F. M. LEAVITT.

SLOTTING MACHINE.

APPLICATION FILED APR. 30, 1901.

996,353.

Patented June 27, 1911.

5 SHEETS—SHEET 1.

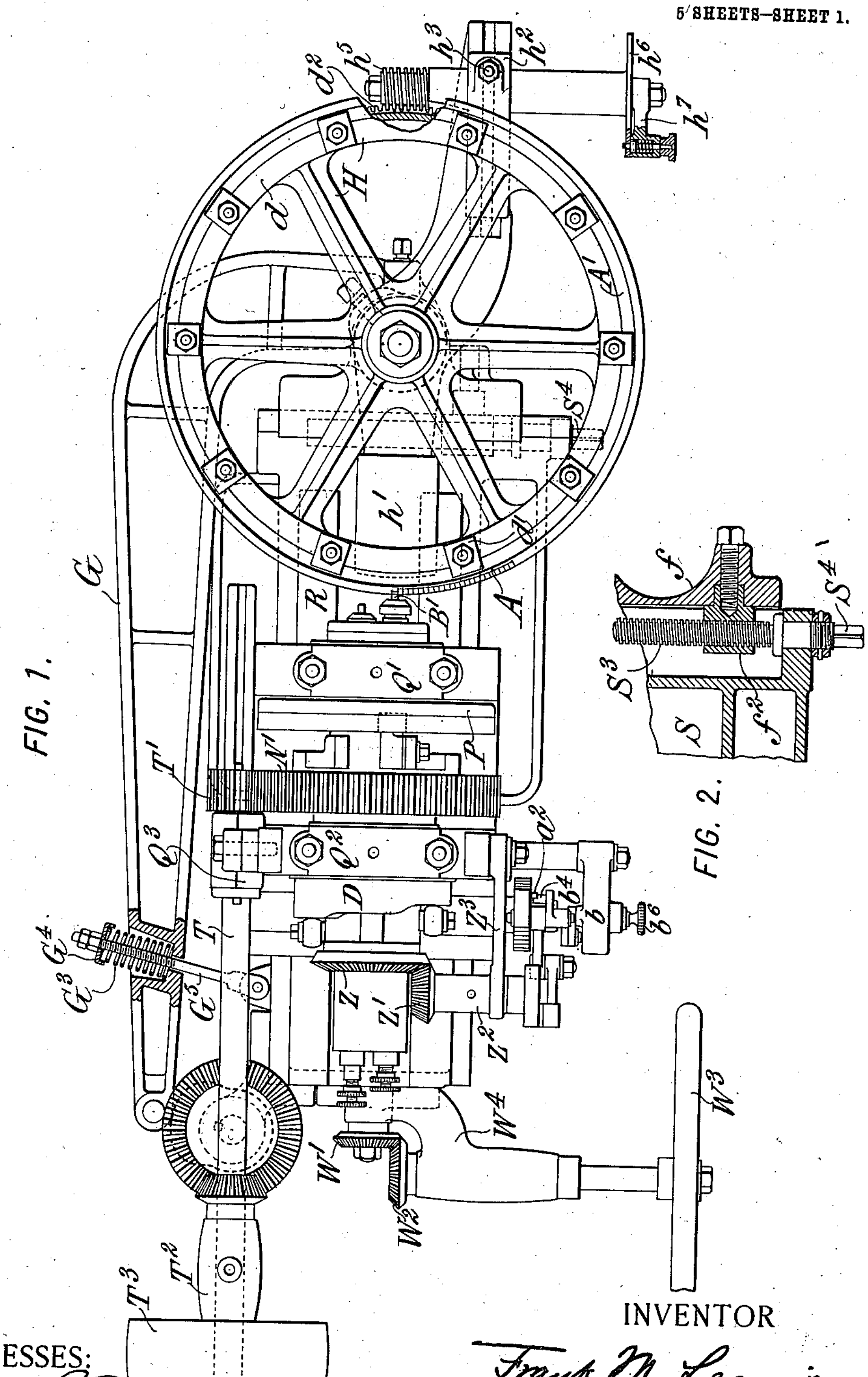

FIG. 1.

FIG. 2.

