No. 678,385. Patented July 16, 1901.

F. E. FERRIS.

MACHINE FOR GENERATING GEAR TEETH.

(Application filed Mar. 21, 1900.)

(No Model.) 6 Sheets—Sheet 1.

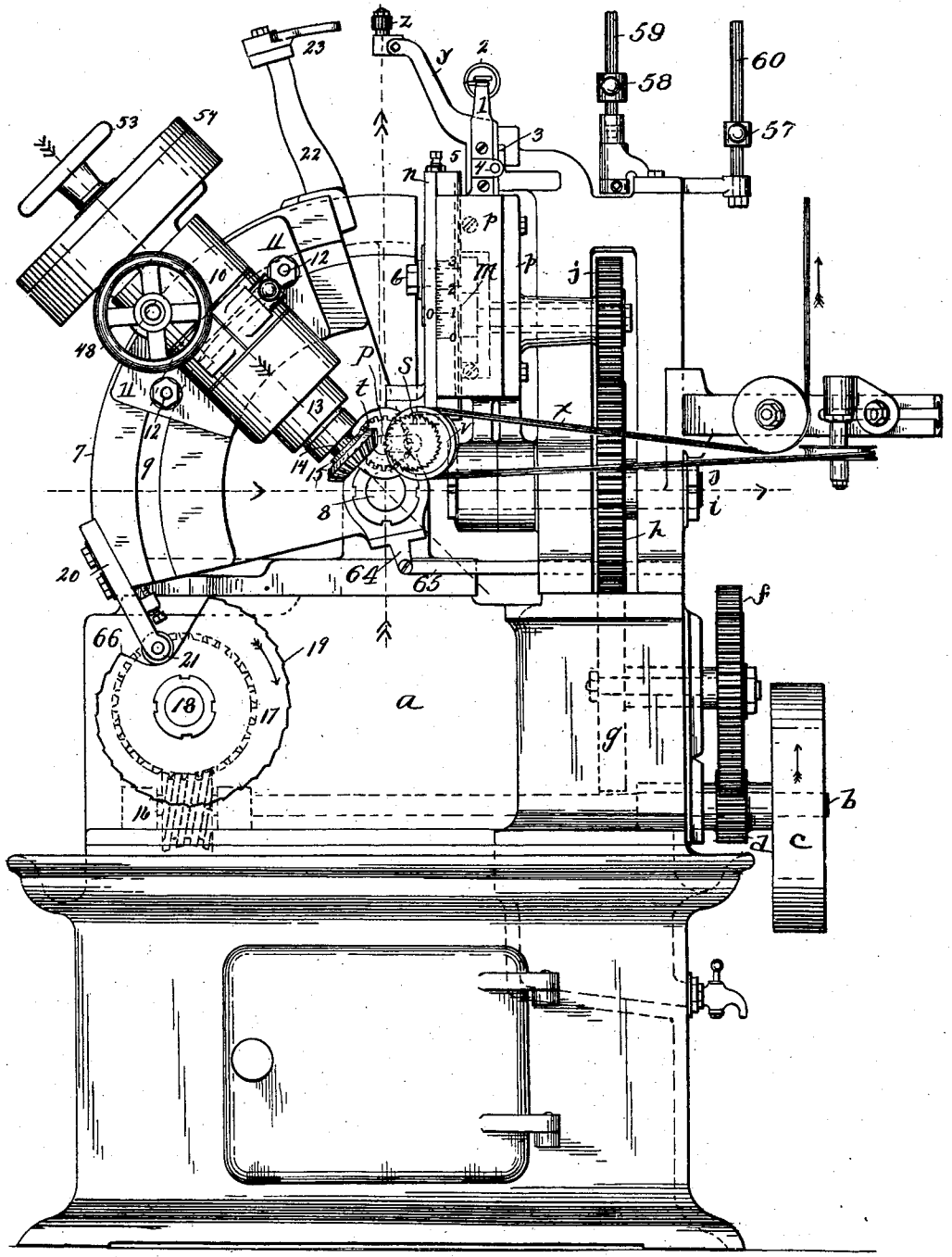


Fig. 1.

WITNESSES.

O. J. Barringer

M. Hickey.

INVENTOR.

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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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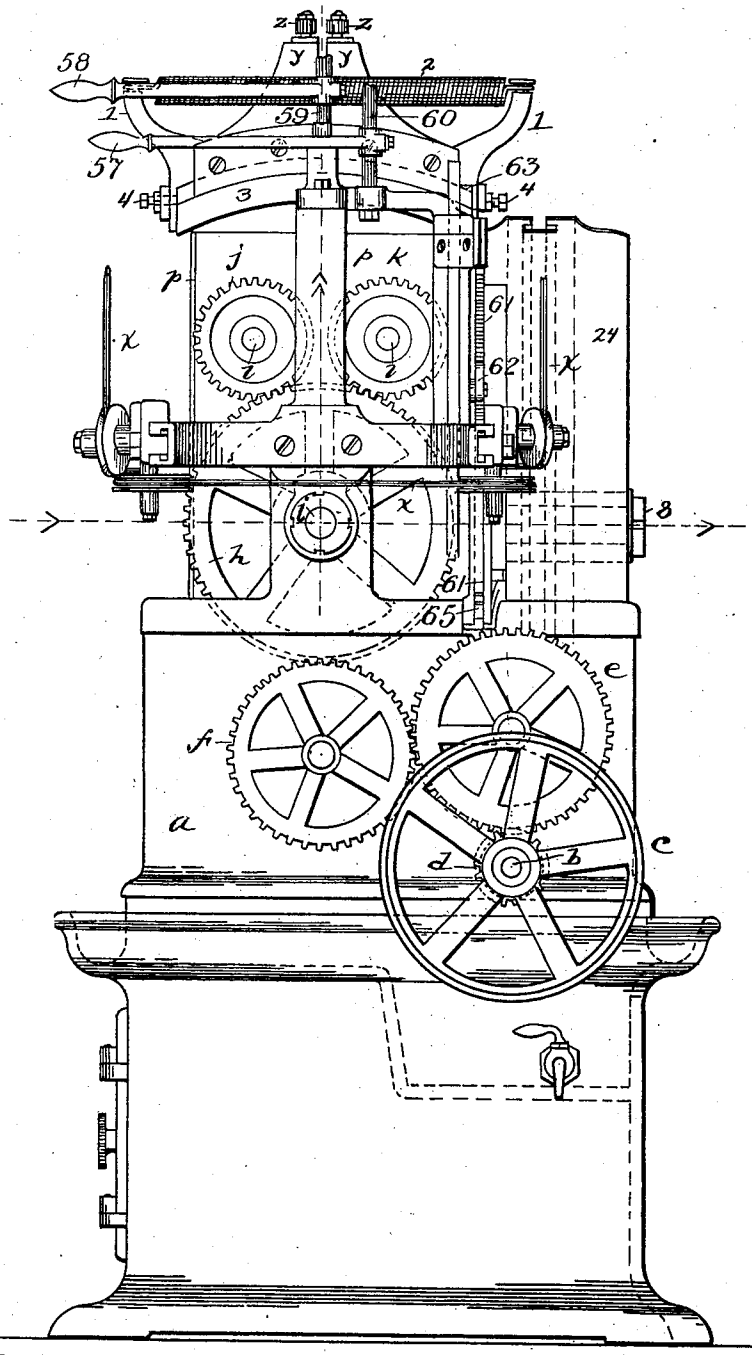


Fig. 2.

