

May 31, 1932.

G. F. RYAN

1,860,723

PATTERN COPYING MACHINE

Filed April 24, 1931

5 Sheets-Sheet 1

Fig. 1.

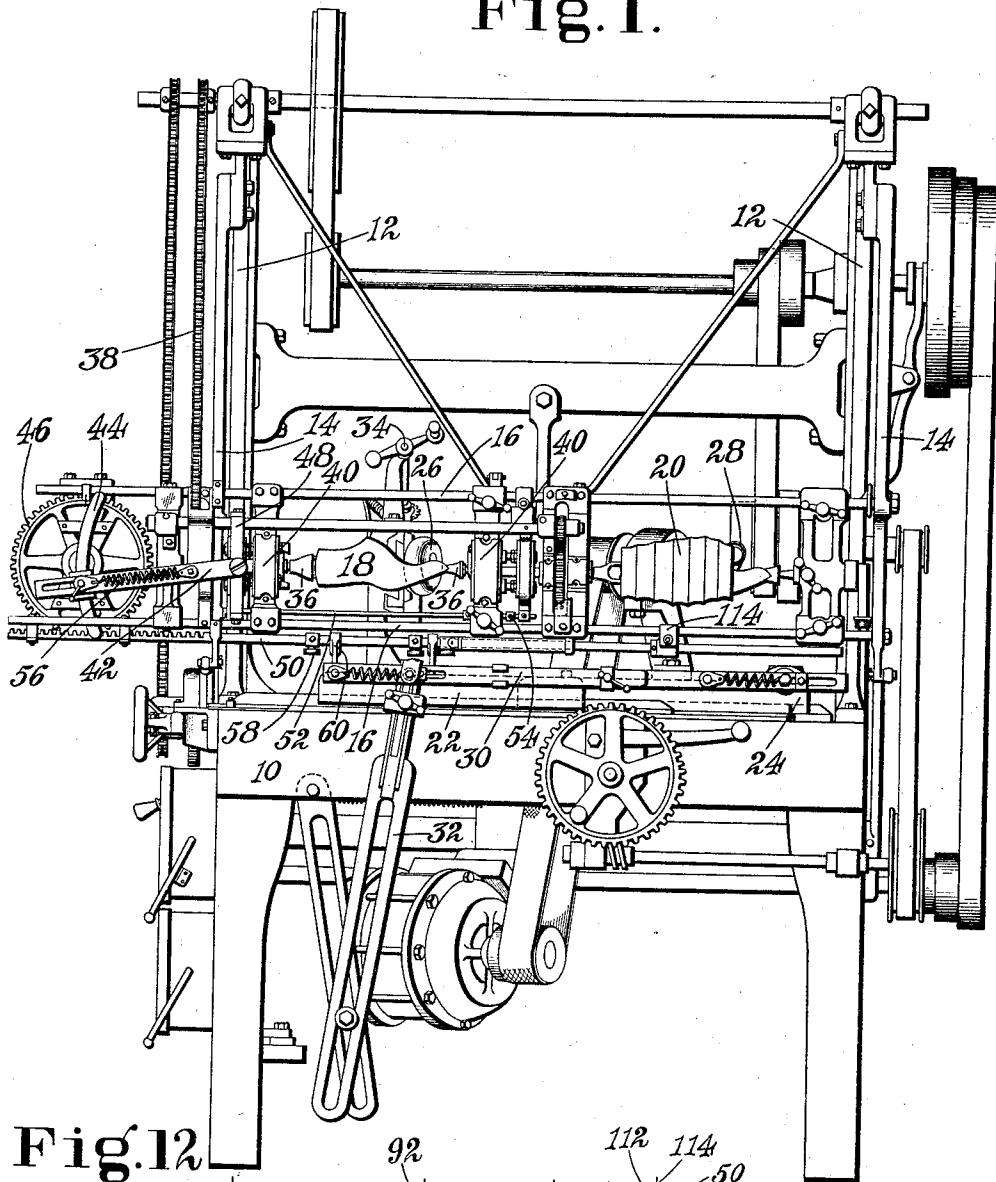


Fig. 12

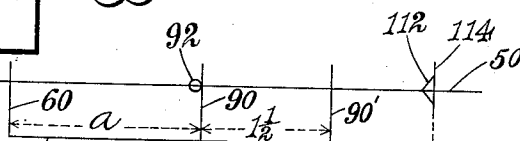
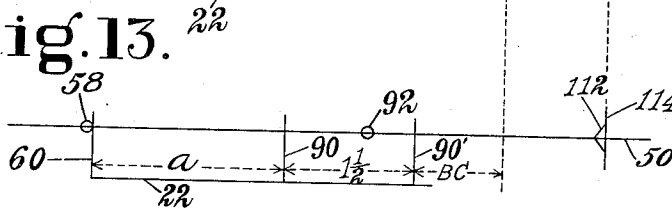


Fig. 13.



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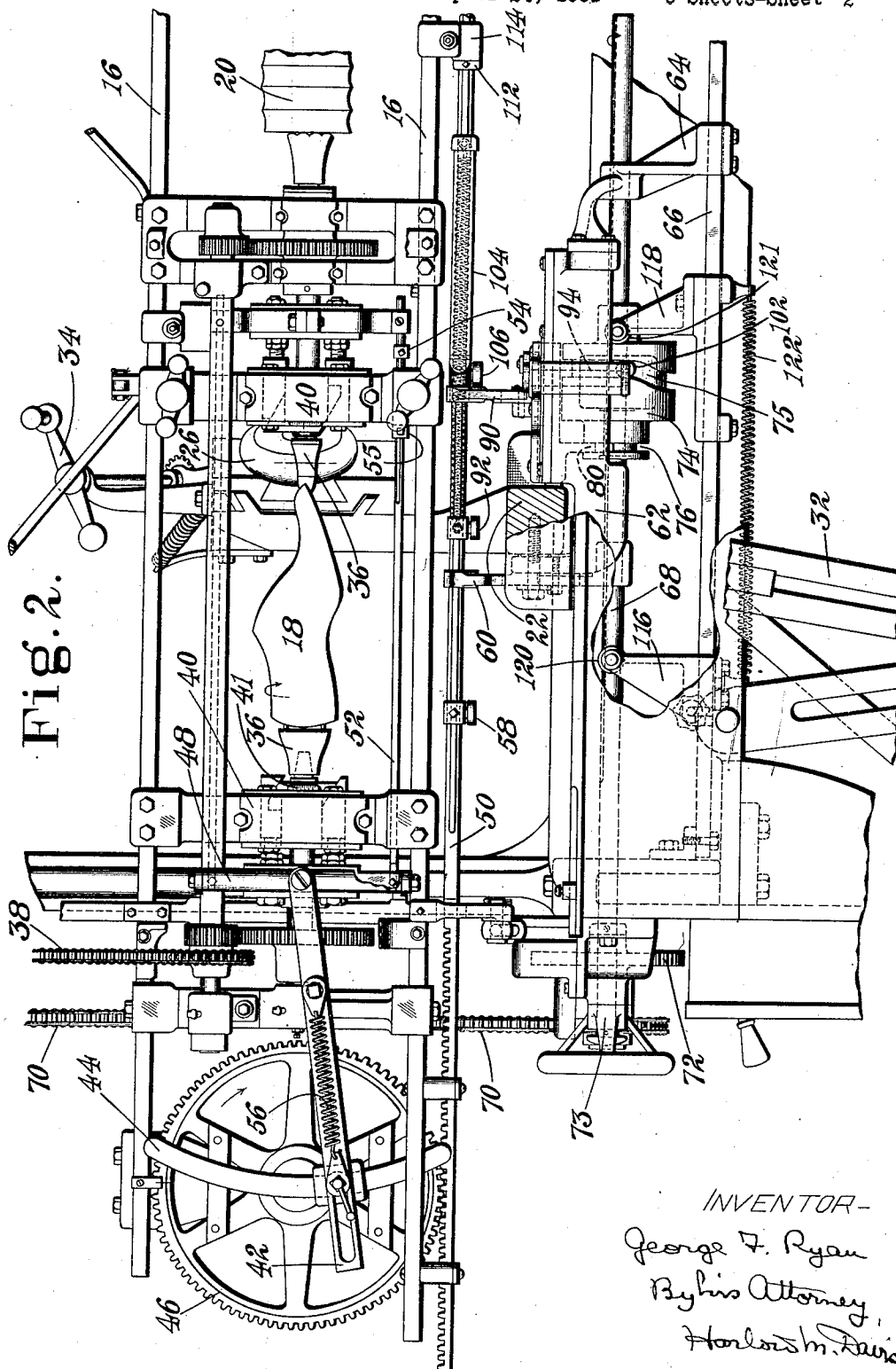
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Fig. 3.