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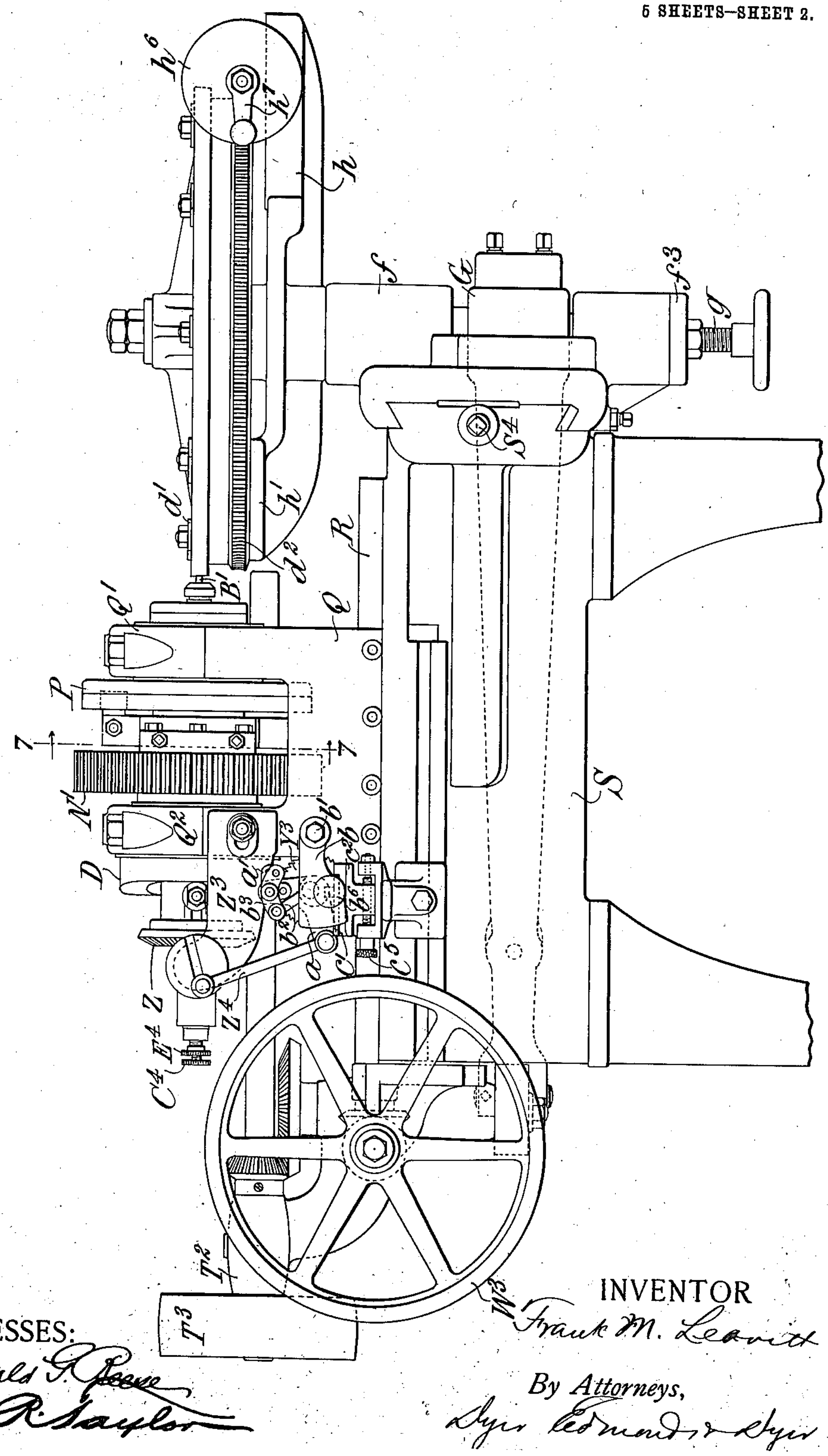
5 SHEETS—SHEET 2.

FIG. 3.



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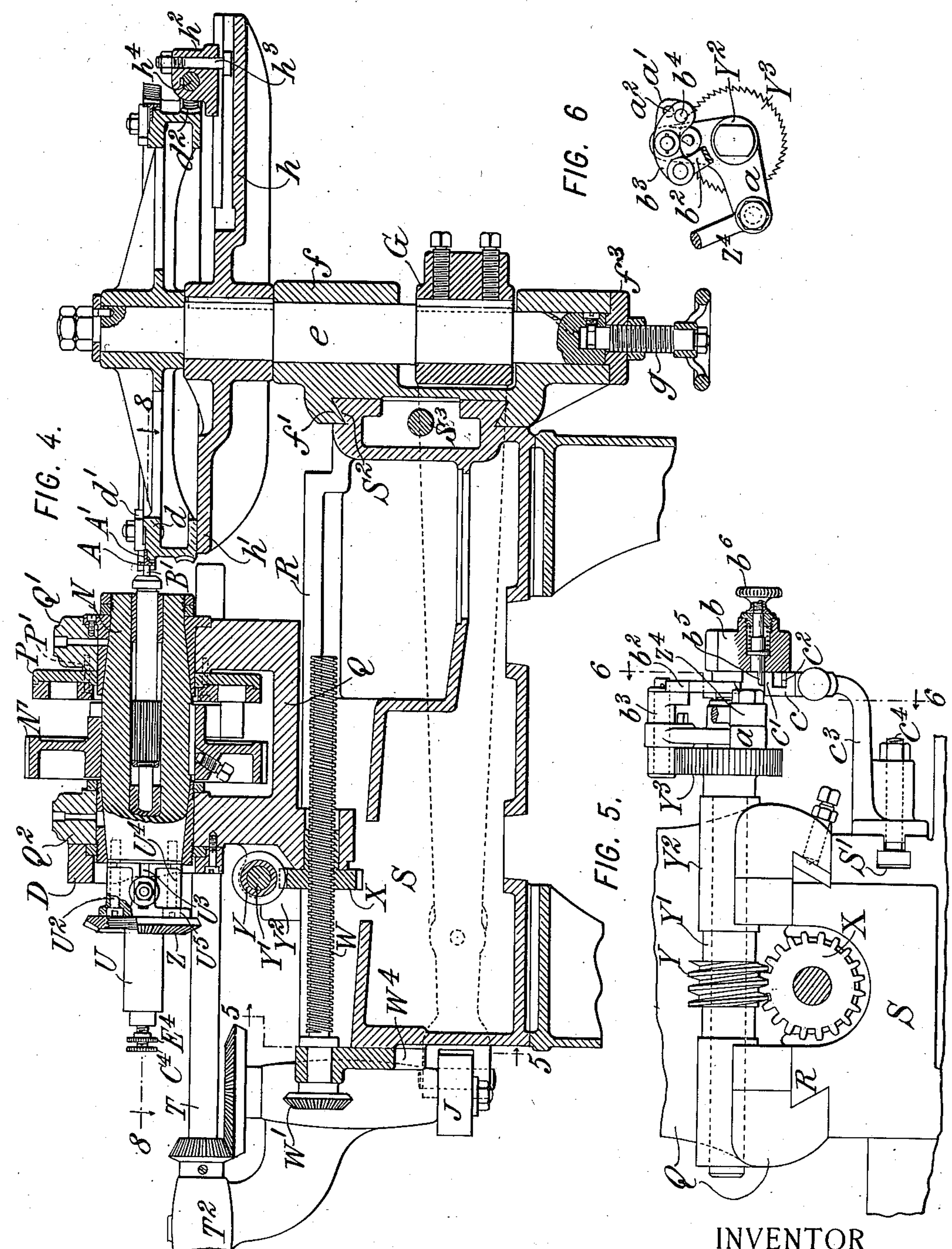

