No. 731,283. PATENTED JUNE 16, 1903.

J. F. COOLEY.

MECHANICAL MOVEMENT.

APPLICATION FILED JAN. 17, 1902.

NO MODEL.

4 SHEETS—SHEET 1.

Fig. 1.

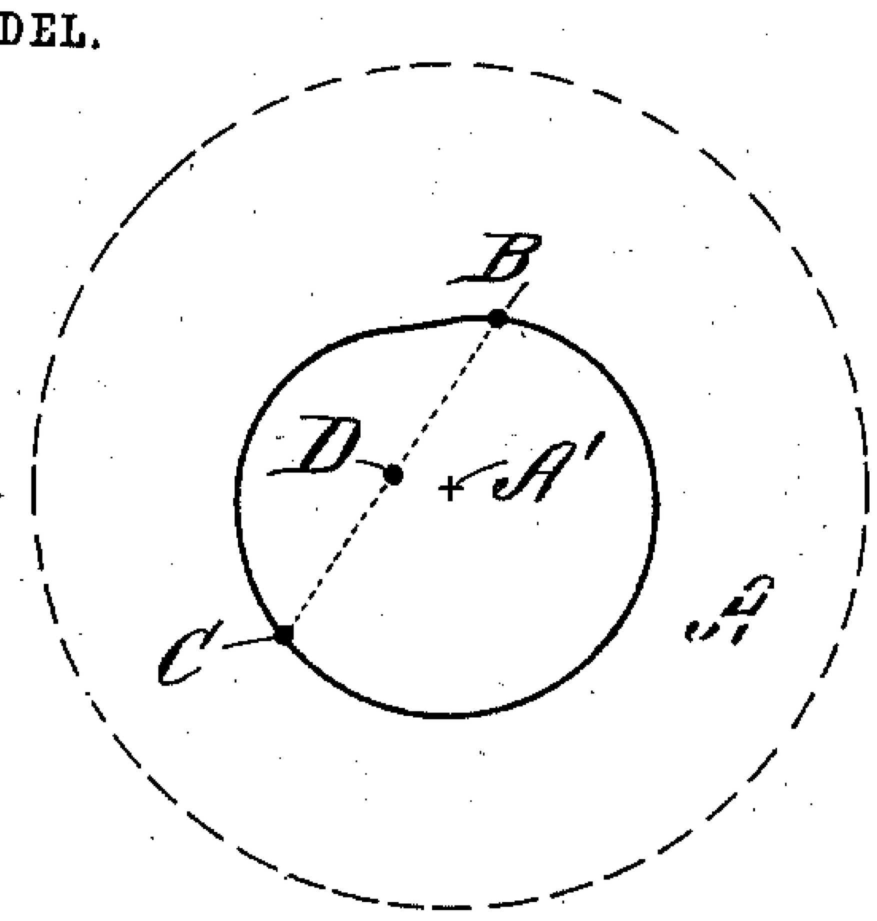


Fig. 5.

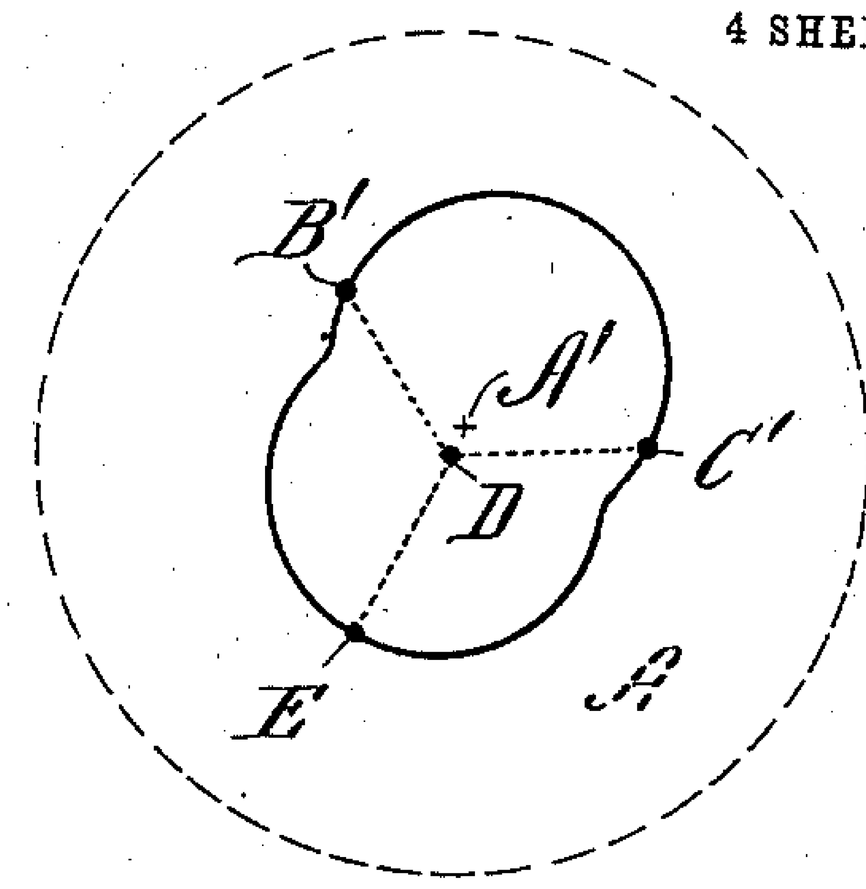


Fig. 2.

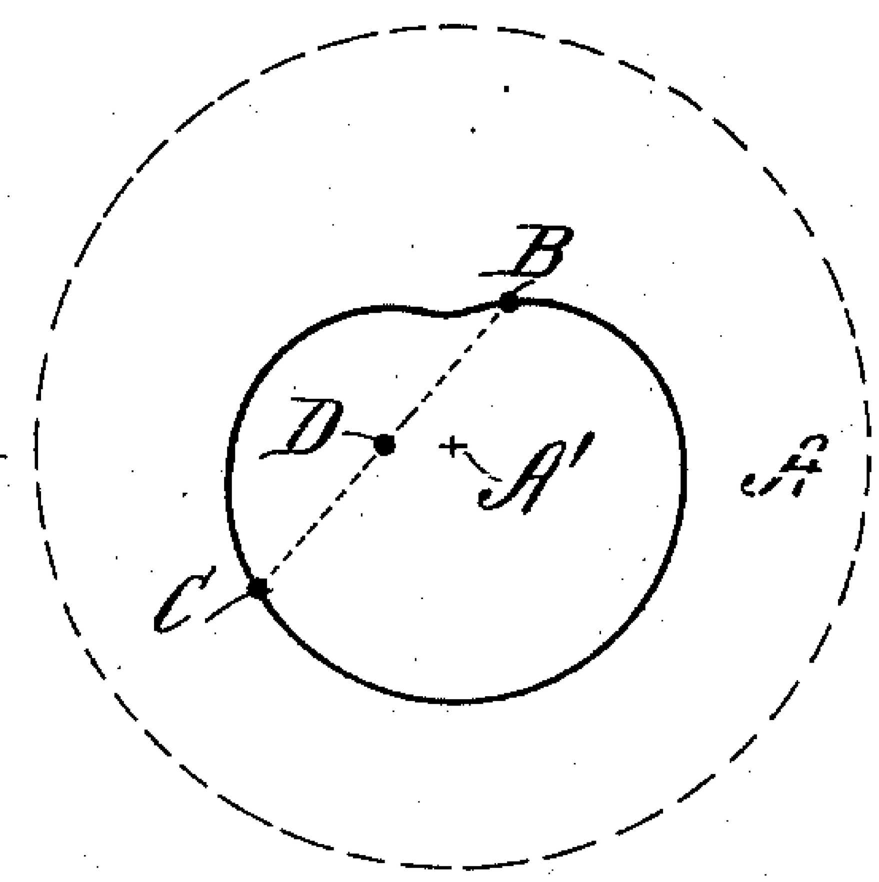


Fig. 6.