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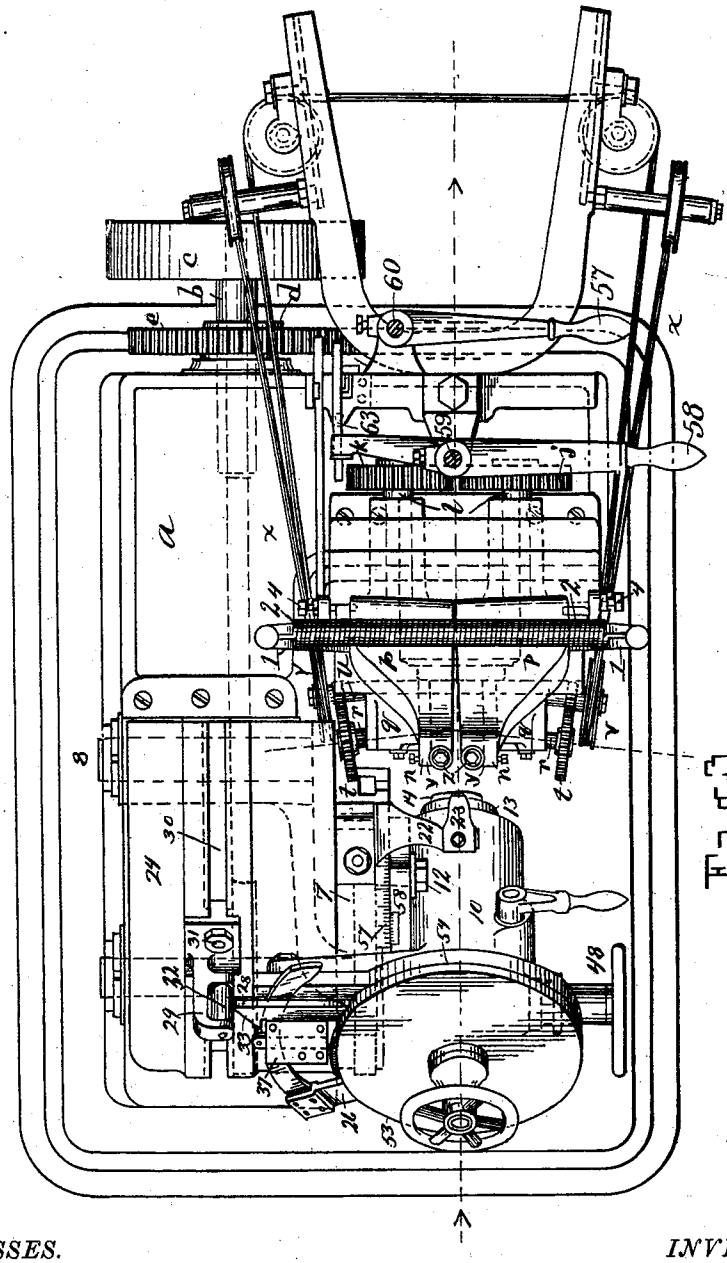


Fig. 3.

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(No Model.) (Application filed Mar. 21, 1900.)

6 Sheets—Sheet 4.

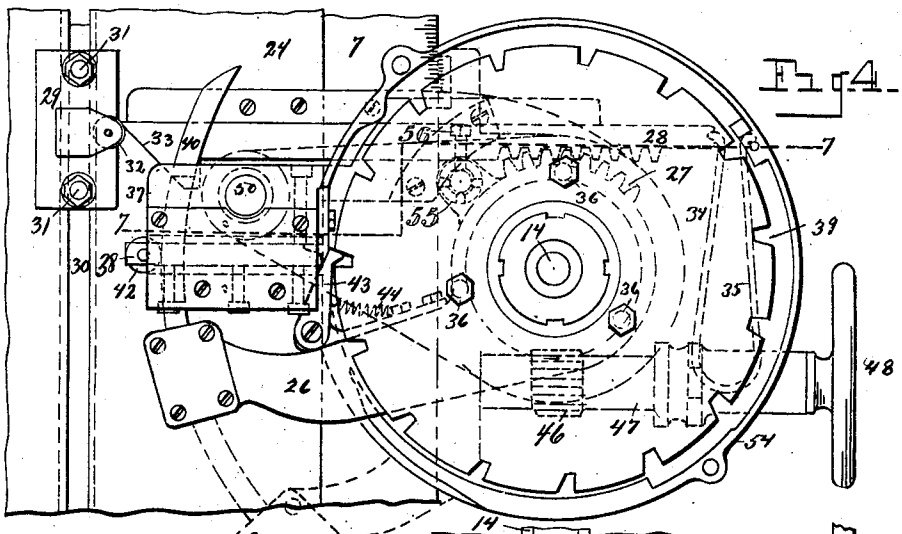


Fig. 4.

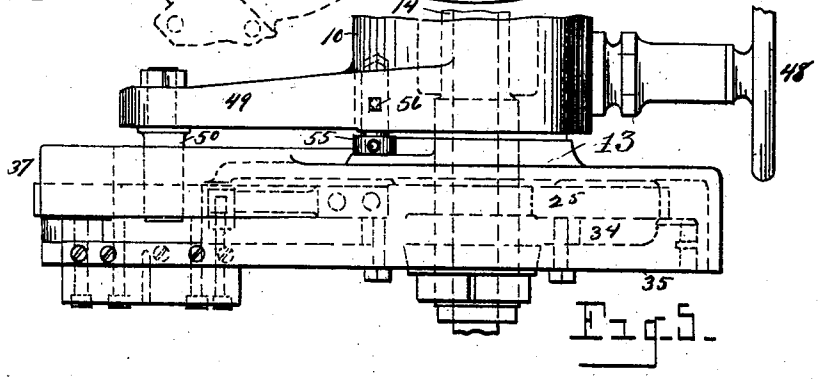


Fig. 5.

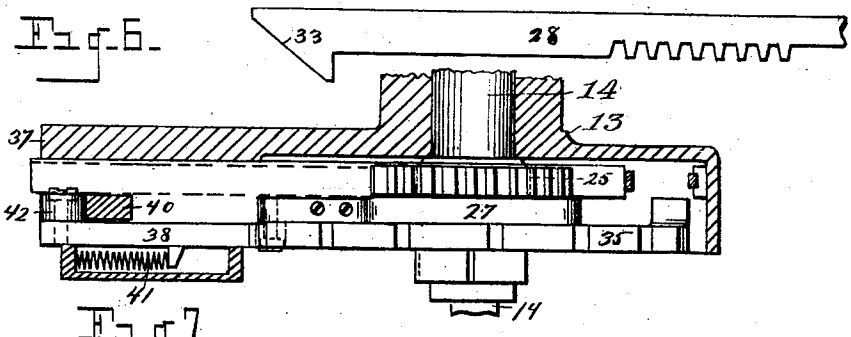


Fig. 6.