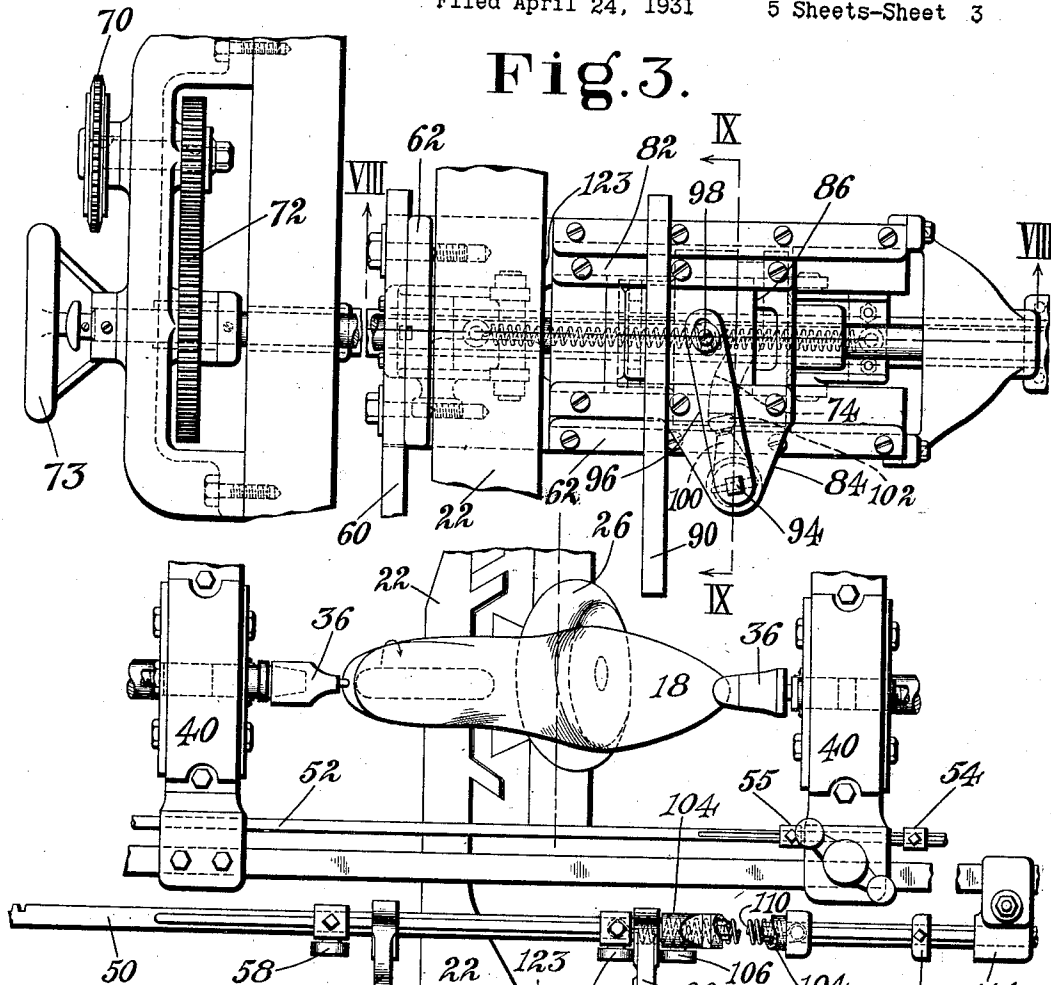


Fig. 4.

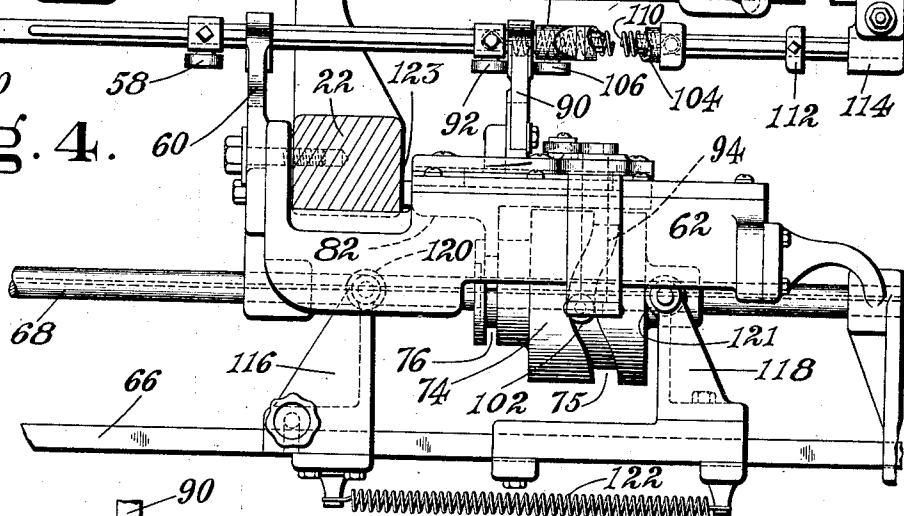
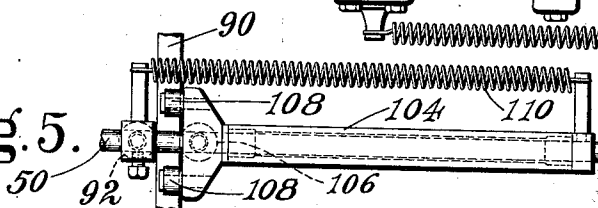


Fig. 5.



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5 Sheets-Sheet 4

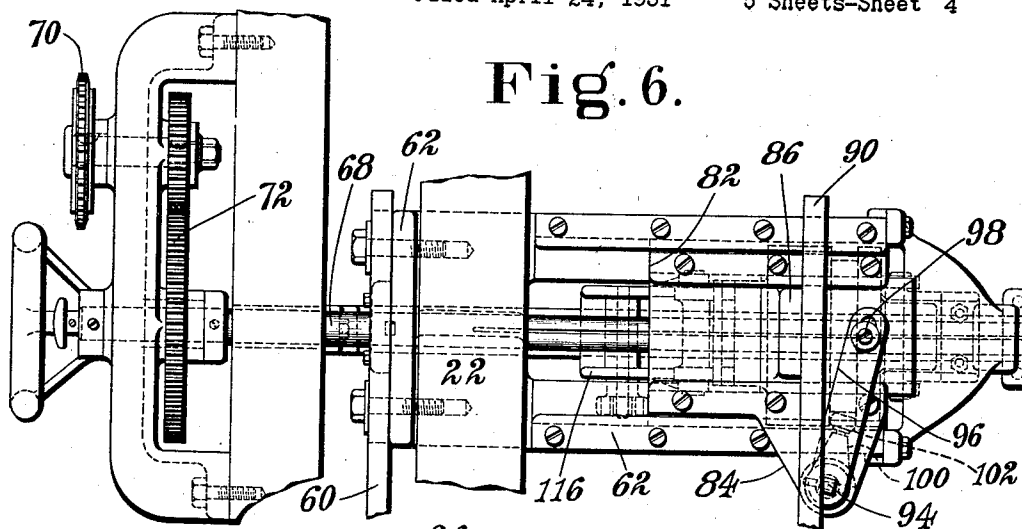


Fig. 6.