FIG. 4.

FIG. 5.

FIG. 6

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5 SHEETS—SHEET 4.

FIG. 10.

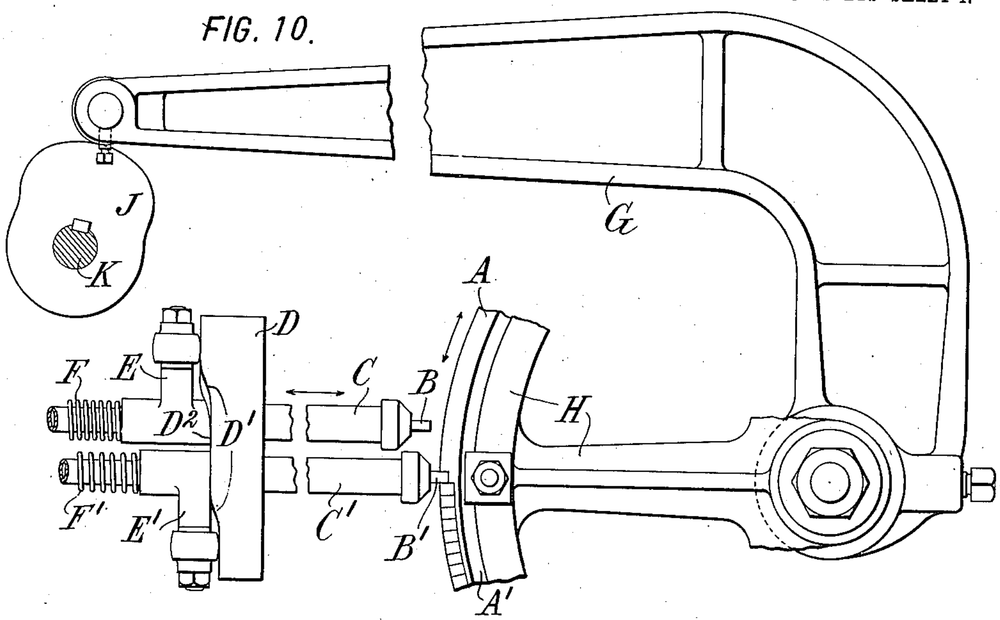


FIG. 7.

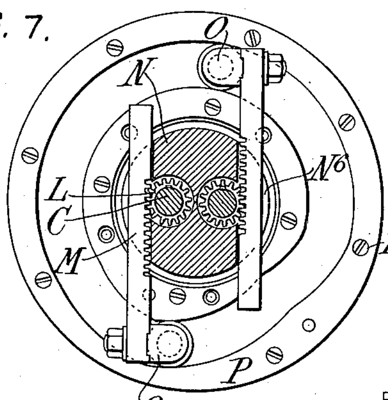


FIG 9.

