C. R. NORTH.

MILLING MACHINE.

APPLICATION FILED JUNE 4, 1910

1,040,983.

Patented Oct. 8, 1912.

6 SHEETS—SHEET 1.

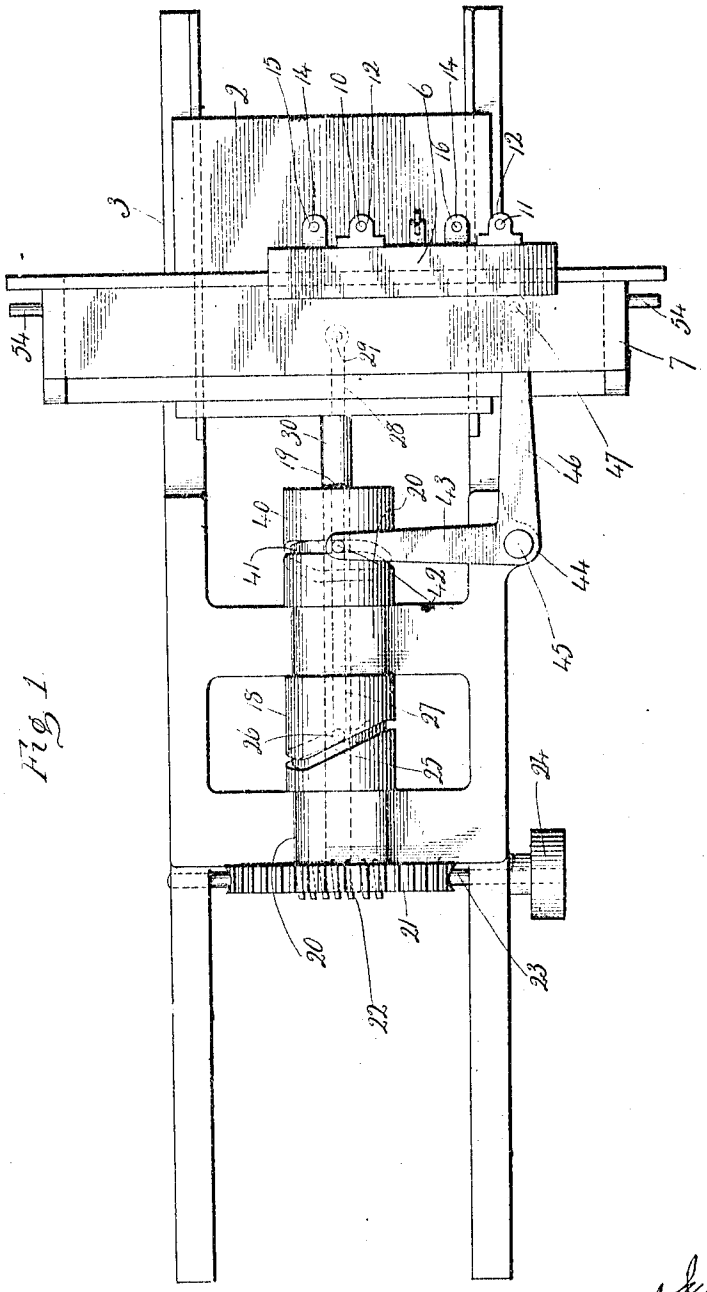

Fig 1.

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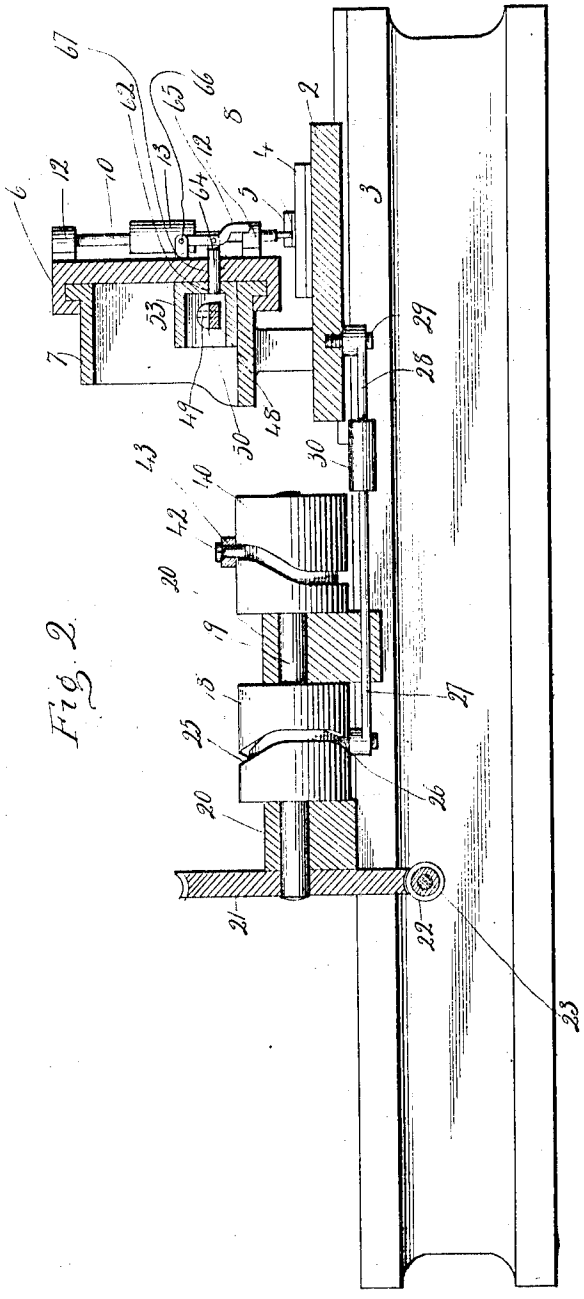