Fig. 7.

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MACHINE FOR GENERATING GEAR TEETH.

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6 Sheets—Sheet 5.

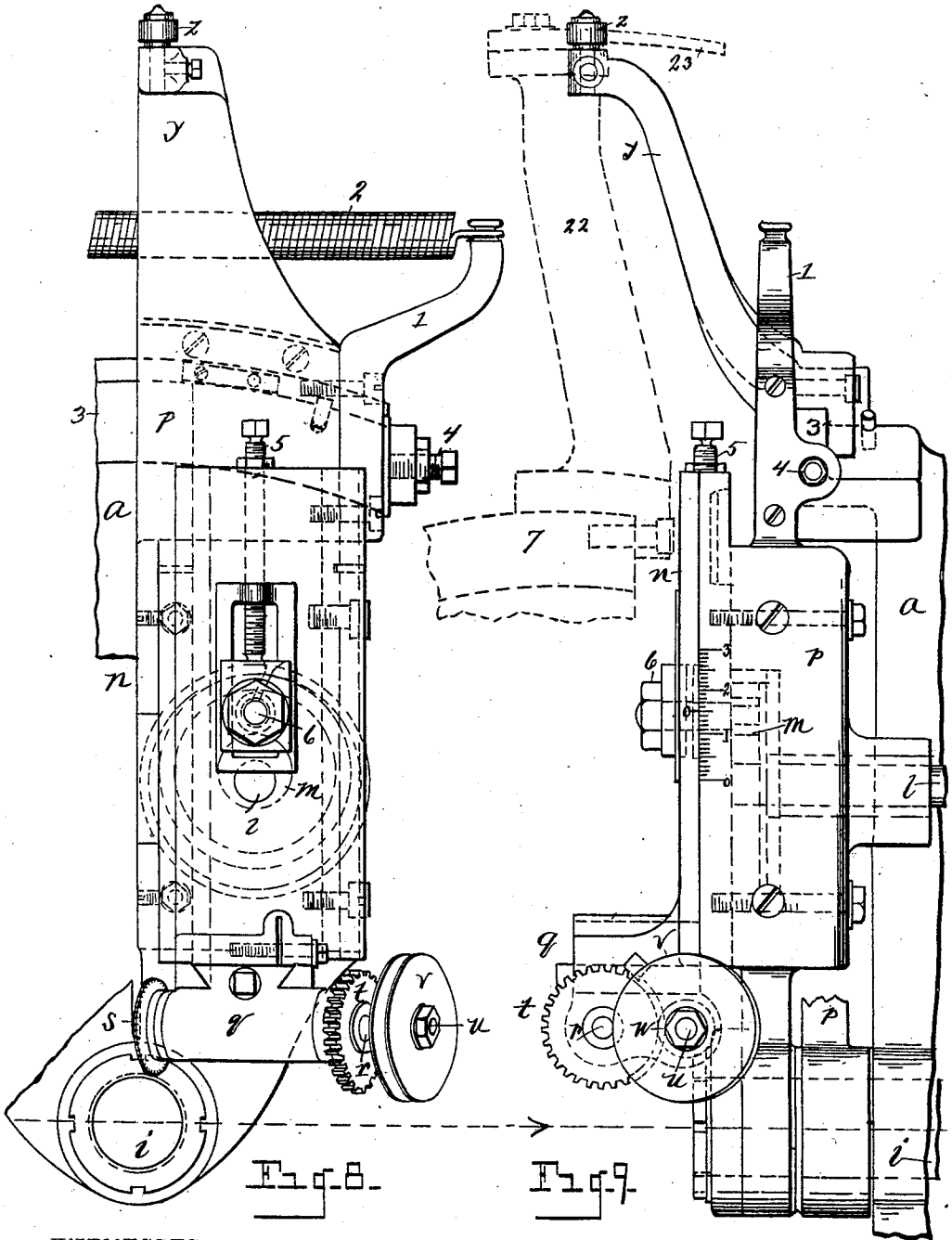


Fig. 8.

Fig. 9.

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(No Model.) 6 Sheets—Sheet 6.

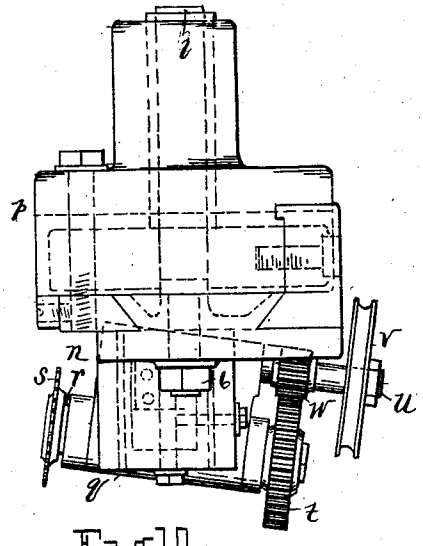


Fig. 10.

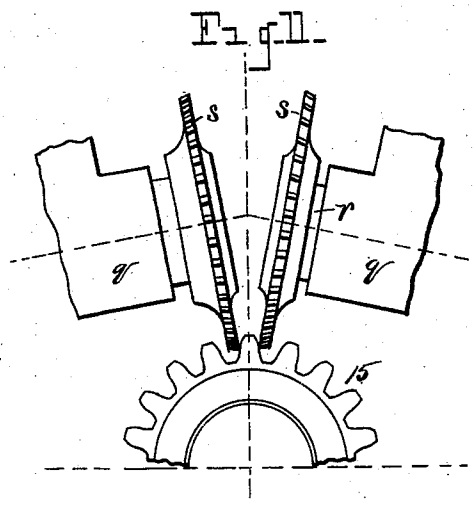


Fig. 11.

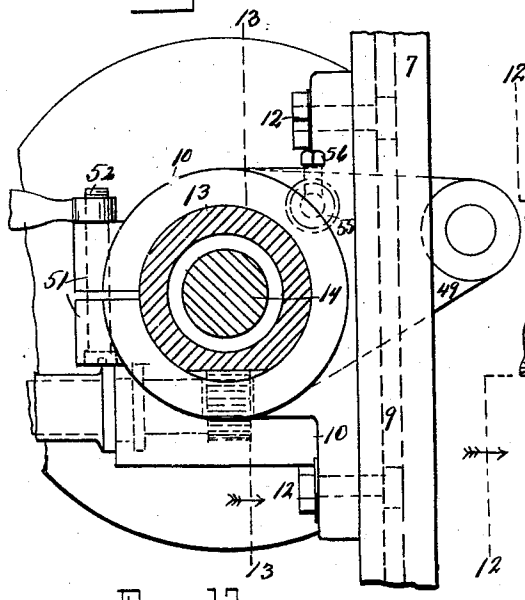


Fig. 12.