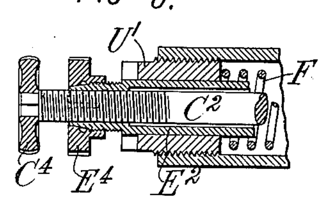
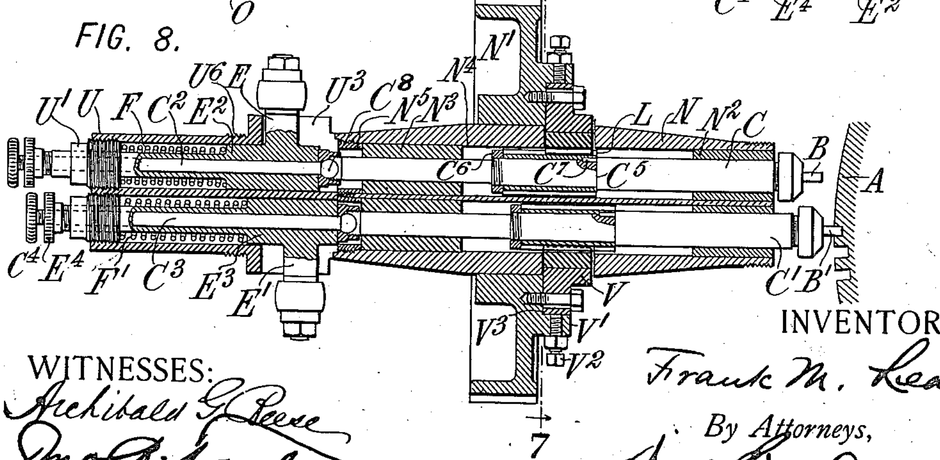


FIG. 8.



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5 SHEETS—SHEET 5.

FIG. 11.

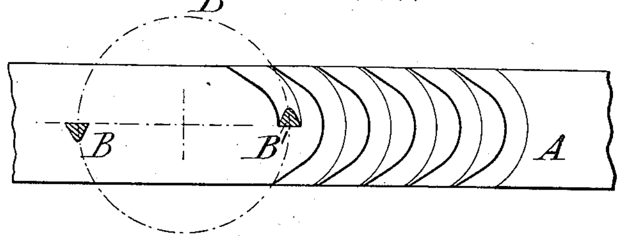


FIG. 12.

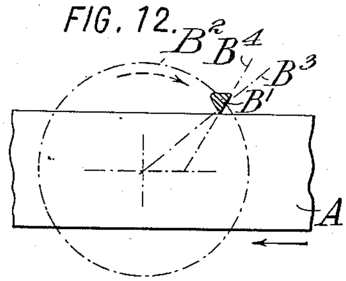


FIG. 13.

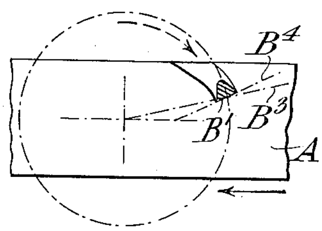


FIG. 14.

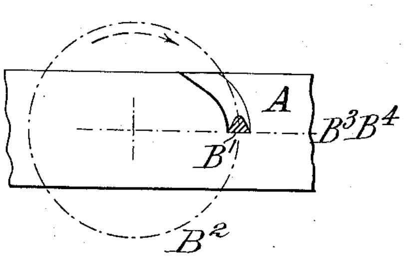
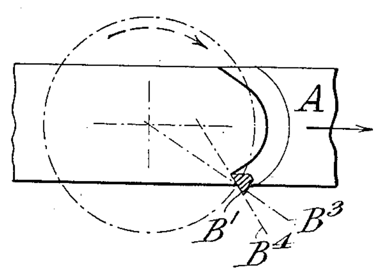


FIG. 15.



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UNITED STATES PATENT OFFICE.

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SLOTTING-MACHINE.

996,353. Specification of Letters Patent. Patented June 27, 1911.

Application filed April 30, 1901. Serial No. 58,108.

To all whom it may concern:

Be it known that I, FRANK M. LEAVITT, a citizen of the United States, residing in the borough of Brooklyn, city of New York, State of New York, have invented a certain new and useful Improvement in Slotting-Machines, of which the following is a description.

My invention relates to machines for cutting curved slots of the character invented by Charles G. Curtis and myself and described in an application for patent filed concurrently herewith (Serial No. 58,129).

My improvement is designed to simplify the machine, to increase its rate of working, and to improve it in respect to some details, all as fully hereinafter explained.

Referring to the accompanying drawings showing an embodiment of my invention, Figure 1 is a plan, partly in section, of a complete machine; Fig. 2 is a detail, in section, of a lateral adjustment of the work carrier; Fig. 3 is a side elevation of a complete machine; Fig. 4 a longitudinal section of the same; Fig. 5 a section on the line 5—5, Fig. 4; Fig. 6 a section on the line 6—6, Fig. 5; Fig. 7 is a cross section approximately on the line 7—7, Figs. 3 and 8; Fig. 8 is a longitudinal section of the tool spindle carrier, approximately on the line 8—8, Fig. 4; Fig. 9 is an enlarged detail of the spindle adjusting means; Fig. 10 is a diagrammatic plan, illustrating a movement of the work and a movement of the cutting tool or tools; Fig. 11 is a diagrammatic elevation, illustrating another movement of the tool or tools; Figs. 12, 13, 14 and 15 are diagrams similar to Fig. 11, illustrating a third movement of the cutting tool.

