March 21, 1939. A. A. NICHOLS 2,151,483

ROTOR GENERATING METHOD AND MACHINE

Filed June 5, 1935 2 Sheets-Sheet 1

Fig. 1.

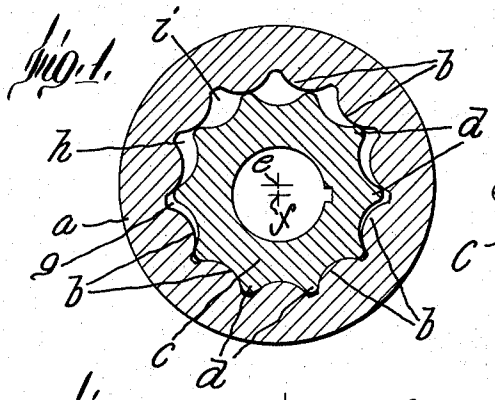


Fig. 2.

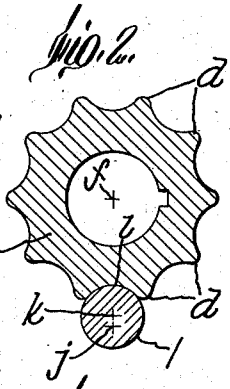


Fig. 3.

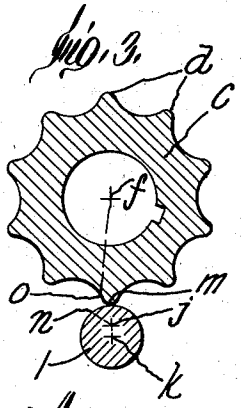


Fig. 4.

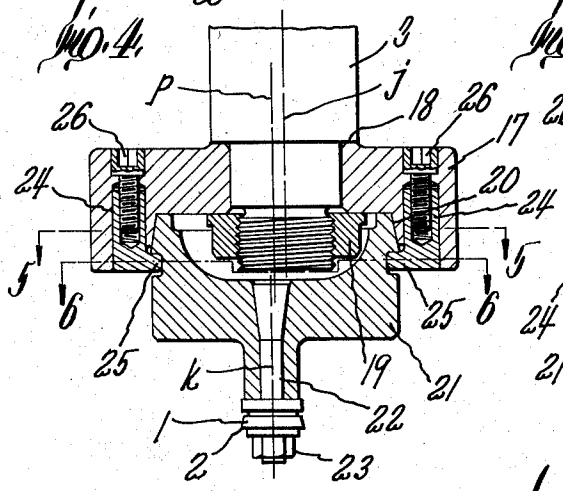


Fig. 5.

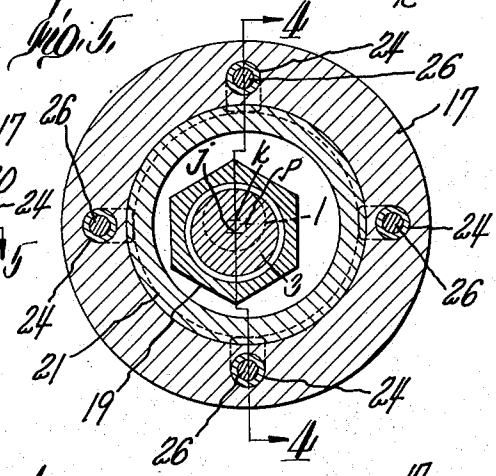


Fig. 6.

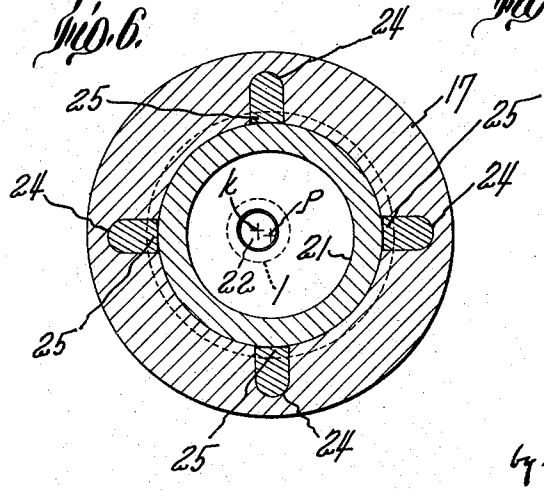
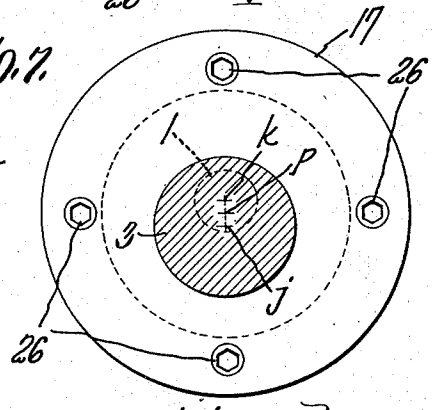


Fig. 7.