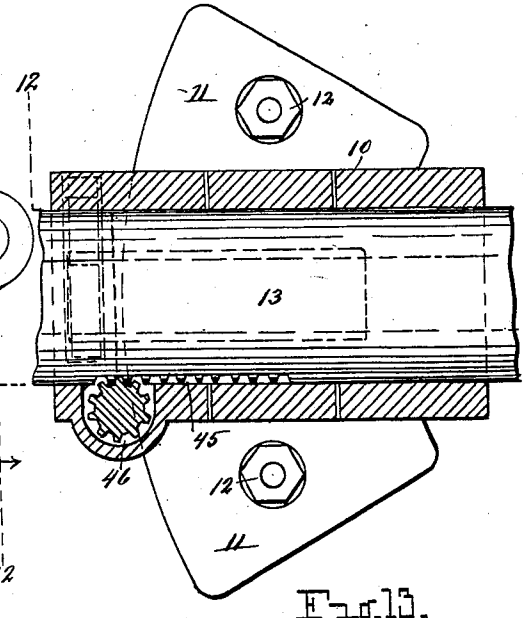


Fig. 13.

WITNESSES.

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UNITED STATES PATENT OFFICE.

FRANK E. FERRIS, OF DETROIT, MICHIGAN, ASSIGNOR TO THE LELAND & FAULCONER MANUFACTURING COMPANY, OF SAME PLACE.

MACHINE FOR GENERATING GEAR-TEETH.

SPECIFICATION forming part of Letters Patent No. 678,385, dated July 16, 1901.

Application filed March 21, 1900. Serial No. 9,537. (No model.)

To all whom it may concern:

Be it known that I, FRANK E. FERRIS, a citizen of the United States, residing at Detroit, county of Wayne, State of Michigan, have invented a certain new and useful Improvement in Machines for Generating Gear-Teeth; and I declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, which form a part of this specification.

My invention has for its object a novel machine for generating gear-teeth; and it consists of the structure, combination, and arrangement of devices hereinafter described and claimed, and illustrated in the drawings submitted herewith and forming a part of this specification, in which—

Figure 1 is a view in side elevation. Fig. 2 is a view in end elevation. Fig. 3 is a plan view, the gear being omitted. Fig. 4 is a view in plan of the indexing mechanism, the cover thereof being removed. Fig. 5 is a side elevation of the same. Fig. 6 is a detail view of the rack-bar. Fig. 7 is a view in section on the line 7 7, Fig. 4. Fig. 8 is a front elevation of one of the rams and related parts. Fig. 9 is a side elevation of the same. Fig. 10 is a plan view of one of the rams. Fig. 11 is a detail view in elevation showing the operation of the cutters upon the teeth of the gear. Fig. 12 is a view in section on the line 12 12, Fig. 13, through the gear-spindle case. Fig. 13 is a view in section on the line 13 13, Fig. 12.

My present invention is designed more particularly for cutting the teeth of gears in soft steel and before the hardening of the gears, my invention having for its purpose a machine for the accomplishment of this work in a speedy, economical, and superior manner.

I carry out my invention as follows: Any suitable support or case is indicated at *a*. A driving-shaft is indicated at *b*, provided with a driving-pulley *c*. The driving-shaft is provided with a pinion (indicated at *d*) meshing with a gear *e*, which in turn meshes with an additional gear *f*, upon the shaft of which is a gear (indicated in dotted lines in Fig. 1 at *g*) meshing with a gear *h* upon a shaft *i*, the gear *h* meshing with gears *j* and *k*, the shafts *l* of which are each provided with eccentric-cams, (indicated in dotted lines *m*,) said eccentric-cams each effecting the reciprocation of a ram *n*. The rams are made reciprocatory in suitable ram-guides or ram-supporting cases *p p*, and each carries at its lower end a cutter-head *q*, adjustable on the corresponding ram. In each of the cutter-heads is a shaft *r*, carrying at its inner end a rotary milling-cutter *s* and at its outer end a driving-gear *t*. Each of the rams also carries an additional shaft *u*, provided with a driving-pulley *v*, the shaft being geared with the gear *t*, as indicated at *w*. The pulleys *v* are driven by a belt *x*, as hereinafter described.

The ram guides or cases *p p* are sleeved upon the shaft *i* and are arranged to be separated or moved apart the one ram-guide from the other in order to bring the cutters into desired relation to the gear-teeth to be generated. Each ram-guide is provided with an arm *y*, supporting an antifriction-roller *z*. Each of the ram-guides is also provided with an arm (indicated by the numerals 1 1) connected by a spring 2, the spring holding the two ram-guides normally together. The case *a* is constructed with guideways 3 to guide the movements of the oscillatory ram-guides. An adjustable stop 4 is provided to limit the inward movements of said guides. This stop may consist of the screw 4, engaged in a threaded ear upon the corresponding arm 1. When the ram-guides are spread apart, the stops are carried with the arms 1, but when said guides are restored to normal position the stops or screws 4 strike against adjacent portions of the case *a* to limit the approach of the ram-guides the one toward the other. The rams *n*, carrying the cutter-heads *q*, are made vertically adjustable in the ram-guides *p p*, as by means of an adjusting-screw 5. The rams may be held in any position of adjustment by means of a corresponding lock-nut 6. The screw 5 and lock-nut 6 upon a corresponding bolt are thus for the purpose of adjusting the relative positions of the rams and their operative mechanisms.

To carry the gear to be generated, I provide an oscillatory quadrant 7, said quadrant be-

ing fulcrumed upon the shaft 8, having its bearings in the case *a*. The quadrant is provided with a T-slot 9, in which is a bracket 10, said bracket being provided with flanges 11, through which bolts 12 are passed, engaging in the slot 9. The bracket may thus be adjusted and held in rigid position wherever it may be desired in said quadrant. Engaged in said bracket is located a longitudinally-movable sleeve 13. Within the sleeve 13 is a rotary spindle 14, which carries the gear 15 to be generated. The sleeve 13 carries an index mechanism at its outer end, which will be more fully hereinafter described.

The quadrant 7 may be actuated in any suitable manner. As shown, the driving-shaft *b* is provided with a worm (indicated at 16 and shown in dotted lines in Fig. 1) meshing with a gear 17 upon the shaft 18, said shaft provided with a cam 19. I prefer that the cam should be provided with a series of steps on its periphery; but I do not limit myself solely thereto. The quadrant is provided with an arm 20, provided with a friction-roller 21, the construction and arrangement being such that as said roller rotates upon the periphery of the cam the quadrant is moved correspondingly to carry the gear to be generated against the cutters. The quadrant also supports an arm 22, carrying a former 23 at its upper end, arranged to be projected between the rollers *z z*, upon the arms *y y*, to spread or separate the ram-guides *p p*. The quadrant 7 is made oscillatory in the quadrant-guide 24, attached to the bed or support *a*.