The improved machine of my invention is adapted for the cutting of slots of various shapes and in various situations, and especially for cutting curved slots across the edge of a plate, as is usual in the cutting of buckets for steam turbines; and I have illustrated a machine especially designed for this purpose. Even though the path of the cut to be made is quite a complex curve, I may, according to my invention, simplify the movement of the tool, and therefore of its operating mechanism, by moving it across the work and simultaneously moving the work so that the slot will be cut in a path compounded of the two movements. By moving the tool in a determined path and varying the nature of the movement given to the work, I may therefore obtain a cut of any desired curvature. Preferably the tool is revolved, and for simplicity in a circular path. I provide also for the use of more than one cutting tool, so that while one is idle, passing from the end of the cut around to the beginning, one or more others are active, cutting out the metal, so that a very rapid operation may be obtained and also the wear and consequent changing of the tools be reduced. For this purpose I provide a carrier for the tool spindle or spindles and rotate the carrier. For cases in which the path of the tool intercepts the work during idle movement, the tool may be arranged to be withdrawn beyond the face of the work during such movement and projected within the face of the work during its active movement, as by reciprocating the tool in its carrier. After each cut, the tool is fed a step forward, in a well known manner, until a slot of the desired depth is obtained. According to my invention, the feeding is then stopped by the action of a weight, spring or the like, which disconnects the feeding mechanism from the tool, and which is so arranged as to be quickly and accurately adjustable for any desired depth of slot.

The various movements of the tool and the work will be understood from the diagrammatic Figs. 10 to 15. Referring first to Figs. 10 and 11, A indicates the work, which in the making of steam turbines is commonly a ring of T-shaped cross section (see Fig. 4), and B B′ are cutting tools, which are carried at the end of spindles C C′. The movement of the tools across the edge of the plate is preferably obtained by rotating them on an axis perpendicular to the edge, as shown in Fig. 11. The tools are arranged to cut only during their downward movement, and as they rise on the upward movement past the uncut portion of the work, they are withdrawn. The means for accomplishing this withdrawal (shown in Fig. 10) is a stationary cam D, against which the arms E E′ of the tool spindles are pressed by means of springs F F′. To convert the simple rotary movement of the tool into a compound movement relatively to the work, the work is oscillated, as shown by the double arrow in Fig. 10. A convenient means for this purpose is provided in the lever G, which is fixed to the work holder

H, and which is given an oscillating movement by means of a cam J on a shaft K, which is connected in operation with the means for rotating the tool. The effect of this compound movement is shown in Fig. 11, the slots A′ being more elongated than the path of the cutting tools B and B′. It is obvious from this figure that during the first half of the operation the work has moved to the left, and during the second half to the right. The rate and amount of this oscillatory movement determine the exact nature of the curve along which the slot is cut, and this may be varied to suit varying conditions of use by suitably varying the design of the cam J.

If the forward or cutting edge of the tool were always normal to its path of rotation, as would be the case if the tool spindle were fixed non-rotatively in its carrier, such cutting edge would not be normal to the slot because of the movement of the work. Therefore I provide for oscillating the cutting edge of the tool on its own axis as it rotates around the axis of its carrier, this movement being illustrated in Figs. 12 to 15, in which B^2 is the path of the tool, B^3 the radius of said path and which is always normal thereto, and B^4 the line of direction of the cutting edge of the tool. As the tool approaches the starting point of the slot, its edge is turned from a normal position coincident with the line B^3 to a position coincident with the line B^4 so as to meet the work A moving toward it in the direction of the arrow (Fig. 12). Between the beginning and the middle point (Fig. 13) the movement of the work is slower, and the angle between the lines B^3 and B^4 is reduced. At the middle position (Fig. 14) the work has made its greatest advance in one direction and is stationary on the point of movement in the opposite direction; the cut is therefore coincident in direction with the path B^2 of the tool, and the lines B^3 and B^4 coincide. Between the middle and the end of the slot (Fig. 15) the edge B^4 is moved at an angle relatively to the line B^3 equal to the angle through which it was moved in the first half of the cut, but the angle being in the opposite direction because the work is moving in the opposite direction. For obtaining this oscillation of the tool to maintain its edge normal to the path of the cut, I preferably employ the mechanism shown in Fig. 7, in which the tool spindle C carries a pinion L engaging a rack M, which partakes of the rotary motion of the spindle carrier N, and which produces a rotation of the spindle on its own central axis by the engagement of the end O of the rack bar with a fixed cam P.

As shown in the drawings, I may use two tools, one of which is in active operation cutting the slot during a part of the time that the other is passing from the end of the slot around to its beginning. Obviously a greater number of tools may be employed if desired, placing them closer together or enlarging the circular path thereof, as desired; or I may employ only one tool, and still obtain some of the advantages of my improved machine.

For feeding the tools forward as the depth of the cut increases, I preferably carry them on a slide Q, which is guided on slideways R of the supporting frame S, the feeding movement of the slide being accomplished by an improved mechanism hereinafter described. At opposite ends of the slide Q may be arranged bearings Q′ Q^2 of any suitable design, in which the spindle carrier N rotates. The rotation of the carrier N is conveniently effected by providing a gear N′ keyed thereon, which is driven from a shaft T by means of a pinion T′ splined on the shaft, as shown, and fed forward with the slide Q, the bearing Q^2 being laterally extended as at Q^3 and revolubly engaging the pinion T′, as is common in the art. The shaft T may be also supported in a fixed bearing T^2, and driven by any suitable means, as a pulley T^3.