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March 21, 1939. A. A. NICHOLS 2,151,483

ROTOR GENERATING METHOD AND MACHINE

Filed June 5, 1935 2 Sheets-Sheet 2

Fig. 8.

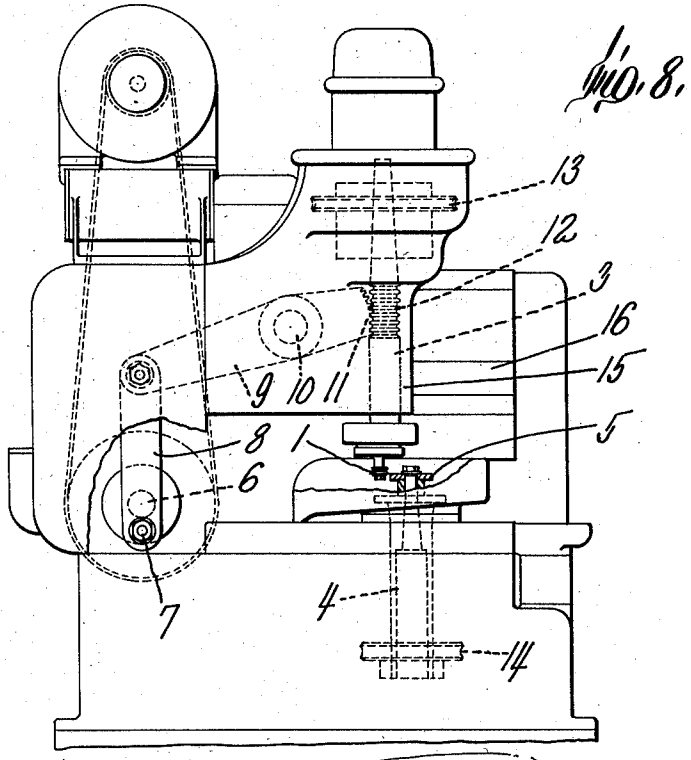
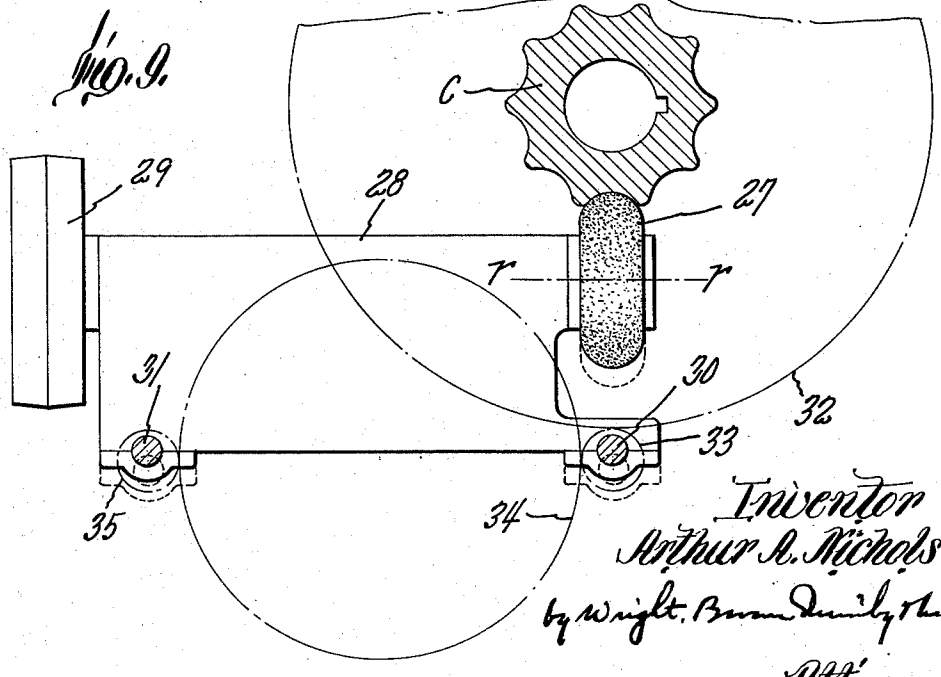


Fig. 9.