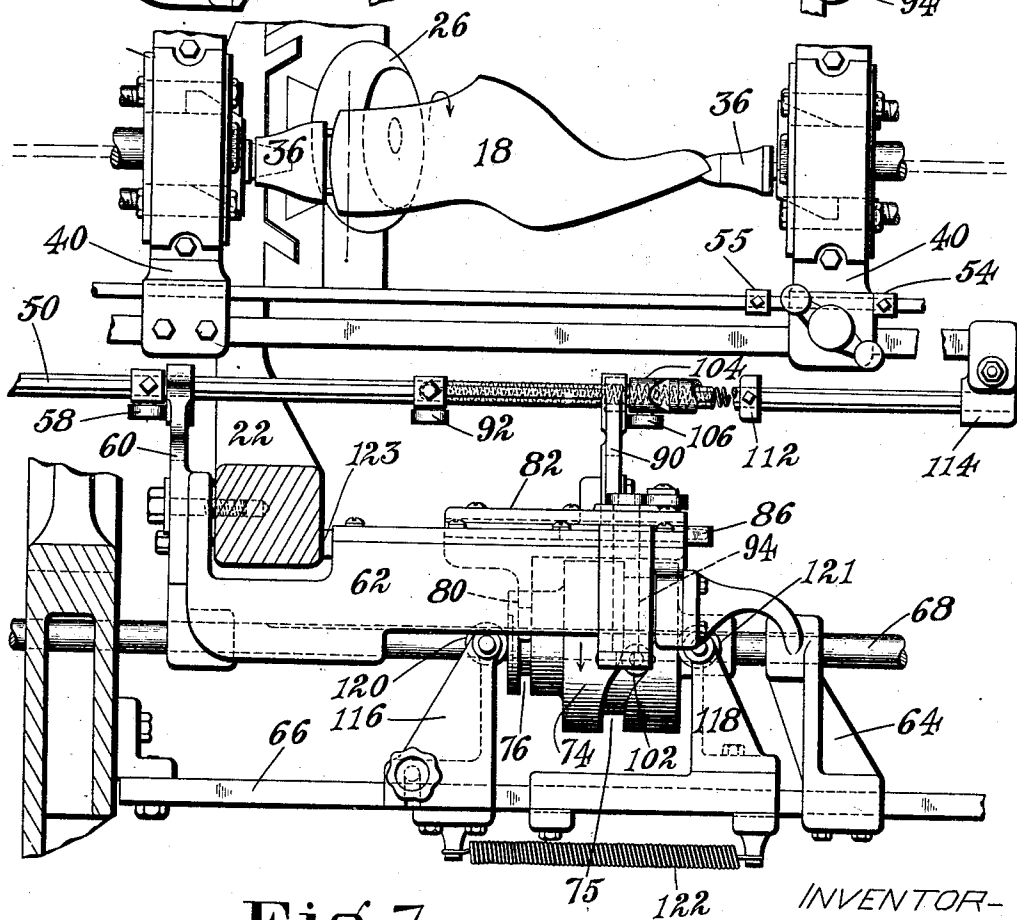


Fig. 7.

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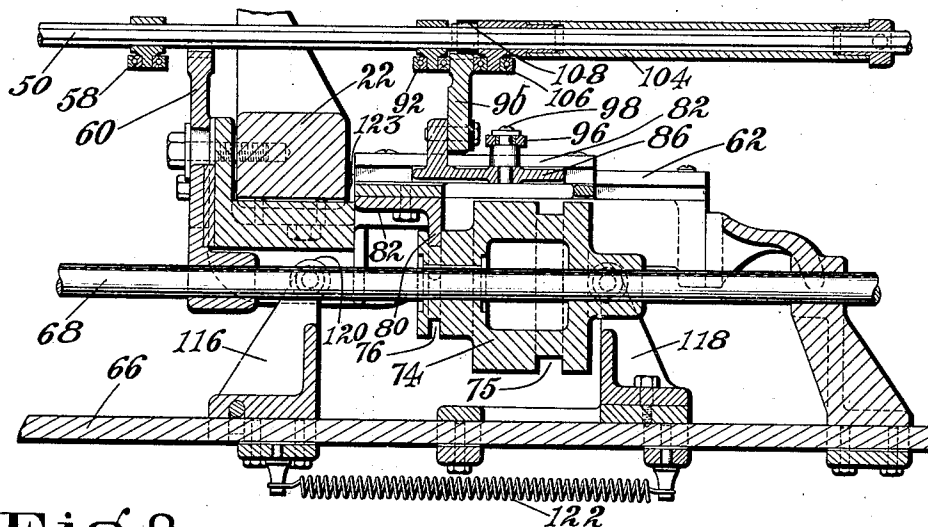


Fig. 8.

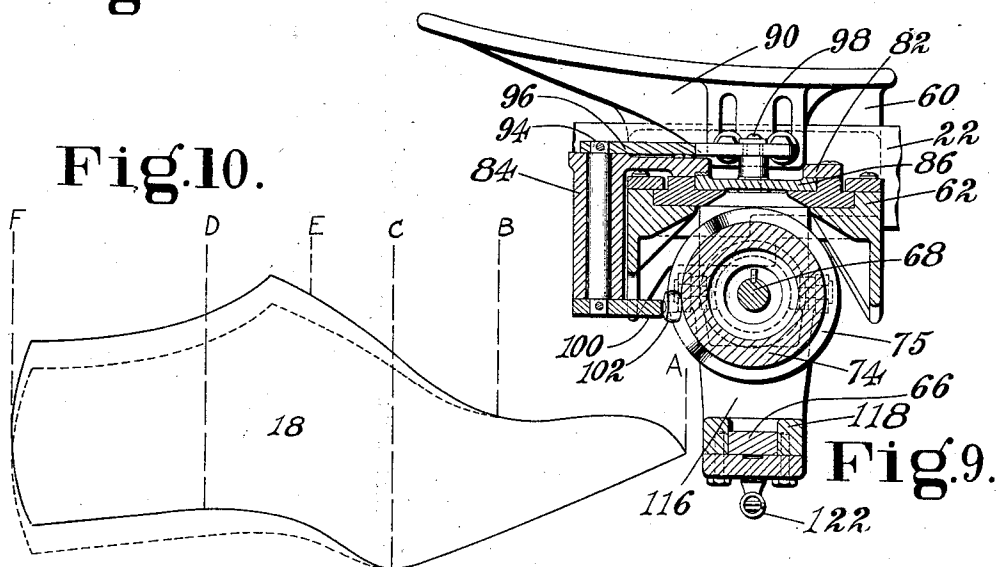


Fig. 9.

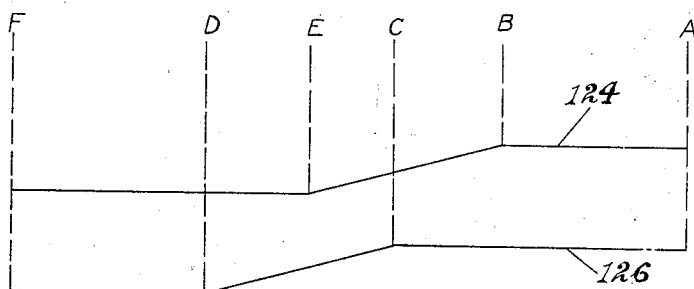


Fig. 11.

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UNITED STATES PATENT OFFICE

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PATTERN COPYING MACHINE

Application filed April 24, 1931. Serial No. 532,566.

This invention relates to pattern copying, and especially to the reproduction of solid objects. The machine illustrated, which embodies the machine aspect of the invention, and by which the method of the invention may be practiced, is a last lathe of the type shown in United States Letters Patent No. 1,733,207, granted October 29, 1929, on the application of Elmer H. Burke and myself.

The action of the ordinary width grader in the last lathe, in cutting a last wider than the model, drops the ball portion of the last, especially in the case of women's lasts, farther from the axis of rotation than it does the heel, so that the bottom becomes longitudinally more convex downward as the last produced grows "wider". This causes the toe to be unduly elevated when the last is set on its appropriate heel on the floor, and causes a prejudicial difference in appearance between lasts of varying widths and sizes cut from the same model, which is ordinarily called a "variation in toe spring".

