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(54) **Method for designing lobe-type rotors**

(57) A method for designing lobe-type rotors is capable of forming a defined rotor (1) and a conjugate rotor (2) smoothly intermeshing and conjugating to each other, wherein each of the defined rotor (1) and the conjugate rotor (2) has at least one lobe including a sharp portion and a base portion. When the defined rotor (1) and the conjugate rotor (2) are applied to machines needed for operating in periodical expansion and compression, the defined rotor (1) and the conjugate rotor (2) can provide higher compression ratio and larger discharge capacity and reduce noise, leakage and vibration.

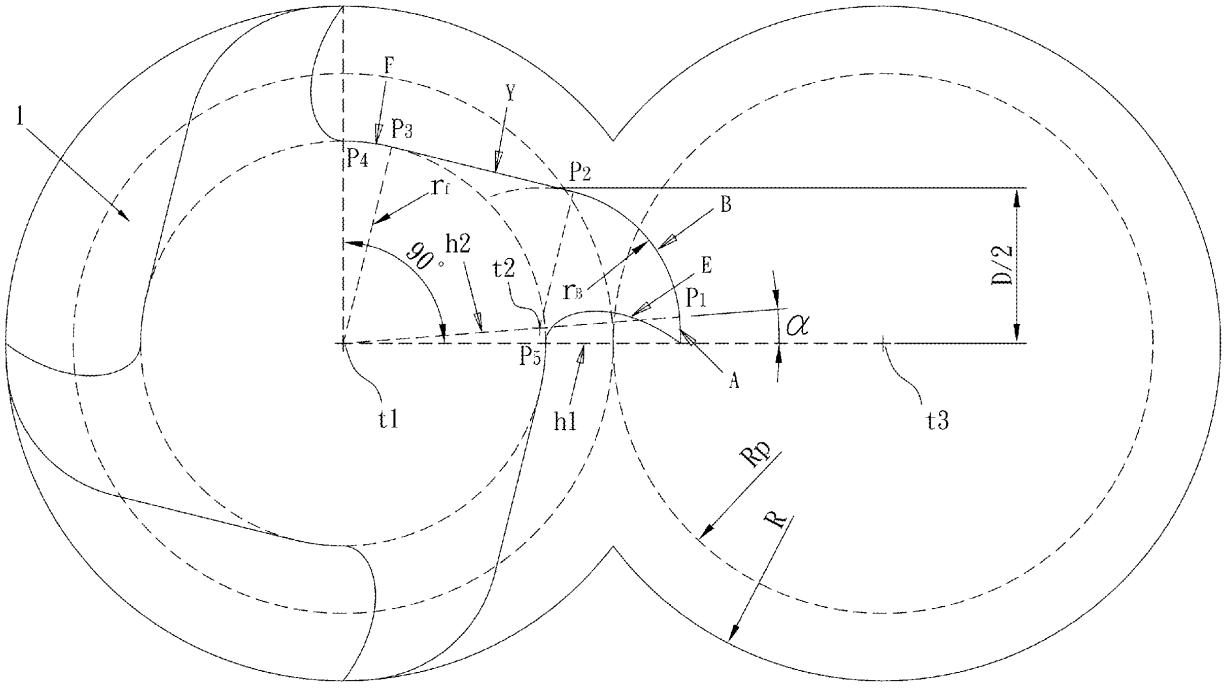

FIG.2

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Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates to a method for designing lobe-type rotors, and particularly to a method for designing lobe-type rotors including a defined rotor and a conjugate rotor having one or multiple lobes intermeshing and conjugating to each other and to provide higher compression ratio and larger discharge capacity, moreover, reduce noise, leakage and vibration.

2. RELATED ART

[0002] A lobe-type rotor generally includes a defined rotor and a conjugate rotor and is categorized into single-lobe type, double-lobe type, three-lobe type and so on. The lobe-type rotor is applied to machines for operating in periodical expansion and compression by the defined rotor and the conjugate rotor intermeshing with each other. U.S. Pat. Nos. 1,426,820, 4,138,848, 4,224,016, 4,324,538, 4,406,601, 4,430,050 and 5,149,256 disclose relevant rotors. The rotors of the prior arts have some defects that profiles of each lobe of the rotors is not formed by curves being continuously and smoothly connected; such defects cause tips of the rotors do not mesh completely with each other during operation. Consequently, in applying to machines needed for operating in periodical expansion and compression, the abnormal situations such as noise and vibration are generated in working chamber enclosed by a defined rotor, conjugate rotor and inner walls of cylinder. Moreover, unevenly intermeshing between the rotors tends to wear the rotors and therefore reduce the durability of the rotors.

SUMMARY OF THE INVENTION

[0003] Accordingly, a primary object of the present invention is to provide a method for designing lobe-type rotors including a defined rotor and a conjugate rotor, each of the defined rotor and the conjugate rotor having one or multiple lobes that can smoothly intermeshing and conjugating to each other in order to provide higher compression ratio and larger discharge capacity and reduce noise, leakage and vibration.

[0004] To achieve the above mentioned object, the method for designing lobe-type rotors of the present invention is capable of forming a defined rotor and a conjugate rotor, each having at least one lobe including a sharp portion and a base portion, wherein the sharp portion includes a curve E, arc A and arc B, which are produced by following steps:

[0005] Designating a common pitch circle radius Rp of the defined rotor and the conjugate rotor, the pitch circle radius Rp being smaller than maximum radius R of the defined rotor and in appropriate proportion to the maximum radius R, designating a center t1 of the pitch circle as the center of the defined rotor, defining a horizontal line h1 with a distance of R from the center t1 to a point P0, producing a conjugate curve E' by rotating the point P0 about the center t1, then producing a curve E by mirror-symmetrically drawing the conjugate curve E' about a tangent point P7 of the pitch circles of the defined rotor and the conjugate rotor;

[0006] Define a second line h2 from the center t1 at an desired central angle α measured from the horizontal line h1, drawing an arc with the radius R about the center t1 to intersect with the second line h2 and the horizontal line h1 respectively at a first point P1 and a point P0, defining the arc between the point P0 and the first point P1 as the arc A; and

[0007] Designate a center t2 at the second line h2 with a radius r_B measured from the first point P1, whereby an arc B is defined by rotating the first point P1 about the center t2 with the radius r_B, the radius r_B being defined by a following equation in which R indicates the maximum radius of the defined rotor (1) and equals a distance between the center t1 and the first point P1:

$$r_B + (R - r_B)\sin\alpha = \frac{D}{2}$$

$$r_B = \frac{D/2 - R\sin\alpha}{1 - \sin\alpha}$$

[0008] According to the above mentioned object, the base portion of the single lobe of the defined rotor includes at

least a curve E, an arc F and a straight line Y connecting the arc B, the base portion combining the sharp portion to form the single lobe of the defined rotor, whereby the defined rotor having more than three lobes can be produced by concentrically duplicating a profile of the single lobe to N-1 units then rotating the multiple lobes in succession at an angle of 360/N to (N-1)360/N (N indicates number of the lobes and is bigger than or equal to three), and a profile of the conjugate rotor can be produced by duplicating curves conjugate to the defined rotor's profile.

[0009] According to the above mentioned object, the arc F is formed by drawing an arc about the center t1 with a radius of $r_F = 2Rp - R$ at an angle of $\Delta\theta$ (360/N) measured from the horizontal line h1 to end at a fourth point P4, and the straight line Y is external common tangent to the arc B and the arc F respectively at a second point P2 and third point P3, whereby the arc F is defined between the points P3 and P4, the straight line Y connects the arc F and the arc B, and the profile of the single lobe of the defined rotor is formed by connecting the curve E, arc A, arc B, straight line Y and arc F.

[0010] Another object of the present invention is that the arc F further includes arcs F1 and F2, wherein the arc F1 is formed by following steps: designate a center t4 of the arc F1 located with a radius r_{F1} about the center t1 of the defined rotor at an angle of 360/N measured from the horizontal line h1, the radius r_{F1} being equal to the maximum radius R ($r_{F1} = R$), the distance between the center t4 and center t1 being 2Rp, a third line h3 defined by connecting the center t4 and the center t1, drawing an arc with the radius r_{F1} about the center t4 at a central angle β from a fifth point P5 at the third line h3 to end at a fourth point P4, whereby the arc F1 is defined as the arc between the fourth point P4 and the fifth point P5; and the arc F2 is formed by follow steps: define a center t5 of the arc F2 with a radius r_{F2} from the fourth point P4, the center t5 being in alignment with the center t4 passing the fourth point P4, the radius r_{F2} of the arc F2 defined by a following equation in which R and D respectively indicate the maximum radius and the width of defined rotor:

$$r_{F2} + (R + r_{F2})\sin\beta = \frac{D}{2}$$

$$r_{F2} = \frac{D/2 - R\sin\beta}{1 + \sin\beta}$$

then drawing an arc with the radius r_{F2} about the center t5 from the fourth point P4, then taking an external common tangent line of the arc B and the arc F2 to gain a tangent second point P2 at the arc B and a tangent third point P3 at the arc F2, the second point P2 serving as an end point of the arc B, whereby the arc F2 is defined as an arc between the points P4 and P3, and the profile of the lobe of the defined rotor is generated by connecting the curve E, arc A, arc B, straight line Y, arc F1 and arc F2.

[0011] Still, another object of the present invention is that the base portion of the single lobe further includes an arc C, whereby a profile of the single lobe of the defined rotor is generated by connecting the curve E, the arcs A, B, F, C and the straight line Y, next mirror-symmetrically duplicates the profile about the center t1 to form the defined rotor of two lobes, thus a profile of the conjugate rotor is produced by connecting respective conjugate curves of the profile of the defined rotor including curve E, the arcs A, B, F, C and the straight line Y.

[0012] According to the above mentioned object, the arc F is produced by following steps: designate a third point P3 located at the horizontal line h1 and spaced a distance of $2R_p - R$ from the center t1, drawing an arc from the third point P3 with a radius $r_F = 2R_p - R$ about the center t1 at an central angle β and end at a fourth point P4, whereby the arc F is defined as the arc between the third point P3 and the fourth point P4;

define a third line h3 by connecting the center t1 and the fourth point P4, designating a center t4 of the arc C located in an extending direction of the third line h3 with a radius r_C from the fourth point P4 passing the center t1, drawing an arc with the radius r_C about the center t4 from the fourth point P4 to end at a fifth point P5 located directly under the center t4, whereby the arc C is defined as the arc between the fourth point P4 and the fifth point P5, the radius r_C defined by a following equation:

$$r_C = x + r_F = x\sin\beta + \frac{D}{2}$$

$$\Rightarrow x = \frac{(D/2) - r_F}{1 - \sin\beta} \;\; ; \quad r_C = \frac{(D/2) - r_F}{1 - \sin\beta} + r_F$$

designate a sixth point P6 by symmetrically rotating the fifth point P5 about the center t1, the sixth point P6 being in alignment with the center t1 and the fifth point P5, drawing a line from the sixth point P6 to be tangent to the arc B at a tangent second point P2, whereby the straight Y is defined between the second point P2 and the sixth point P6.