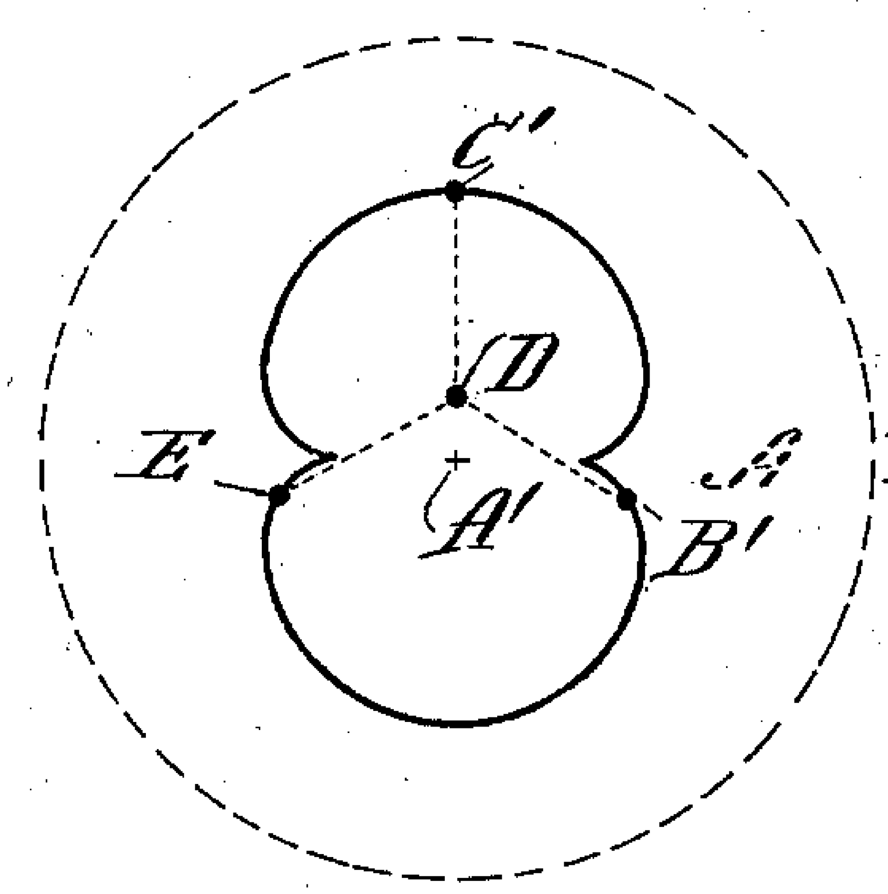


Fig. 3.

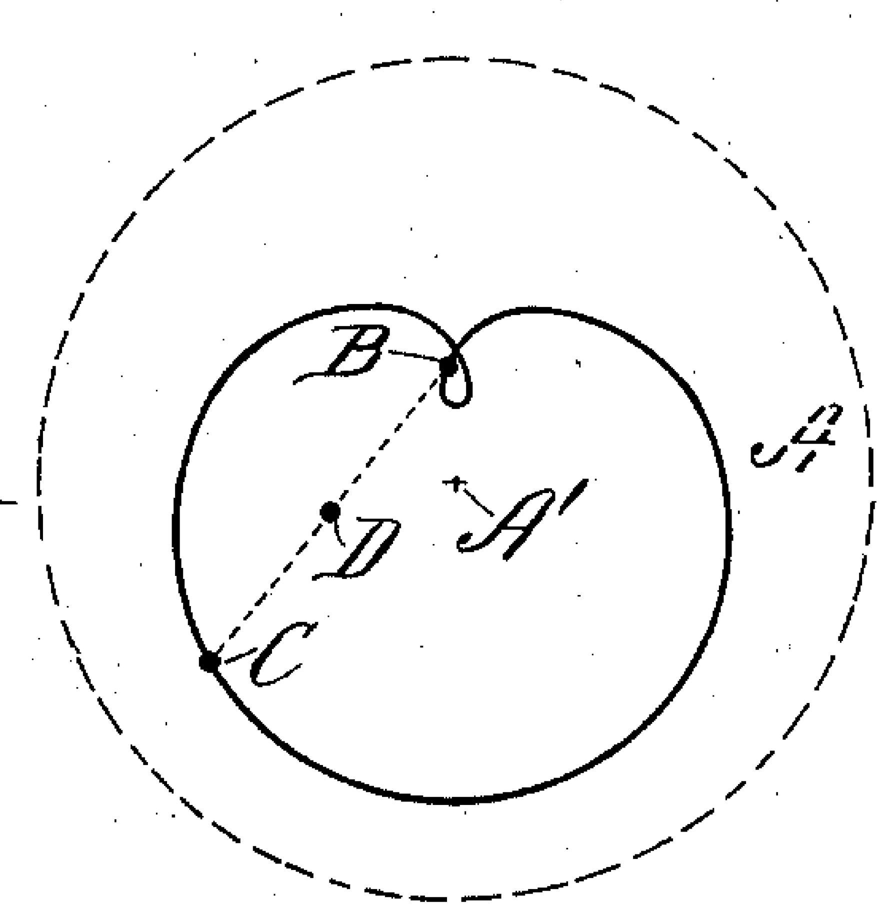


Fig. 7.