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Patented Mar. 21, 1939 2,151,483

UNITED STATES PATENT OFFICE

2,151,483

ROTOR GENERATING METHOD AND MACHINE

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Application June 5, 1935, Serial No. 25,081

16 Claims. (Cl. 90—1)

The present invention relates to methods and means for generating rotors with external lobes to be conjugate with surrounding rotors having internal lobes, the number of which is one greater or less than the number of lobes of the rotor to be produced. Such rotors as I have here in mind and have briefly designated above are those designed to cooperate in a rotary pump or the like, by rotating (one within the other) about axes eccentric to one another, and of which the lobes of one rotor are conjugate to the other in such manner as to transmit rotation thereto, and at the same time maintain tangent contact at all times with contiguous points of the companion rotor.

Such rotary pumps have gone into use as an article of commerce, and their principles are disclosed and explained in prior patents. Their efficiency, and for some purposes even their operativeness, depends on a very high quality of accuracy in the form and dimensions of the conjugate lobes of the respective rotors. Methods have been devised, and are disclosed in Letters Patent of the United States of William H. Nichols, Nos. 1,997,227 and 1,997,228 granted April 9, 1935, by which such accuracy is obtained in commercial manufacture. It is my present purpose to simplify and reduce the cost of making the externally lobed rotors of such pump combinations and related cams such as those disclosed in said patents while maintaining an equal order of accuracy and precision in the manufactured product. A method and means for doing so constitute the subject of the present disclosure. The invention consists not only in the method and means thus disclosed, but also in all substantial equivalents thereof within the scope of the appended claims.

These will now be described and explained with reference to the drawings furnished herewith.

In the drawings:

Fig. 1 is a plan view of the cooperating rotor elements of a pump of the type above referred to;

Figs. 2 and 3 show two positions in the operation of finishing an externally lobed rotor according to the method of this invention;

Fig. 4 is a fragmentary view, partly in section, of a cutting tool and adjustable holder for the same, usable to carry out the generating method of the invention and illustrating a part of the apparatus phase of the invention;

Fig. 5 is a cross section taken on line 5—5 of Fig. 4, and designating by the line 4—4 the plane on which the section of Fig. 4 is taken;

Fig. 6 is a cross section taken on line 6—6 of Fig. 4;

Fig. 7 is a plan view of the parts shown in Fig. 4 and illustrating the different positions of adjustment of the cutting tool;

Fig. 8 is a diagrammatic elevation of a type of machine for actuating the tool shown in Figs. 2, 3 and 4, to perform the method;

Fig. 9 is a diagrammatic plan view of an alternative form of apparatus for carrying out the finishing step of the method phase of the invention.

Attention is directed first to Fig. 1 to illustrate the type of pump to which the invention relates. This pump comprises an outer or ring rotor *a* having a circular series of internal lobes *b*, and an inner rotor *c* having external lobes *d*. These rotors are adapted to turn about the axes *e* and *f* respectively, eccentric to one another, and the rotor *c*, being keyed to a driving shaft and rotated thereby, is designed to impart rotation to the rotor *a* by the engagement of its lobes *d* with the lobes *b*. There are eleven of the lobes *b* and ten of the lobes *d*. This relationship is expressed generically by the statement that the numbers of lobes on the respective rotors differ by one. Either rotor may have one lobe more or one lobe less than the other. Hence the lobes *d* of the driving rotor come progressively into and out of full driving mesh with the lobes *b* of the driven rotor; and in the course of each rotation any lobe *d* passes from engagement with one lobe *b* into a corresponding engagement with the next lobe of the driven rotor. In thus passing from one lobe to the next of the outer rotor, the lobes of the inner rotor must maintain sufficiently close tangent contact therewith to prevent objectionable leakage between them of the fluid which is being drawn into the widening, or expelled from the narrowing, interspaces *g*, *h*, *i*, etc. When the pump is used as an air compressor for instance, (which is a feasible use), this contact must be very close indeed, while being at the same time free enough to minimize friction losses. The fit of the pump casing with the side faces of the rotors to prevent leakage of fluid around the lobes is a matter with which the present invention is not concerned.

In the design of pump here illustrated, the lobes *b* are of circular curvature, and they are arranged with their centers of curvature equally spaced apart from one another by distances longer than the diameter of their arc of curvature, and equidistant from the center or axis *e*. These values, the numbers of lobes of the two rotors, and the eccentricity of their axes, are determined according to the duty required of the pump.

In producing inner rotors by the present invention to be conjugate to any ring rotor of the foregoing description, I provide a cutter of such form, and impart to it such a cutting movement that its cutting points sweep a curve, the projection of which on the plane of the work is identical with the like projection of any one of the ring rotor lobes. In addition a generating motion of revolution is given to the tool in an orbit of which the radius is equal to the given eccentricity, while the work piece (the rotor blank) is rotated about its own axis at an angular speed which, relatively to the speed of such generating revolution, is the reciprocal of the number of lobes to be generated. One of the possible modes of performing the method phase of the invention is shown in Figs. 2–8 inclusive, and another is shown in Fig. 9. These illustrations likewise show forms of apparatus for which I claim protecttion as a part or phase of the invention.