To rotate the spindle 14 and to give it a step-by-step movement, the sleeve 13 is provided with an integral hub 25, upon which is mounted an arm 26, provided with a segment-gear 27, meshing with a rack-bar 28. The arm 26 and gear 27 are preferably made integral and rotate upon the hub extending from the end of said sleeve 13. Upon the quadrant-guide 24 is a bracket 29, made adjustable in a T-shaped slot 30 in the quadrant-guide and held in a given position by means of bolts 31. Carried by the bracket 29 is a roll 32, bearing against the rear end of the rack-bar 28, the outer end of the rack-bar being constructed with an inclined face, as indicated at 33, to contact with the roll 32. As the quadrant returns to normal position, said roll 32, striking the inclined face of the rack-bar, will throw the segmental gear 27 and its arm correspondingly to bring another tooth of the gear to be generated into position.

The spindle 14 is provided with a flanged hub 34, upon which is engaged an index-plate 35, as by bolts 36. These index-plates are made interchangeable, so as to correspond with the number of teeth to be generated in a given gear.

The sleeve 13 is provided with an arm 37, preferably made integral therewith and non-rotatable, carrying a plunger 38, arranged to engage in the notches 39 of the index-plate. The plunger is actuated by a cam 40, carried by the arm 26, and by a retracting-spring 41. The plunger is provided with a roll 42, bearing against the edge of the cam 40.

It will be seen by reference to Fig. 4 that when the quadrant moves downward the cam 40, carried by the arm 26, will move upward, withdrawing the plunger 38 from the index-plate. Upon the opposite movement the spring 41 will restore the plunger to position to engage the index-plate. The numeral 43 indicates a pawl to engage the index-plate. A spring 44 normally holds the pawl in engagement with the plate, the pawl being carried by the arm 26, and in the downward movement of said arm the pawl will obviously ride out of engagement with the index-plate.

To bring the work into position for the cutters, the sleeve 13 is provided with rack-teeth, (indicated at 45, Fig. 13,) with which engages a gear 46 upon a spindle 47, operated by a hand-wheel 48. To prevent the sleeve 13 rotating in the bracket 10, said bracket is provided with an arm 49, through which a pin or stud 50 is passed to engage the arm 37, which is formed integral with the sleeve 13, as above described. To lock the sleeve 13 in any given position to which it may be adjusted relative to the bracket 10, said bracket is provided with ears 51, through which is passed a clamping-bolt 52. A hand-wheel 53 may be employed to clamp the gear to be generated upon its spindle. The index mechanism and related parts may be inclosed in a suitable case, (indicated at 54.)

The pulleys *v* may be driven by a single belt *z* in any suitable manner, said belt being shown engaging over various idlers and running to a counter-shaft. The spindles of the cutters *s* are adjusted in the corresponding cutter-head in any suitable manner.

It is obvious that when a gear has been generated the sleeve 13, carrying the spindle 14, may be moved longitudinally to carry the gear away from the cutters. When a new gear has been put upon the spindle ready to be generated, the sleeve 13 is moved back into position, a micrometer stop-screw (indicated at 55) being carried by the bracket 10, against which the sleeve 13 strikes to limit its inward movement. The micrometer-screw 55 is locked by a screw 56.

The operation of the device is as follows: A gear to be generated having been located properly upon its spindle and brought into position, the cutters are then put into rotation. At the same time the main driving-shaft *b*, through the train of gears described, reciprocates the rams carrying the cutter-heads, causing the cutters to travel along the length of the face of the teeth to be generated. Simultaneously with this operation the quadrant is moved by the mechanism hereinbefore described, advancing the gear between the cutters. The former 23 at the same time is moved forward between the rolls *z z* to separate the upper ends of the ram-guides, there-

by giving the proper taper to the tooth being generated. This operation also gives the proper contour or curvature to the tooth being generated. The extreme throw of the cam 17 is then under the roll 21 and the tooth has been formed to its full depth. The cam 17 continuing to move allows the quadrant 7 to return by its own gravity to the position shown in Fig. 1, and the distance that the quadrant returns is more than sufficient to retract the gear from the cutters. While the gear is removed beyond the cutters, the gear is indexed, bringing the next tooth into operative position, and on the first forward step of the cam the indexing mechanism is locked and the cutters begin to operate upon the tooth when the point 66 of the cam is under the roll 21. These operations are continued until the gear has been completed. The cutter-heads are set at an angle, so as to give proper clearance to the inner faces of the cutters, the cutters being constructed to cut at their adjacent peripheral corners or edges. The axis of the shaft upon which the ram-guides swing and the axis of the gear-spindle lie in the same plane. As shown, they are in the same vertical plane and their axes intersect, said plane being parallel to the face of the quadrant. So, also, the axis of the quadrant-shaft and the axis of the ram-guides are in the same plane and intersect the plane that is parallel to the face of the quadrant. So, also, the axis of the gear-spindle intersects the axis of the quadrant-shaft and the axis of the shaft upon which the ram-guides oscillate intersect the axis of the quadrant-shaft. The quadrant is graduated, as shown more particularly in Fig. 3 at 57, while the bracket 10 is provided with a vernier 58, so as to give the readings in degrees and minutes in order to get the proper angle of the gear. While the cam 19 carries the quadrant upward, the reverse movement is caused by its own gravity.

It will be understood that the teeth must be centered correctly relative to the cutters, which may be done in any desired manner. It will be seen that when the two ram-guides are closed normally together the plane between them will centrally intersect the shaft upon which they are mounted, also the gear-spindle, and also the central line of the tooth of the gear that is being generated. Said plane between the closed ram-guides also centrally intersect the former. Inasmuch as both sides of the teeth are shaped simultaneously, it is obvious that the machine is of superior capacity as well as of superior utility, inasmuch as there is not only a saving of time in generating the teeth, but also in the operation of the index mechanism.

The horizontal cone lines of the machine are indicated by single arrow-heads, the vertical lines by double arrow-heads, and the cone line passing through the spindle carrying the gear to be generated is indicated by a triple arrow-head.

The numerals 57 and 58 indicate belt-shifting hand-levers, the two shafts 59 and 60, actuated thereby, extending upward to the counter-shaft (not shown) to operate the belt-shifter mechanism, which may be of any desired construction. When there has been a complete revolution, the belt-shifting mechanism is released by a rack-bar 61 and pawl 62, which trips a latch 63. This pawl is actuated by the arm 64 and bar 65.

In Figs. 1 and 9 a scale is shown, there being a zero-line on the ram. A scale being on the ram-guide, readings are taken, thereby showing the distance from the center of the cutter-spindle to the axis of the quadrant pivot-shaft.

What I claim as my invention is—

1. In a machine for generating gear-teeth, means to carry a gear to be generated, and two rotatable cutters arranged at an angle to an intermediate plane passing through the cone center of the gear, whereby said cutters will cut at their adjacent peripheral edges or corners, means to reciprocate said cutters in operation to shape both sides of a gear-tooth simultaneously, and a former to guide the movement of the cutters to give the desired contour of the tooth.

2. In a machine for generating gear-teeth, an oscillatory quadrant, means to carry a gear to be generated carried upon said quadrant, and rotatable cutters arranged to act simultaneously upon the two opposite faces of a tooth to be generated at an angle to an intermediate plane passing through the cone center of the gear, whereby said cutters will cut at their adjacent peripheral edges or corners, means to reciprocate said cutters in operation, and a former carried by said quadrant to guide the movement of the cutters to give the desired contour to the tooth.