Fig. 2

Witnesses
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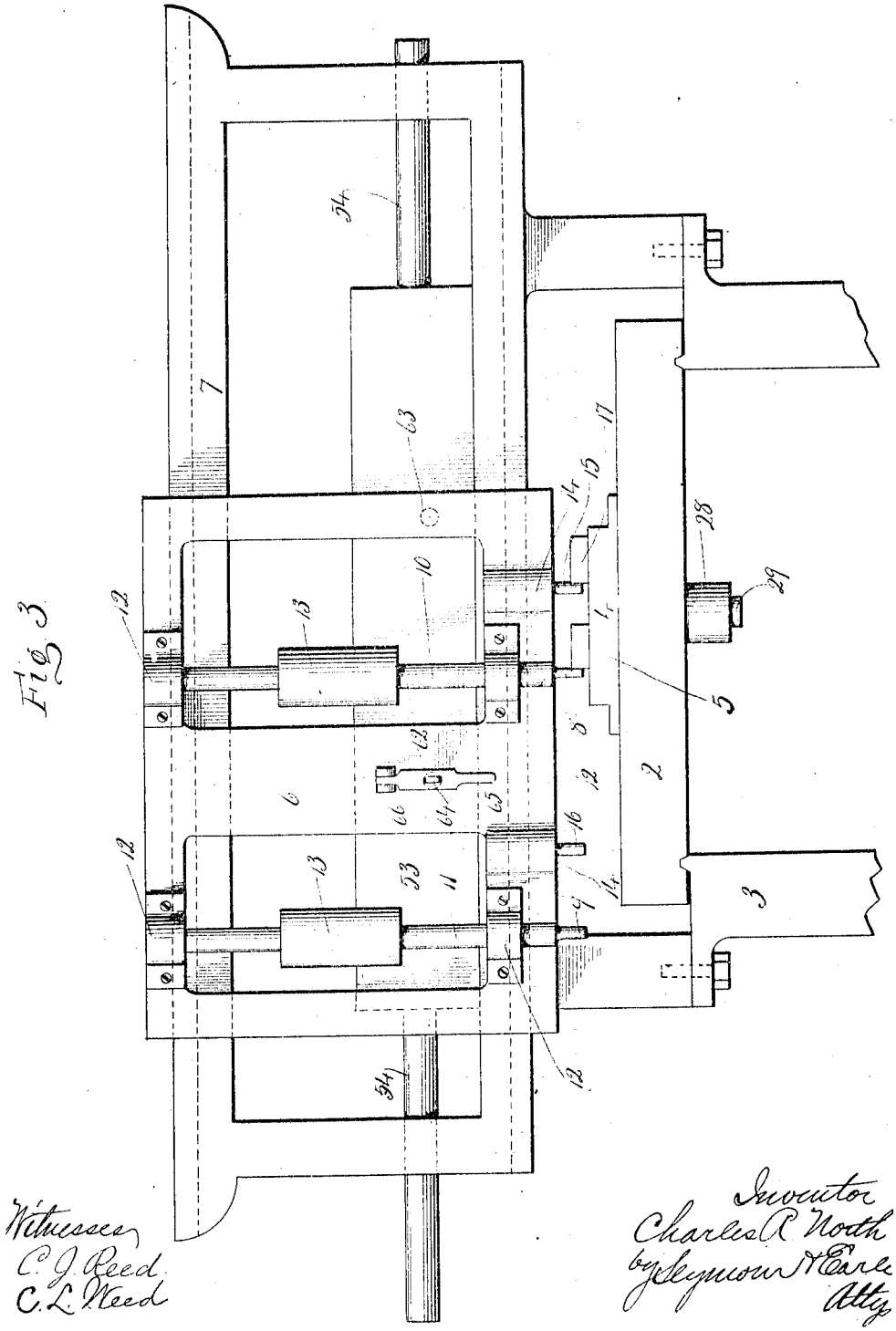
6 SHEETS—SHEET 3.

Fig. 3



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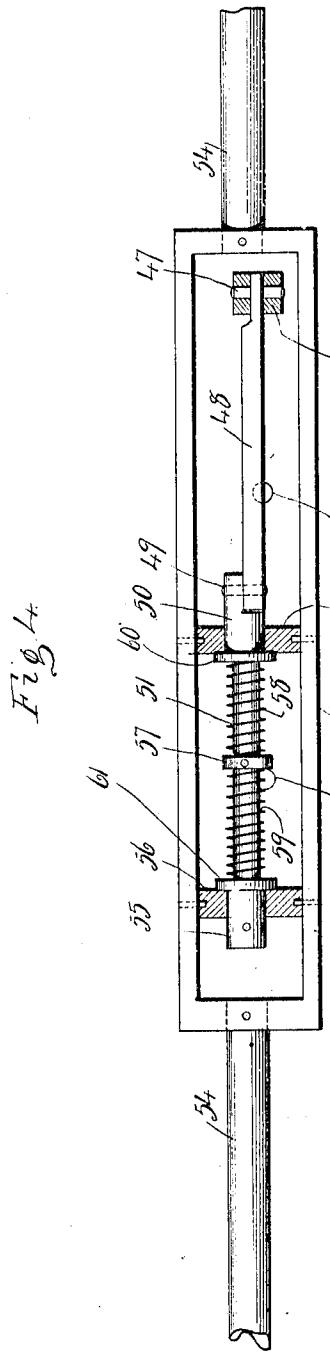

Fig. 4.