In Figs. 2–8 the tool is a circular or disk cutter 1 having a cutting edge 2 defined by the intersection between its circumference and one end face (Fig. 4). Its sides are tapered slightly, preferably at an angle in the order of 1½°, for cutting clearance, and the radius of its cutting edge is made equal to the radius of the lobes *b*. It is caused to reciprocate in the direction of its axis across the edge of the circular blank from which the rotor *c* is to be made, so as to cut the blank with a planing action, and at the same time it is revolved about an axis *j* eccentric to its own center *k* by an eccentricity equal to that between the axes *e* and *f*. The blank meanwhile is rotated about its axis *f*, separated from axis *j* by a distance equal to that of the centers of lobes *b* from the ring rotor center *e*, at a relative rate which is the reciprocal of the number of lobes to be cut. In this illustration the rate of rotation of the blank is one-tenth of that of the revolution of the cutter.

These motions of the cutter and work, and adjustment of the distance between cutter and work, may be effected by the mechanisms of an organized machine of the type of the well known Fellows gear shaper, the principles of which are illustrated by the patents of Edwin R. Fellows 676,227, June 11, 1901, and 1,478,472, December 25, 1923, and a diagrammatic illustration of which is shown in Fig. 8 of the present drawings. Referring to said Fig. 8, spindles 3 and 4 are shown by broken lines carrying respectively the cutter 1 and a work piece 5, which is a circular blank which, when suitably planed away on its circumference, is converted into the finished rotor *c*. The cutter spindle 3 is reciprocated endwise, so as to carry the cutter back and forth across the rim of the work piece, by a main shaft 6 acting through a crank 7, connecting rod 8, rock arm 9 pivoted at 10, and gear segment 11 meshing with encircling rack teeth 12 on the spindle 3. The spindles 3 and 4 are simultaneously rotated at the proper relative speeds, and in opposite directions of rotation, by means of worm wheels 13 and 14 respectively, driven from the main shaft 6 by worms and intermediate gearing and shafting, not shown here but of which the principles are fully disclosed in said Fellows patents. The cutter spindle has a sliding, rotation-transmitting, engagement with its worm wheel 13. Said spindle and the means for reciprocating it are carried by a carriage or saddle 15 supported by horizontal guideways 16 on the machine base, whereby the cutter may be withdrawn from the work piece and advanced into proper cutting relationship with work pieces of various dimensions. The work spindle is preferably withdrawn slightly from the cutter after each cutting stroke in order to avoid rub of the cutter on the work during its return strokes. Means for this purpose are parts of the standard Fellows machines and illustrative forms thereof are shown in the before mentioned patents.

It may be noted here that I claim no novelty in the machine as thus far described, except in combination with a cutter of the character described and with means of the character presently to be described for connecting the same eccentrically to the cutter spindle and adjusting its eccentricity. I wish to make clear, however, that the generating method which is performed with the aid of the tool and mechanisms described is unlike the methods heretofore practised for shaping gears and analogous machine elements or tools, and that my new method is capable of being carried out by various specifically different generating means, as will more fully appear in the course of this specification.

Although the generating procedure occurs simultaneously with that of cutting, and indeed necessarily is accompanied with a cutting effect in order to produce the generated forms in solid metal, yet it is in a sense independent of the cutting procedure, and may be accomplished in cooperation with a variety of different modes of cutting.

It will be understood that the strokes of the cutter in the planing mode of cutting here described are relatively very rapid in proportion to the rate of rotation of the work; so rapid that the successive cuts, which actually are concave grooves of the same curvature as the cutter circumference, merge together without perceptible ridges between them. The effect of smooth and accurate finish with sufficiently rapid production is preferably obtained by carrying out the operation with two series of cuts; i. e., a roughing cut performed on the solid blank, by which the blank is brought to an approximation of its final form, and in which the rotary feed (angles of rotation between successive cutting strokes) may be relatively coarse or large, and a finishing cut in which small amounts of metal are removed with a fine rotary feed. Such differences between the rates of rotary feeding in the roughing and finishing cuts may be easily effected by substituting gears of different ratios in the train through which rotation is imparted to the cutter and work spindles; in a manner well known and generally practised in the operation of machine tools.