3. In a machine for generating gear-teeth, means to carry a gear to be generated, rotatable cutters reciprocatory in operation arranged to act simultaneously upon the two faces of a given tooth to be generated, means to spread the centers of said cutters apart while in operation, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

4. In a machine for generating gear-teeth, means to carry a gear to be generated, and two rotatable milling-cutters arranged to act simultaneously upon the two faces of a given tooth to be generated, means to give a reciprocatory movement to said cutters in operation upon said faces, and means to guide the movement of the cutters to give the desired outline to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

5. In a machine for generating gear-teeth, means to carry a gear to be generated, two ro-

tatable cutters acting simultaneously upon opposite faces of a tooth to be generated, means to cause the cutters to reciprocate while in operation along the faces of the tooth to be generated, means to spread said cutters apart the one from the other, and a former to guide the movement of the cutters to give the desired outline to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear, whereby said cutters will cut at their adjacent peripheral edges or corners.

6. In a machine for generating gear-teeth, means to carry a gear to be generated, rotatable cutters reciprocatory in operation arranged to act simultaneously upon the opposite faces of a given tooth of the gear, a former to guide the movement of the cutters to give the desired outline to the tooth, and means to advance the gear between the cutters.

7. In a machine for generating gear-teeth, means to carry a gear, cutters reciprocatory in operation arranged to act simultaneously upon the two faces of a given tooth of the gear, a former, and means to advance the former to separate said cutters, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

8. In a machine for generating gear-teeth, means to carry a gear to be generated, and two rotatable cutters reciprocatory in operation arranged to act simultaneously upon the two faces of a given tooth of the gear, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners, and a former to guide the movement of the cutters to give the desired contour to the tooth.

9. In a machine for generating gear-teeth, means to carry a gear to be generated, two rotatable cutters reciprocatory in operation to shape both sides of a tooth simultaneously, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners, and a former to guide the movement of the cutters to give the desired outline to the tooth, and means to index said gear.

10. In a machine for generating gear-teeth, means to carry a gear to be generated, rotatable cutters reciprocatory in operation to shape both sides of a tooth of a gear simultaneously, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear, whereby said cutters will cut at their adjacent peripheral edges or corners, a former to guide the movement of the cutters to give the desired outline to the tooth, and means to give a step-by-step movement to said gear.

11. In a machine for generating gear-teeth, means to carry a gear to be generated, two reciprocatory rams, a cutter-head provided with a rotatable cutter reciprocatory in operation carried by each of said rams, whereby the cutters may act simultaneously upon opposite sides of a given gear-tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners, and a former to guide the movement of the cutters to give the desired contour to the tooth.

12. In a machine for generating gear-teeth, means to carry a gear to be generated, two reciprocatory rams, rotatable cutters reciprocatory in operation carried by said rams, means to separate said rams in the operation of the cutters, and means to restore said rams to normal position, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear, whereby said cutters will cut at their adjacent peripheral edges or corners.

13. In a machine for generating gear-teeth, means to carry a gear to be generated, two reciprocatory rams, means to oscillate said rams, a cutter-head provided with a rotatable cutter reciprocatory in operation carried by each of said rams, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners, and a former to guide the movement of the cutters to give the desired contour to the tooth.

14. In a machine for generating gear-teeth, means to carry a gear to be generated, two reciprocatory rams, an oscillatory ram-guide to carry each of said rams, a rotatable cutter reciprocatory in operation carried by each of said rams, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear, whereby said cutters will cut at their adjacent peripheral edges or corners, and means to guide the movement of the cutters to give the desired contour to the tooth.

15. In a machine for generating gear-teeth, means to carry a gear to be generated, driving mechanism provided with a shaft, oscillatory ram-guides mounted upon said shaft, a reciprocatory ram carried by each of said guides, and a cutter reciprocatory in operation carried by each of said rams, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

16. In a machine for generating gear-teeth, means to carry a gear to be generated, two reciprocatory rams, a rotatable cutter-head provided with a cutter reciprocatory in operation carried by each of said rams, means to drive said cutters, and a former to guide the movement of the cutters to give the desired contour to the tooth.

17. In a machine for generating gear-teeth, means to carry a gear to be generated, two re-

ciprocatory rams, a rotatable cutter-head provided with a cutter reciprocatory in operation carried by each of said rams, a shaft carried by each of said rams to drive the corresponding cutter, and a former to guide the movement of the cutters to give the desired contour to the tooth.

18. In a machine for generating gear-teeth, means to carry a gear to be generated, a shaft, ram-guides having an oscillatory engagement upon said shaft, reciprocatory rams engaged in said ram-guides, means to reciprocate said rams, rotatable cutters reciprocatory in operation carried by said rams, and a former to guide the movement of the cutters to give the desired contour to the tooth.

19. In a machine for generating gear-teeth, means to carry a gear to be generated, two rams each provided with a rotatable cutter reciprocatory in operation, rotatable cams to reciprocate said rams, and means to move said rams the one from the other, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

20. In a machine for generating gear-teeth, means to carry a gear to be generated, two oscillatory rams each provided with a rotatable cutter reciprocatory in operation, means to limit the oscillation of said rams, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

21. In a machine for generating gear-teeth, means to carry a gear to be generated, rotatable cutters reciprocatory in operation arranged to act simultaneously upon the two faces of a given gear-tooth, means to oscillate said cutters, means to limit the oscillation of said cutters, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone-center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

22. In a machine for generating gear-teeth, means to carry a gear to be generated, two reciprocatory rams each provided with a cutter-head, a shaft in each of said cutter-heads provided with a rotatable cutter reciprocatory in operation, and a former to guide the movement of the cutters to give the desired contour to the tooth, said heads each provided with an additional rotatable shaft to drive the corresponding cutter.

23. In a machine for generating gear-teeth, means to carry a gear to be generated, rotatable cutters arranged to act simultaneously upon the opposite faces of a given gear-tooth to be generated, means to oscillate said cutters in operation in opposite directions, and means to advance the gear to the work, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

24. In a machine for generating gear-teeth, means to carry a gear to be generated, two oscillatory ram-guides, a ram provided with a cutter reciprocatory in operation carried by each of said guides, an arm provided with a roller carried by each of said guides, a former, means to advance the former between said rollers, and means to restore said guides to normal position, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

25. In a machine for generating gear-teeth, means to carry a gear to be generated, a case or bed provided with guideways, two ram-guides oscillatory in said guideways, and a ram provided with a rotatable cutter reciprocatory in operation carried by each of said ram-guides, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

26. In a machine for generating gear-teeth, means to carry a gear to be generated, a case or bed provided with guideways, two ram-guides reciprocatory in said guideways, a ram provided with a rotatable cutter reciprocatory in operation carried by each of said ram-guides, means to limit the inward movement of said ram-guides, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

27. In a machine for generating gear-teeth, means to carry a gear to be generated, two oscillatory ram-guides, rams vertically adjustable in said guides, a rotatable cutter reciprocatory in operation carried by each of said guides, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

28. In a machine for generating gear-teeth, means to carry a gear to be generated, two oscillatory ram-guides, a reciprocatory ram provided with a cutter reciprocatory in operation carried by each of said guides, and a former, means to advance the former to separate said guides, the plane between the ram-guides in closed position centrally intersecting the former, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cut-

ters will cut at their adjacent peripheral edges or corners.