This difficulty was at first dealt with by cutting opposed slots in the regularly graded last and wedging one slot until the opposite one closed, thus actually bending the last into the desired shape, and forming a corrected model of that size and width. This, called "hand breaking", was a very expensive, skilled operation, and its results were not uniform and were not easily reproducible with accuracy if the original work became lost. The problem has in later years been successfully dealt with mechanically by providing the ordinary last lathe with a dog shifting mechanism, one form of which is shown in the patent referred to, which displaces the model (or work piece) heightwise of itself as the cutting proceeds along its length, thus reproducing each lamina, or differential element of the model, which is dealt with in one revolution, in a slightly displaced position relatively to its neighbors, in the block. Thus the last is automatically bent, or its toe spring corrected, while being cut.

In the first machines (such as the one above mentioned) which were built to produce lasts in this way the model laminae which were shifted in reproduction were all parallel, and

were all perpendicular to the axis of rotation of the model. A substantial improvement over this procedure was brought about by the invention described and claimed in my application Serial No. 372,315, filed June 20, 1929. According to this invention the planes of the laminae which are moved relatively to each other in reproduction, are progressively tilted, from one part of the last to another, so that, at the ball, waist and instep, they practically coincide with the planes in which the ball, waist and instep girth measurements are taken. These planes are oblique, and differently oblique, to the axes of rotation of the model and block, and one advantage of this invention is that these measurements are taken around complete laminae, respectively, instead of embracing several laminae the relative displacement of which causes these measurements to vary from the standard in use.

The object of the present invention is to provide a simpler method of effecting the correction of the toe spring difficulty which will secure many of the advantages of the invention just discussed and to provide a considerably simpler machine by which it may be practiced. This is accomplished, in cutting from the toe to the heel of a last, by beginning the drop of the top profile of the last, hereinafter called the "top drop", at a point considerably in advance of the point at which the drop of the bottom profile, or "bottom drop", is begun. The latter advantageously begins at the bottom of the ball, and the former at a point about an inch ahead of this, at the point where the top of the last begins to curve upwardly and backwardly into the instep. Thus the points at the top and bottom of the last in the upwardly and forwardly sloping plane of an above-mentioned girth measurement will have been dropped by substantially equal amounts and the girth measurement will be substantially the same as in the uncorrected last. The drop ceases on the top of the last correspondingly earlier than on the bottom so that when the whole dropping operation is over (at the heel breast portion) the heel will be reproduced in the regular way.

The reproduction during the dropping op-

eration is not pantographic as regards the individual differential elements or laminae, as it has been in machines heretofore used. These laminae, all perpendicular to the axis of rotation, are flattened more and more at the top, from the beginning of the correction, to the ball, their bottoms remaining normal; from this point to the place where the top drop ceases, the accumulated distortion is preserved and the distorted laminae are dropped the same amount at the top and bottom. From this point to the heel breast portion the laminae are gradually restored to normal shape by dropping at the bottom, and progressively taking out the distortion that has been built up between the beginning of the corrective operation and the reproduction of the ball.

As above explained, an important aspect of the method of the present invention consists in reproducing a model, lamina by lamina, and progressively distorting corresponding (that is, similarly situated) portions of a selected series of laminae. The distortion, as illustrated, consists in progressive displacement of corresponding parts, only, of the peripheries of the laminae of the selected series.

The method also comprises following the procedure just described by the preservation, during the reproduction of a succeeding series of laminae, of the distortion already accumulated, while progressively displacing such laminae, each on the preceding, in the same direction as before, this procedure being preferably followed by the progressive displacement of parts only of the peripheries of a succeeding series of laminae, these parts lying on the opposite side of the work from the parts first mentioned, whereby the distortion accumulated is progressively removed.

This method effects a progressive shift in the position of a part of the profile-lines on opposite sides of a work piece, such shift beginning and ending earlier on one side than on the other.

The above-described method may be practiced by the machine illustrated herein, which embodies the machine aspects of the invention. This machine is provided with a mechanism for automatically shifting the model holding and rotating dogs, which mechanism may take various forms, and as illustrated is like the mechanism shown in the patent above referred to. This dog shifting mechanism is, in the illustrated machine, operated, as in the patent, by a rod or bar mounted in the swing frame and pushed by one of the carriages as it moves along from one end of the model (or block) to the other. In accordance with the present invention this bar, instead of being moved steadily after it is picked up by the carriage at the desired point (generally the ball portion of the last),

is picked up by an oscillating member on the carriage, which is arranged to reach its most advanced position as the top of the model passes over the model wheel, and its most retracted position as the bottom of the model passes over the model wheel. This oscillating member as it is carried along, causes a progressive shift of the dogs heightwise of the model when the top of the last is being cut, returning them to normal position as the bottom is cut, until the carriage has moved so far that the full retraction of the oscillating member will not return the dogs to normal position, and from then on, a progressive shift of the dogs is effected at the cutting of both top and bottom, but the accumulation of "top shift" built up during the first part of the operation is retained.

The mechanism, as shown also in the patent, is provided with a lost motion device, which stops the dog shift when a certain point has been reached, though permitting further onward movement of the operating bar. In accordance with the present invention this mechanism comes into action first as the top of the last is being cut, when the oscillating driving member is most advanced, and stops the top shift; and some time later when the driving carriage has advanced sufficiently for the retracted position of the oscillating member to have reached the advanced position corresponding to the stoppage of the top shift, the shifting at the bottom also stops completely.

The effect of this is as discussed above. The oscillating member picks up the operating bar at the point where the toe begins its curve up into the instep, and pushes it farther and farther with each revolution, returning it to normal position at the bottom of the last. This drops the top of the last, leaving the bottom unaffected, until the ball is reached, when top and bottom drop together, for a time. During this first interval, the transverse, vertical laminae which are reproduced, one by one at each revolution, are distorted progressively more and more, by having their tops dropped progressively. After the ball is passed this accumulated distortion is preserved unchanged, as the top and bottom drop together. Later, before the end of the shank portion of the last is reached, the top shift stops and the bottom shift continues, until the distortion has been progressively eliminated when the end of the shank has been reached.

Thus the dropping of the top and bottom profiles begins on the top in front of the place where it begins on the bottom, and a girth measurement taken in an upwardly forwardly sloping plane will encircle points which have been dropped to approximately the same degree.

In another way of looking at the matter, the dogs start oscillating heightwise of the

model when the point is reached at which the top of the model begins to curve upward into the instep, and the amplitude of oscillation becomes progressively greater until the ball is reached, the dogs returning to normal position during each oscillation. After the ball is reached, the amplitude of oscillation remains at the maximum already built up, but the region over which the oscillation takes place keeps on shifting progressively. Then the amplitude of oscillation gradually diminishes, the dogs returning to their extreme shifted position during each oscillation.

In a broad aspect the invention comprises mechanism for oscillating one of the primary instrumentalities of the pattern copying machine, in addition to its normal reproducing movement. Preferably, mechanism is provided for progressively varying the amplitude of oscillation and for progressively shifting the range over which the oscillation takes place. In the illustrated machine the mean position of the oscillating instrumentality is moved progressively from its normal position, but one of its extreme positions remains unchanged during the first part of the action of the mechanism, both extreme positions are progressively moved from normal position during the middle part of the action, and the other extreme position is maintained unchanged during the ending part of the action. These extreme positions correspond to the reproductions of points on the top and bottom of the model, respectively.

In another aspect the invention comprises mechanism for progressively distorting one side only of a series of differential elements, to effect a change in profile; preferably again, the mechanism is arranged to preserve the accumulated distortion over a succeeding series of elements, and to progressively eliminate it over a still later succeeding series of elements.

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 front elevation of the entire machine;

Fig. 2 is an enlarged front elevational detail, showing the beginning of the cut;

Figs. 3 and 4 are a plan and elevation, respectively, showing the condition of things between the sections C and E of Fig. 10;

Fig. 5 is a plan of a detail of the bar 50;

Figs. 6 and 7 are views corresponding to Figs. 3 and 4, but showing the condition of things between the sections D and F of Fig. 10;

Fig. 8 is a cross-section on the line VIII—VIII of Fig. 3;

Fig. 9 is a cross-section on the line IX—IX of Fig. 3; and

Figs. 10, 11, 12 and 13 are illustrative diagrams.