For effecting the reciprocation of the tools in the carrier N, I preferably arrange the cam D on the outer face of the bearing Q^2. The tool spindles C C′ are provided at their rear ends with adjusting rods C^2 C^3, which engage revolubly, as by ball-and-socket joints C^5, with the spindles C, C′, so as to transmit longitudinal movement of the spindles without receiving oscillatory movement therefrom. On the rods C^2 C^3 are sleeves E^2 E^3 carrying arms E E′. The sleeves are clamped tightly on the rods C^2 C^3, and are pushed by the springs F F′ in a direction to move the tools outward, while the cam D acts preferably through rollers, as shown, to move the sleeves and consequently the rods, spindles and tools inward or away from the work.

The length of movement of the sleeves E^2 E^3 may be longitudinally made so as to determine the extent to which the spindles are projected out of the carrier, and especially so as to set the forward edge of the tools even at starting. A convenient arrangement of this adjustment is shown in Fig. 9, in which the sleeve E^2 is formed at its end to screw on the rod C^2, but is split, as shown, and adapted to be clamped tightly at any point on the rod by a hand nut E^4, the rods being turned to set it to any desired position by means of the head C^4. The extension rods, sleeves and springs are carried in a double-barreled extension U of the spindle carrier N, which may be conveniently bolted thereto, as shown in dotted lines at U^2 in Fig. 4. Screw plugs U′ close the outer ends of the bores of the member U and form a support against which the springs F F′

end of the support, so that the weight b will fall when the pin b^5 passes the upper ledge c' and will be caught by the lower ledge c^2, such movement being sufficient to throw the pawl out of engagement with the ratchet wheel. The dropping of the weight may be arranged to give a signal to the operator that the cutting of the bucket is finished. Thereupon the slide and tools are withdrawn to their original position by means of the hand wheel W^3, as explained, the pin b^5 and the weights traveling on the lower ledge c^2 of the support. If the slide has been drawn back to its rearmost position, which will be before the pin b^5 escapes from the rear edge of the ledge c^2, the pin b^5 is withdrawn by means of the knob b^6 and the weight lifted again to its former position (Fig. 5), which brings the feed again into action.

The support c of the weight is preferably carried by an arm c^3 attached to the main frame S at any suitable position thereon by means of the groove S′ in the side thereof, and the bolt c^4. After being set by this means approximately in the desired position, the nicety of adjustment of the support c is arranged for by mounting it on an adjusting screw c^5 (Fig. 3) supported at opposite ends in the outer end of the arm c^3, and by turning which the support c is moved slightly forward or backward. I can thus adjust to a nicety the depth of the slot, as well as the absolute uniformity of the successive slots.

The work holder may be of any suitable form which permits the relative movement of the work previously explained, and permits the proper feeding of it to produce the successive slots. In the form which I show and which I have found very well adapted for the specific purpose, I employ a ring d (Figs. 1 and 4), to which the work A may be attached in any suitable manner, as by means of the rear flange A′ thereof resting in a rabbet on the upper edge of the work holder and clamped thereto, as by means of clamps d' and bolts. The work holder d is mounted on a shaft e rotatably, but during the cutting of a single bucket is held fast to said shaft so as to be oscillated by the movement of the lever G which is keyed to the shaft e. The shaft e is adjustable vertically to provide for work upon pieces of different dimensions, and is also adjustable laterally of the frame of the machine, whereby it is accurately alined with the cutting tools in any desired relative position. A simple arrangement of the shaft for this purpose consists in mounting it in a frame f, which has on one side an undercut groove f' engaging an undercut tongue S^2 on the forward end of the main frame. A screw shaft S^3 extends across the front of the frame of the machine, and screws through a nut f^2 carried by the frame f of the upright shaft e. By turning the screw shaft S^3 in one direction or the other by means of a square head, as S^4, the desired lateral adjustment is effected. The vertical adjustment of the shaft e is conveniently effected by means of a screw g passing through the plate f^3 attached to the under side of the frame f and carrying the shaft e up or down by screwing inward or outward.

For holding the work holder d rigid with the shaft e during the cutting of each bucket, and permitting at the same time the feeding of the work from the position for cutting one bucket to that for cutting the next, I provide an arm h, which is keyed on to the shaft e, and which has also an extension h' supporting the work at the point at which the cutting actually takes place. Carried on the arm h is a bearing h^2, which is adjustable thereon as shown, and held in any desired position by means of a bolt h^3. A shaft h^4 is carried in the bearing h^2 and has at one end a helical gear h^5 (Fig. 1) which engages with a corresponding gear d^2 on the work holder. The bearing h^2 is extended on the opposite side from the gear, and carries at its outer end a disk h^6, upon which is any desired means, such as an aperture, for engaging a spring-pressed pin at the end of the hand lever h^7, by which the shaft h^4 is turned and the work moved from one position to another. The pin being withdrawn from the aperture and the handle rotated, the parts are so arranged that the pin automatically springs into the aperture and checks the further movement of the work as soon as it has advanced the desired distance. Any other stop of a similar nature may be used in place of that shown, various expedients being possible for this purpose.