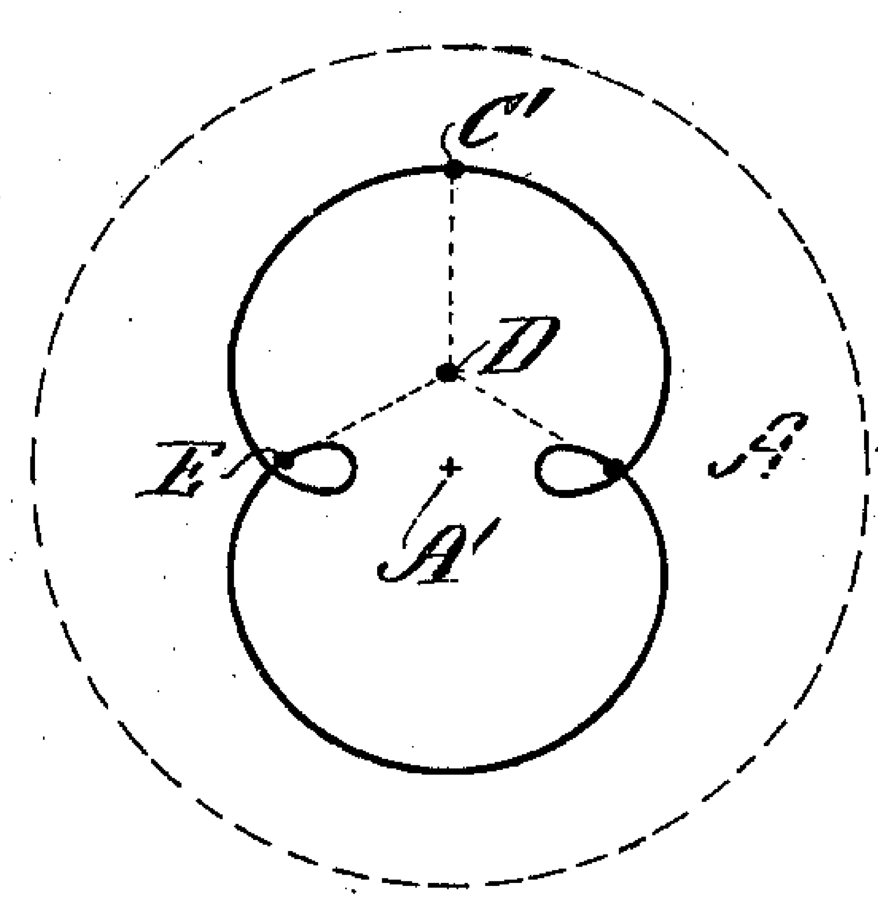


Fig. 4.

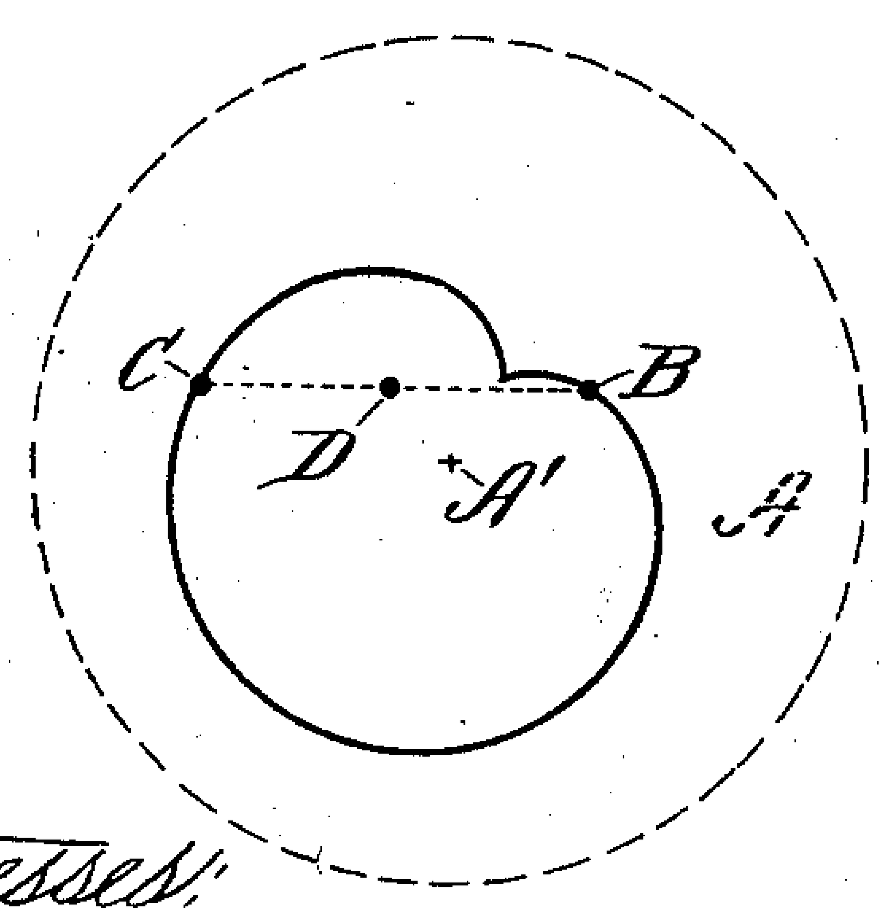
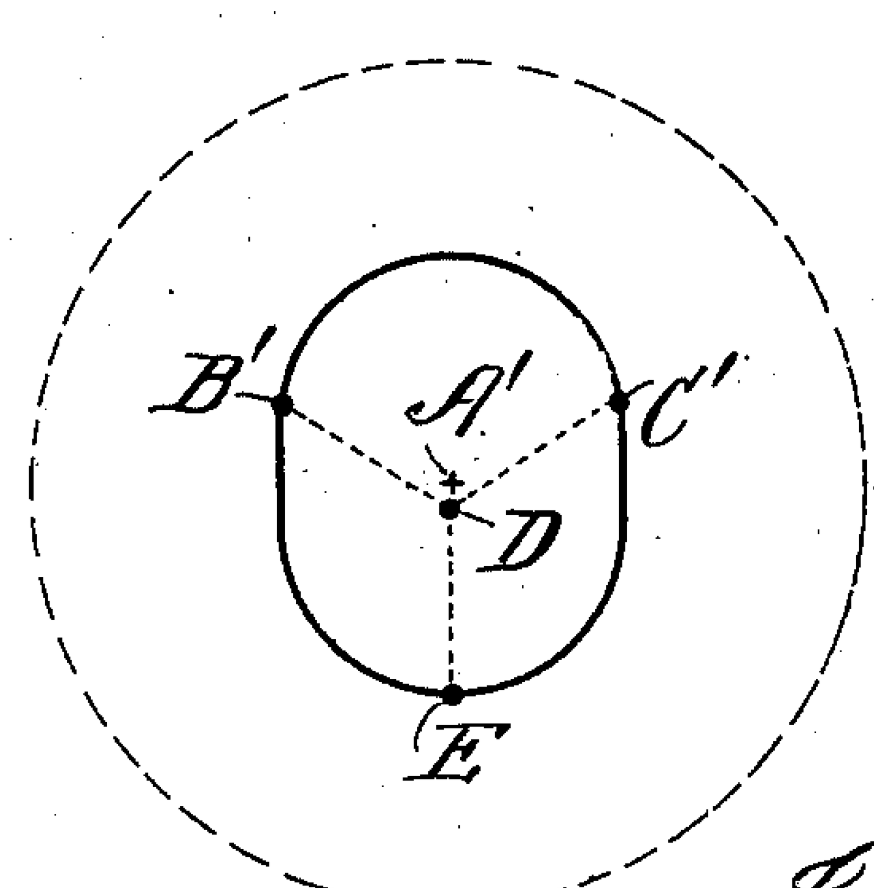


Fig. 8.



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A. L. Messer

Inventor:
John F. Cooley
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atty

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4 SHEETS—SHEET 2.