The illustrated machine is a last lathe of the Gilman type. It is provided with a main frame 10 having an upwardly extending frame 12 from which the swing frame 14 hangs on pivots at its upper end. The lower end of the swing frame has two bars 16, carrying the mechanism for holding and rotating the model 18 and block 20. The model follower carriage 22 and cutter carriage 24 slide along the top of the frame 10, and carry the model wheel 26 and cutter 28 respectively. These two carriages are connected by the length grading link 30 and lever 32, and the machine is provided with a width grading mechanism 34 of the ordinary type. All of this structure is well known.

The model dogs 36 are rotated by the sprocket chain 38 and suitable gearing. They are mounted on spindles extending into housings 40, within which there are mechanisms for offsetting the dogs equally, heightwise of the model 18, from their mechanical axes of rotation, the offset being indicated on a scale 41. These mechanisms are operated by a link 42 (Figs. 1 and 2) which, when adjusted off center on the arc 44 on the gear 46, pulls or pushes on a bar 48 as the gear 46 is oscillated by the rack bar 50, which slides in the swing frame, and is always pulled to the right by a spring 110 (Fig. 5) to be later described. The bar 48 is connected to the mechanisms in the housings 40 and to a rod 52 which slides in the swing frame with the bar 48. When the bar 48 moves to the left and right, the dogs 36 move down and up. The rod 52 has adjustable stops 54 and 55 arranged to come up against an abutment (herein shown as a housing 40) to stop the movement of the link 42 at times. At such times the motion of the elements 44, 46 is taken up by a spring 56 which connects the link 42 to the arc 44 of the gear 46. All of this mechanism is shown and described in detail in Letters Patent No. 1,733,207, already referred to.

In the machine shown in the patent referred to rollers 90 mounted on the bar 88 is picked up by an arm 114 mounted on the model wheel carriage 18 as it slides along to the left in Fig. 1, and the bar 88 is continuously driven thereafter by the movement of the model wheel carriage, to operate the dog shifting means.

The mechanism, in the machine illustrated herein, for operating the bar 50 will now be described. The model wheel carriage, in addition to the arm 60, has bolted to it a large casting 62 (Figs. 2, 7 and 8) which has a tail 64 sliding on a main-frame bar 66. This casting 62 moves with the model wheel carriage from right to left, as the cutting proceeds. Mounted in bearings in this casting is a shaft 68 driven, at the same angular rate

as that of the model, by a sprocket chain 70 and gears 72 through a clutch 73 (Fig. 3). A barrel cam 74 with a cam slot 75 is splined on the shaft 68 and has a ring-shaped slot 76 in which nests a yoke 80 on a slide 82 (Fig. 8) working in guides in the top of the casting 62. Thus this slide and the cam 74 move to the left or right together. The slide 82 has a projecting part 84 (Figs. 3 and 6) and has in its upper surface a guideway for a second slide 86, on which is mounted an arm 90 similar in construction and purpose to the arm 60 and arranged to run at times with its left side against a wheel stop 92 clamped on the bar 50. Mounted in bearings in the projection 84 is a vertical rock shaft 94 (see particularly Figs. 6 and 9) with an arm 96 having a pin-and-slot connection at 98 with the slide 86, and another arm 100 with a roller 102 on its end running in the slot 75 of the barrel cam 74. Thus, as long as the cam 74 is fixed longitudinally in position in the casting 62, its rotation will oscillate the arm 96 and the second slide 86 with the bar 90. The cam 74 normally is so fixed, and the function of the slide 82 will appear later.

The cam slot 75, reckoning around the barrel, has about $18\frac{1}{2}^\circ$ of dwell at its leftmost point, operative when the top of the model is on the model wheel, followed by about 74° of drop, operative when the inside of the model is on the wheel, followed by about 180° of dwell, operative across the bottom of the model, and about $87\frac{1}{2}^\circ$ rise operative on the outside of the model. The throw of the arm 90 is about $1\frac{1}{2}$ inches and is to the left when the high point of the cam is operating and the top of the model is on the model wheel. This distance is greater than the distance BC (Figs. 10 and 11) (discussed later) in any model which will be ordinarily used in the machine. The matter of turning left lasts from right models may be taken care of by reversing the direction of the blank.

The connection between the arm 90 and the bar 50 is as follows. A sleeve 104 is slidable on the bar 50 and has a roller 106 on its lower side engaging the arm 90 on its right side. It has also rollers 108 running on the arm 90 to prevent its rotation on the bar 50. See Fig. 5. It is connected by a spring 110 to the block on which the wheel 92 is mounted. An adjustable stop 112 is mounted on the bar 50, and arranged to come against one abutment 114 on the swing frame at times, as will be seen. The spring 110 tends to pull the bar 50 to the right, to a position where its movement is stopped by the member 112, wheel 92 or roller 58, as will be seen.

Mechanism for avoiding undue stress on the machine is provided as follows. The main-frame bar 66 is provided with two sliding members 116, 118, the former of which is adjustable along the bar but is normally fixed in position, and the latter of

which is freely slidable along the frame bar. Antifriction rollers 120 and 121 are provided on these slides for contact with the rotating barrel cam 74. A strong spring 122 connects the slides 116, 118, and tends to force the barrel cam 74 to the left. The function of this structure will be explained below.

Suppose we are to cut a last larger than the model and wish to diminish the normal toe-spring. The stop 112 is set so that when it is in contact with the abutment 114 the arc 44 is symmetrical about a horizontal diameter of the wheel 46, which brings the dogs 36 to neutral position. The stop 55 may also be set so that when it rests against the housing 40 the same result is attained. The model wheel carriage 22 is racked to the right. It carries with it the casting 62. The slide 82 is at this time held firmly against a stop surface 123 on the model wheel carriage 22 (see Figs. 2, 3 and 4) by the pull of the spring 122 acting from the fixed point 116, through the slide 118, roller 121, cam 74 and yoke 80, and all these elements are moved to the right with the model wheel carriage 22. The slide 86 and arm 90 are carried along also, the slide 86 being positively connected to the cam 74 by the crank lever 96, 94, 100. The arm 90, through the roller 106, sleeve 104 and spring 110, pulls the bar 50 to the right until the stop 112 contacts with the abutment 114, after which the spring 110 stretches to permit the rest of the movement of the carriage 22 (see Fig. 4). The model 18 is then turned over with its upper surface to the model wheel 26. This turns the cam 75 so as to throw the roller 102, pin 98, slide 86, and arm 90 to their extreme leftmost positions, as far as the cam is concerned. The carriage 22 is then racked to the left until the model wheel 26 comes to the section B of the model (Fig. 10). The wheel 92 is then set up to the arm 90 and clamped to the bar 50. The model is then turned over a half revolution, with its bottom to the model wheel, which reverses the position of the cam 74 and moves the bar 90 to its rightmost position as governed by the cam and the carriage 22 is racked to the left until the model wheel comes to the point C, at the bottom of the ball. Since the throw of the arm 90 is greater than the distance BC, the arm 90 will not now be in contact with the wheel stop 92, and the stop 112 will still lie against the abutment 114 at this time. The wheel 58 is then set up against the arm 60 and clamped to the bar 50. The carriage 22 is then racked again to the left until the model wheel comes to the section D of the model, substantially at the heel breast portion, or end of the shank. Up to this time all parts carried by the casting 62 have moved to the left with the carriage 22, under the pull of the spring 122. The slide 116 is now moved so that the roller 120 will come against the cam cylinder 74, and is clamped to the frame bar 66. This will stop

the cam cylinder 74 and slide 82 at the section D. The desired drop required between the ball and heel breast is now set into the machine by moving the arm 42 down on the arc 44 to such a position as will drop the dogs 36 the proper amount as shown on the scale 41. The stop 54 is then moved up to the housing 40 and clamped on the rod 52. The carriages are then racked to the right again, and the cutting begins.

The machine then operates as follows. The cutting is started at the point A at the toe end and proceeds from there to the section B just the same as in ordinary last cutting. The cam 75 causes the arm 90 to oscillate, but causes no movement of the bar 50, the oscillation being all taken up by the spring 110. When the section B is reached by the model wheel the arm 90 will just touch the wheel 92 at the leftmost extremity of its movement when the upper surface of the model is on the model wheel. As the carriages 22 and 24 are driven to the left, the wheel stop 92 and rod 50 are given oscillations of continually increasing amplitude separated by dwells of continually decreasing lengths. This pulls the model more and more downward (heightwise of itself) when the top of the model is on the model wheel, and restores it to normal position when its bottom is on the model wheel, during the dwells. This will cause the cutter to cut deeper than in ordinary last cutting on the top of the block and to cut to ordinary depth on the bottom. The result is indicated by the dotted line in Fig. 10 between the sections B and C. The top of the last being cut is dropped, but the bottom is not interfered with.