Accuracy in the finished product is of course dependent upon the accuracy with which the radius of the cutter conforms with the radius of the lobes of the ring rotor. I am able, with available shop methods of making the ring rotors and disk cutters, to obtain such conformity within minute limits of error, that is, with a tolerance in the order of one ten-thousandth of an inch. The disk cutters here described are made with this quality of accuracy at very moderate cost. When dull, they are sharpened by lightly grinding the end face at the larger end. When, due to repeated grindings and their external taper, the cutters become too small for accurate finish-cutting, they may be used for a further long period and with repeated sharpenings in performing the roughing out operation above described. Thus, by reserving new and accurate cutters for the finish-cutting operation, where the depth of cut is no more than two or three

thousandths of an inch, but may be less, and relegating them to the rough cutting service after one or two sharpenings, a large production of rotors finished to the desired accuracy is obtainable at very low expense for cutters. By making the cutters of the most durable alloys of steel, or other materials, available for metal cutting tools, several hundred rotors may be finished by one cutter with a single sharpening. The time required for producing rotors according to this method, where the cutter spindle can be reciprocated as fast as six hundred strokes per minute, is less than one minute for rough cutting the rotor, and approximately one minute for the finish-cutting operation; the time being relatively longer or shorter for rotors of larger or smaller diameters, in proportion to the diameter. But a series of rotor blanks may be mounted in tandem on the work spindle and cut all at once, by making the cutter strokes slightly longer than the combined thickness of all the blanks.

One feature of the invention resides in means for connecting the cutter eccentrically to the cutter spindle, and adjusting its eccentricity. The preferred form of such means is shown in Figs. 4–7 inclusive of the present drawings. The lower end of the spindle **3** is shown in Fig. 4. A head **17** is placed on the reduced end portion of the spindle and clamped against a shoulder **18** thereon by a nut **19**. In the under side of the disk is a cavity bounded by a surface **20** (preferably conical) the axis of which, designated by the line *p* in Fig. 4, and by the point *p* in Figs. 5, 6 and 7, is eccentric to the axis *j* of the spindle. A holder **21** is fitted in such cavity, having an external bearing surface complemental to the surface **20**. Said holder carries an arbor **22** to which the cutter is secured by a nut **23**. The axis *k*, common to this arbor and to the cutter, is eccentric to the axis *p* in the same amount as the eccentricity of the axis *p* to the axis *j*. Hence by turning the cutter holder **21** in its bearing **20** within the head **17**, the cutter axis *k* may be revolved in a circle which passes through the spindle axis *j*; which enables the cutter to be set at any eccentricity to the spindle between zero and a maximum which is equal to the sum of the eccentricities *j*—*p* and *p*—*k*. Fig. 7 shows the setting for maximum eccentricity, while Figs. 4, 5 and 6 show an intermediate setting. The adjustments once made are secured, and the entire holder made firm and rigid, by clamps **24** which are slidingly mounted in the head and have lugs **25** entering a groove in the circumference of the holder **20**, and are taken up by screws **26** so as to force the tapered surface of the holder **21** against the tapered bearing surface **20** in the head, as clearly shown by Fig. 4. The upper side of the cutter holder is recessed to give room for the threaded extremity of the spindle and the clamp nut **19**. These parts are made so massive in proportion to the dimensions of the cutter and to the service required of the cutter, as to make an amply rigid assemblage.

An alternative mode of performing essentially the same generating method is illustrated diagrammatically in Fig. 9, where the tool is represented as being a grinding wheel **27** mounted to rotate about an axis *r*, *r* transverse to the work spindle axis, but at one side thereof. The spindle carrying the grinding wheel may be assumed to be rotatably mounted in a carriage **28** and to be driven by a pulley **29**. The carriage **28** is movable bodily in a plane perpendicular to the axis of the work piece, and is so moved by eccentrics **30** and **31** on two parallel upright shafts. The eccentric **30** is driven by a gear **32** connected to the spindle on which the work piece *c* is mounted, and a meshing pinion **33** on the shaft of eccentric **30**; the pitch circle ratio of gear **32** to gear **33** being equal to the number of lobes to be cut in the rotor. An idle gear **34**, or equivalent gear train, connects gear **33** with a gear **35**, of the same pitch circle diameter as gear **33**, on shaft of eccentric **31**. The centers of both eccentrics are on relatively the same side of the axes of their respective shafts, so that such centers revolve in orbits of which the radius is equal to the eccentricity between the rotor to be made and its companion rotor. Thus all points of the carriage and grinding wheel are revolved in similar orbits at the same time and in the same direction of revolution.