[0013] Still, another object of the present invention is that the profile of the single lobe further includes an arc C' and an arc G, wherein the arc C' is produced by following steps: designate a eighth point P8 located by symmetrically rotating the fourth point P4 about the center t1 to be in alignment with the fourth point P4 and the center t1, defining a center t4 with a radius r_C measured from the fourth point P4 over the center t1, then designating a center t4' of the arc C' by symmetrically rotating the center t4 about the center t1, drawing an arc with the radius r_C about the center t4' from the eighth point P8 to be tangent to the straight line Y at a sixth point P6, whereby the arc C' is defined as the arc between the points P6 and P8; and

the arc G is defined with the radius r_F, the center t1 and the fifth point P5 and the eighth point P8, whereby the arc C' smoothly connects the straight line Y and the arc G smoothly connects the arc C', and the single lobe of the defined rotor is generated by connecting the curve E, the arcs A, B, the straight line Y, the arcs C', G, C and F.

[0014] According to the above mentioned object, the arc F can be produced as well by following steps: take a center of the pitch circle of the conjugate rotor as a center t3, defining a third point P3 located at the horizontal line h1 and spaced the maximum radius R from the center t3, drawing an arc with the radius R at a central angle β of the center t3 from the third point P3 to end at a fourth point P4, whereby the arc F is defined as the arc between the third point P3 and the fourth point P4; and

the arc C is produced by following steps: define a third line h3 by connecting the center t3 and the fourth point P4, designating a center t4 of the arc C located in an extending direction of the third line h3 with a radius r_C from the fourth point P4, drawing an arc with the radius r_C about the center t4 from the fourth point P4 to end at a fifth point P5 directly under the center t4, whereby the arc C is defined as the arc between the fourth point P4 and the fifth point P5, the radius r_C defined by a follow equation in which R indicates the maximum radius of the defined rotor (1) and equals a distance between the center t3 and the fourth point P4:

$$r_C + (R + r_C)\sin\beta = \frac{D}{2}$$

$$r_C = \frac{D/2 - R\sin\beta}{1 + \sin\beta}$$

the straight line Y is defined by following steps: designate a sixth point P6 by symmetrically rotating the fifth point P5 about the center t1, drawing a line from the sixth point P6 to be tangent to the arc B at a tangent second point P2, whereby the straight Y is defined between the second point P2 and the sixth point P6, and the profile of the single lobe of the defined rotor (1) is generated by connecting the curve E, the arcs A, B, F, C and the straight line Y.

[0015] Still, according to the above mentioned object, the profile of the single lobe further includes an arc H and arc G, wherein the arc H is produced by following steps: designate a center t5 of the arc H by symmetrically rotating the center t4 about the center t1, the center t5 being in alignment with the center t1 and center t4, designating a sixth point P6 being spaced a distance r_C away from and directly over the center t5, drawing an arc from the sixth point P6 with a the radius r_C about the center t5 to end at a eighth point P8, the eighth point P8 being in alignment with the center t5 and the center t1, whereby the arc H is defined as the arc between the points P6 and P8; and the arc G is defined from the eighth point P8 to the fifth point P5 with a radius measured from the eighth point P8 to the center t1 , whereby the arc G smoothly connects the arc H and the arc C.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Fig. 1 is a schematic view showing a tip conjugate curve produced by a method for designing lobe-type rotors of the present invention;

[0017] Fig. 2 is a schematic view showing a profile of a defined rotor of four lobes designed by the method of the

present invention;

[0018] Fig. 3 is a schematic view showing a profile of a conjugate rotor of four lobes designed by the method of the present invention;

[0019] Fig. 4 is a schematic view showing variation of the profile of the four lobes when width D of the defined rotor is 45, 50, 55...80 mm and a central angle α is 6°;

[0020] Figs. 5 to 8 are embodiments of five lobes, six lobes, eight lobes and nine lobes of the defined rotor of the present invention;

[0021] Fig. 9A is another embodiment showing a profile of three lobes of the defined rotor designed by the present invention;

[0022] Figs. 9B and 9C are another embodiments respectively showing a profile of two lobes of the defined rotor designed by the present invention; and

[0023] Figs. 10A and 10B are embodiments respectively showing a profile of one single lobe of the defined rotor designed by the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] Referring to Figs. 1 to 3 showing a method for designing a defined rotor 1 and a conjugate rotor 2 each having four lobes, a profile of the lobes of the defined rotor 1 is defined by following steps:

1. Specify maximum radius R=60 mm, width D=65 mm of the defined rotor 1, pitch circles of the defined rotor 1 and the conjugate rotor 2 with a common pitch circle radius Rp=40 mm and centers t1 and t3 respectively, wherein the pitch circle radius is smaller then the maximum radius R and in the ratio R=3 Rp/2.

2. Referring to Figs.1 and 2, define the center t1 as a center of the defined rotor 1, and a horizontal line h1 with a distance of R from the center t1 to a point P0, producing a conjugate curve E' by rotating the point P0 about the center t1, then producing a curve E by mirror-symmetrically drawing the conjugate curve E' about a tangent point P7 of the pitch circles of the defined rotor (1) and the conjugate rotor (2), the curve E then intersects with the horizontal line h1 at a fifth point P5, taking the curve E as a part of the sharp portion of the defined rotor (1).

3. Further referring to Fig.2, define a second line h2 from the center t1 at an desired central angle α measured from the horizontal line h1 (α =6° as shown in Fig.2), drawing an arc with the radius R about the center t1 to intersect with the second line h2 and the horizontal line h1 respectively at a first point P1 and a point P0, whereby the arc A is defined as the arc between the point P0 and the first point P1.

4. Designate a center t2 at the second line h2 with a radius r_B measured from the first point P1.

5. The radius r_B is defined by a following equation in which R indicates the maximum radius of the defined rotor (1) and equals a distance between the center t1 and the first point P1:

$$r_B + (R - r_B)\sin\alpha = \frac{D}{2}$$

$$r_B = \frac{D/2 - R\sin\alpha}{1 - \sin\alpha}$$

6. An arc B is defined by rotating the first point P1 about the center t2 with the radius r_B, and a sharp portion of the lobe of the defined rotor is formed by connecting the curve E, arc A and arc B.

7. Define an arc F with the center t1, a radius of $r_F = 2Rp - R$, and at an angle of $\Delta\theta$ ($\Delta\theta$ =90°) measured from the horizontal line h1 to end at a fourth point P4.

8. Take a straight line Y to be external common tangent to the arc B and the arc F respectively at a second point P2 and third point P3, the third point P3 being defined as another end point of the arc F is, whereby a base portion of the lobe of the defined rotor (1) is formed by connecting the arc F and straight line Y.

9. Combine the sharp portion and the base portion of the lobe to complete the profile of one single lobe of the defined rotor 1, duplicating the profile to four lobes then rotating the four lobes in succession at an angle of 90°, 180°, 270° to form the defined rotor 1 of four lobes.

[0025] With reference to Fig. 3, a profile of the conjugate rotor 2 is formed by duplicating the above-described steps through a conjugate curve portions profiled respectively from each arc and curve of the three-lobe of the defined rotor 1.

[0026] Referring to Fig. 4 showing an application of the defined rotor 1' of four lobes of the present invention, the maximum radius R of the defined rotor 1' is 60 mm, the pitch circle radius of the defined rotor 1' is 45 mm, width D of the defined rotor 1' is 45, 50, 55, 60 mm, respectively, and the central angle α is 6°, according to the characteristic of intermeshing and conjugating, the profile of the conjugate rotor 2'is subject to change to the profile of the defined rotor 1' such that is when the minimum width D of the defined rotor 1' is being minimum (S1'), the profile of the corresponding conjugate rotor 2' is being maximum. In analogy with such characteristic, applications can be vary depends on practical situations.

[0027] Referring to Figs. 5 to 8 respectively showing embodiments of 5 lobes, 6 lobes, 7 lobes and 8 lobes, a method for designing the defined rotor and the conjugate rotor of more than 4 lobes is same as the method for designing 4 lobes as described in preceding paragraphs, wherein the only difference is that the angle of $\Delta\theta$ of the arc F is defined by 360/N (N indicates number of the lobes), that is, $\Delta\theta$ is 90° for 4 lobes, 72° for 5 lobes, 60° for 6 lobes, 45° for 8 lobes and 40° for 9 lobes.

[0028] Accordingly, as the defined rotor and the conjugate rotor designed by the method of the present invention are applied to machines needed for operating in periodical expansion and compression, the defined rotor and the conjugate rotor smoothly intermesh and conjugate to each other and can provide higher compression ratio and secure a smooth operation process to further reduce noise and vibration. Moreover, because of the conjugate curve of the conjugate rotor is a smoothly curve-shape, the leakage can be reduced while working chambers undergoing compression and expansion so that to produce higher compression ratio and larger discharge capacity.

[0029] Further referring to Figs. 9A, 9B 9C and Figs. 10A and 10B respectively showing embodiments of three lobes, two lobes and single lobe of the defined rotor of the present invention, a method for designing the curve E, arc A and arc B of the sharp portion of each lobe is same as the method for design the defined rotor of four lobes as described in preceding paragraphs, wherein the differences are that the arc F and the straight line Y and the base portion further includes a arc C, arc C', curve H, and curve G.

[0030] With reference to Fig. 9A, the arc F and the straight line Y of the three lobes of defined rotor are produced by following steps:

1. The arc F further includes an arc F1 and arc F2, wherein the arc F1 is produced by following steps:

   Designating a center t4 of the arc F1 located with a radius r_{F1} about the center t1 of the defined rotor (1) at an angle of 120° measured from the horizontal line h1, the radius r_{F1} being equal to the maximum radius R (r_{F1} = R), the distance between the center t4 and center t1 being 2Rp, a third line h3 defined by connecting the center t4 and the center t1, drawing an arc with the radius r_{F1} about the center t4 at a central angle β (β = 6°) from a fifth point P5 at the third line h3 to end at a fourth point P4, whereby the arc F1 is defined as the arc between the fourth point P4 and the fifth point P5;

2. The arc F2 is produced by following steps:

   Define a center t5 of the arc F2 with a radius r_{F2} from the fourth point P4, the center t5 being in alignment with the center t4 passing the fourth point P4, the radius r_{F2} of the arc F2 defined by a following equation in which R and D respectively indicate the maximum radius and the width of defined rotor (1):

$$r_{F2} + (R + r_{F2}) \sin \beta = \frac{D}{2}$$

$$r_{F2} = \frac{D/2 - R \sin \beta}{1 + \sin \beta}$$

3. Draw an arc with the radius r_{F2} about the center t5 from the fourth point P4;
4. Then take an external common tangent line of the arc B and the arc F2 to have a tangent second point P2 at the

arc B and a tangent third point P3 at the arc F2, the second point P2 serving as an end point of the arc B, whereby the arc F2 is defined as an arc between the points P4 and P3;
5. The straight line Y is defined by connecting the points P2 and P3.