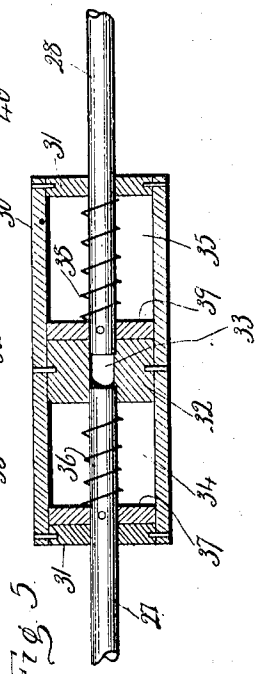

Fig. 5.

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6 SHEETS-SHEET 5.

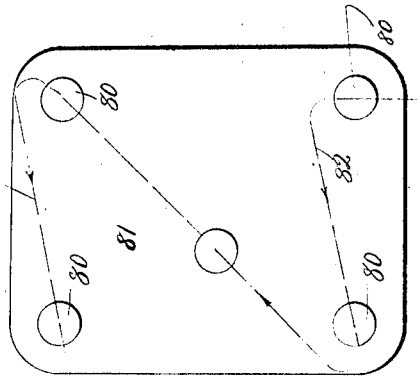

Fig. 7.

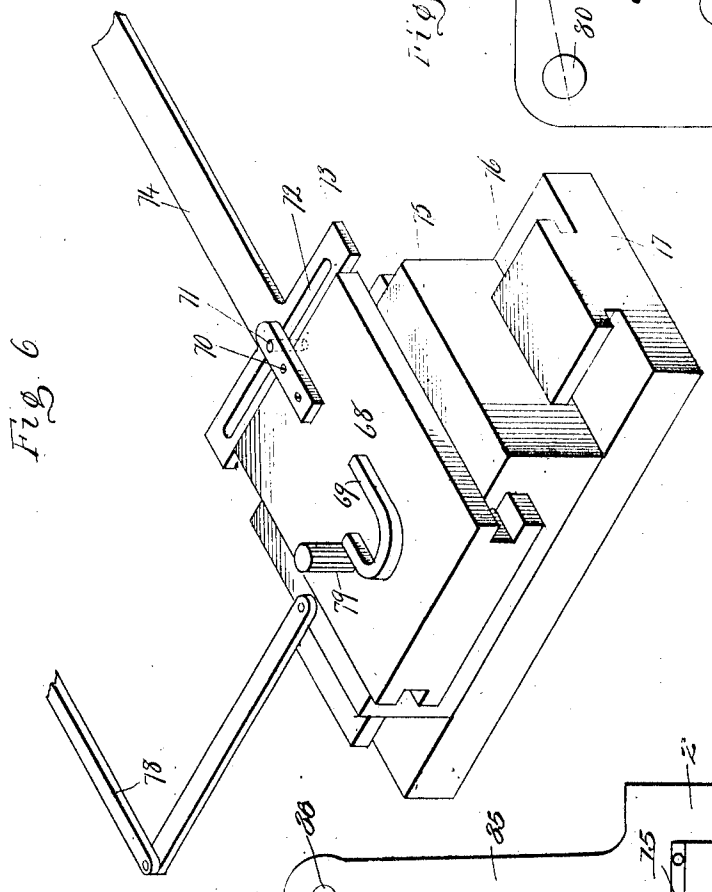

Fig. 6.

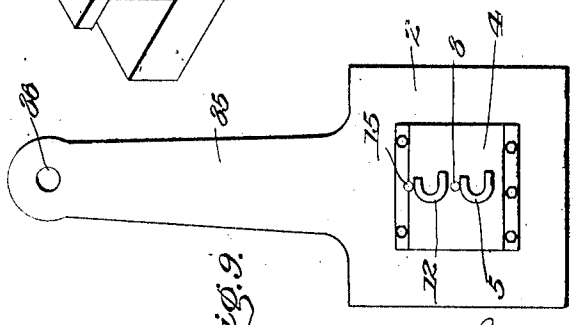

Fig. 9.

Witnesses
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6 SHEETS—SHEET 6.