This goes on until the section C is reached. The throw of the cam 75 is so great that, until the section C is reached, the stop 112 will always come back to the abutment 114 on the rightward movement of the bar 50. When the section C is reached the arm 60 just touches the wheel 58 when the wheel is in its rightmost position, with the bottom of the model on the model wheel.

The distance BC, as stated above, is less than the $1\frac{1}{2}$ inch throw of the arm 90, so that the throw of the bar 50 at the section C is equal to the distance BC, part of the movement of the arm 90 caused by the cam being lost motion, absorbed by the spring 110.

Beyond the section C the bar 50 oscillates continuously and is pushed farther and farther to the left when the top of the model is on the model wheel, and also when the bottom of the model is on the wheel.

This matter may be made clearer by reference to Figs. 12 and 13. Suppose the distance BC is 1 inch, and that the distance between the arms 60 and 90 varies between a inches and $a+1\frac{1}{2}$ inches, due to the oscillation. (It should be remembered that the carriage 22 and the casting 62 have all this

time been moving as one piece, under the pull of the spring 122.) The leftmost and rightmost positions of the arm 90 are shown at 90 and 90', respectively, in both figures. Fig. 12 represents the condition of things at the setting of the wheel 92 (model wheel at section B), and Fig. 13, at the setting of the wheel 58 (model wheel at section C). Looking at Fig. 13, it will be clear that at the section C, the arm 90, starting a cycle at 90', will have $\frac{1}{2}$ inch lost motion from 90' to the left, will then strike the wheel stop 92 and move it 1 inch=BC to the left, will then let it come back 1 inch (at which time the wheel 58 will contact with the arm 60), and the arm 90 will then move idly $\frac{1}{2}$ inch to 90' again, thus ending the cycle. The total throw of the bar 50 will be 1 inch=BC, and as the carriage 22 feeds to the left, this will continue to be true. The bar 50 will oscillate through the distance 1 inch=BC, and the physical range of oscillation will shift continually further to the left as the carriage 22 moves to the left. Thus, the top and bottom of the last being cut will continue to drop, and to drop equally.

This continues until a section E is reached, located such that ED=BC. It will be remembered that the stop 54 has been set to contact with the housing 40 at section D with the bottom of the model on the model wheel. Now since the bar 50, while the model wheel is passing from section C to section E, is always the distance BC farther to the left when the top of the model is on the wheel than it is when the bottom of the model is on the wheel, the stop 54, which so far has followed the movement of the bar 50, will contact with the housing 40 when the top of the model goes over the wheel at a section distant BC to the right of the section D, that is, at the section E. This causes the drop at the top of the last to stop at E, while that at the bottom continues to the section D, beyond which the stop 54 remains against the housing during the whole rotative cycle. In passing from section E to D the amplitude of the oscillation of the dogs gradually decreases and, at section D, ceases. Thereafter the model dogs remain motionless on their slides and the heel part EF is reproduced regularly, but in a position dropped by the dog shift due to the traverse CD, or BE.

Nothing has yet been said about the function of the roller 120 which contacts with the cam barrel 74 at the section D, and about that of the slide 82. These parts have no theoretically necessary function. If they did not act as described, and hold the barrel cam against further leftward movement after the section D has been reached, causing the carriage 22 to move away from the slide 82, the bar 50 would keep on oscillating farther and farther to the left as the cam 74 followed the carriage 22, and the spring 56 would be stretched more and more. Inasmuch as the

pull of the spring 56 against the swing frame tends to distort the swing frame into a rhomboidal form, it was thought advisable not to allow the stress in the spring 56, caused by the progressive movement of the bar 50, to increase beyond necessary limits, and at the section D the function of the dog shifting mechanism is over.

The effect of the described dog shifting is to drop the top of the last being cut, progressively from the section B to the section E, and the bottom of the last, progressively from the section C to the section D. This is illustrated in Fig. 11, the upper line 124 in which represents the positions of the model dogs during the reproductions of points on the longitudinal top line of the model, and the line 126 in which represents their positions during the reproductions of points on the longitudinal bottom line of the model. Thus, the top and bottom profiles of the last are changed in the same way over certain equal ranges, BE at the top and CD at the bottom, but these ranges are offset from each other on the top and bottom, relatively to the longitudinal axis of the last. It will be obvious that the vertical transverse laminae of the last will be flattened progressively more and more at their tops from B to C, that this distortion is maintained unchanged from C to E, and that the distortion is progressively eliminated from E to D, by dropping the bottoms of the laminae. The heel DF will then be reproduced in normal shape, but dropped below normal position by the amounts indicated on the lines 124, 126.

For the reverse operation of cutting a last smaller than the model and increasing the toe spring, the bar 50 is set to the other side of the center of the wheel 46, and the stop 55 is used.

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

1. That improvement in methods of reproducing solid models which consists in reproducing the model in the work piece, lamina by lamina, and progressively distorting corresponding portions of a selected series of laminae.

2. That improvement in methods of reproducing solid models which consists in reproducing the model in the work piece, lamina by lamina, and progressively displacing corresponding parts only of the peripheries of a selected series of laminae.

3. That improvement in methods of reproducing solid models which consists in reproducing the model in the work piece, lamina by lamina, and progressively displacing portions of the peripheries of a selected series of laminae, such portions lying on one and the same side only of the work piece, whereby a progressive distortion is built up

on one side of the work piece, in the selected series of laminae.

4. That improvement in methods of reproducing solid models which consists in reproducing the model in the work piece, lamina by lamina, and progressively displacing portions of the peripheries of a selected series of laminae, such portions lying on one and the same side only of the work piece, whereby a progressive distortion is built up on one side of the work piece, in the selected series of laminae, and in preserving the accumulated distortion unchanged in the reproduction of an immediately succeeding series of laminae.

5. That improvement in methods of reproducing solid models which consists in reproducing the model in the work piece, lamina by lamina, while progressively displacing those parts of the peripheries of a selected series of laminae which parts lie on one side only of the work piece, in parallel directions, which directions lie in the planes of the lamina to which they belong, then progressively displacing those parts of the peripheries of a succeeding series of laminae, lying on the same said side and also the opposite side of the work piece, in the same direction, but by the same amounts, in each lamina.

6. That improvement in methods of reproducing solid models which consists in reproducing the model in the work piece, lamina by lamina, while progressively displacing those parts of the peripheries of a selected series of laminae which parts lie on one side only of the work piece, in parallel directions, lying in the planes of the lamina to which they belong, then progressively displacing those parts of the peripheries of a succeeding series of laminae, lying on the same said side and also on the opposite side of the block, in the same direction, but by the same amounts, in each lamina, and then progressively displacing those parts of the peripheries of a succeeding series of laminae, such parts lying on the said opposite side of the work piece, only, in the same direction.

7. That improvement in manufacturing lasts with corrected profiles which consists in reproducing, in a last block, a series of parallel model laminae, one after the other, and progressively displacing heightwise of the last, the upper edges only of such laminae from a point lying substantially forward of the ball portion, to the ball, then progressively displacing both the upper and lower edges of a succeeding series of laminae in the same direction, but by equal amounts in each lamina, and then progressively displacing the lower edges only of a succeeding series of laminae, in the same direction, whereby the top and bottom profiles of the last are similarly displaced, the top displaced

region lying, as a whole, in advance of the bottom displaced region.

8. That improvement in manufacturing lasts which consists in reproducing, in a last block, a series of parallel model laminae in succession, while progressively shifting the top and bottom profiles of the last produced, in a direction heightwise of the last, the shift of the top profile beginning earlier in the reproduction than the shift of the bottom profile, as the reproduction proceeds from one end of the last to the other.

9. That improvement in manufacturing lasts which consists in reproducing, in a last block, a series of parallel model laminae in succession, while progressively shifting the top and bottom profiles of the last produced, in a direction heightwise of the last, the shift of the top profile beginning earlier in the reproduction than the shift of the bottom profile and ending earlier in the reproduction than the shift of the bottom profile, as the reproduction proceeds from one end of the last to the other.