29. In a machine for generating gear-teeth, an oscillatory quadrant and its shaft, means carried by said quadrant to carry a gear to be generated, oscillatory ram-guides, rotatable cutters reciprocatory in operation carried by said ram-guides arranged to act simultaneously upon the two faces of a given gear-tooth, a former to guide the movement of the cutters to give the desired contour to the tooth, and adjustable devices to carry the gear toward and from the intersection of the quadrant-shaft and the axis of the ram-guides.

30. In a machine for generating gear-teeth, an oscillatory quadrant, means carried by said quadrant to carry a gear to be generated, rotatable cutters reciprocatory in operation to act simultaneously on opposite faces of a gear-tooth, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

31. In a machine for generating gear-teeth, a support provided with a guideway, a quadrant having an oscillatory movement in said guideway, means engaged with said quadrant to carry a gear to be generated, means to actuate the quadrant, rotatable cutters reciprocatory in operation to act simultaneously on opposite faces of a gear-tooth, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

32. In a machine for generating gear-teeth, an oscillatory quadrant, a bracket adjustably engaged with said quadrant, a sleeve in said bracket, a spindle to carry a gear to be generated located in said sleeve, means to give a step-by-step rotary movement to the gear-spindle, means to move the gear-spindle longitudinally, rotatable cutters reciprocatory in operation to act simultaneously on opposite faces of a gear-tooth, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

33. In a machine for generating gear-teeth, an oscillatory quadrant, a bracket adjustably engaged with said quadrant, a sleeve in said bracket, a spindle to carry a gear to be generated located in said sleeve, means to give a rotary step-by-step movement to the gear-spindle, means to move the gear-spindle longitudinally, a micrometer stop-screw carried by said bracket to limit the inward movement of the spindle, rotatable cutters reciprocatory in operation to act simultaneously on opposite faces of a gear-tooth, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

34. In a machine for generating gear-teeth, an oscillatory quadrant, mechanism engaged with said quadrant to carry a gear to be generated, cutters reciprocatory in operation to act simultaneously upon the two faces of a given gear-tooth, and means to separate said cutters carried by said quadrant, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

35. In a machine for generating gear-teeth, an oscillatory quadrant, means engaged with said quadrant to carry a gear to be generated, rotatable cutters reciprocatory in operation to act simultaneously upon opposite faces of a given gear-tooth, means to carry the gear away from the cutters, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

36. In a machine for generating gear-teeth, an oscillatory quadrant, means connected therewith to carry a gear to be generated, two rotatable cutters reciprocatory in operation to generate the teeth upon said gear, means to adjust the oscillation of the quadrant to adjust the depth of the cut of the gears, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

37. In a machine for generating gear-teeth, an oscillatory quadrant, means engaged with said quadrant to carry a gear to be generated, an arm adjustably engaged with the quadrant, means acting upon said arm to actuate the quadrant, rotatable cutters reciprocatory in operation to act simultaneously on opposite faces of a gear-tooth, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

38. In a machine for generating gear-teeth, a support or bed, an oscillatory quadrant fulcrumed upon said bed, a bracket adjustable upon said quadrant, means connected with said bracket to carry a gear to be generated, rotatable cutters reciprocatory in operation to act simultaneously on opposite faces of a gear-tooth, and a former to guide the movement of the cutters to give the desired con-

tour to the tooth, said support or bed provided with a guideway for said quadrant.

39. In a machine for generating gear-teeth, the combination with a support or bed, a driving-shaft, a worm upon said shaft, an oscillatory quadrant, mechanism driven by said worm to drive said quadrant, rotatable cutters reciprocatory in operation to act simultaneously upon opposite faces of a gear-tooth, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

40. In a machine for generating gear-teeth, the combination with a support or bed, of an oscillatory quadrant, a bracket adjustable upon said quadrant, a longitudinally-movable sleeve in said bracket, a rotatable spindle within said sleeve to carry a gear to be generated, index mechanism carried by said sleeve, rotatable cutters reciprocatory in operation to act simultaneously on opposite faces of a gear-tooth, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

41. In a machine for generating gear-teeth, the combination with a support or bed, of cutters reciprocatory in operation, a quadrant, a bracket adjustable upon the quadrant, a longitudinally-movable sleeve in said bracket, a spindle within said sleeve, means to give to said spindle a step-by-step rotation, a hub upon said sleeve, an arm engaged upon said hub provided with a segment-gear, a rack-bar meshing with said segment-gear, a guide for said quadrant, a bracket adjustable upon said quadrant-guide, and a roller carried by said bracket, said rack-bar having an inclined face at its outer end adjacent to said roller.

42. In a machine for generating gear-teeth, the combination with a support or bed, of cutters reciprocatory in operation, an oscillatory quadrant, a bracket adjustable upon said quadrant, a longitudinally-movable sleeve engaged in said bracket, a rotatable spindle in said sleeve, an arm 26 engaged upon said sleeve provided with a segmental gear, a rack-bar meshing with said segmental gear, means to actuate said rack-bar, an index-plate engaged with said spindle, an arm 37 connected with said sleeve and carrying a plunger to engage the index-plate, a cam carried by the arm 26 to actuate the plunger, and means to retract said plunger.

43. In a machine for generating gear-teeth, the combination with a support or bed, of cutters reciprocatory in operation, an oscillatory quadrant, a bracket adjustable upon said quadrant, a longitudinally-movable sleeve engaged in said bracket, a rotatable spindle in said sleeve, an arm 26 engaged upon said sleeve provided with a segmental gear, a rack-bar meshing with said segmental gear, means to actuate said rack-bar, an index-plate engaged with said spindle, an arm 37 connected with said sleeve and carrying a plunger to engage the index-plate, a cam carried by the arm 26 to actuate the plunger, means to retract said plunger, and a pawl carried by the arm 26 to rotate the index-plate.

44. In a machine for generating gear-teeth, the combination with a support or bed, of rotatable cutters reciprocatory in operation, an oscillatory quadrant, a bracket adjustable upon said quadrant, a longitudinally-movable sleeve in said bracket, a rotatable spindle in said sleeve, said sleeve provided with rack-teeth, a gear meshing with the rack-teeth, a hand-wheel to actuate said gear, and a former to guide the movement of the cutters to give the desired contour to the tooth.

45. In a machine for generating teeth, the combination with a support or bed, of cutters reciprocatory in operation, an oscillatory quadrant and a bracket adjustable upon said quadrant, a longitudinally-movable sleeve in said bracket, a rotatable spindle in said sleeve, said bracket provided with an arm 49, an arm 37 carried by said sleeve, an index-plate carried by the spindle, a plunger carried by the arm 37, and means engaging the arm 49 with the arm 37 to prevent the sleeve from rotating in the bracket.