[0031] With reference to Fig. 9B, the arc F, the arc C and the straight line Y of the defined rotor are produced by following steps:

1. The arc F is produced by following steps: designate a third point P3 located at the horizontal line h1 and spaced a distance of $2Rp - R$ from the center t1, drawing an arc from the third point P3 with a radius $r_F = 2Rp - R$ about the center t1 at an central angle β (β =15°) to end at a fourth point P4, whereby the arc F is defined as the arc between the third point P3 and the fourth point P4;
2. The arc C is produced by following steps: define a third line h3 by connecting the center t1 and the fourth point P4, designating a center t4 of the arc C, the center t4 being located in an extending direction of the third line h3 with a radius r_C from the fourth point P4 passing the center t1, drawing an arc with the radius r_C about the center t4 from the fourth point P4 to end at a fifth point P5 located directly under the center t4, whereby the arc C is defined as the arc between the fourth point P4 and the fifth point P5, the radius r_C defined by a following equation:

$$r_C = x + r_F = x\sin\beta + \frac{D}{2}$$

$$\Rightarrow x = \frac{(D/2) - r_F}{1 - \sin\beta} \;;\quad r_C = \frac{(D/2) - r_F}{1 - \sin\beta} + r_F$$

3. Designate a sixth point P6 by symmetrically rotating the fifth point P5 about the center t1, wherein the sixth point P6 is in alignment with the center t1 and the fifth point P5, drawing a line from the sixth point P6 to be tangent to the arc B at a tangent second point P2, whereby the straight Y is defined between the second point P2 and the sixth point P6.

[0032] Further mirror-symmetrically duplicate the profile of the curve E, the arcs A, B, F, C and the straight line Y about the center t1 to form a second lobe whereby the defined rotor of two lobes is generated.
[0033] With reference to Fig. 9C showing another embodiment of the present invention, the arc F, the arc C and the straight line Y of the defined rotor are produced by following steps:

1. Take a center of the pitch circle of the conjugate rotor as a center t3, and define a third point P3 located at the horizontal line h1 and spaced the maximum radius R from the center t3, drawing an arc with the radius R at a central angle β of the center t3 from the third point P3 to end at a fourth point P4, whereby the arc F is defined as the arc between the third point P3 and the fourth point P4;
2. Define a third line h3 by connecting the center t3 and the fourth point P4;
3. Designate a center t4 of the arc C located in an extending direction of the third line h3 with a radius r_C from the fourth point P4, drawing an arc with the radius r_C about the center t4 from the fourth point P4 to end at a fifth point P5 directly under the center t4, whereby the arc C is defined as the arc between the fourth point P4 and the fifth point P5;
4. The radius r_C is defined by a follow equation in which R indicates the maximum radius of the defined rotor (1) and equals a distance between the center t3 and the fourth point P4:

$$r_C + (R + r_C)\sin\beta = \frac{D}{2}$$

$$r_C = \frac{D/2 - R\sin\beta}{1 + \sin\beta}$$

5. Designate a sixth point P6 by symmetrically rotating the fifth point P5 about the center t1, drawing a line from the

sixth point P6 to be tangent to the arc B at a tangent second point P2, whereby the straight Y is defined between the second point P2 and the sixth point P6, and further mirror-symmetrically duplicate the profile of the curve E, the arcs A, B, F, C and the straight line Y about the center t1 to form a second lobe so that the defined rotor of two lobes is generated.

[0034] With reference to Fig. 10A, the arc F, arc C and the straight line Y are designed by the same method as described above. The profile of the lobe of the defined rotor further includes an arc C' and arc G, the arcs C' and G produced by following steps:

1. Designate a eighth point P8 which is located by symmetrically rotating the fourth point P4 about the center t1 to be in alignment with the fourth point P4 and the center t1, defining a center t4 with a radius r_C measured from the fourth point P4 over the center t1, then designating a center t4' of the arc C' located by symmetrically rotating the center t4 about the center t1;
2. Draw an arc with the radius r_C about the center t4' from the eighth point P8 to be tangent to the straight line Y at a sixth point P6, whereby the arc C' is defined as the arc between the points P6 and P8;
3. The arc G is defined with the radius r_F, the center t1 and the fifth point P5 and the eighth point P8;
4. Accordingly, the arc C' smoothly connects the straight line Y, the arc G smoothly connects the arc C', and the single lobe of the defined rotor is generated by connecting the curve E, the arcs A, B, the straight line Y, the arcs C', G, C and F.

[0035] With reference to Fig. 10B, the arcs F and C and the straight line Y are designed by the same method as described above. The profile of the single lobe of the defined rotor further includes an arc H which is produced by following steps:

1. Designate a center t5 of the arc H by symmetrically rotating the center t4 about the center t1, the center t5 being in alignment with the center t1 and center t4;
2. Designate a sixth point P6 being spaced a distance r_C away from and directly over the center t5;
3. Draw an arc from the sixth point P6 with a the radius r_C about the center t5 to end at a eighth point P8 which is in alignment with the center t5 and the center t1, whereby the arc H is defined as the arc between the points P6 and P8;
4. The arc G is produced from the eighth point P8 to the fifth point P5 with a radius measured from the eighth point P8 to the center t1, whereby the arc G smoothly connects the arc H and the arc C.

[0036] It is understood that the invention may be embodied in other forms without departing from the spirit thereof. Thus, the present examples and embodiments are to be considered in all respects as illustrative and not restrictive, and the invention is not to be limited to the details given herein.

Claims

1. A method for designing lobe-type rotors, being capable of forming a defined rotor (1) and a conjugate rotor (2) intermeshing and conjugating to each other, the defined rotor (1) and the conjugate rotor (2) each having at least one lobe including a sharp portion and a base portion,
characterized in that the sharp portion of the lobe of the defined rotor comprises a curve E, arc A and arc B, steps of forming the curves E, A, B including :

designating a common pitch circle radius Rp of the defined rotor (1) and the conjugate rotor (2), the pitch circle radius Rp being smaller than maximum radius R of the defined rotor (1) and in appropriate proportion to the maximum radius R, designating a center t1 of the pitch circle as the center of the defined rotor (1), defining a horizontal line h1 with a distance of R from the center t1 to a point P0, producing a conjugate curve E' by rotating the point P0 about the center t1, then producing a curve E by mirror-symmetrically drawing the conjugate curve E' about a tangent point P7 of the pitch circles of the defined rotor (1) and the conjugate rotor (2), taking the curve E as a part of the sharp portion of the defined rotor (1);
defining a second line h2 from the center t1 at an desired central angle α measured from the horizontal line h1, drawing an arc with the radius R about the center t1 to intersect with the second line h2 and the horizontal line h1 respectively at a first point P1 and a point P0, defining the arc between the point P0 and the first point P1 as the arc A; and
designating a center t2 at the second line h2 with a radius r_B measured from the first point P1, whereby an arc B is defined by rotating the first point P1 about the center t2 with the radius r_B, the radius r_B being defined by

a following equation in which R indicates the maximum radius of the defined rotor (1) and equals a distance between the center t1 and the first point P1 :

$$r_B + (R - r_B)\sin\ \alpha = \frac{D}{2}$$

$$r_B = \frac{D/2 - R\sin\ \alpha}{1 - \sin\ \alpha}$$

2. The method for designing lobe-type rotors as claimed in claim 1, wherein the base portion of a single lobe of the defined rotor (1) comprises at least an arc F connecting the curve E and a straight line Y connecting the arc B, the base portion combining the sharp portion to form the single lobe of the defined rotor (1), whereby the defined rotor (1) with more than three lobes can be produced by concentrically duplicating a profile of the single lobe to N-1 units then rotating the multiple lobes in succession at an angle of 360/N to (N-1)360/N (N indicates number of the lobes and is bigger than or equal to three), and therefore a profile of the conjugate rotor (2) can be produced by the above-described steps through a conjugate curve portions profiled respectively from each arc and curve of the defined rotor (1).

3. The method for designing lobe-type rotors as claimed in claim 2, wherein the arc F is formed by drawing an arc about the center t1 with a radius of $r_F = 2Rp - R$ at an angle of $\Delta\theta$ (360/N) measured from the horizontal line h1 to end at a fourth point P4; the straight line Y being external common tangent to the arc B and the arc F respectively at a second point P2 and third point P3, whereby the arc F is defined between the points P3 and P4, the straight line Y connects the arc F and the arc B, and the profile of the lobe of the defined rotor (1) is formed by connecting the curve E, arc A, arc B, straight line Y and arc F.

4. The method for designing lobe-type rotors as claimed in claim 2, wherein the arc F further includes an arc F1 and arc F2, and the arc F1 is formed by following steps:

designating a center t4 of the arc F1 located with a radius r_{F1} about the center t1 of the defined rotor (1) at an angle of 360/N measured from the horizontal line h1, the radius r_{F1} being equal to the maximum radius R ($r_{F1} = R$), the distance between the center t4 and center t1 being 2Rp, a third line h3 defined by connecting the center t4 and the center t1, drawing an arc with the radius r_{F1} about the center t4 at a central angle β from a fifth point P5 at the third line h3 to end at a fourth point P4, whereby the arc F1 is defined as the arc between the fourth point P4 and the fifth point P5; and
the arc F2 is formed by follow steps:

defining a center t5 of the arc F2 with a radius r_{F2} from the fourth point P4, the center t5 being in alignment with the center t4 passing the fourth point P4, the radius r_{F2} of the arc F2 defined by a following equation in which R and D respectively indicate the maximum radius and the width of defined rotor (1):

$$r_{F2} + (R + r_{F2})\sin\ \beta = \frac{D}{2}$$

$$r_{F2} = \frac{D/2 - R\sin\ \beta}{1 + \sin\ \beta}$$

drawing an arc with the radius r_{F2} about the center t5 from the fourth point P4, then taking an external common tangent line of the arc B and the arc F2 to have a tangent second point P2 at the arc B and a tangent third point P3 at the arc F2, the second point P2 serving as an end point of the arc B, whereby the arc F2 is defined as an arc between the points P4 and P3, and the profile of the lobe of the defined rotor

(1) is generated by connecting the curve E, arc A, arc B, straight line Y, arc F1 and arc F2.

5. The method for designing lobe-type rotors as claimed in claim 1, wherein the base portion of a single lobe of the defined rotor (1) comprises at least an arc F connecting the curve E, a straight line Y connecting the arc B, and an arc C connecting the arc F, whereby a profile of the single lobe of the defined rotor (1) is generated by connecting the curve E, the arcs A, B, F, C and the straight line Y, further mirror-symmetrically duplicates the profile about the center t1 to form the defined rotor (1) of two lobes, and
a profile of the conjugate rotor (2) is produced by connecting respective conjugate curves of the profile of the defined rotor (1), including the curve E, the arcs A, B, F, C and the straight line Y.

6. The method for designing lobe-type rotors as claimed in claim 5, wherein the arc F is produced by following steps:

designating a third point P3 located at the horizontal line h1 and spaced a distance of $2Rp - R$ from the center t1, drawing an arc from the third point P3 with a radius $r_F = 2Rp - R$ about the center t1 at an central angle β to end at a fourth point P4, whereby the arc F is defined as the arc between the third point P3 and the fourth point P4; and
the arc C is produced by following steps:

defining a third line h3 by connecting the center t1 and the fourth point P4, designating a center t4 of the arc C located in an extending direction of the third line h3 with a radius r_C from the fourth point P4 passing the center t1, drawing an arc with the radius r_C about the center t4 from the fourth point P4 to end at a fifth point P5 located directly under the center t4, whereby the arc C is defined as the arc between the fourth point P4 and the fifth point P5, the radius r_C defined by a following equation:

$$r_C = x + r_F = x\sin\beta + \frac{D}{2}$$

$$\Rightarrow x = \frac{(D/2) - r_F}{1 - \sin\beta} \;\; ; \;\; r_C = \frac{(D/2) - r_F}{1 - \sin\beta} + r_F$$

the straight line Y is produced by following steps:

designating a sixth point P6 by symmetrically rotating the fifth point P5 about the center t1, the sixth point P6 being in alignment with the center t1 and the fifth point P5, drawing a line from the sixth point P6 to be tangent to the arc B at a tangent second point P2, whereby the straight Y is defined between the second point P2 and the sixth point P6.