Fig. 9.

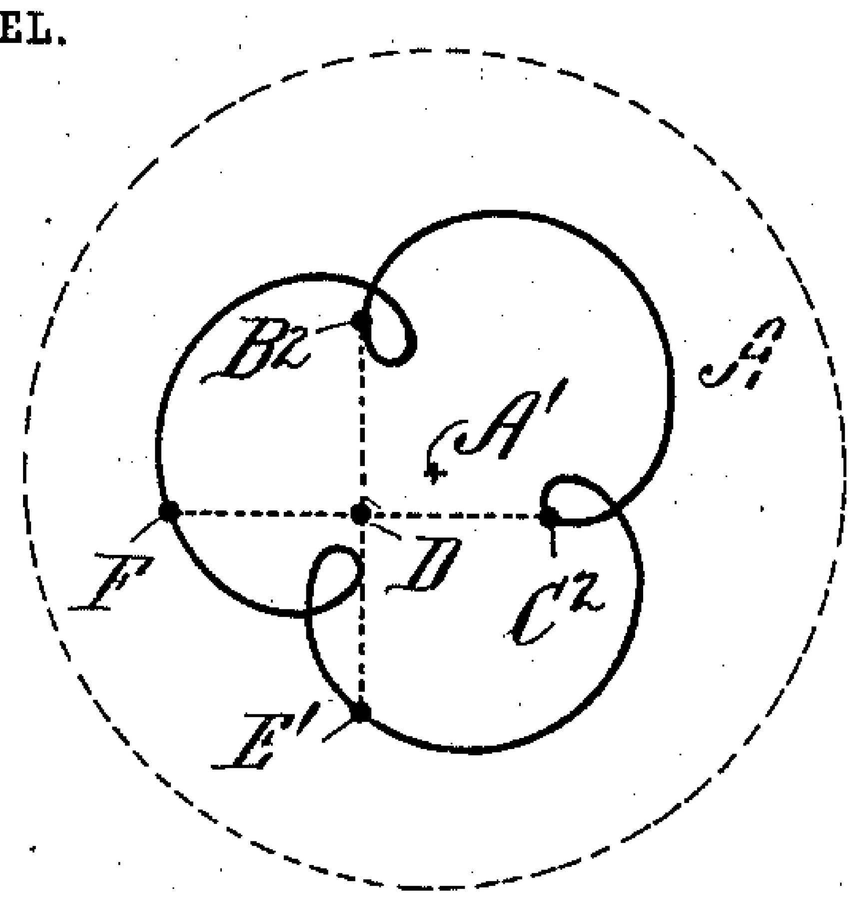


Fig. 13.

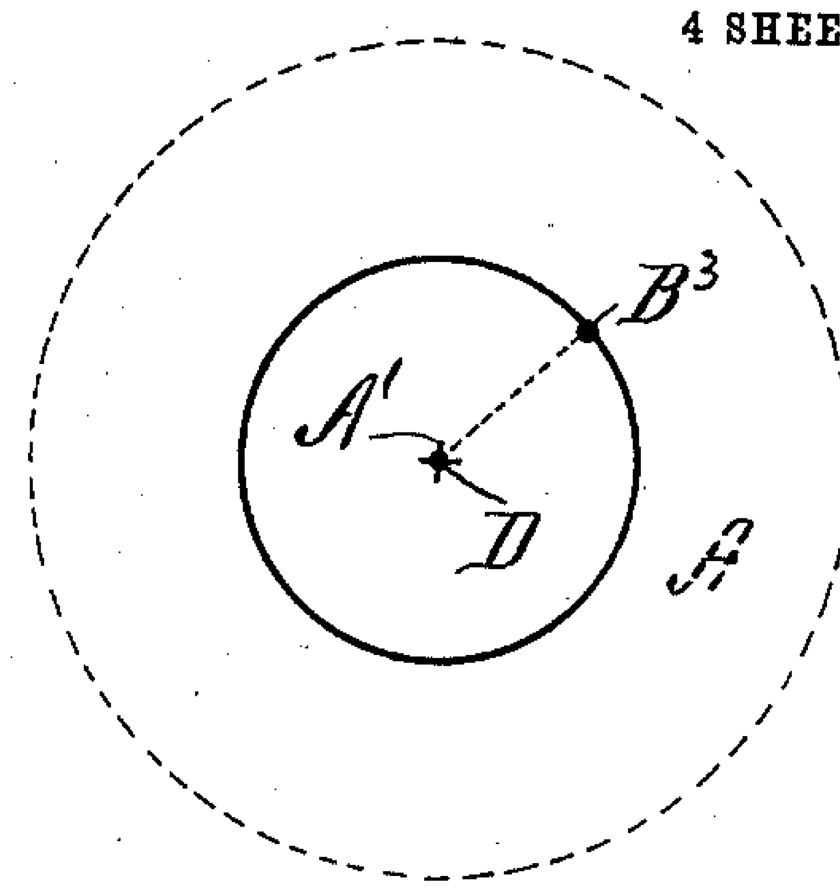


Fig. 10.

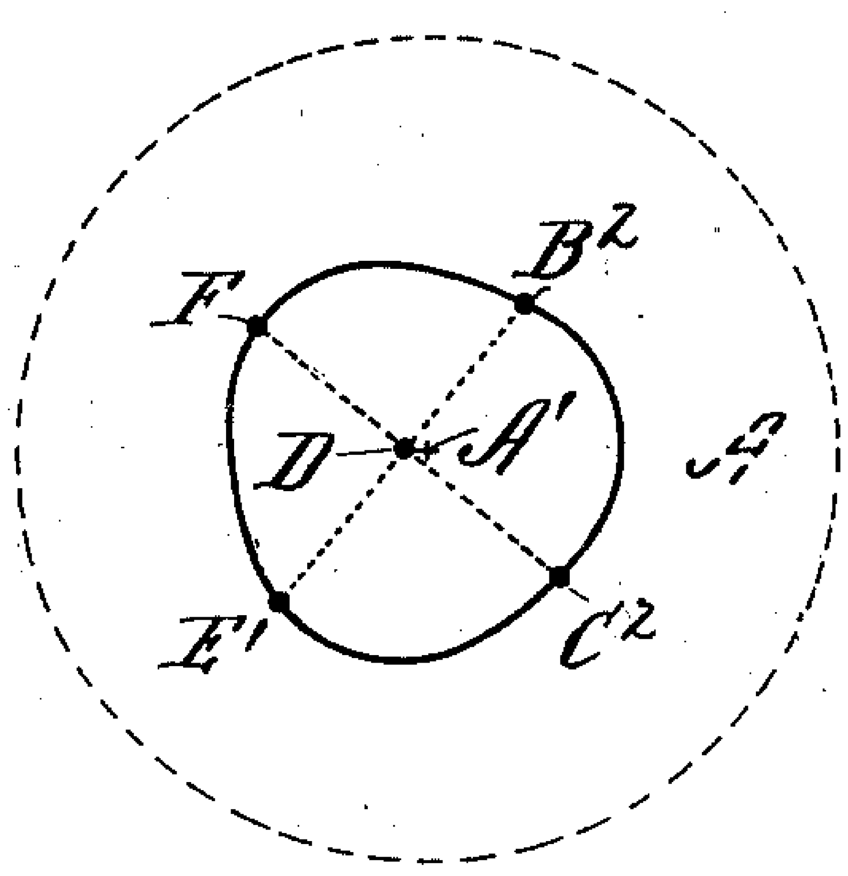


Fig. 14.

