slideway for actuating the rack when the slideway is oblique to the axis of the screw.

13. In a copying lathe, a carrier for a model wheel, a carrier for a cutter, a model holder and a work holder, a screw for driving the carriers, a nut mounted in each carrier to be driven by the screw, one of said nuts being rotative in its carrier to effect length grading, a member for progressively turning the nut, an angularly adjustable slideway, and a slide block thereon pivoted to the member for driving the member, the pivot of the slideway being in the line of movement of the pivot in the slide block whereby when the pivots are alined adjustment of the slideway causes no movement of the said member, the model wheel holder being shaped to bring the following lateral face of the model wheel to the length grading center of the machine when the two said pivots are in alinement, irrespective of the dimensions of that particular model wheel.

14. In a copying lathe, a pivoted model holder, a model wheel carrier pivoted to swing toward and from a model in the model holder in order to effect transverse grading movements, and a transverse grading linkage connecting the holder and the carrier, arranged to effect grading movements of the model wheel in response to movements of the pivoted model holder.

15. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and a transverse grading mechanism comprising a bell crank one arm of which carries one of the holders, a second bell crank one arm of which carries the corresponding carrier, and two links, each extending from the other arms of the bell cranks to the same intermediate point.

16. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and a transverse grading mechanism comprising a bell crank one arm of which carries one of the holders, a second bell crank one arm of which carries the corresponding carrier, two links, each extending from the other arms of the bell cranks to the same intermediate point, and a third link pivoted at one end at the intermediate point and at its other end pivoted at a normally fixed but adjustable point.

17. In a copying lathe, a work holder, a model holder, a tool carrier and a model wheel carrier, and a transverse grading mechanism comprising a bell crank one arm of which carries one of the holders, a second bell crank one arm of which carries the corresponding carrier, two links, each extending from the other arms of the bell cranks to the same intermediate point, and a third link pivoted at one end at the intermediate point and at its other end pivoted at a normally fixed but adjustable point, the two first-mentioned links being of the same effective length, and the third link being of such length that when its adjustable end is in neutral transverse grading position the said intermediate point is on the axis of the first-named bell crank, any adjustment of the third link carrying the intermediate point away from the axis of the first-named bell crank.

18. In a copying lathe, a model wheel carrying mechanism comprising a bell crank, a member mounted on the axis of the bell crank and rotatively adjustable about this axis, and a block mounted on the member and carrying the model wheel whereby the model wheel may be predeterminedly set out of its normal 1:1 grading position toward a model in order to add a layer of uniform thickness to a work piece.

19. In a copying lathe, a carrier arranged to traverse a rotating model from end to end, a slideway adjustable toward and from the model, a slide block on the slideway carrying a model wheel in contact with the model and arranged to be driven along the slideway by the carrier, and a grading mechanism for oscillating the slideway toward and from the model as the rotation of the model effects relative movements of approach and separation between the model wheel and model.

20. In a copying lathe, a crank arm carrying a rotating model, a carrier arranged to move a model wheel from end to end of the model, a crank arm carrying a slideway, a slide block on the slideway, a model wheel carrying block pivoted to the slide block, said model wheel car-

rying block having an arm, a guideway on which the outer end of the arm moves as the second-named crank arm swings, and a transverse grading mechanism between the two crank arms for swinging the second-named crank arm in response to the encounter of varying radii of the model with the model wheel, whereby the center of the model wheel is kept substantially on a line joining its neutral position and the axis of the model.

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