7. The method for designing lobe-type rotors as claimed in claim 6, wherein the conjugate rotor (2) is generated by the steps through a conjugate curve portions profiled respectively from each arc and curve of the defined rotor (1).

8. The method for designing lobe-type rotors as claimed in claim 6, wherein the profile of the single lobe of the defined rotor (1) further comprises an arc C' and arc G, the arc C' defined by following steps:

designating a eighth point P8 located by symmetrically rotating the fourth point P4 about the center t1 to be in alignment with the fourth point P4 and the center t1, defining a center t4 with a radius r_C measured from the fourth point P4 over the center t1, then designating a center t4' of the arc C' located by symmetrically rotating the center t4 about the center t1, drawing an arc with the radius r_C about the center t4' from the eighth point P8 to be tangent to the straight line Y at a sixth point P6, whereby the arc C' is defined as the arc between the points P6 and P8;
the arc G defined with the radius r_F, the center t1 and the fifth point P5 and the eighth point P8, whereby the arc C' smoothly connects the straight line Y and the arc G smoothly connects the arc C', and the single lobe of the defined rotor (1) is generated by connecting the curve E, the arcs A, B, the straight line Y, the arcs C', G, C and F.

9. The method for designing lobe-type rotors as claimed in claim 5, wherein the arc F is produced by following steps:

taking a center of the pitch circle of the conjugate rotor (2) as a center t3, defining a third point P3 located at the horizontal line h1 and spaced the maximum radius R from the center t3, drawing an arc with the radius R at a central angle β of the center t3 from the third point P3 to end at a fourth point P4, whereby the arc F is defined as the arc between the third point P3 and the fourth point P4; and
the arc C is produced by following steps:

defining a third line h3 by connecting the center t3 and the fourth point P4, designating a center t4 of the arc C located in an extending direction of the third line h3 with a radius r_C from the fourth point P4, drawing an arc with the radius r_C about the center t4 from the fourth point P4 to end at a fifth point P5 directly under the center t4, whereby the arc C is defined as the arc between the fourth point P4 and
the fifth point P5, the radius r_C defined by a follow equation in which R indicates the maximum radius of the defined rotor (1) and equals a distance between the center t3 and the fourth point P4:

$$r_C + (R + r_C)\sin\beta = \frac{D}{2}$$

$$r_C = \frac{D/2 - R\sin\beta}{1 + \sin\beta}$$

the straight line Y is defined by following steps:

designating a sixth point P6 by symmetrically rotating the fifth point P5 about the center t1, drawing a line from the sixth point P6 to be tangent to the arc B at a tangent second point P2, whereby the straight Y is defined between the second point P2 and the sixth point P6, and the profile of the single lobe of the defined rotor (1) is generated by connecting the curve E, the arcs A, B, F, C and the straight line Y.

10. The method for designing lobe-type rotors as claimed in claim 9, further mirror-symmetrically duplicating the profile to form the defined rotor (1) with two lobes, and a profile of the conjugate rotor (2) is produced by connecting respective conjugate curves of the profile of the defined rotor (1), including the curve E, the arcs A, B, F, C and the straight line Y.

11. The method for designing lobe-type rotors as claimed in claim 9, wherein the profile of the single lobe of the defined rotor (1) further comprises an arc H and an arc G, and the arc H is produced by following steps:

designating a center t5 of the arc H by symmetrically rotating the center t4 about the center t1, the center t5 being in alignment with the center t1 and center t4, designating a sixth point P6 being spaced a distance r_C away from and directly over the center t5, drawing an arc from the sixth point P6 with a the radius r_C about the center t5 to end at a eighth point P8, the eighth point P8 being in alignment with the center t5 and the center t1, whereby the arc H is defined as the arc between the points P6 and P8; and
the arc G is defined from the eighth point P8 to the fifth point P5 with a radius measured from the eighth point P8 to the center t1, whereby the arc G smoothly connects the arc H and the arc C.

12. The method for designing lobe-type rotors as claimed in claim 11, wherein a profile of the conjugate rotor (2) is generated by the steps through a conjugate curve portions profiled respectively from each arc and curve of the defined rotor (1).

13. A method for manufacturing lobe-type rotors, which method includes the following steps:

(a) designing a lobe-type rotor by the method as claimed in any preceding claim; and
(b) materially producing the lobe-type rotor so designed.

14. A method as claimed in any preceding claim, wherein the method for designing lobe-type rotors is implemented by a computer.