The oscillation of the lever G is conveniently obtained from a cam J on a vertical shaft K driven by gearing, as shown, from the driving shaft T, and mounted in bearings carried upon the main frame of the machine. This cam throws the end of the lever outward, and a spring G^3, adjustable by means of the plate G^4 and adjusting nuts, and carried upon a rod G^5 pivoted to the frame of the machine, draws the lever in and maintains its free end against the cam. The shape of the cam produces such an oscillation of the work as to give any desired shape of slot. The slots produced by the particular cam shown are best shown in Figs. 11, 12, 13, 14 and 15, which also show the effect of the rotation of the tool upon its individual axis.

What I claim is:

1. In a machine for cutting curved slots across the edge of a plate by a succession of cuts, the combination of a cutting tool traveling through the work on a path concentric to a fixed center, means for simultaneously mov-

bear. The rear end of the extension U is made just of sufficient size to carry the rods, sleeves and springs. The front end is provided with lateral slots U^3, through which the arms E E′ extend, and with ribs U^4 perpendicular thereto, a flange U^5 uniting the slotted and plain ribs at the outer end, which flange carries a screwthreaded ring U^6 for attachment of a carrier, as hereinafter described (see Figs. 4 and 8).

The inclined portions of the cam D, which I designate as a whole by D′ and of which there are two reversely arranged on opposite sides of the cam, are provided at their central and therefore immediately opposite points with a level portion D^2 half way between the highest and the lowest points of the incline. For setting the tools, the carrier is revolved until the opposite arms E and E′ coincide with the opposite level points D^2, and the outermost edges of the tools are then set in a plane perpendicular to their axis of revolution by any suitable means. Now as they are revolved and as each arm E E′ in turn comes opposite the lowest point of the cam D, the corresponding tool projects exactly the same distance into the slot as the other tool projected when at the same point.

The cam P for oscillating the spindles may be conveniently secured to the bearing Q′ of the slide Q, as by bolts P′ (Figs. 4 and 7). The pinions L and racks M may be supported in any suitable manner. In the machine shown, the bore of the carrier N is made large enough throughout for the pinions L, the spindles being carried in fixed bearings N^2 at the outer end of the bore and in removable bearings N^3 at the inner end of the latter, being stopped at one end by a shoulder N^4 and at the other end by a removable ring N^5. The pinions L are held on the spindles by shoulders C^5 at one end and nuts C^6 at the other, while keys C^7 hold them against rotation. The carrier N is cut on opposite sides to form grooves N^6 for the rack bars M. To form the outer wall of the guide in which the rack bars move, I preferably use bars V, which are carried by the gear N′ which, as shown in Fig. 4, is keyed to the spindle carrier N. The gear N′ is formed with ribs V′ through which pass bolts V^2 for adjusting the position of the bar V. The bar V is bolted, as shown, to the gear N′, the bolt holes V^3 being enlarged to permit the adjustment referred to. By this means the rack bars partake of the rotary motion of the spindle carrier, and are free to have an additional reciprocatory motion to oscillate the pinions L and the tools, as explained.

For feeding the slide Q, I preferably employ a screw shaft W (Fig. 4), which operates within a nut X carried by the slide. For the rearward movement, I provide for the rotation of the shaft W through a pinion W′ on its end engaging a second pinion W^2 (Fig. 1) which is operated by a hand wheel W^3, the bearings for the shafts of the two pinions W′ and W^2 being preferably in a single casting W^4 carried on the end of the supporting frame, as shown best in Fig. 1. The forward movement is given to the slide by rotating the nut X on the shaft, and for this purpose it is formed externally with helical teeth engaging corresponding teeth on a helical pinion Y carried on a cross shaft Y′ supported in bearings Y^2 on the slide Q.

For operating the shaft Y′, I preferably provide it with a ratchet wheel Y^3 at one end (Fig. 5), which is driven from a gear Z which is screwed on to the rear portion U of the spindle carrier. The preferred means for transmitting motion from the gear Z to the ratchet wheel Y^3 comprises a pinion Z′ on a shaft Z^2 supported in a bearing member Z^3 which is attached to the rear end Q^2 of the slide, said shaft carrying at its outer end an adjustable pin, to which is connected a link Z^4 connected at its opposite end to an oscillating member *a*, upon which a pawl *a′* is mounted and in engagement with the ratchet Y^3. The pin is made adjustable radially so as to adjust the amount of movement of the pawl, and consequently the amount of feed for each revolution of the spindle carrier. The member *a* is preferably an angle lever pivoted on the shaft Y^2.