The periphery of the grinding wheel is formed with a toric curvature of radius equal to that of the ring rotor lobes to which the work piece is to be made conjugate. Hence, when the work piece is rotated at one tenth of the rate of such orbital motion of the grinding wheel, about a fixed axis at the proper distance away from the nearer side of the wheel, a ten lobed rotor is produced conjugate to an outer rotor having internal lobes of the same radius as the toric curvature of the grinding wheel. In order to make the surface generated in the work piece of cylindrical character, instead of concave in complement to the circumferential curvature of the grinding wheel, the work piece may be reciprocated in the direction of its axis through a distance sufficient to bring its opposite end planes, and intermediate planes in turn, into the diametral plane of the grinding wheel; or, conversely, the wheel and its holder may be so displaced as to bring the rotational axis of the wheel into the planes so defined.

This grinding method may be used to cut rotors from a circular blank or, and preferably, to finish-grind rotors which have been previously roughed out either by the shaping method previously described, by grinding, or otherwise.

The distance between the axis of the work piece and the grinding wheel, above referred to as the proper one, is that which causes the limits of approach and recession of the contacting limb of the wheel, toward and from that axis, to be the same as the corresponding limits between which any lobe of the ring rotor in the pump approaches and withdraws from the axis of the inner rotor while running in the normal way. This statement applies to cutters of the type first decribed (Figs. 2–8), of which different points in the cutting curve travel in concentric orbits of respectively different radii, as well as to those of which all points travel revolubly in orbits of the same radius but about different centers (Fig. 9). In either case, the arc of the cutter momentarily nearest to the axis of the work piece takes different positions between radial limits from that axis which are exactly the same as the radial limits of the eccentric travel of the ring rotor lobes in the pump around the axis of the inner rotor, and its center travels in an orbit of which the radius equals the eccentricity between the two rotors.

It will be apparent from the foregoing description of alternative means for carrying out the generated method, that this generating principle is not limited to the use of a particular cutter or mode of cutting, but may be carried out with cutters of a variety of forms and characters.

The essential principle common to all embodiments is the revolution of the tool in an orbit of which the radius is equal to the eccentricity between the two rotors, while the work piece is rotated about a fixed axis at a speed in inverse ratio to the number of lobes to be generated. The circular shape of the ring rotor lobes and corresponding shape of the cutter *l* is important in that it enables a cutter of the simplest possible form and lowest possible cost to be used, and enables also all points in the circumference of the cutter to obtain equally accurate results on the work. This same characteristic makes possible also the use of a rotating cutter, such as a cylindrical grinding wheel or circumferentially toothed metal cutter rotating about the axis designated at *k* in the drawing while revolving about the axis *j*. As no specific claim is made to such a rotatable as well as revoluble cutter, I have not shown or described it in detail herein, and refer to it merely as indicating the scope of equivalents which I intend to protect under the generic claims herein.

As concerns the type of tool shown in Fig. 9, its circular outline in profile (i. e., in planes radial to its axis of rotation) is useful as being one which can be easily and accurately preserved by the aid of a truing tool, of well known character, mounted to swing in a circular arc. But otherwise the embodiment of the invention shown in Fig. 9 is not limited to the use or employment of a tool having such circular profile; such a tool may be made with the same profile as any form of lobe capable of being employed in such rotor combinations of the type referred to in this specification. That is to say, whatever may be the outline of the internal lobes of the ring rotor, a tool having the same profile at its cutting portion, when rotated and revolved in the manner disclosed with respect to Fig. 9, will generate a correct conjugate rotor with external lobes, provided the other essential conditions of the invention are maintained.

The principles of this invention are applicable to making rotors with any number of lobes from three upward, and of all sizes. They are also applicable to produce cams and the like bearing the same relationship to the rotors herein described as is borne by the cam shown in the aforesaid Nichols Patent 1,997,228. That is, by simply increasing the center distance between the cutter and work spindles beyond that required for generating a pump rotor according to the herein described method, a machine element having a periphery of which all points are radially equidistant from corresponding points in the rotor outline may be produced. That is, the same method and machine are applicable to generate either rotors directly or cams for use in machines of the type of the Nichols Patent 1,997,227 for controlling the motion of rotors being cut or finished by other methods.

What I claim and desire to secure by Letters Patent is:

1. The method of generating rotors with external lobes to be conjugate with ring rotors having internal lobes in circular series, when rotating about an axis eccentric to the axis of such a ring rotor, which consists in providing a cutting tool having cutting points so arranged as to generate a curve complemental to the curvature of one of the lobes of such ring rotor when caused to travel in a prescribed cutting path, actuating said tool so as to cause said points to travel in such path, revolving such tool in an orbit of which the radius is equal to the prescribed eccentricity between the inner and outer rotors, mounting a work piece with its rim in position to be cut by said tool, and rotating the work piece about one axis only, fixed in position, at a speed, the ratio of which to the speed of revolution of the cutting tool is in inverse proportion to the number of lobes to be generated.