46. In a machine for generating gear-teeth, the combination with a support, of rotatable cutters reciprocatory in operation, a former to guide the movement of the cutters to give the desired contour to the tooth, an oscillatory quadrant, a bracket adjustable upon said quadrant, a longitudinally-movable sleeve in said bracket, a rotatable spindle in said sleeve to carry a gear to be generated, means to effect the longitudinal movement of said sleeve, and means to lock the sleeve in a given position of adjustment.

47. In a machine for generating gear-teeth, a support or bed provided with a shaft, oscillatory ram-guides engaged upon said shaft, an oscillatory quadrant upon said support or bed, a gear-spindle to carry a gear to be generated engaged upon said quadrant, and means to actuate said spindle, cutters reciprocatory in operation to act simultaneously on opposite faces of a gear-tooth, the axis of the shaft upon which the ram-guides swing, and the axis of the gear-spindle lying in the same plane, said plane being parallel to the face of the quadrant, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

48. In a machine for generating gear-teeth, the combination with a support or bed, of oscillatory ram-guides, a shaft carrying said guides, an oscillatory quadrant fulcrumed upon said support or bed, cutters reciproca-

tory in operation to act simultaneously on opposite faces of a gear-tooth, the axis of the quadrant-shaft being perpendicular to a plane parallel to the face of the quadrant and in the same horizontal plane as the axis of the shaft on which the ram-guides oscillate, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

49. In a machine for generating gear-teeth, the combination with a support or bed, of oscillatory ram-guides, a shaft upon which said guides oscillate, an oscillatory quadrant, a shaft upon said bed upon which said quadrant oscillates, a spindle to carry a gear to be generated upon said quadrant, cutters reciprocatory in operation to act simultaneously on opposite faces of a gear-tooth, the axis of the gear-spindle intersecting the axis of the quadrant-shaft, and the axis of the shaft upon which the ram-guides oscillate intersecting the axis of the quadrant-shaft, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

50. In a machine for generating gear-teeth, means to carry a gear to be generated, rotatable cutters arranged to act upon both faces of a given tooth to be generated, means to reciprocate said cutters in operation, means to advance the gear to the cutters in operation, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

51. In a machine for generating gear-teeth, means to carry a gear to be generated, ram-guides, reciprocatory rams carried by said guides, a cutter-head provided with a rotatable cutter carried by each of said rams, means to oscillate said ram-guides, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

52. In a machine for generating gear-teeth, an oscillatory quadrant, means carried by the quadrant to carry a gear to be generated, an oscillatory ram-guide, a reciprocatory ram in said guide, a rotatable cutter carried by said guide, and a former to actuate the ram-guide to guide the movement of the cutter to give the desired contour to the surface of the tooth, said cutter arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutter will cut at its adjacent peripheral edge or corner.

53. In a machine for generating gear-teeth, means to generate a gear to be generated, an oscillatory ram-guide, a reciprocatory ram in said guide, a rotatable cutter carried by said ram, means to move said ram in one direction in the operation of the cutter, means to restore said ram to normal position and to guide the movement of the cutter to give the desired contour to the surface of the tooth, said cutter arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutter will cut at its adjacent peripheral edge or corner.

54. In a machine for generating gear-teeth, an oscillatory quadrant, means carried by said quadrant to carry a gear to be generated, an oscillatory ram-guide, a reciprocatory ram carried by said quadrant, a rotatable cutter carried by said ram, means to guide the movement of the cutter to give the desired contour to the surface of the tooth, said cutter arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutter will cut at its adjacent peripheral edge or corner.

55. In a machine for generating gear-teeth, an oscillatory quadrant, means carried by said quadrant to carry a gear to be generated, driving mechanism provided with a shaft, an oscillatory ram-guide mounted upon said shaft, a reciprocatory ram carried by said guide, a rotatable cutter carried by said ram, and means to guide the movement of the cutter to give the desired contour to the surface of the tooth, said cutter arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutter will cut at its adjacent peripheral edge or corner.

56. In a machine for generating gear-teeth, an oscillatory quadrant, means carried by said quadrant to carry a gear to be generated, an oscillatory and reciprocatory ram, a cutter-head carried by said ram provided with a rotatable cutter reciprocatory in operation, a shaft carried by the cutter-head to drive said cutter, and a former to guide the movement of the cutter to give the desired contour to the tooth, said cutter arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutter will cut at its adjacent peripheral edge or corner.

57. In a machine for generating gear-teeth, means to carry a gear to be generated, reciprocatory rams provided with rotatable cutters, a rotatable cam to reciprocate said rams, means to oscillate said rams, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

58. In a machine for generating gear-teeth, means to carry a gear to be generated, oscillatory ram-guides, reciprocatory rams provided with rotatable cutters carried by said

guides, an arm provided with a roller carried by each of said guides, a former to guide the movement of the cutter to give the desired contour to the surface of the tooth, means to advance the former between said rollers, and means to restore said guides to normal position, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

59. In a machine for generating gear-teeth, means to carry a gear to be generated, a case or bed provided with a guideway, ram-guides oscillatory in said guideway, reciprocatory rams, a rotatable cutter carried by each of said ram-guides, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

60. In a machine for generating gear-teeth, means to carry a gear to be generated, oscillatory ram-guides, reciprocatory rams adjustable in said guides, a rotatable cutter carried by each of said rams, and a former to guide the movement of the cutters to give the desired contour to the tooth, said cutters arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutters will cut at their adjacent peripheral edges or corners.

61. In a machine for generating gear-teeth, an oscillatory quadrant, mechanism engaged with said quadrant to carry a gear to be generated, a rotatable cutter to act upon one face of a given gear-tooth, and means carried by said quadrant to oscillate said cutter in one direction, and to guide the movement of the cutter to give the desired contour to the surface of the tooth, said cutter arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutter will cut at its adjacent peripheral edge or corner.

62. In a machine for generating gear-teeth, an oscillatory quadrant, means engaged with said quadrant to carry a gear to be generated, a rotatable cutter to act upon a given gear-tooth, means to carry a gear away from the cutter, and a former to guide the movement of the cutter to give the desired contour to the tooth, said cutter arranged at an angle to an intermediate plane passing through the cone center of the gear whereby said cutter will cut at its adjacent peripheral edge or corner.

63. In a machine for generating gear-teeth, an oscillatory quadrant, means connected with said quadrant to carry a gear to be generated, a rotatable cutter reciprocatory in operation arranged to act upon the adjacent face of a given tooth of the gear, a former to guide the movement of the cutter to give the desired outline to the adjacent face of the tooth, and means to advance the quadrant to carry the gear to the cutter.

64. In a machine for generating gear-teeth, an oscillatory automatically-retracting quadrant, means connected with said quadrant to carry a gear to be generated, a rotatable cutter reciprocatory in operation arranged to act upon the adjacent face of a given tooth of the gear, a former to guide the movement of the cutter to give the desired outline to the adjacent face of the tooth, and means to advance the quadrant to carry the gear to the cutter.

In testimony whereof I sign this specification in the presence of two witnesses.

FRANK E. FERRIS.

Witnesses:
N. S. WRIGHT,
M. HICKEY.