10. In a pattern copying machine, two pairs of primary instrumentalities, namely, a model holder, a work holder, and a model follower and a tool, grading mechanism interconnecting them for effecting normally geometrically similar relative movements between the model holder and the follower, and between the work holder and the tool, respectively, and mechanism for effecting substantially unequal geometrically dissimilar relative movements between the members of the said pairs of primary instrumentalities, during the reproductions of two opposite portions of the periphery of a lamina of the model.

11. In a pattern copying machine, four primary instrumentalities, namely, a model holder, a work holder, a model follower and a tool, grading mechanism interconnecting them for effecting normally geometrically similar relative movements between the model holder and the follower, and between the work holder and the tool, respectively, to reproduce a model in successive parallel laminae, and mechanism for effecting additional relative movements between two of the primary instrumentalities in one direction, operated by a relative movement between two of the primary instrumentalities in a perpendicular direction, said mechanism being operable during the reproduction of selected parts of opposite portions of the periphery of the model, said parts lying at most only partially opposite each other.

12. In a pattern copying machine, four primary instrumentalities, namely, a model holder, a work holder, a model follower and a tool, grading mechanism interconnecting them for effecting normally geometrically similar relative movements between the model holder and the follower, and between

the work holder and the tool, respectively, to reproduce a model progressively in parallel laminae, and mechanism for effecting additional relative movements between two of the primary instrumentalities in one direction, operated by a relative movement between two of the primary instrumentalities in a perpendicular direction, said mechanism being operable during the reproduction of a selected portion of the periphery of the model and inoperative during the reproduction of the opposite portion of the periphery of the model.

13. In a machine for copying solid objects, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, and mechanism comprising an offsetting device operable, over predetermined portions of the reproduction, to distort one side only of such reproduced differential elements in the work.

14. In a machine for copying solid objects, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, and means for displacing one of said holding and rotating means from normal position operable, over predetermined portions of the reproduction, to distort progressively and increasingly one side only of such reproduced differential elements in the work.

15. In a machine for copying solid objects, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, and mechanism operable during the reproduction of a predetermined portion of the model, to distort one side only of successively reproduced differential elements in the work piece in a progressively increasing manner, operable during the reproduction of a succeeding portion of the model to preserve the accumulated distortion, and operable during the reproduction of a still succeeding portion of the model, to progressively eliminate the accumulated distortion, of successively reproduced differential elements.

16. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic repro-

duction of differential elements of the model in the work piece, mechanism for oscillating one of said primary instrumentalities, and controlling means for moving the mean position of the oscillating instrumentality progressively farther from its normal position during a portion of the reproduction.

17. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, mechanism for oscillating one of said primary instrumentalities, and controlling means for moving the mean position of the oscillating instrumentality progressively farther from its normal position during a portion of the reproduction while maintaining the position of one extreme of the oscillatory movement unchanged.

18. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, mechanism for oscillating one of said primary instrumentalities, and controlling means for moving the mean position of the oscillating instrumentality progressively farther from its normal position during a portion of the reproduction while maintaining the position of one extreme of the oscillatory movement unchanged during the terminal parts of the said portion of the reproduction.

19. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, mechanism for oscillating one of said primary instrumentalities, and controlling means for moving the mean position of the oscillating instrumentality progressively farther from its normal position during a portion of the reproduction while maintaining the position of one extreme of the oscillatory movement unchanged during the beginning part of the said portion and maintaining the position of the other extreme of the oscillatory movement unchanged during the ending part of the said portion.

20. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool,

grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, mechanism for oscillating one of said primary instrumentalities, and controlling means for moving the mean position of the oscillating instrumentality progressively farther from its normal position during a portion of the reproduction while maintaining the position of one extreme of the oscillatory movement unchanged during the beginning part of the said portion and maintaining the position of the other extreme of the oscillatory movement unchanged during the ending part of the said portion, both said extreme positions being progressively variable during the middle part of said portion.

21. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, and mechanism for oscillating one of the said holding and rotating means in a direction transverse to its axis of rotation, during a selected portion of the reproduction.

22. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, and mechanism for oscillating one of the said primary instrumentalities in a direction transverse to the axis of rotation of one of the said holding and rotating means, during a selected portion of the reproduction.

23. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, and mechanism for oscillating one of the said primary instrumentalities in a direction transverse to the axis of rotation of one of the said holding and rotating means, during a selected portion of the reproduction, said mechanism comprising a dog shifting means on said axis, and a member mounted on one of said instrumentalities for controlling the dog shifting means.

24. In a machine for copying solid objects,

means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, one of said holding and rotating means being movable transversely to its axis of rotation, and a mechanism for oscillating said holding and rotating means transversely to its axis of rotation, to extreme positions which lie progressively more distant from the axis of rotation as the reproduction proceeds along the model.

25. In a machine for copying solid objects, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, one of said holding and rotating means being movable transversely to its axis of rotation, and a mechanism for oscillating said holding and rotating means transversely to its axis of rotation, to extreme positions which lie progressively more distant from the axis of rotation as the reproduction proceeds along the model, said mechanism comprising a dog shifting means on said axis, and a member mounted on one of said instrumentalities for controlling the dog shifting means.

26. In a machine for copying solid objects, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, one of said holding and rotating means being movable transversely to its axis of rotation, and a mechanism for oscillating said holding and rotating means transversely to its axis of rotation, to extreme positions which lie progressively more distant from the axis of rotation as the reproduction proceeds along the model, said mechanism comprising a dog shifting means on said axis, and a member mounted on one of said instrumentalities for controlling the dog shifting means, the period of oscillation of the oscillating member being equal to the period of rotation of the model.

27. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, one of said holding and rotating means being movable transversely to its axis of rotation, and a mechanism for os-

cillating said holding and rotating means from its axis of rotation in substantially constant amplitudes but to progressively greater distances, and back again toward the said axis, as the reproduction proceeds along the model.

28. In a machine for copying solid objects, four primary instrumentalities, namely, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, one of said holding and rotating means being movable transversely to its axis of rotation, and a mechanism for oscillating said holding and rotating means from its axis of rotation in substantially constant amplitudes but to progressively greater distances, and back again toward the said axis, as the reproduction proceeds along the model, said mechanism comprising a dog shifting means carrying said holding and rotating means, and an oscillating member for operating the dog shifting means, mounted on one of said primary instrumentalities and arranged to be moved generally progressively past another of said primary instrumentalities.

29. In a machine for copying solid objects, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, one of said holding and rotating means being movable transversely to its axis of rotation, and a mechanism for oscillating said holding and rotating means from its axis of rotation to progressively greater distances, and back again toward the said axis, as the reproduction proceeds along the model, the period of oscillation being equal to the rotation period of the model.

30. In a machine for copying solid objects, means for holding and rotating a model and a work piece, a model follower and a tool, arranged to be traversed past the said means, respectively, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, one of said holding and rotating means being movable transversely to its axis of rotation, and a mechanism for oscillating said holding and rotating means from its axis of rotation to progressively greater distances, and back again toward the said axis, as the reproduction proceeds along the model, the period of oscillation being equal to the rotation period of the model, said mechanism comprising a member arranged to move with one

of said traversing instrumentalities and also to oscillate, and a shifting means operated by said member.

31. In a machine for copying solid objects, means for holding and rotating a model and a work piece, a model follower and a tool, grading mechanism interconnecting them for causing relative movements between them in pairs to effect normally pantographic reproduction of differential elements of the model in the work piece, and mechanism for displacing one of the said holding and rotating means transversely to its axis of rotation during the reproduction of a portion of the model which lies at one side only of the said axis of rotation.

32. In a pattern copying machine, four primary instrumentalities, namely, a model holder, a work holder, a model follower and a tool, grading mechanism interconnecting them for effecting normally geometrically similar relative movements between the model holder and the follower, and between the work holder and the tool, respectively, and mechanism for effecting a displacement of one of the primary instrumentalities transverse to a certain line in the model, such displacements corresponding to reproductions of portions of the model periphery which follow one another in the general direction of the said line being progressively greater, and being unequal to the displacements corresponding to reproductions of the model periphery lying directly opposite the first-named portions relatively to the said line.