15. A lobe-type rotor obtainable by the method of manufacture as claimed in Claim 13.

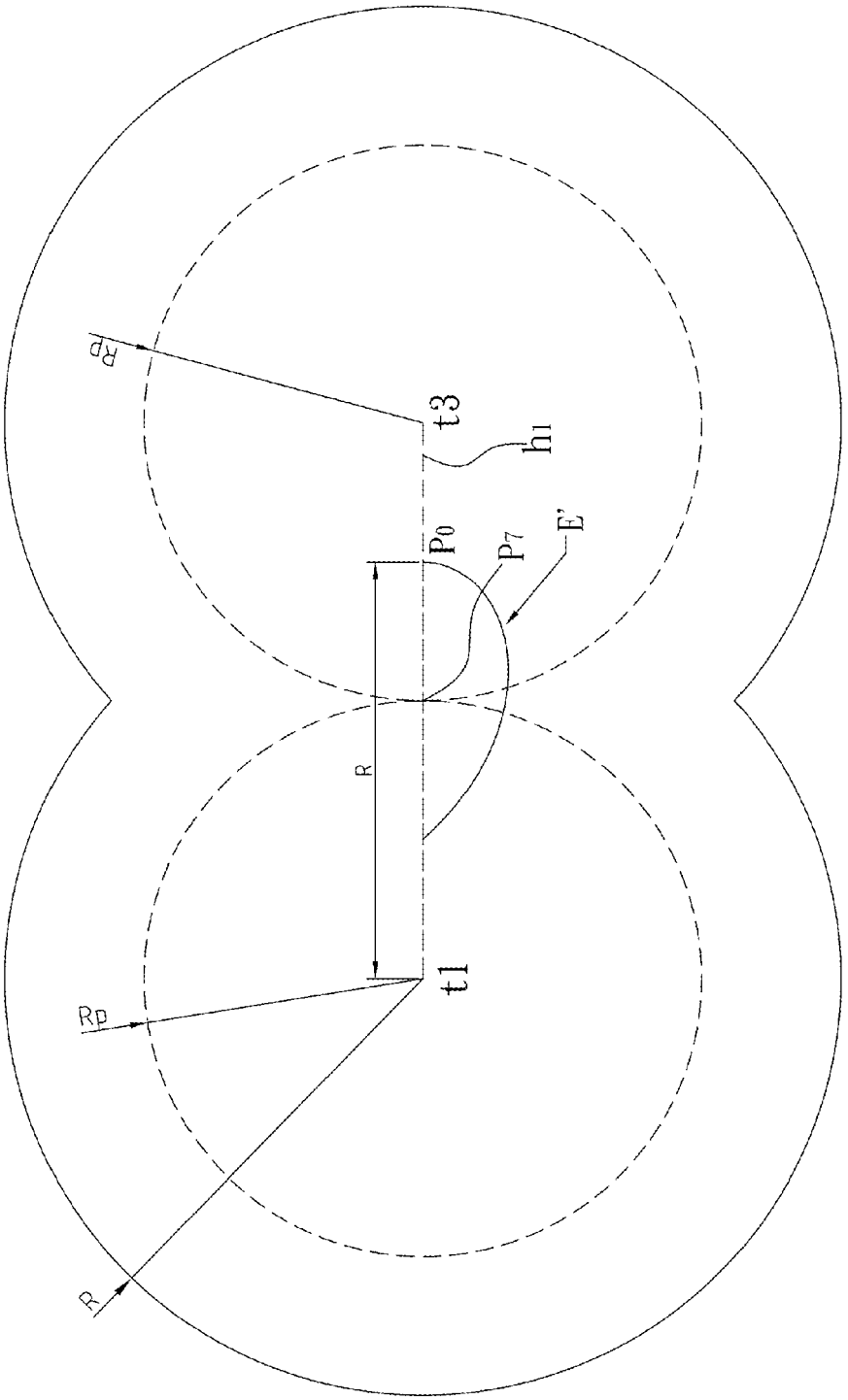


FIG.1

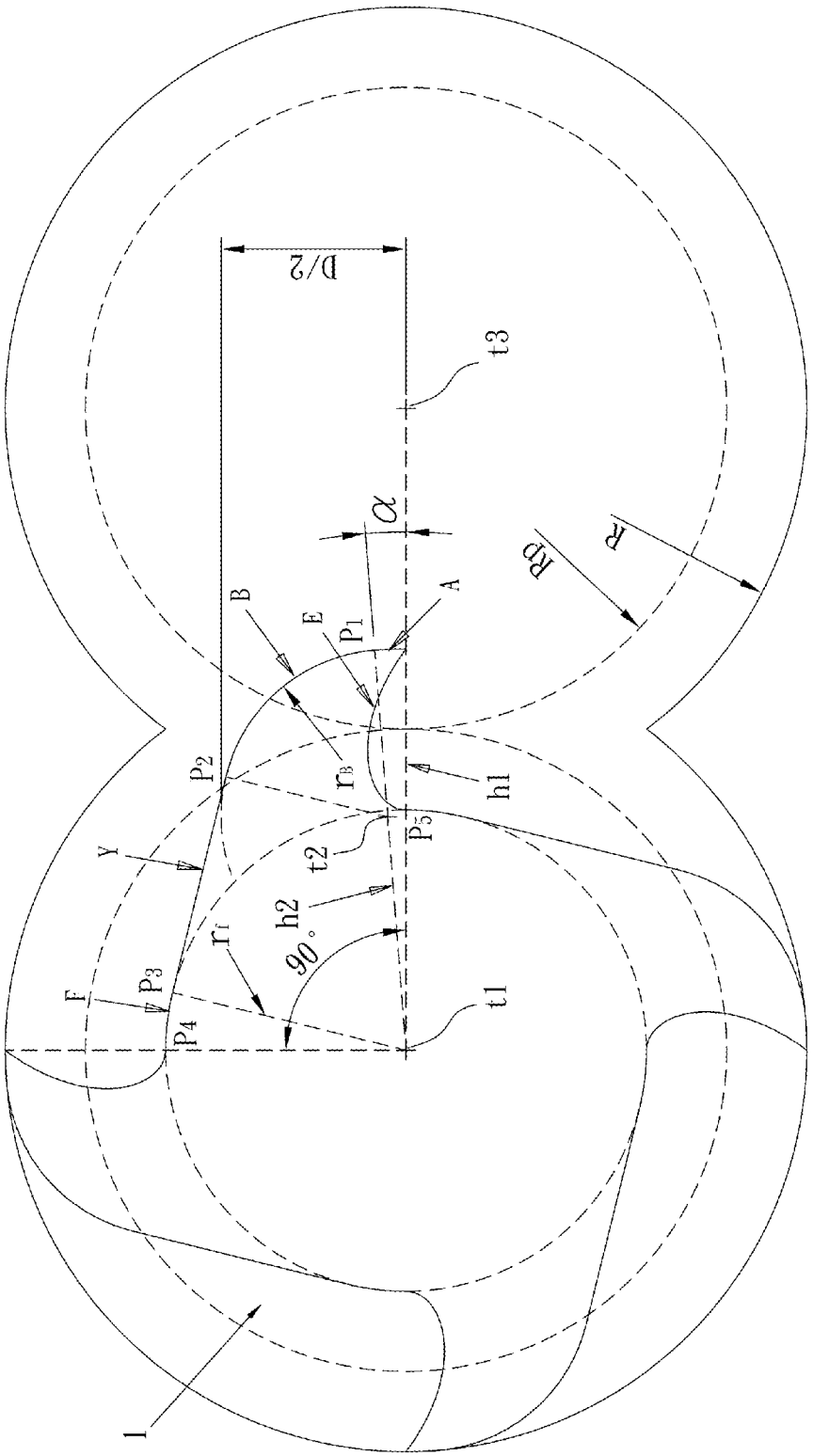


FIG.2

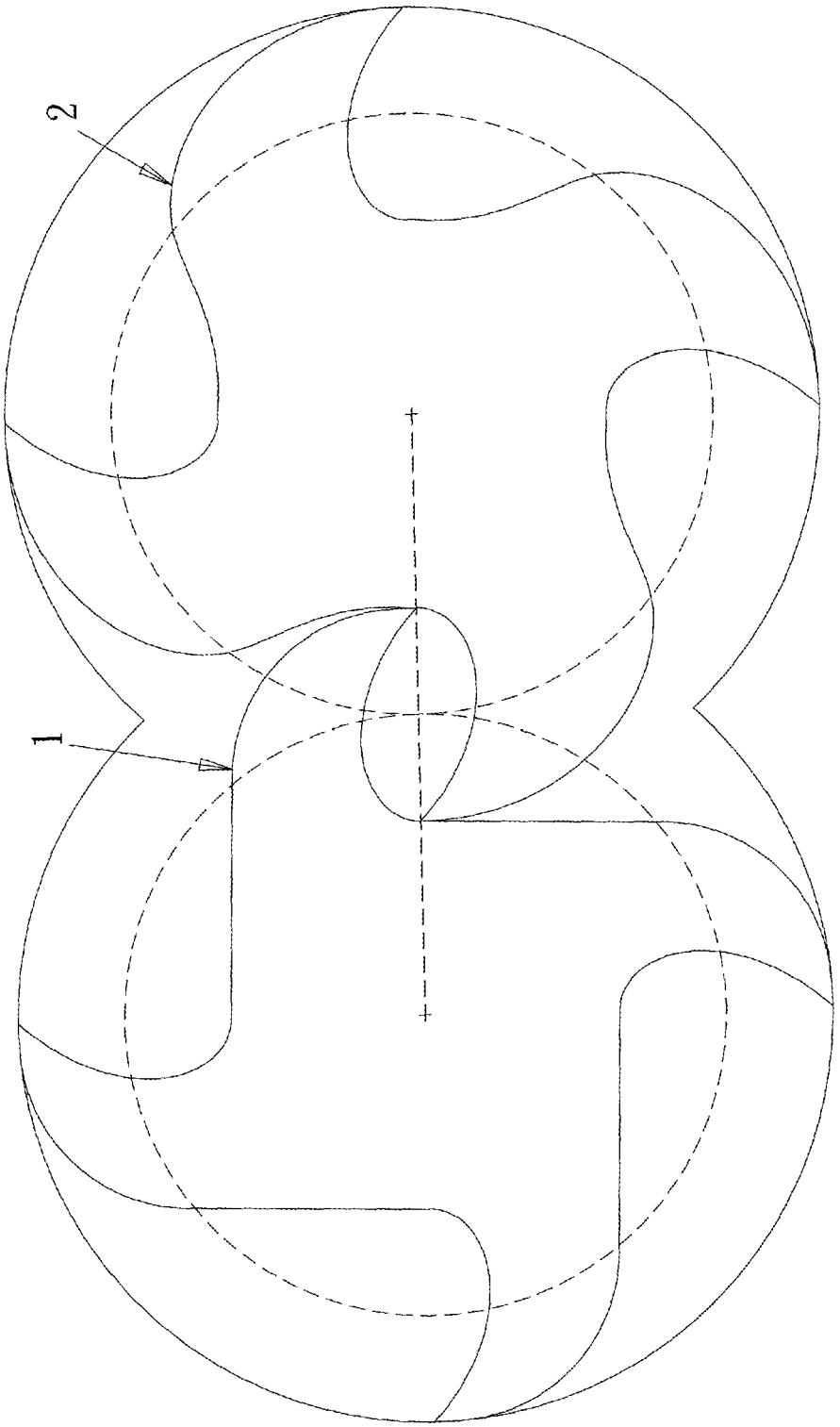