I provide also a very simple means for stopping the feed automatically, whereby the successive slots may be made of uniform depth, and their depth may be accurately and easily regulated. This mechanism is arranged to automatically free the pawl from engagement with the ratchet. For this purpose I arrange a weight *b* in such a way that it is supported during the time which it is desired to continue the cutting, but which drops from its support at the end of such predetermined feed and thereby stops the movement, as explained. The weight is preferably pivoted at *b′* upon the slide, and is connected by a link b^2 with one end of an arm b^3 pivoted on the supporting arm *a* of the pawl, and carrying a pin b^4 which normally lies under a similar pin a^2 near the free end of the pawl *a′*, as shown best in Fig. 1. The support for the weight may be a fixed portion of the machine, or may be adjustably attached to any fixed portion of the machine, such as the main frame. This support is shown at *c* (Fig. 5), and is arranged underneath a pin b^5 on the inner face of the weight, and which is held in position by a spring but which may be withdrawn by means of a knob b^6. To prevent the weight from dropping too far, the support *c* is provided with an upper ledge *c′* (Fig. 3) and a lower ledge c^2, the upper ledge being terminated short of the forward ing the work toward the center of movement of the tool as the tool enters the work and away from the center of movement of the tool as the tool leaves the work, and means for oscillating the cutting edge of the tool on its axis to keep it normal to the cut.

2. In a machine for cutting curved slots across an edge of a plate by a succession of cuts, the combination of a cutting tool having a circular movement, and means for simultaneously moving the work toward the center of movement of the tool as the tool enters the work, and away from the center of movement of the tool as the tool leaves the work.

3. In a machine for cutting curved slots across an edge of a plate by a succession of cuts, the combination of a cutting tool having a circular movement, means for simultaneously moving the work to vary the path of the cut from a true circle, and means for reciprocating the tool toward and away from the work, so that the tool engages the work on one side of the circular path and clears it on the other side.

4. In a machine for cutting curved slots across an edge of a plate by a succession of cuts, the combination of a cutting tool having a circular movement, means for simultaneously moving the work to vary the path of the cut from a true circle, and means for oscillating the cutting edge of the tool on its own axis to keep it normal to the cut.

5. In a machine for cutting curved slots across an edge of a plate by a succession of cuts, the combination of a cutting tool having a circular movement, means for simultaneously moving the work to vary the path of the cut from a true circle, means for oscillating the cutting edge of the tool on its own axis to keep it normal to the cut, and means for reciprocating the tool toward and away from the work, so that the tool engages the work on one side of the circular path and clears it on the other side.

6. In a machine for cutting curved slots across an edge of a plate by a succession of cuts, the combination of a plurality of cutting tools, means for moving them in the same curved path across the work, and means for successively withdrawing said tools, so as to clear the work on their return movement.

7. In a machine for cutting curved slots across an edge of a plate by a succession of cuts, the combination of a plurality of cutting tools, means for moving them in the same circular path across the work, means for feeding the tools and work together, whereby a succession of cuts will be made in the same path, and means for withdrawing a tool beyond the face of the work during its idle period, while another tool during its active movement is projected within the face of the work, and means for simultaneously moving the work toward the center of movement of the tools as a tool enters the work and away from the center of movement of the tools as a tool leaves the work.

8. In a machine for cutting curved slots across an edge of a plate by a succession of cuts, the combination of a plurality of cutting tools, means for supporting the work within the path of the tools, means for moving the tools in the same circular path across the work so as to make a succession of cuts in the same path, and means for withdrawing a tool beyond the face of the work during its idle period, while another tool during its active movement is projected within the face of the work, and means for simultaneously moving the work toward the center of movement of the tools, as a tool enters the work, and away from the center of movement of the tools as a tool leaves the work.

9. In a machine for cutting curved slots across an edge of a plate by a succession of cuts, the combination of a plurality of cutting tools, means for moving them in the same circular path across the work, and means for withdrawing a tool beyond the face of the work during its idle period, while another tool during its active movement is projected within the face of the work, means for simultaneously moving the work to vary the path of the cut from a true circle, and means for oscillating the cutting edges of the tools on their own axis to keep them normal to the cut.

10. The combination with a plurality of cutting tools, of a carrier for said tools, means for rotating said carrier, and means for oscillating said tools in said carrier during the rotation thereof.

11. The combination with a plurality of cutting tools, of a carrier for said tools, means for rotating said carrier, means for longitudinally reciprocating said tools in said carrier during the rotation thereof, and means for oscillating said tools in said carrier during the rotation thereof.

12. The combination with a cutting tool, of feeding mechanism comprising a ratchet, a pawl, means for oscillating said pawl in engagement with said ratchet, a weight, means whereby the dropping of said weight frees said pawl from engagement with said ratchet, and a support for said weight, said weight and support being relatively movable as said tool is fed, said weight arranged to drop from said support at the end of a determined feed to free said pawl and stop the feeding movement.

13. The combination with a cutting tool, of feeding mechanism, a weight for disconnecting said feeding mechanism, and a support for said weight, said support being adjustable to determine the disconnection of said feeding mechanism.

14. In a machine for cutting curved slots

across the edge of a plate by a succession of cuts, the combination with a cutting tool having a circular movement, of a work holder pivotally supported at an angle to the axis about which the tool revolves, a cam coördinated in movement with the revolving cutting tool, and an arm connected with the work holder and engaging said cam for rocking the work holder and varying the cut of the tool in the work from a true circle.

This specification signed and witnessed this 26th day of April 1901.

FRANK M. LEAVITT.

Witnesses:

ARCHIBALD G. REESE,

JNO. R. TAYLOR.