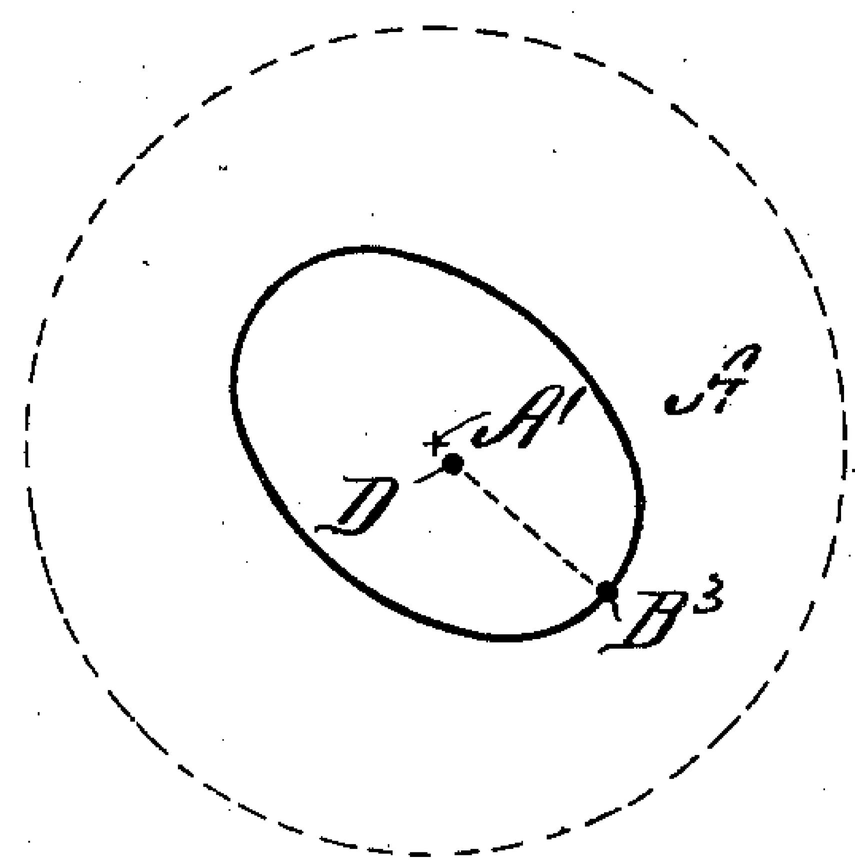


Fig. 11.

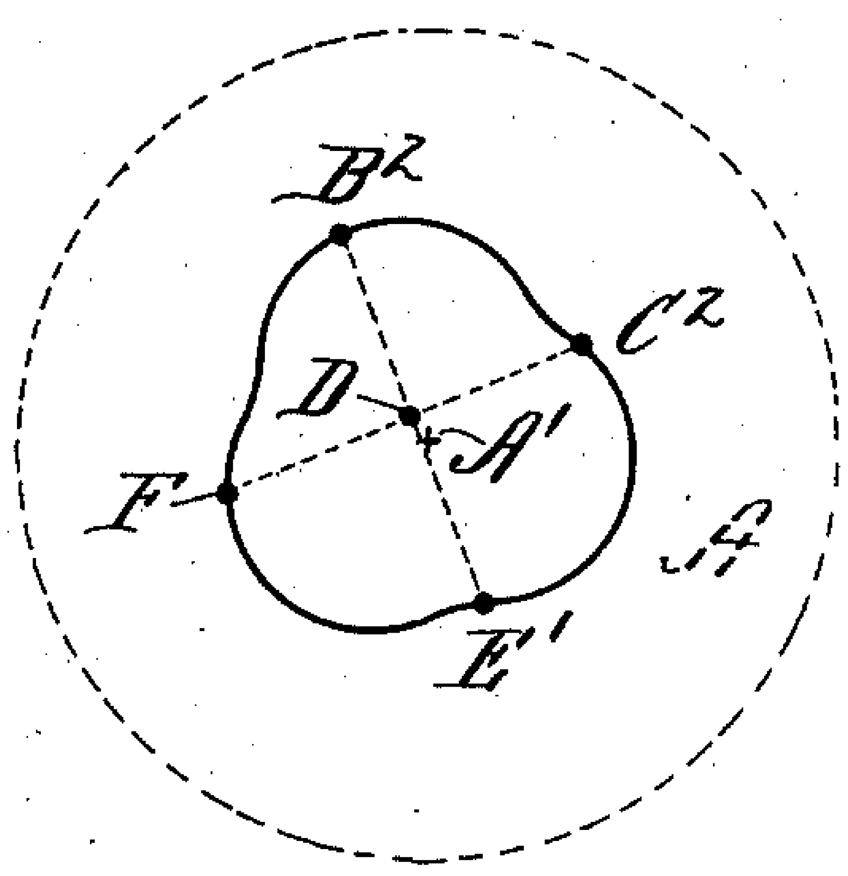


Fig. 15.

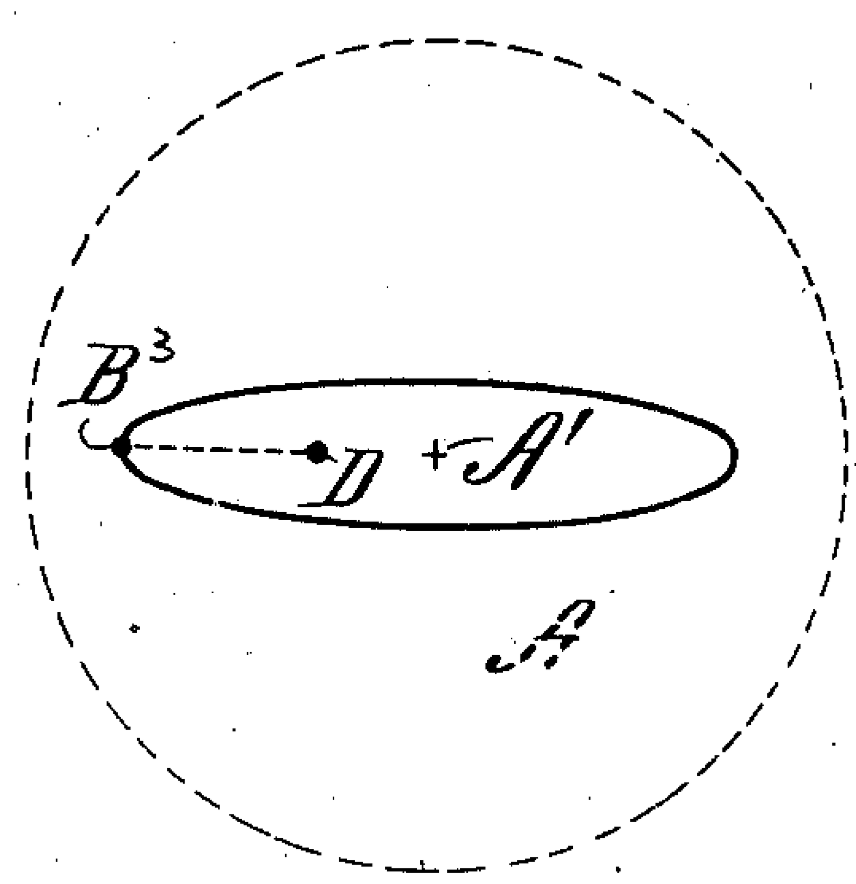


Fig. 12.