FIG.3

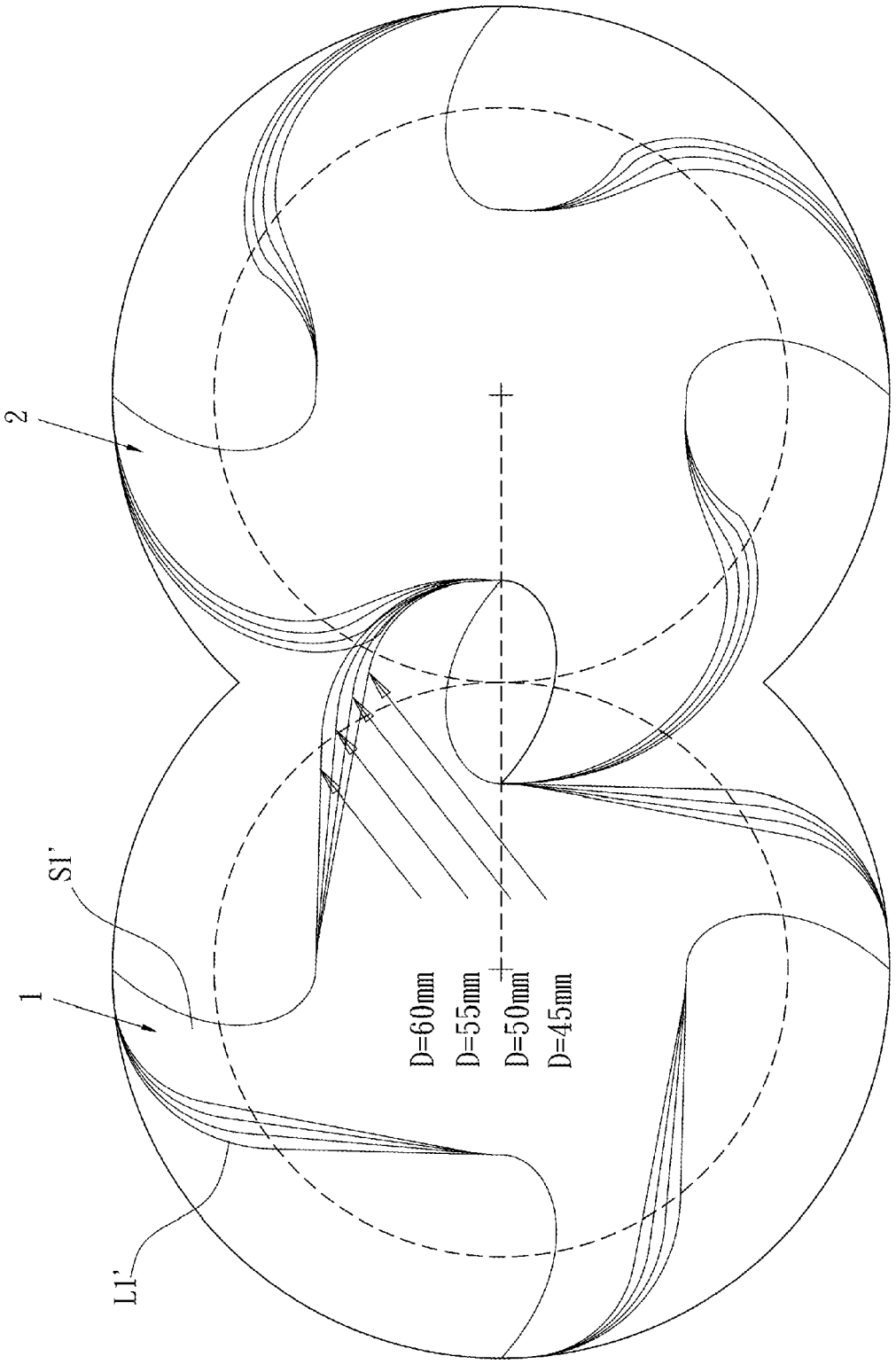


FIG. 4

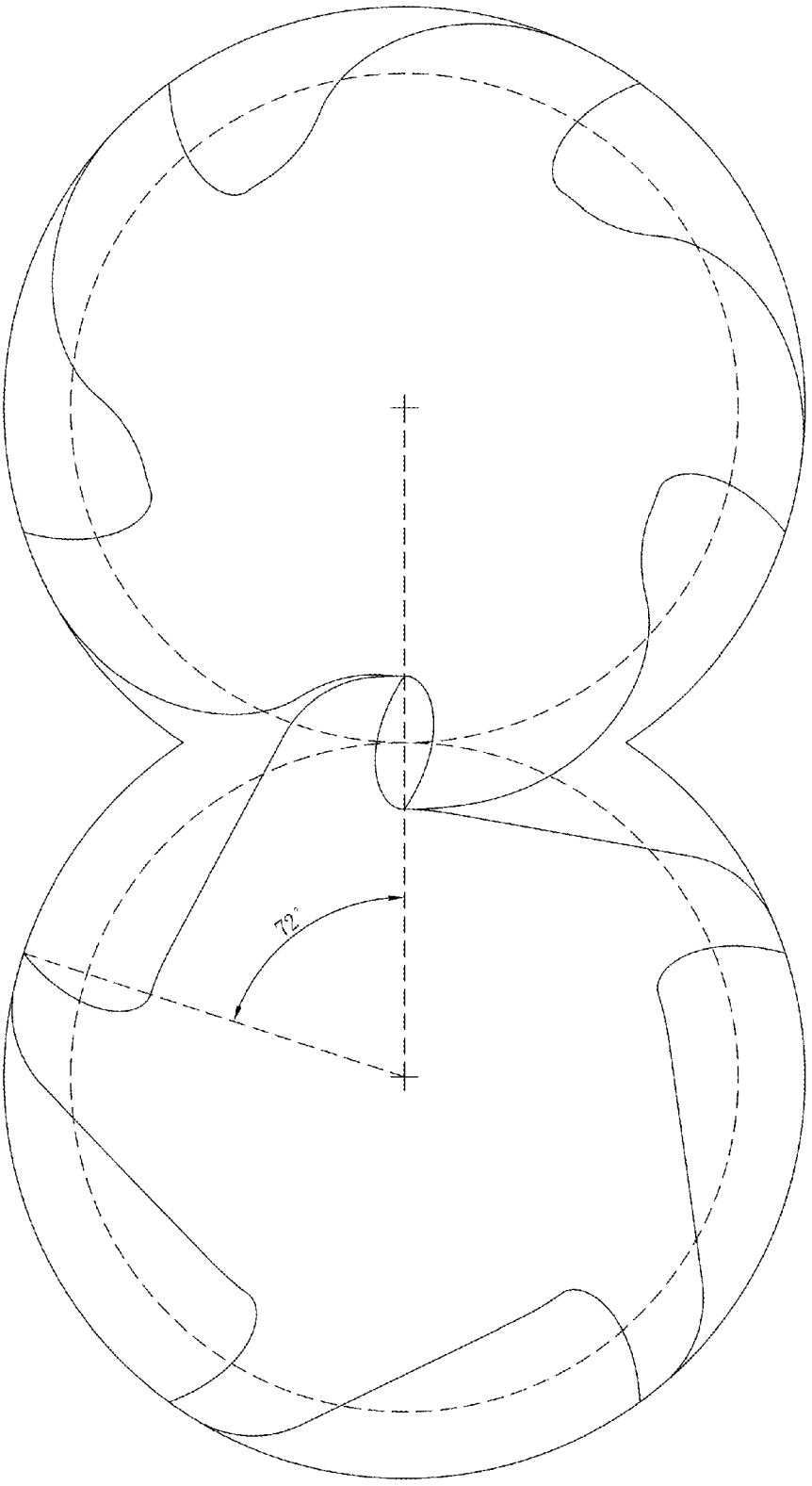


FIG.5

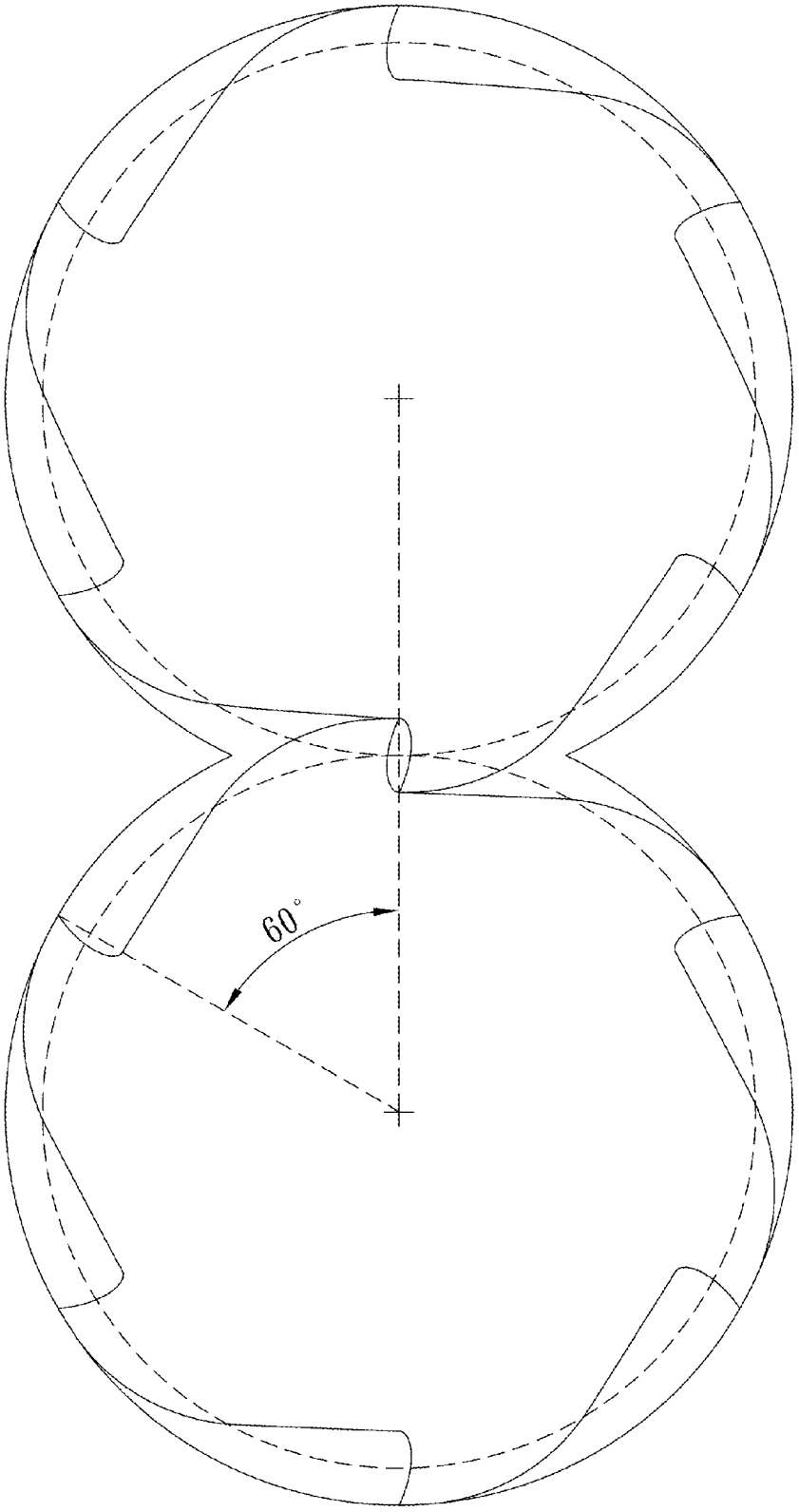


FIG.6

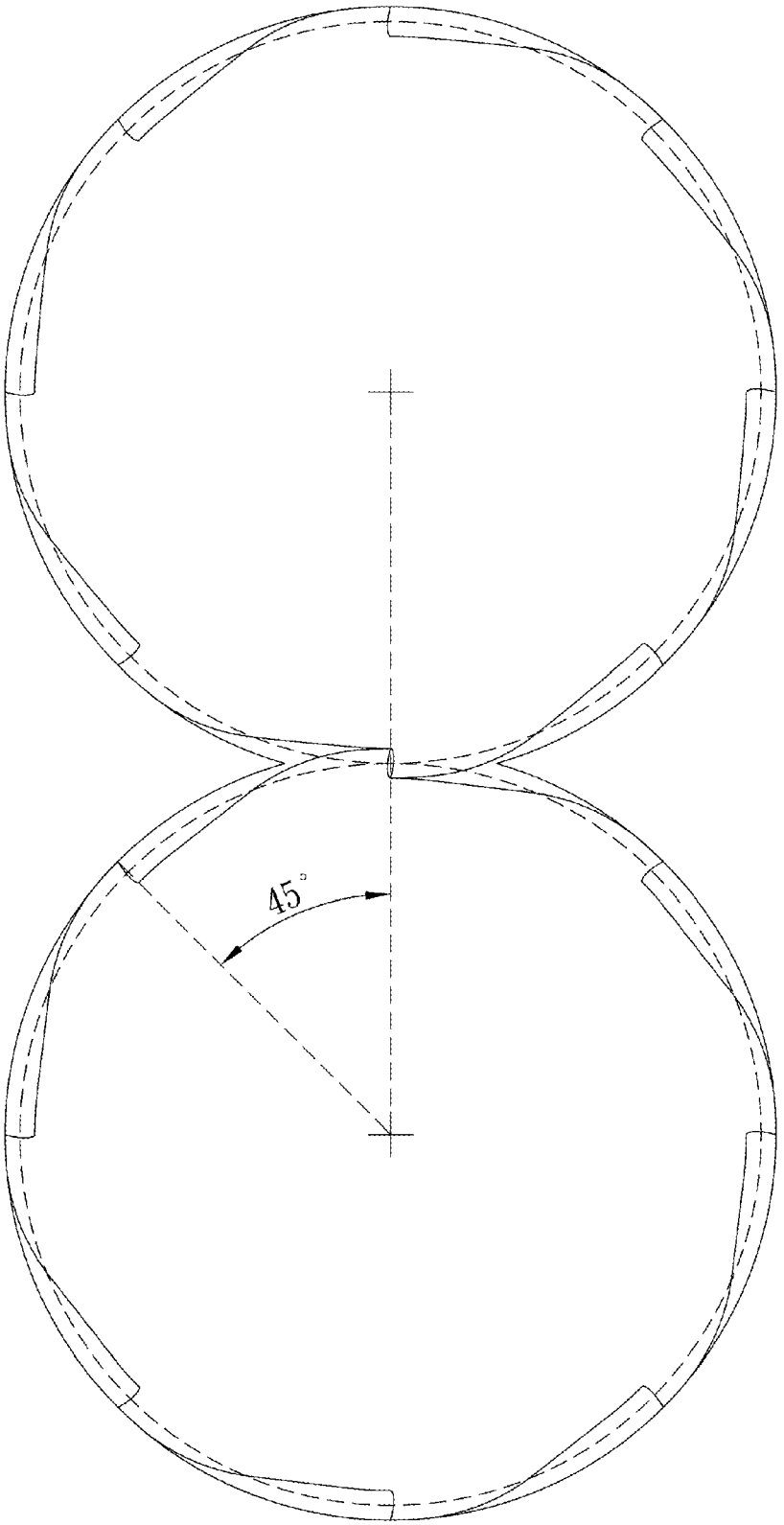


FIG. 7

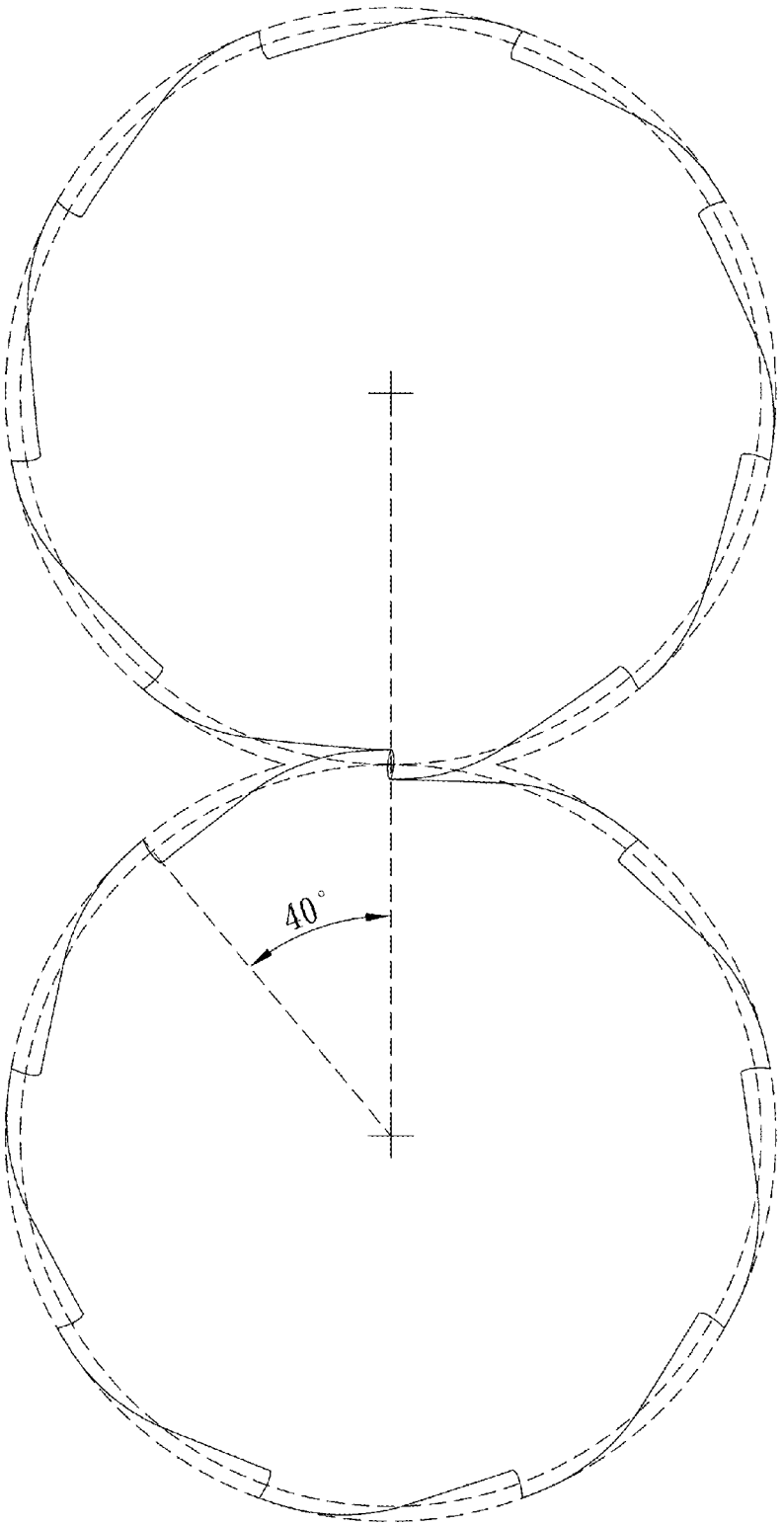