2. The method of generating external lobes in a rotor conjugate to a ring rotor having a series of internal lobes equally spaced apart from one another about a center eccentric to the axis of the rotor to be generated, which consists in mounting the workpiece to rotate about a single fixed axis only, providing a cutting tool having cutting points arranged to generate a curve identical with that of such an internal lobe when actuated in the manner prescribed for performing only its cutting function, revolving the tool bodily in a circular path of which the radius at the middle of the tool is equal to the prescribed eccentricity between the rotors, and the plane of which is perpendicular to the axis of the work piece, establishing the limits of operating distance between the axis of the work piece and the nearer side of the tool in equality to the limits of distance between the lobes of the ring rotor and the rotor to be generated in their working assemblage, and at the same time propelling the tool in its cutting path and rotating the work piece about the said fixed axis at a speed which, in proportion to the speed of revolution of the tool, is in inverse proportion to the number of lobes to be generated.

3. The method of generating a machine element with a plurality of identical lobes which consists in rotating a work piece about a single fixed axis only, providing a cutting tool having the capacity of generating a cylindrical curve when operated in its normal cutting manner, revolving said cutting tool about an axis eccentric to that of such cylindrical curve, at an angular speed which is a multiple of the angular speed of the work piece equal to the number of lobes to be cut in the latter, and at the same time actuating said tool in its normal cutting manner.

4. The method of generating a plurality of lobes in a machine element which consists in rotating a work piece about a single normally stationary axis exclusively, providing a planing cutter in the form of a disk having a circular cutting edge, effecting a relative reciprocation between such cutter and work piece in a path which is both parallel to the axis of the work piece and perpendicular to the plane of the cutting edge, and simultaneously revolving the cutter about an axis eccentric to the center of curvature of said cutting edge.

5. The method of generating a plurality of lobes in the periphery of a machine element which consists in rotating a work piece about a normally fixed axis with no other rotary movement, providing a planing cutter having a circular cutting edge in a plane perpendicular to the said axis, reciprocating the cutter in a path which causes its edge to overlap and plane the peripheral part of the work piece, and simultaneously revolving the cutter about an axis eccentric to the center of curvature of its cutting edge.

6. The method of generating external lobes in the periphery of a machine element which consists in rotating a work piece about a single normally fixed axis and restraining it from revolution about any other axis, providing a plan-

ing cutter having a circular cutting edge and mounting such cutter with such edge in a plane perpendicular to the said axis, reciprocating the cutter in a path which causes its edge to overlap and plane the peripheral part of the work piece, and simultaneously revolving the cutter about an axis eccentric to the center of curvature of its cutting edge at a speed of angular rotation which is a multiple of the speed of angular rotation of the work piece equal to the number of lobes to be generated.

7. In a machine as and for the purpose set forth, a cutter carrying spindle, a cutter, and means for securing the cutter to the spindle eccentric to the spindle axis and with provision for varying its eccentricity, comprising a head secured to the spindle and having an eccentric bearing surface, and a holder having a complemental bearing surface and to which the cutter is secured eccentric to said complemental bearing surface.

8. In a machine as and for the purpose set forth, a cutter carrying spindle, a cutter, and means for securing the cutter to the spindle eccentric to the spindle axis and with provision for varying its eccentricity, comprising a head secured to the spindle and having an eccentric bearing surface, and a holder having a complemental bearing surface and to which the cutter is secured eccentric to said complemental bearing surface, the eccentricity of the cutter to the complemental bearing surface being equal to the eccentricity of the first named bearing surface to the spindle axis.

9. In a rotor generating machine of the character described, a cutter spindle, a head secured to said spindle and having a bearing surface eccentric to the axis of the spindle, a cutter holder having a surface complemental to the first named surface and being adjustable angularly around the axis thereof, means for securing said holder to the head in different adjusted positions, and a cutter having a circular cutting edge secured to said holder with the plane of its edge perpendicular to, and the center of curvature of the edge eccentric to, the axis of said bearing surfaces.

10. In a generating machine, a cutter carrying spindle mounted to reciprocate endwise and rotate about its axis, a cutter holder, means connecting said holder to said spindle with provision for angular adjustment about an axis eccentric, and substantially parallel, to the axis of the spindle, and a cutter secured to the holder in a position such that it is eccentric to said axis of adjustment.