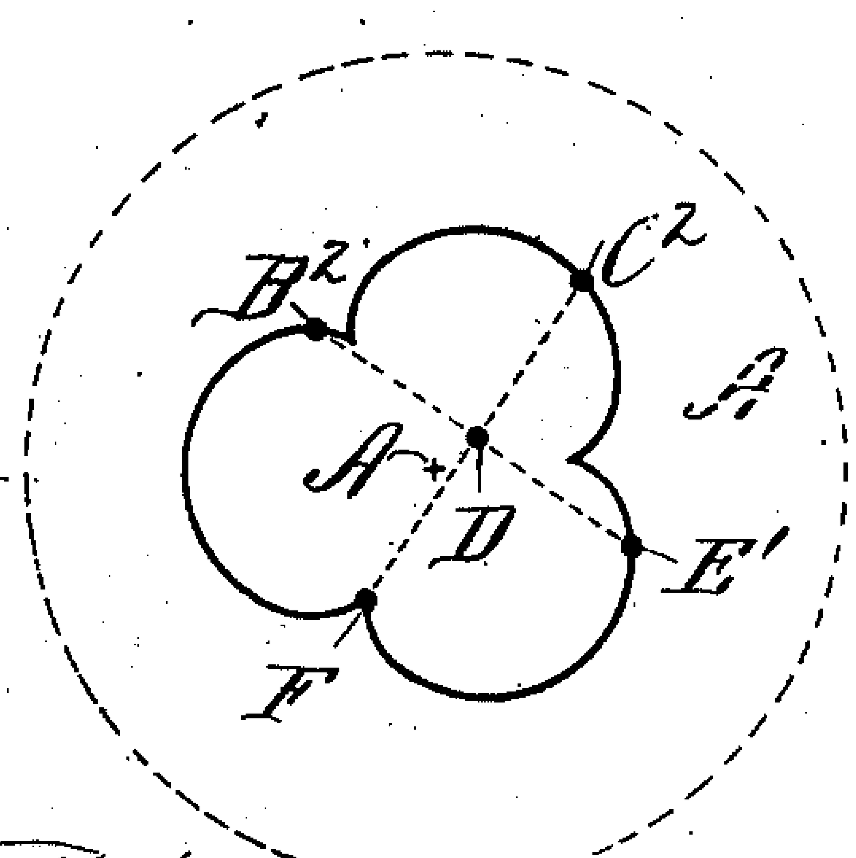
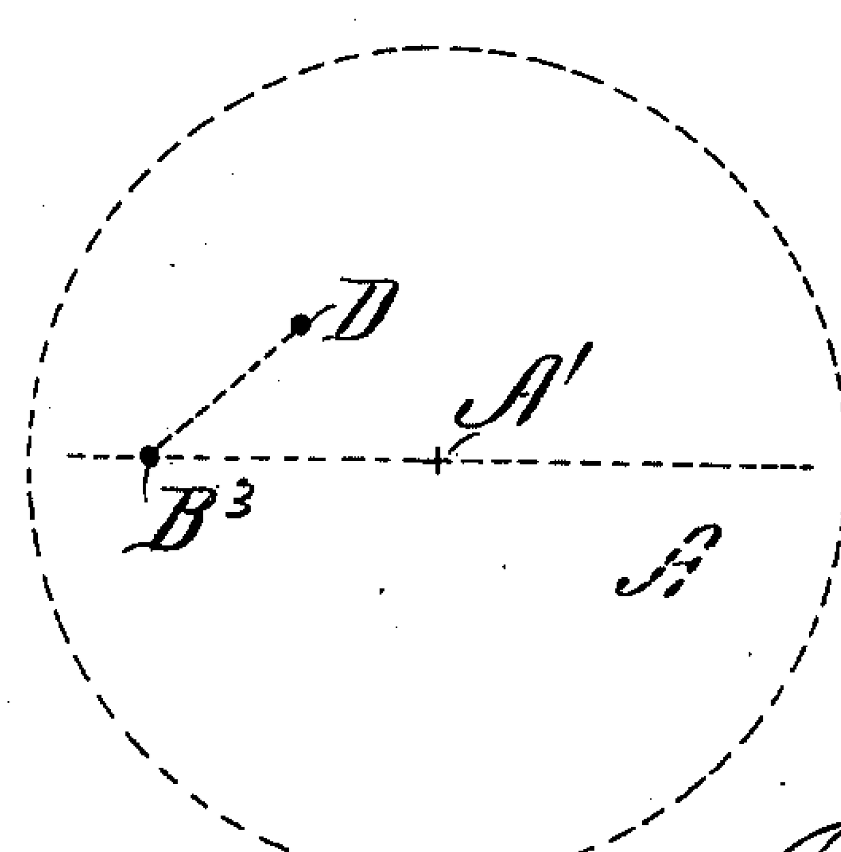


Fig. 16.



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4 SHEETS—SHEET 3.

Fig. 21.