33. In a pattern copying machine, four primary instrumentalities, namely, a model holder, a work holder, a model follower and a tool, grading mechanism interconnecting them for effecting normally geometrically similar relative movements between the model holder and the follower, and between the work holder and the tool, respectively, and mechanism for effecting a displacement of one of the primary instrumentalities transverse to a certain line in the model, said displacement-effecting mechanism being driven by the relative movement of the primary instrumentalities in the direction of the said line, and the displacements effected being progressively greater as the reproduction of a portion of the model periphery lying on one side of said line proceeds generally in the direction of the said line, and said driving action being also effective during the reproduction of a portion of the periphery of the model lying on the other side of the said line, said second-named portion being not wholly directly opposite the first-named portion relatively to the line.

34. In a pattern copying machine, four primary instrumentalities, namely, a model holder, a work holder, a model follower and a tool, grading mechanism interconnecting them for effecting normally geometrically

similar relative movements between the model holder and the follower, and between the work holder and the tool, respectively, and mechanism for effecting a displacement of one of the primary instrumentalities transverse to a certain line in the model, said displacement-effecting mechanism being driven by the relative movement of the primary instrumentalities in the direction of the said line, and the displacements effected being progressively greater as the reproduction of a portion of the model periphery lying on one side of said line proceeds generally in the direction of the said line, and said driving action being also effective during the reproduction of a portion of the periphery of the model lying on the other side of the said line, said second-named portion being not wholly directly opposite the first-named portion relatively to the line, said mechanism comprising a dog shifting means and a driving member operated by the movement of one of said primary instrumentalities.

35. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage, a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, and an oscillating member on one of the carriages arranged, when moving in one direction, to displace the said holding and rotating means, its motion in the other direction being accompanied by a movement of return of the holding and rotating means.

36. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage, a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, an oscillating member on one of the carriages arranged, when moving in one direction, to displace the said holding and rotating means, its motion in the other direction being accompanied by a movement of return of the holding and rotating means, the period of oscillation being equal to the rotation period of the model.

37. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage, a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, and an oscillating member on one of the carriages arranged, when moving in one direction, to displace the said holding and rotating means, its motion in the other direction being accom-

panied by a movement of return of the holding and rotating means, the extremes of displacement progressively increasing as the said carriage moves.

38. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage, a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, an operating member arranged for oscillatory movement, and arranged to effect a displacement of the holding and rotating means when moved in one direction and a return thereof toward normal position when the member moves in the other direction, and an oscillating member on one of the carriages arranged to pick up and to drive the operating member at a certain time as it moves forward in its oscillatory cycle, its return movement being accompanied by a return movement of the operating member, and the amplitude of oscillation of the operating member increasing progressively as the carriage progresses.

39. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage and a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, an operating member arranged for oscillatory movement and arranged to effect a displacement of the holding and rotating means when moved in one direction and a return thereof toward normal position when moved in the other direction, an oscillating member on one of the carriages arranged to pick up and to drive the operating member at a certain time in the feeding movement of the carriage as it moves forward in its oscillatory cycle, its return movement being accompanied by a return movement of the operating member, and to increase the amplitude of oscillation of the operating member progressively as the carriage progresses, and means for maintaining the said amplitude unchanged when a desired maximum has been reached.

40. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage, a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, an operating member arranged for oscillatory movement and arranged to effect a displacement of the holding and rotating means when moved in one direction and a return thereof toward normal position when

moved in the other direction, an oscillating member on one of the carriages arranged to pick up and to drive the operating member at a certain time as it moves forward in its oscillatory cycle, its return movement being accompanied by a return movement of the operating member, and the amplitude of oscillation of the operating member increasing progressively as the carriage progresses, and means for maintaining the said amplitude unchanged when a desired maximum has been reached, while increasing the mean distance of the holding and rotating means from its axis of rotation.

41. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage, a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, an operating member arranged for oscillatory movement and arranged to effect a displacement of the holding and rotating means when moved in one direction and a return thereof toward normal position when moved in the other direction, an oscillating member on one of the carriages arranged to pick up and to drive the operating member at a certain point of the reproduction as it moves forward in its oscillatory cycle, its return movement being accompanied by a return movement of the operating member, and the amplitude of oscillation of the operating member increasing progressively as the carriage progresses, and means for maintaining the said amplitude unchanged when a desired maximum has been reached, said last-named means comprising a member fixed on the said carriage arranged to arrest the backward movement of the operating member.

42. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage, a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, an operating member arranged for oscillatory movement and arranged to effect a displacement of the holding and rotating means when moved in one direction and a return thereof toward normal position when moved in the other direction, an oscillating member on one of the carriages arranged to pick up and to drive the operating member at a certain time in the reproduction as it moves forward in its oscillatory cycle, its return movement being accompanied by a return movement of the operating member, and a fixed member on the carriage arranged to pick up the operating member on its return movement at a time substantially later in the reproduction than the said

certain time, whereby the amplitude of oscillation of the operating member may be progressively increased from the said certain time to the said later time, and held unchanged thereafter.

43. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage, a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, an operating member arranged for oscillatory movement and arranged to effect a displacement of the holding and rotating means when moved in one direction and a return thereof toward normal position when moved in the other direction, an oscillating member on one of the carriages arranged to pick up and to drive the operating member at a certain time in the reproduction as it moves forward in its oscillatory cycle, its return movement being accompanied by a return movement of the operating member, and a fixed member on the carriage arranged to pick up the operating member on its return movement at a time substantially later in the reproduction than the said certain time, whereby the amplitude of oscillation of the operating member may be progressively increased from the said certain time to the said later time, and held unchanged thereafter, while the region of oscillation of the holding and rotating means is progressively withdrawn from the axis of rotation thereof.

44. In a machine for copying solid objects, model holding and rotating means, work holding and rotating means, a model follower carriage, a tool carriage arranged to feed past the two holding and rotating means, respectively, mechanism permitting displacement of one of the holding and rotating means transverse to its axis of rotation, an operating member arranged for oscillatory movement and arranged to effect a displacement of the holding and rotating means when moved in one direction and a return thereof toward normal position when moved in the other direction, an oscillating member on one of the carriages arranged to pick up and to drive the operating member at a certain time in the reproduction as it moves forward in its oscillatory cycle, its return movement being accompanied by a return movement of the operating member, and a fixed member on the carriage arranged to pick up the operating member on its return movement at a time substantially later in the reproduction than the said certain time, whereby the amplitude of oscillation of the operating member may be progressively increased from the said certain time to the said later time, and held unchanged thereafter, while the region of oscillation of the holding and rotating means

is progressively withdrawn from the axis of rotation thereof, and means for inhibiting the effect of the forward movement of the oscillating member at a still later time.

45. In a lathe, a swing frame, model and last block holding and rotating means, a model follower carriage, and a tool carriage arranged to run past the holding and rotating means parallel to the axes of rotation thereof, an offsetting device for moving one of the holding and rotating means from its axis of rotation in a direction heightwise of the object held therein, a bar movable parallel to the axis of rotation of the said offsettable holding and rotating means, and operatively connected to the offsetting device, two adjustable spaced abutments on said bar, an oscillating member on one of the carriages having a movement of oscillation parallel to the direction of movement of the bar, and arranged to pick up one of the said abutments at a predetermined time in the reproduction, the period of oscillation of the member being equal to the period of rotation of the holding and rotating means, whereby the oscillating member produces, in its forward movements, a series of forward movements of the bar of progressively increasing amplitude, means for producing a return movement of the bar succeeding each forward movement thereof, a second member on one of the carriages arranged to pick up the second abutment on the bar during said return movement after a desired maximum amplitude of movement of the bar has been accumulated, and to preserve such amplitude, while the region of oscillation of the offsetting means departs progressively from the said axis of rotation, and means for arresting movement of the holding and rotating means from its axis of rotation beyond a predetermined limit on its forward movement while permitting further progressive movement from the axis on the return movement, whereby the object in the holding and rotating means is moved heightwise progressively over different predetermined parts of the reproductions of opposite sides of the model.

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

GEORGE F. RYAN.