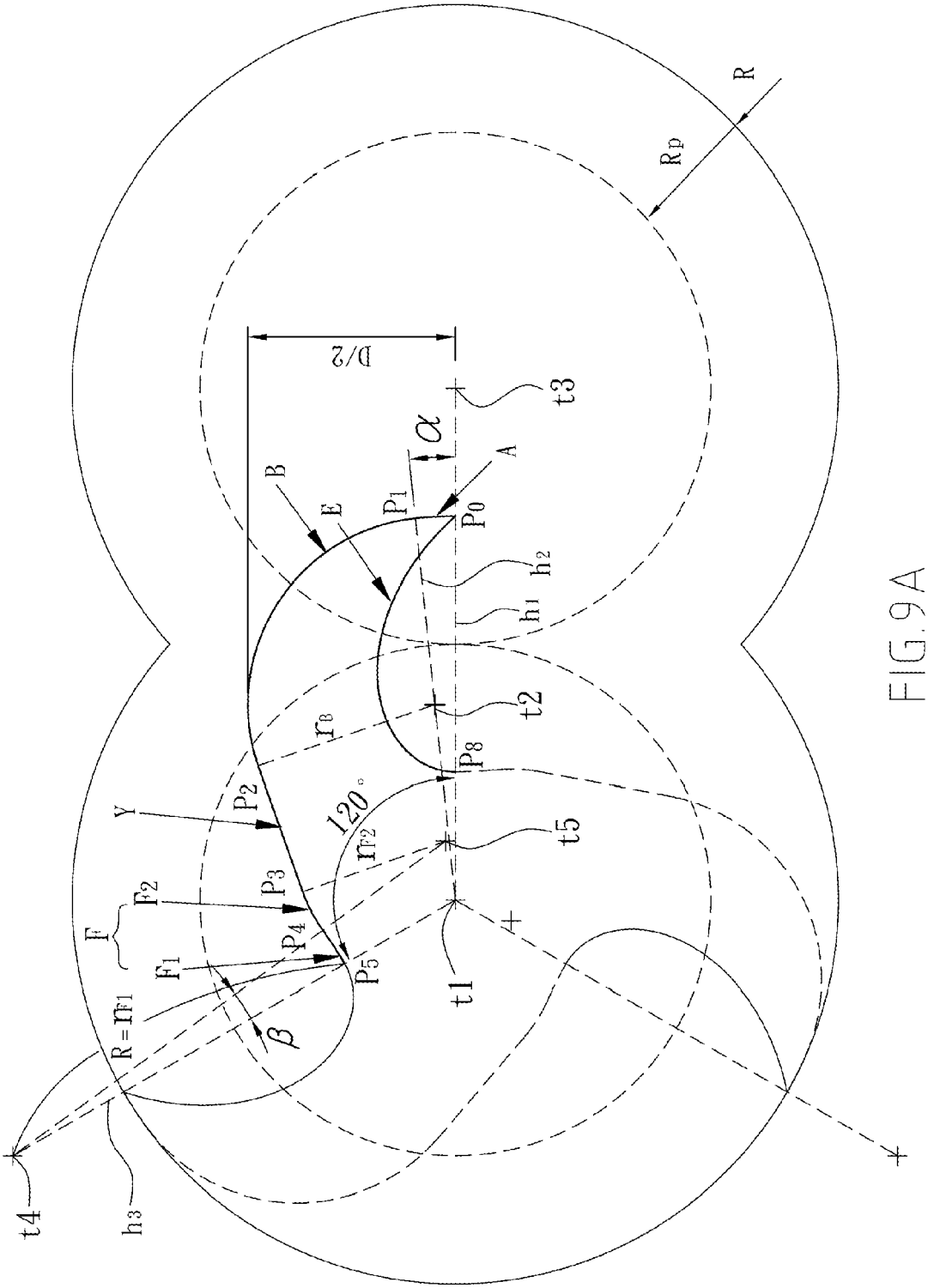


FIG.8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Rp
D/2
t3
α
A
B
E
P1
P0
h2
h1
t2
r8
P8
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P5
t1
R=rF1
β
t4
h3