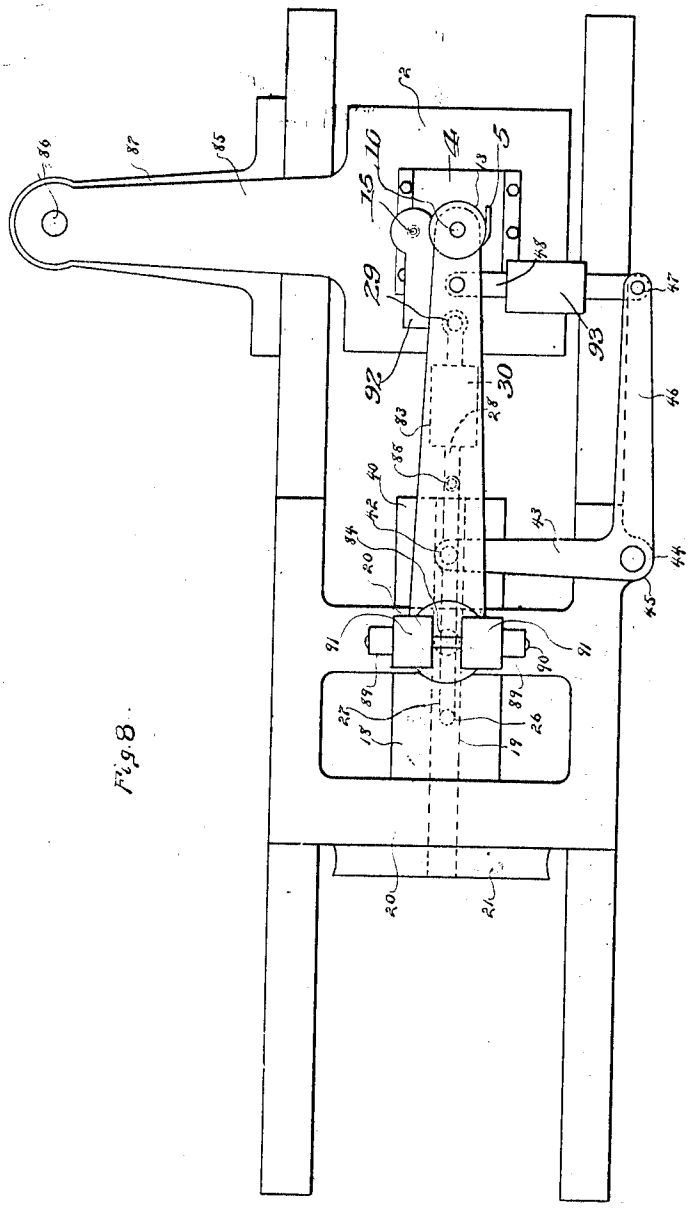

Fig. 8.

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UNITED STATES PATENT OFFICE.

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MILLING-MACHINE.

1,040,983. Specification of Letters Patent. Patented Oct. 8, 1912.

Application filed June 4, 1910. Serial No. 565,028.

To all whom it may concern:

Be it known that I, CHARLES R. NORTH, a citizen of the United States, residing at Hartford, in the county of Hartford and State of Connecticut, have invented a new and useful Improvement in Milling-Machines; and I do hereby declare the following, when taken in connection with the accompanying drawings and the letters of reference marked thereon, to be a full, clear, and exact description of the same, and which said drawings constitute part of this specification, and represent, in—

Figure 1 a plan view of a milling machine constructed in accordance with my invention. Fig. 2 a view thereof in vertical longitudinal section. Fig. 3 a view of the machine in end elevation on an enlarged scale looking toward the tool-carrier. Fig. 4 a detached view partly in elevation and partly in vertical section showing the box-shaped slide employed to connect the bell-crank lever with the tool-carrier. Fig. 5 a broken view in vertical section showing the elastic connection between the work-carrier and the work-carrier cam. Fig. 6 a perspective view of one of the modified forms which my invention may assume. Fig. 7 a diagrammatic illustration of the application of my invention to a machine for milling irregularly placed bosses upon a flat surface. Fig. 8 a plan view showing a modification of my improved machine. Fig. 9 a detached plan view of the swinging-arm 85 of the modified construction shown by Fig. 8, the cutter-carrying arm 83 being broken away, and the cutter 8 and the former-pin 15 being shown in horizontal section in their proper relations to the former 17 and the work-blank 5, both of which are supported upon the work-holder 4 which is mounted upon the arm 85. The curved path traversed by the cutting tool 8 is not separately shown, but it is represented by the contour of the work-blank 5.

My invention relates to that class of milling machines which have two parts or carriers movable transversely with respect to each other, and a revolving cutter whose axis is at right angles to both the transverse movements of said movable parts or carriers, the object being to produce a simple, reliable, convenient and efficient mechanism providing for automatically feeding the cutter or work, or both, so that the cutting will be done in any desired irregular path, whereas in milling machines of the same class of the prior art, the feeding movement has been made by hand.

With these ends in view, my invention consists in the combination with two parts or carriers movable transversely with respect to each other, of a revolving cutter having its axis at right angles to a plane parallel to the transverse movement of both of said parts or carriers, and automatic means for imparting predetermined individually variable movements and speeds to the respective parts or carriers, whereby the same re-act upon each other to conjointly cause the cutting to be done by the said cutter in a predetermined curved or irregular path.

My invention further consists in certain details of construction and combinations of parts as will be hereinafter described and pointed out in the claims.

In carrying out my invention as herein shown, I employ a reciprocating work-carrier 2 consisting of a table suitably mounted upon the machine frame 3 so as to be moved back and forth lengthwise thereof. Upon the work-carrier 2 is mounted a block or head 4 to which the blank 5 to be milled is secured.

In conjunction with the work-carrier 2, I employ a tool-carrier 6 arranged to be moved transversely to the movement of the work-carrier 2 and mounted upon an upright frame 7 bolted to the machine frame 3. As shown, the tool-carrier 6 is provided with two rotary cutters 8 and 9 removably mounted in the lower ends of spindles 10 and 11 journaled in bearings 12 secured to the carrier 6, each spindle being furnished with a driving pulley 13, one cutter being intended to be employed as a roughing-out cutter and the other as a finishing cutter.

In carrying out the embodiment of my invention now being described, provision must be made for moving the work-carrier 2 and the tool-carrier 6 automatically and concurrently each with predetermined in-

dividually variable movements and speeds, the provision for the movement of each being independent for the movement of the other, so that the resultant action of the cutters 8 and 9, either or both, upon the blank 5 shall be to mill the latter in accordance with a predetermined pattern whether that pattern be included in the machine or not in the shape of a "former," so called.