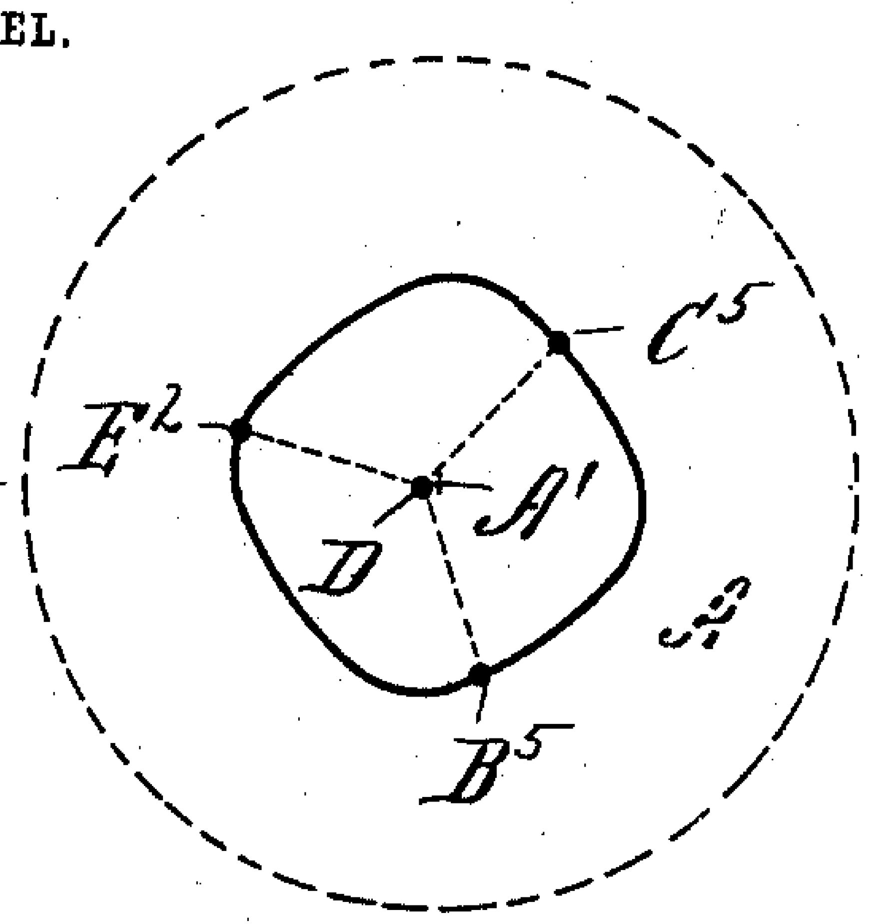


Fig. 17.

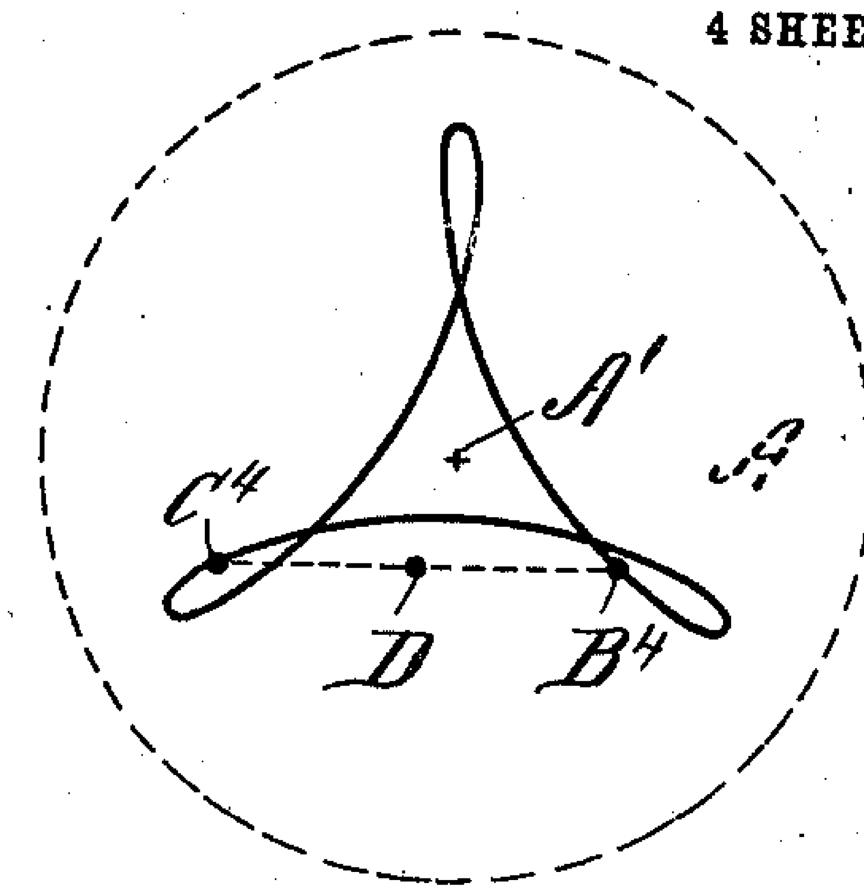


Fig. 22.

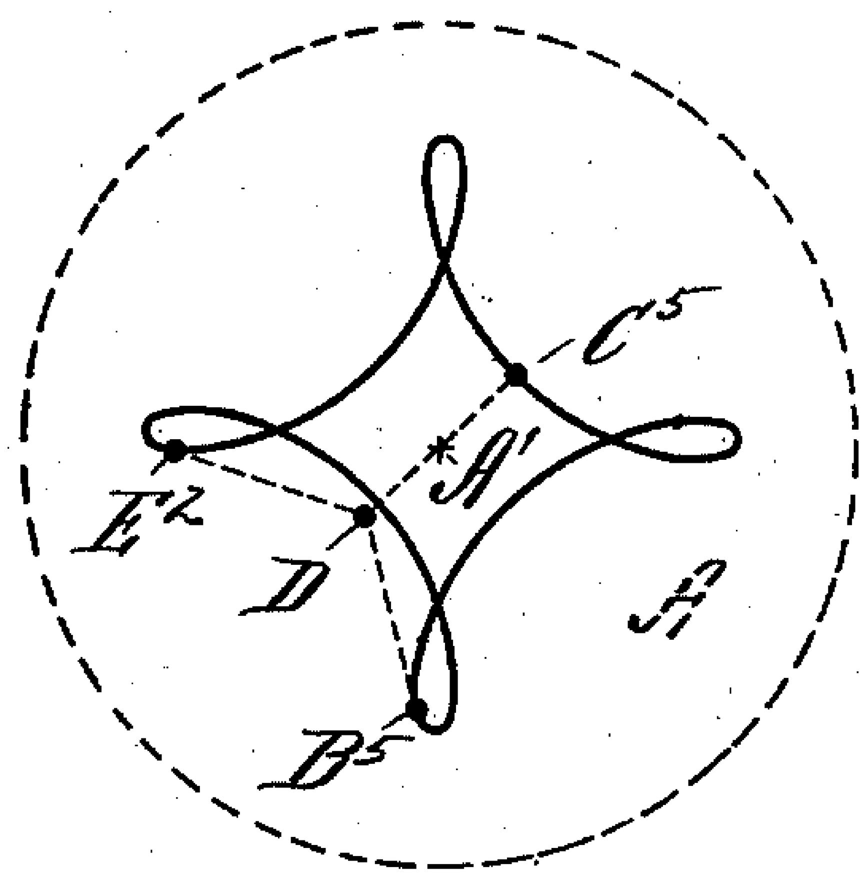


Fig. 18.