FIG.9A

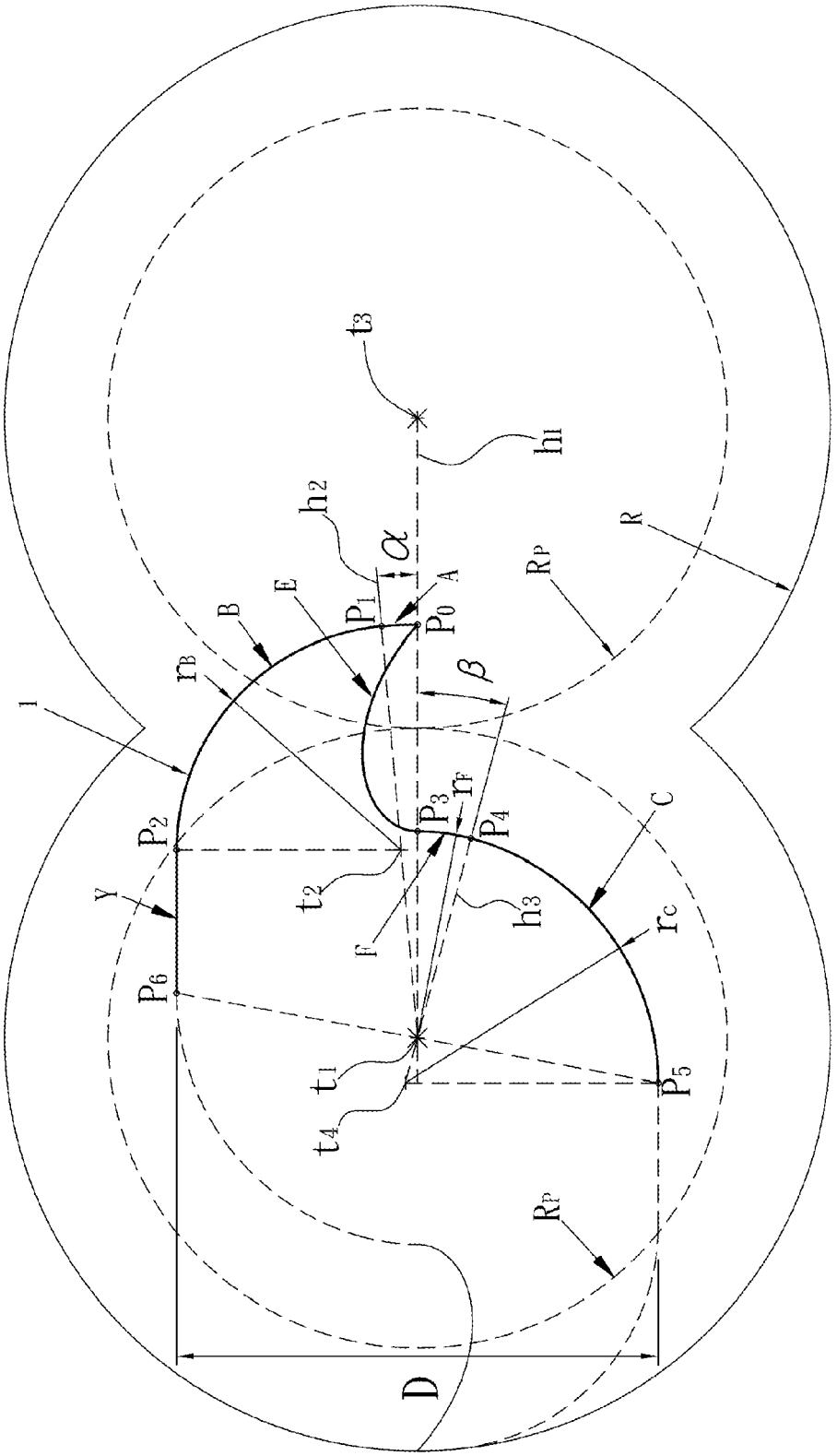


FIG.9B

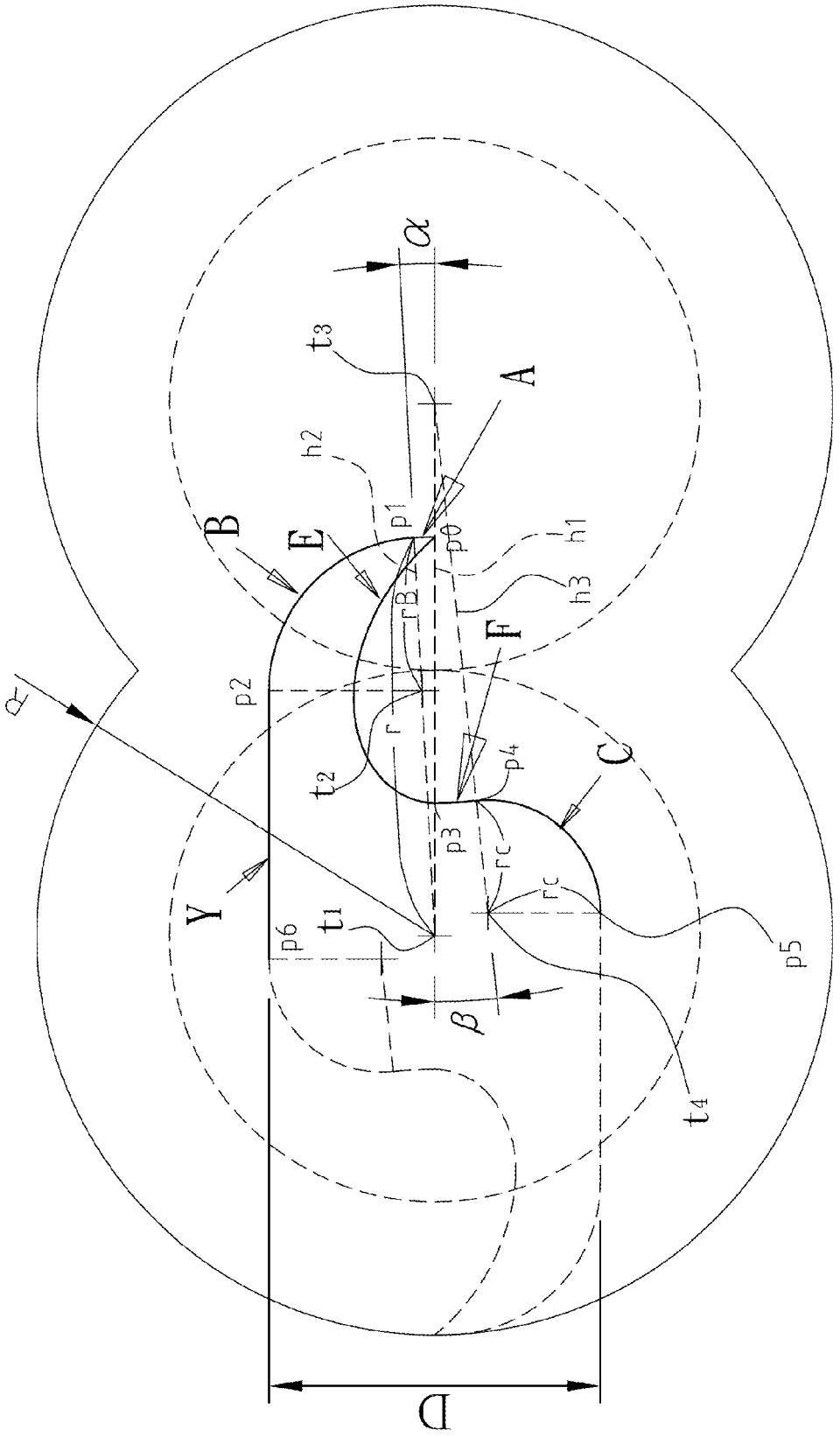
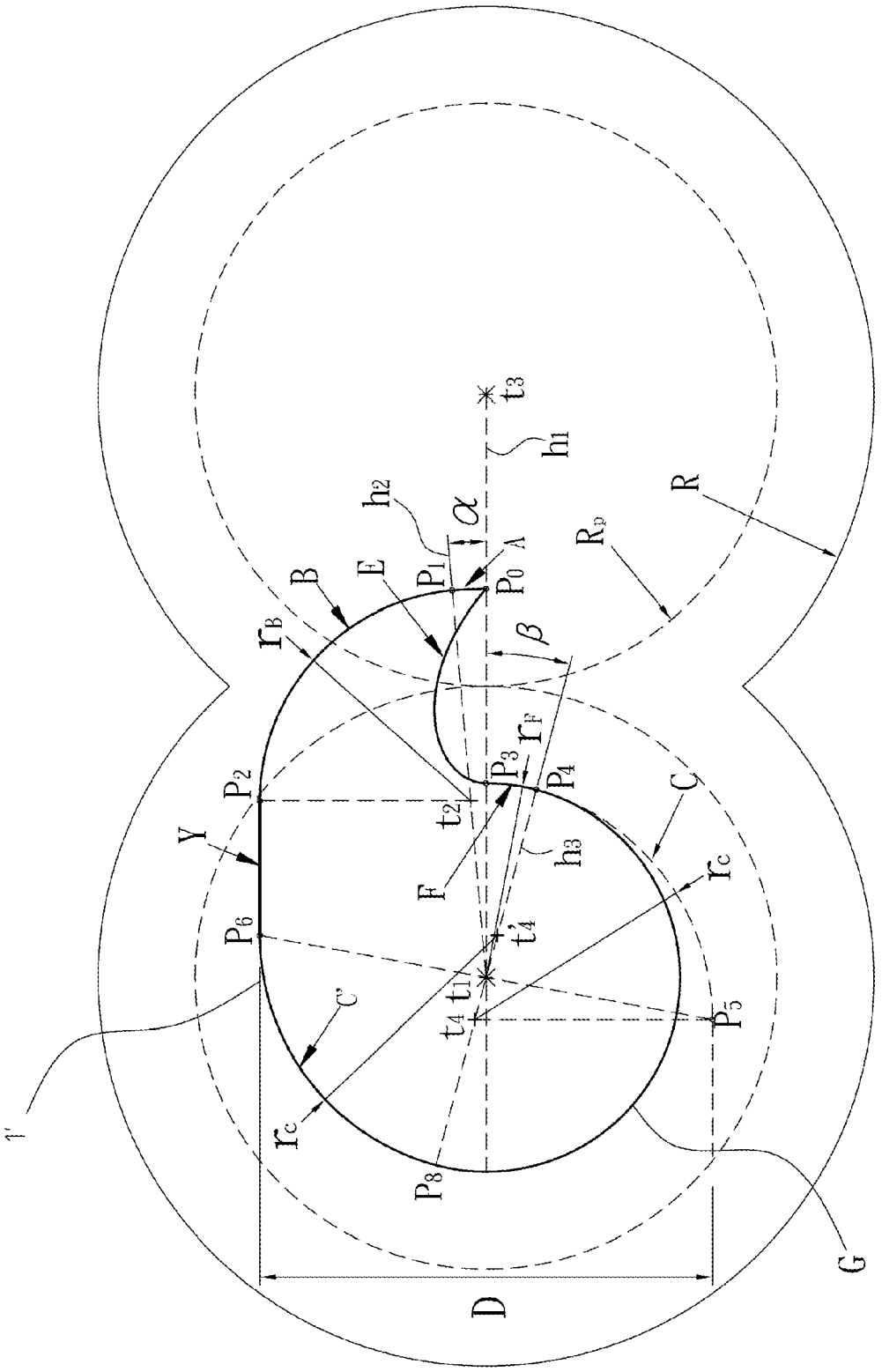


FIG.9C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P6
Y
P2
B
E
P1
P0
h2
α
h1
t3
R
Rp
rB
β
rF
P3
P4
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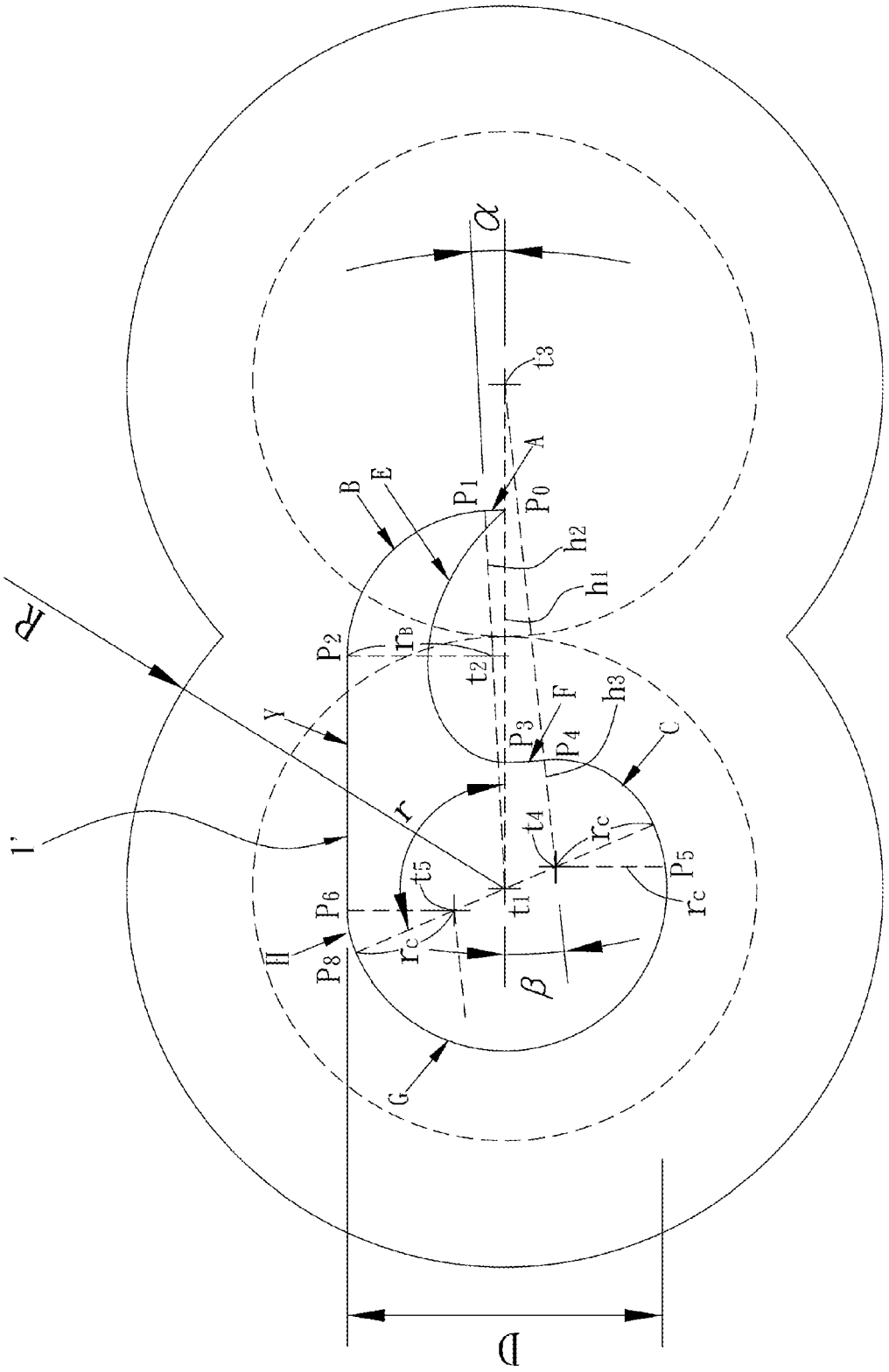
t2
F
h3
rc
t'4
t11
t4
C'
P5
P8
G
D

FIG.10A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P0
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rB
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F
h3
P3
P4
C
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1'
r
t4
rc
P5
t5
t1
P6
rc
II
P8
β
G
D

FIG.10B

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 15 1261

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Place of search	Date of completion of the search	Examiner
The Hague	14 July 2008	Biloen, David

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