The automatic variable movements of the carriers 2 and 6 are as herein shown, effected by means of cams having concurrent and continuous movement during the operation of the milling and provided with paths shaped in each instance according to the dictation of the curved or irregular paths in which the milling is to be done. In other words, every time the work to be done changes its form new cams must be specifically designed in accordance with that form. Every machine made in accordance with my invention will probably be furnished with interchangeable sets of cams covering the range of the work to be done by the machine.

As herein shown, I employ a work-carrier cam 18 mounted upon a horizontal camshaft 19 journaled in bearings 20 and provided at its rear end with a worm-gear 21 meshed into by a worm 22 mounted on a worm-shaft 23 provided at one end with a pulley 24 receiving a driving belt from any convenient source of power.

The work-carrier cam 18 is formed with a cam-path 25 the specific shape of which conjointly with the shape of its companion cam path 41 is dictated by the form of the path in which it is designed that the cutting shall be done, the cam-paths being plotted with the assistance of a sample pattern of the desired ultimate form. Different methods of laying out the cam-paths 25 and 41 may, of course, be employed. The said path 25 is entered, as shown, by a cam-pin 26 mounted in the rear end of the rear section 27 of a connecting-rod, the front section 28 of which is secured by a screw-bolt 29 to the under face of the work-carrier 2.

In feeding a profiling machine by hand, it is absolutely essential that a former and former-pin be used.

While it is quite possible to make the cams in my machine sufficiently accurate to do good work, this is a matter of some difficulty, which difficulty is encountered with each new set of cams for a different profile.

A more serious source of inaccuracy is the wear of the different parts of the mechanism, causing loss of motion, which may cause inaccuracy in various ways. For example, when the motion of one of the transversely moving parts or carriers is reversed, that part must respond immediately. Any such lost motion would cause a delay, which would result in inaccuracy in the work and such inaccuracy may also be caused in a different manner by the wear of the cutter.

The use of the former and former-pin in combination with the mechanism above described and the elastic connections hereinafter mentioned, prevents this inaccuracy and causes the piece milled to conform to the contour of the former, and the cams can easily be made sufficiently accurate to insure good work in such a combination.

As shown the tool-carrier 6 is formed on its lower edge with lugs 14 for the reception of former-pins 15 and 16 respectively arranged to operate in conjunction with the cutters 8 and 9. One or the other of the former-pins 15 and 16 co-acts with a former or pattern 17 secured to the block or head 4, according to the position of the carrier 6 upon the upright frame 7 as will be hereafter explained.

It is essential that whichever of said pins is in use shall be pressed by an elastic pressure into contact with the edge of the said former. This elastic pressure may be provided for in different ways. As shown, I provide for it by elastic connections between the cams and the work-carriers. For the elastic connection between the cam 18 and the work-carrier 2 I employ a connecting-rod consisting of the rear and front sections 27 and 28 already specified, and connect their adjacent ends by means of a sleeve 30 having its ends closed by heads 31 and provided midway of its length with an abutment 32 having a central opening 33 receiving the extremities of the adjacent portions of the rod-sections 27 and 28, whereby the sleeve 30 is divided into chambers 34 and 35. Within the chamber 34 I locate a spiral spring 36 encircling the projecting forward end of the rod-section 27 and interposed between the rear face of the abutment 32 and the front face of a collar 37 secured to the said rod-section 27. Within the chamber 35 I locate a spiral spring 38 encircling the rear end of the rod-section 28 and interposed between the inner face of the front head 31 and the front face of a collar 39 secured to the rear end of the rod-section 28. The said springs 36 and 38 press the collars 37 and 39 against the rear head 31 and the central abutment 32 respectively with an elastic pressure, the rear head 31 and the central abutment 32 both serving as abutments to limit the extent of movement of the springs 36 and 38. Under the construction described, the parts will normally have the positions shown in Fig. 5, and virtually act as one piece, since the springs 36 and 38 will be confined as above stated and strongly compressed and sufficiently heavy not to yield under any of the thrust exerted by the cam 18 through the rod-section 27 and 28 in doing the actual cutting when a former-pin is not employed. The springs, however,

provide an elastic connection between the work-carrier 2 and the said cam 18 for use in connection with the former-pins 15 and 16 and former 17 as will be described later on.