11. In a generating machine, a cutter carrying spindle mounted to reciprocate endwise and rotate about its axis, a cutter holder, means connecting said holder to said spindle with provision for angular adjustment about an axis eccentric, and substantially parallel, to the axis of the spindle, and a cutter having a circular cutting edge secured to the holder with the plane of its cutting edge transverse to said axis and its center eccentric to the axis of adjustment of the holder.

12. A generating machine comprising a work spindle adapted to hold a work piece in a plane perpendicular to the axis of the spindle, a cutter spindle mounted to reciprocate in a path parallel to the work spindle and to rotate about an axis in its path of reciprocation, a cutting tool having a continuous, smooth circular edge in a plane transverse to the cutter spindle axis and secured to said spindle with its center at one side of said axis, and at a distance from the axis shorter than the radius of said circular edge, mechanism for rotating said spindles simultaneously at a speed ratio such that the cutter spindle rotates as many times as the number of lobes to be cut in the work piece while the work spindle rotates once, and means for reciprocating the cutter spindle in the course of such rotation.

13. A machine for generating one of the rotors of a machine consisting of a ring rotor having equally spaced internal lobes and an inner rotor eccentric to the ring rotor and having external lobes one less in number than those of the ring rotor and adapted to make gear-like mesh and continuous contact with the lobes of the ring rotor when rotated simultaneously about their respective centers; comprising a work spindle adapted to hold a work piece in a plane transverse to the axis of the spindle, a cutter having cutting points arranged to generate a curve which is the counterpart of one of the lobes of the companion rotor when said cutter is moved in the cutting direction, means for holding and moving the cutter in a path intersecting the rim of the work piece, means for mounting the cutter with capacity for revolution in the after-mentioned orbit, means for revolving said cutter in an orbit transverse to the axis of the work spindle and of which the radius is equal to the eccentricity of the rotor to be produced with respect to its companion rotor, and means for simultaneously rotating the work spindle at a ratio to the speed of revolution of the cutter equal to unity divided by the number of lobes to be generated in the work piece.

14. A machine for generating a rotor with external lobes adapted to mesh and make continuous contact with an eccentric surrounding ring rotor having internal equally spaced identical lobes of which the number is greater by one than the lobes of the inner rotor; comprising a work spindle mounted to rotate in a fixed location and adapted to carry a rotor blank in a plane transverse to the spindle, a cutter having cutting points arranged to generate a circular concave curve of equal radius to the internal lobes of the ring rotor when moved only in the cutting direction, means for mounting the cutter with capacity for revolving in an orbit of which the radius is equal to the eccentricity of the rotor to be produced with respect to its companion rotor, the plane is transverse to the axis of the work spindle and the location is such that the cutter approaches and recedes from the axis of the work spindle in the same measure that the lobes of such ring rotor approach and recede from the axis of the externally toothed rotor when in driving mesh therewith, means for so revolving the cutter, means for simultaneously rotating the work spindle at a speed ratio to the revolution of the cutter equal to unity divided by the number of lobes to be generated in the work piece, and means for driving the cutter in the cutting direction.

15. A machine for generating in a rotor a plurality of identical lobes adapted to serve as torque transmitting teeth conjugate to the lobes of an eccentrically located mating rotor, comprising a work spindle adapted to support and rotate a rotor blank, a cutter having a continuous circular cutting edge free from projecting teeth and of which the radius is approximately equal to the shortest radius of curvature of the spaces to be generated between lobes of the work piece, a work spindle mounted to rotate about its longitudinal axis and to reciprocate lengthwise to which said cutter is secured with an eccentricity equal to that of such mating rotor, said cutter spindle being located with its axis parallel to the work

spindle and in a position such that its reciprocations carry the cutter back and forth across the plane of the rotor blank and in a path intersecting the rim of the blank, means for reciprocating the cutter spindle, means for rotating the work spindle, and means for rotating the cutter spindle at a rate which causes it to make a complete rotation while the cutter spindle turns through a fraction of a rotation equal to the reciprocal of the number of lobes to be generated.

16. A machine for generating lobes in a rotor conjugate to the lobes of a mating rotor, comprising a grinding wheel of which the profile in radial planes is identical with the outline of the lobes of such companion rotor, a holder for said tool on which the latter is mounted with ability to rotate about its axis, a rotor blank holder located to support said blank in a diametral plane of the grinding wheel, means for rotating the grinding wheel about its axis, means for rotating the blank holder about the axis of the rotor blank in fixed location, and means for simultaneously revolving the cutter holder in an orbit at a speed which is a multiple of the speed of rotation of the blank holder equal to the number of lobes to be generated in the blank, said revolving means being constructed to maintain the axis of the grinding wheel parallel to itself in all positions in the orbit.

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