For moving the tool-carrier 6 at a right angle to the path in which the work-carrier 2 moves, I employ a tool-carrier cam 40 mounted upon the cam-shaft 19 and provided with a cam-path 41 which will be shaped conjointly with its companion cam-path 25, before mentioned, in accordance with the form of the path in which it is designed that the cutting shall be done, the same as in the case of the cam-path 25 in the work-carrier cam 18. The said cam-path 41 is entered by a pin 42 mounted in the inwardly extending arm 43 of a bell-crank lever 44 swinging upon a vertical stud 45 and having a forwardly projecting arm 46 connected by a pin 47 with the outer end of a connecting-rod 48 having its inner end connected by a pivot 49 with the head 50 of a plunger 51 one end of which is supported by the bearing of its head 50 in an upright partition 52 located within and about midway the length of a box-shaped slide 53 provided at its opposite ends with trunnions 54 adapting it to be mounted with a capacity for endwise sliding movement in the frame 7. To the opposite end of the plunger 51 is rigidly secured a bushing 55, bearing in a partition 56, corresponding to the partition 52, and located near one end of the slide 53. Upon the plunger, and about midway of its length, is rigidly secured an abutment collar 57, forming an abutment for the adjacent inner end of springs 58 and 59 encircling the plunger, and abutting at their outer ends against washers 60 and 61 respectively bearing against the inner ends of the head 50 and the bushing 55. The springs 58 and 59 are confined and strongly compressed, and force the washers 60 and 61 against the head 50 and the bushing 55 with an elastic pressure, the head 50 and bushing 55 but serving as abutments to limit the extent of movement of the springs 58 and 59. The washer 60 is also in contact with the inner face of the partition 52, while the washer 61 is in contact with the inner face of the partition 56. Under this construction, whenever the plunger 51 is moved, the box-like slide 53 is moved with it, the springs 58 and 59 being confined, as above stated, and strongly compressed, and stiff enough not to yield under the resistance created by the cutting of the blank. If, however, either the blank 51 or the slide 53 is moved and the movement of the door is with sufficient force obstructed, there will be a relative movement of the plunger 51 in the partitions 52 and 56, and one of the springs 58 and 59 will be further compressed between the abutment-collar 57 and the adjacent partition, the washer between moving upon the plunger 51. A movement in the opposite direction, if obstructed, would cause the other spring to be further compressed, and, in either case, a force equal to the strength of the spring would be exerted to restore the parts to their normal position. There is thus formed an elastic connection between the tool-carrier 6 and the cam 40, but this elastic connection like that between the work-carrier 2 and cam 18 may be replaced by an elastic device of some other form, it being only necessary to provide means in the machine to constantly hold the former-pin upon the former with an elastic pressure during the progress of the work. It is only when the former-pin 15 or 16 and former 17 are brought into play that either of the springs 36, 38, 58 or 59 is caused to yield. The use of the former and former-pin and the elastic connections in the operation of the machine will be further explained later on.

It will be understood that the cam 18 will move the work-carrier 2 with variable movements and speeds predetermined in their character by the form of the cam-path 25 so that dependent upon the form of the cam-path 25, the work-carrier 2 will move in a right line, slow or fast, or come to rest, or retreat and advance, and the same is true as to the tool-carrier 6 the cam 40 and the cam-path 41.

In order to provide for shifting the tool-carrier 6 to bring either the cutter 8 or the cutter 9 into play, I form two holes 62 and 63 in the vertical wall of the box-like slide 53 at points separated from each other to correspond to the separation of the cutters 8 and 9. The said slide 53 is coupled with the tool-carrier 6 through one or the other of the two holes 62 and 63 by means of a coupling-pin 64 secured to a lever handle 65 pivotally suspended from a bracket 66 fastened to the tool-carrier 6 which is formed with a hole 67 through which the pin 64 projects into one or the other of the two holes 62 and 63 in the box-like slide 53.

With reference now to the use of the former-pin and former, I may say that it will be convenient to use them in cutting the cam-paths 25 and 41 in the cams 18 and 40, although the cam-paths in question may be laid out in some other way. In case the pin 15 for instance, and former 17 are used in laying out the said cam-paths, blank cams corresponding to the cams 18 and 40 are mounted upon the shaft 19 and the pins 26 and 42 replaced by tracing pins the pointed ends of which will then rest upon the surface of the blank cams. Now it is apparent that if the former-pin 15 is moved around the former 17 in contact with the edge thereof, and, if the cams are at the same time revolved, the said tracing pins will trace upon

the surface of the blank cam, lines to be followed in the cutting of the cam-paths in the cams. The proportionate speeds of the revolution of the blank cams and the movement of the former-pin upon the former may be regulated as may be found expedient. When the cam-paths are cut the cams are restored to the machines, the pins 26 and 42 are restored thereto, and entered into the respective cam-paths. Now when the machine is operated, the combined cam-paths in the cams will reproduce in the combined movement of the work-carrier 2 and the tool-carrier 6 the exact path of the former-pin 15 around the former 17. It is possible also that the cams might be cut without removing them from the machine by replacing the pins 26 and 42 with revolving cutters instead of with tracing pins, but as already explained I do not limit myself to any method of laying out or cutting the cam-paths in the cams, it being only necessary that they shall be shaped so that in the operation of the machine, they will result in the cutting being done in the desired path.

Assuming that the machine has been constructed so that the cam-paths in the cams will cause the cutting to follow a path of the same form as the form of the pattern or former, it is apparent that the elastic connection between the cam 18 and the work-carrier 2 will act as one piece and that the elastic connection between the cam 40 and the tool-carrier 6 will act as one piece and that none of the springs described will yield. If, however, the former-pin used in connection with the former in tracing the cams, is removed and replaced by a larger former-pin, and a cutter corresponding in diameter to such larger former-pin is employed, it is apparent that one of the two springs of one or the other of the two elastic connections must yield in order to accommodate the larger former-pin with the result that the spring caused to yield will exert a constant effort as long as it is compressed to force the former-pin against and keep it in close contact with the former, whereby all wear, inequalities and back lash will be taken up and an accurate product be secured. Of course in the movement of the former pin in its travel around or over the former, one or more, or all of the springs will be caused to yield in regular or irregular order according to the contour of the former.

In the modified construction shown by Fig. 6 of the drawings, I also utilize the transverse movement of two movable parts or carriers driven automatically and concurrently with predetermined individually variable movements and speeds for securing an ultimate doing of the cutting in the predetermined path. In the employment of this principle, I employ a work-carrier 68 upon which the blank 69 to be milled is mounted. This work-carrier 68 is furnished at one end with a bracket 70 carrying a pin 71 entering a long slot 72 arranged at a right angle to the axis of the work-carrier and formed in an arm 73 at the inner end of a bar which is connected with a cam corresponding to the cam 18. The work-carrier 68 partakes not only of the movement of the cam corresponding to the cam 18, but also of the movement of a cam corresponding to the cam 40 for which purpose the work-carrier 68 is mounted upon a carrier 75 moving at a right angle to the movement of the work-carrier 68 upon an under-cut bearing 76 secured to a bed 77, the carrier 75 being connected at one end by a bell-crank lever 78 with a cam corresponding to the cam 40. In this modification of my invention it will be apparent that the combination of the movements produced by the two cams produces a movement which is imparted to the work which is thereby fed to a revolving stationary cutter 79 indicated conventionally and extending downward from above. If desired, of course, the work-carrier 68 might be connected with the cam 40 and the carrier 75 with the cam 18, this being a mere reversal of connections. What I wish to make clear is that in this modified construction as in the construction shown in Figs. 1 to 5 inclusive, the control of the cutting in accordance with a predetermined form is automatic rather than manual.

I have shown and described my invention as applied to profiling objects by cutting their edges, but my invention is equally applicable for the construction of machines working on the same principle but milling irregularly placed points or bosses on flat surfaces where the cutting is being done in an irregular path. This is illustrated diagrammatically in Fig. 7 in which a series of irregularly placed bosses 80 rise above the surface of a plate 81. By providing the two cams 18 and 40 with cam-paths cut with regard to the irregular placing of the bosses 80 upon the plate 81, the said bosses will, by the ultimate irregular movement derived from the two cams, be successively milled off to the same level, the cutting being done approximately in the line 82. Conversely the manual reproduction of the line 82 may be utilized for tracing upon blank cams lines which, if followed, in cutting cam-paths in the same blank cams, will automatically reproduce the movement represented by the path 82.

It will appear from the showing of Fig. 7 that my invention is not limited to embodiment in machines designed solely for profiling in the strict sense of that word, but that it is adapted to be used in the construction of machines designed for the execution of milling operations of an unsymmetrical character in which the path of the

cutting is irregular as distinguished from a regular path.

I will repeat that the resultant path of the cutting is the product of a movement derived not from either cam taken by itself, but from both cams. Thus, although the carriers may move in regular paths, the variable character of their movements, each acting transversely upon the other, results in the cutting being done in an irregular path. In accomplishing this result the cutter and the work may both move in regular paths or the cutter may move in an irregular path while the work remains stationary, or the work may move in an irregular path while the cutter remains stationary, according to the different arrangements of the combination, but in either arrangement the cutting may be done in an irregular path.

While in the constructions shown in Figs. 1 to 7 of the drawings the carriers move in straight lines, they might be so arranged as to move in arcs of circles as shown in Fig. 8 and the same result be obtained, provided that the carriers were moved transversely with respect to each other and the movements and speeds of each made individually variable so as to conjointly produce the cutting in a predetermined path.

With regard to the modification shown in Fig. 8, it may be said that the construction of the frame 3, the cam-shaft 19 and its supporting bearings, the cams 18 and 40, the worm-gear 21, the worm with the worm shaft, (not shown in this sketch) and the bell-crank lever 44 is the same as shown in Fig. 1. The cutter spindle 10, however, is mounted in bearings formed in the outer end of a long arm 83 which is caused to swing on the fulcrum 84 at the inner end of the arm. The cutter spindle 10 is thereby caused to move in a curved path represented by the dotted line. Movement is given to the arm 83 by means of the cam-path in the cam 40 operating through the bell-crank lever 44. The arm 46 of the bell-crank lever 44 is connected to the cutter-carrying arm 83 by the connecting rod 48, as shown. The work-carrier 2 is mounted also on the end of a long arm 85, which is caused to swing on a stud 86 rising from a bracket 87 secured to the side of the frame 3 as shown. The work-carrier 2 is thereby caused to move in a curved path also represented by a dotted line. The work-carrier 2 receives movement from the cam 18 through the cam-pin 26 mounted in the rear end of the rear section 27 of a connecting rod. The front section 28 of the connecting rod is secured to the rear section by a pivot 88 and to the work-carrier 2 by the pivot bolt 29. This arrangement allows the slight lateral movement of the front section 28 required by the curved movement of the work-carrier 2. The work to be milled is mounted on the work-carrier 2 in position to be acted upon by a revolving cutter mounted in the lower end of the spindle 10. By means of the cams 18 and 40 and the connections described, such movements are given to the cutter spindle 10 and the work carrier 2 as to cause the work to be milled to the required shape. To determine the cam paths in the cams 18 and 40, a former-pin is secured in the place of the cutter in the lower end of the spindle 10 and a former in the place of the blank to be cut on the work carrier 2. The cam-pins 26 and 42 are replaced by tracers and the cam-paths are traced as before described. In order to give a rotary movement to the cutter spindle 10, a bracket is rigidly secured to the upper surface of the arm 83 over the fulcrum 84. From this bracket rises the arm 89 in which is secured the shaft 90 upon which the pulleys 91 are so mounted as to rotate thereon. A belt descending from a revolving shaft overhead is turned by the pulleys 91 in a horizontal direction, and passing around the pulley 13 gives rotary movement to the cutter spindle 10. A bracket 92 secured to one edge of the arm 83 provides for carrying the former-pin 15. Provision may also be made for the use of a former and former-pin in the active operation of this device, but it has not been considered necessary to show it in this drawing.

The method above disclosed of determining the contours of cam paths is not herein claimed as it is made the subject of a separate application filed September 6th, 1912, Serial No. 718,878.

I claim:—

1. In a milling machine for milling in a curved or irregular path, the combination with two parts or carriers movable with respect to each other in transverse paths, of a revolving milling cutter having continuous independent rotary movement with its axis at right angles to the transverse movements of both of said parts or carriers, a single continuously revolving shaft bearing and giving rotary movements to two cam-paths, and motion-transmitting independent connections between said cam-paths and said carriers respectively, each of said cam-paths being so shaped as to give its respective carrier such variable movements and speeds that said carriers, acting conjointly in said transverse paths, may determine the curved or irregular path of the cutting conformably to a predetermined pattern.

2. A milling machine for milling in a curved or irregular path, having two parts or carriers movable with respect to each other in transverse paths, a revolving milling cutter having its axis at right angles to a plane parallel to the transverse movements of said both parts or carriers, and an automatic feeding device including a single re-

volving shaft bearing and giving rotary movements to two cam-paths conjointly so determined in their contours by the contour of the path in which the milling is to be done that when employed in the machine and acting through driving connections upon the parts or carriers they conjointly determine the path of the milling by said milling cutter conformably to the predetermined pattern, said driving connections including means for changing the direction of movement for one of said parts or carriers so that they may move in transverse paths.

3. In a milling machine for milling in a curved or irregular path, the combination with two parts or carriers movable with respect to each other in transverse paths, of a revolving milling cutter having continuous independent rotary movement with its axis at right angles to the transverse movements of both of said parts or carriers, a single continuously revolving shaft bearing and giving rotary movements to two cam-paths, motion transmitting independent connections between said cam-paths and said carriers respectively, and a bell-crank lever for changing the direction of motion imparted to one carrier, each of said cam-paths being so shaped as to give to its respective carrier such variable movements and speeds that said carriers acting conjointly in said transverse paths may determine the curved or irregular path of the cutting conformably to a predetermined pattern.

4. In a milling machine for milling in a curved or irregular path, the combination with a work-carrier and a tool-carrier movable with respect to each other in transverse paths, of a single revolving shaft bearing and giving rotary movement to two cam-paths, a revolving milling cutter mounted upon said tool-carrier, means for securing the work to said work-carrier, and driving connections between the respective carriers and cam-paths including means for changing the direction of movement for one carrier, each of said cam-paths being shaped in such manner as to give to its respective carrier such individually variable movements and speeds that the variable movements of these carriers each acting transversely upon the variable movements of the other in said transverse parts conjointly determine the curved or irregular path of the cutting by said cutter conformably to a predetermined pattern.

5. In a milling machine for milling in a curved or irregular path, the combination with two parts or carriers, movable with respect to each other in transverse paths, of a milling cutter having a continuous independent rotary movement, with its axis at right angles to a plane parallel to the transverse movements of both of said parts or carriers, automatic means for imparting such predetermined individually variable movements and speeds in said transverse paths to the respective parts or carriers that said carriers by re-acting transversely, each upon the variable movements produced by the other, conjointly determine conformably with a predetermined pattern the curved or irregular path of the cutting by said cutter and cause the cutting to be done in said path, which automatic means consist of a single revolving shaft bearing and giving rotary movement to two peripheral cam-paths, each shaped to produce conjointly with the other said variable movements, cam-pins moving in their respective cam-paths, and connections between said cam-paths and said carriers respectively adapted to transmit said variable movements, and including a bell-crank lever for changing the direction of movement for one carrier, whereby the carriers are caused to move in said transverse paths.

6. In a milling machine, the combination with two parts or carriers movable transversely with respect to each other, of two concurrently and continuously revolving cam-paths, a revolving cutter, a former, a former-pin, driving means connecting the respective cam-paths with the respective parts or carriers, whereby the said parts or carriers are automatically driven with predetermined individually variable movements and speeds re-acting upon each other to conjointly cause the cutting to be done in a predetermined path, and elastic means for pressing the former-pin against the former during the operation of the cutter upon the work.

7. In a milling machine, the combination with a work-carrier and a tool-carrier movable transversely with respect to each other, of two concurrently revolving cam-paths, a work-holder carried by the work-carrier, a revolving cutter mounted upon the tool-carrier, a former, a former-pin, driving means connecting the respective cam-paths with the work-carrier and with the tool-carrier respectively for moving the same with predetermined individually variable movements and speeds re-acting upon each other to conjointly cause the cutting to be done in a predetermined path, and elastic means for pressing the former-pin against the former during the operation of the cutter upon the work.

8. In a milling machine, the combination with two parts or carriers movable transversely with respect to each other, of two revolving cam-paths, a work-holder, a revolving cutter, a former, a former-pin, driving connections between the respective parts or carriers and the respective cam-paths, whereby the said parts or carriers are automatically and concurrently moved in transverse directions with predetermined individually

variable movements and speeds re-acting upon each other to cause the cutting to be done in a predetermined path, springs for pressing the said former-pin against the said former during the operation of the cutter upon the work, and means for confining the said springs in a state of compression.

In testimony whereof, I have signed this specification in the presence of two subscribing witnesses.

CHARLES R. NORTH.

Witnesses:
S. E. SPAFFORD,
G. J. SPAFFORD.