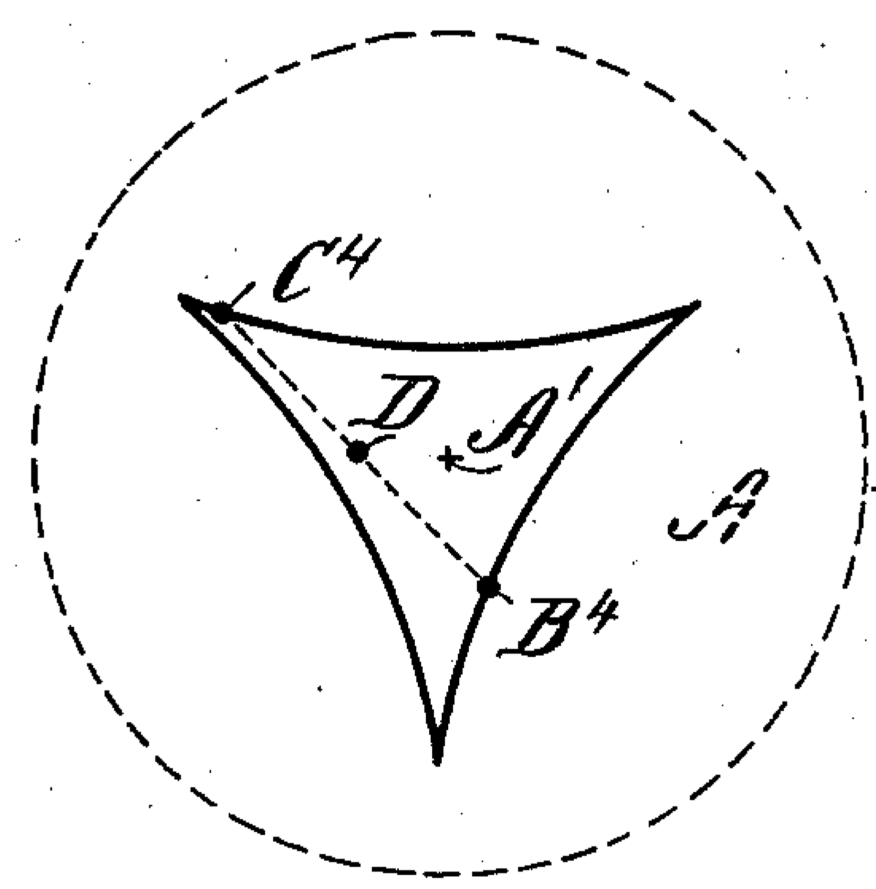


Fig. 23.

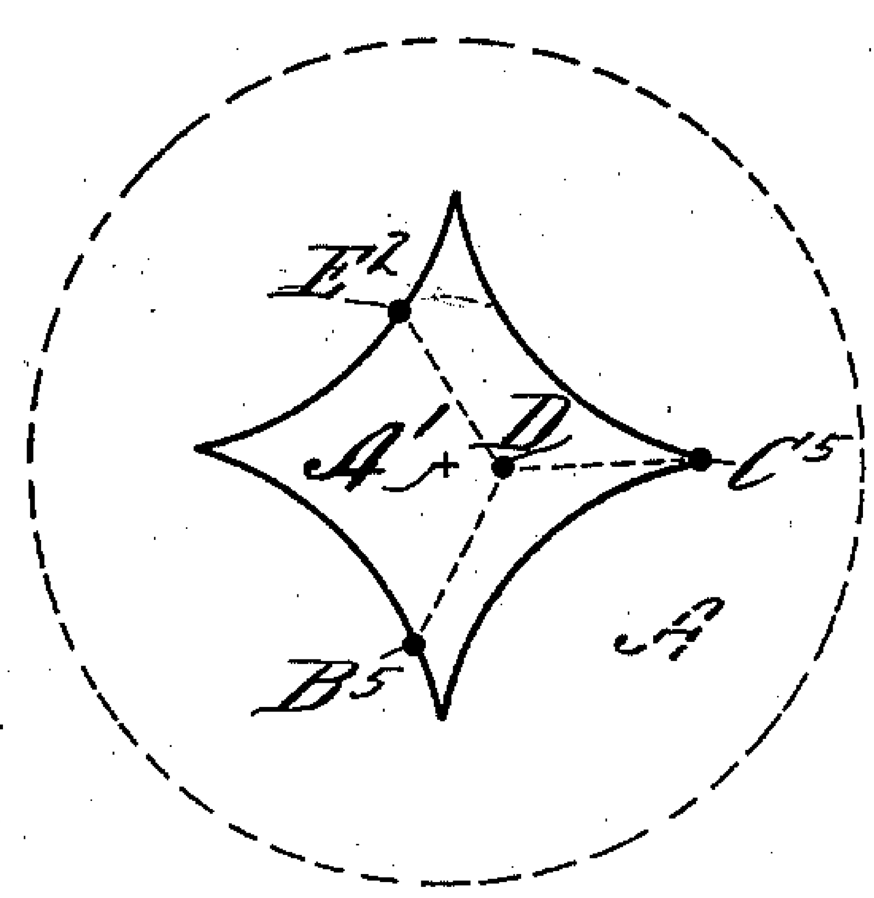


Fig. 19.

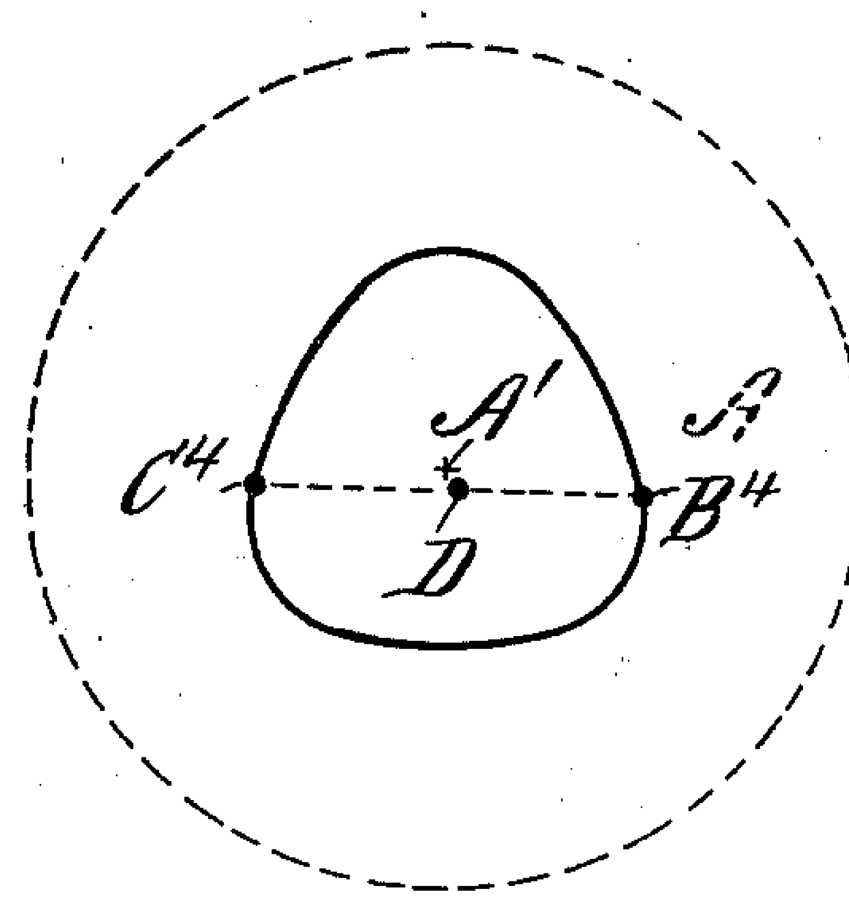


Fig. 24.

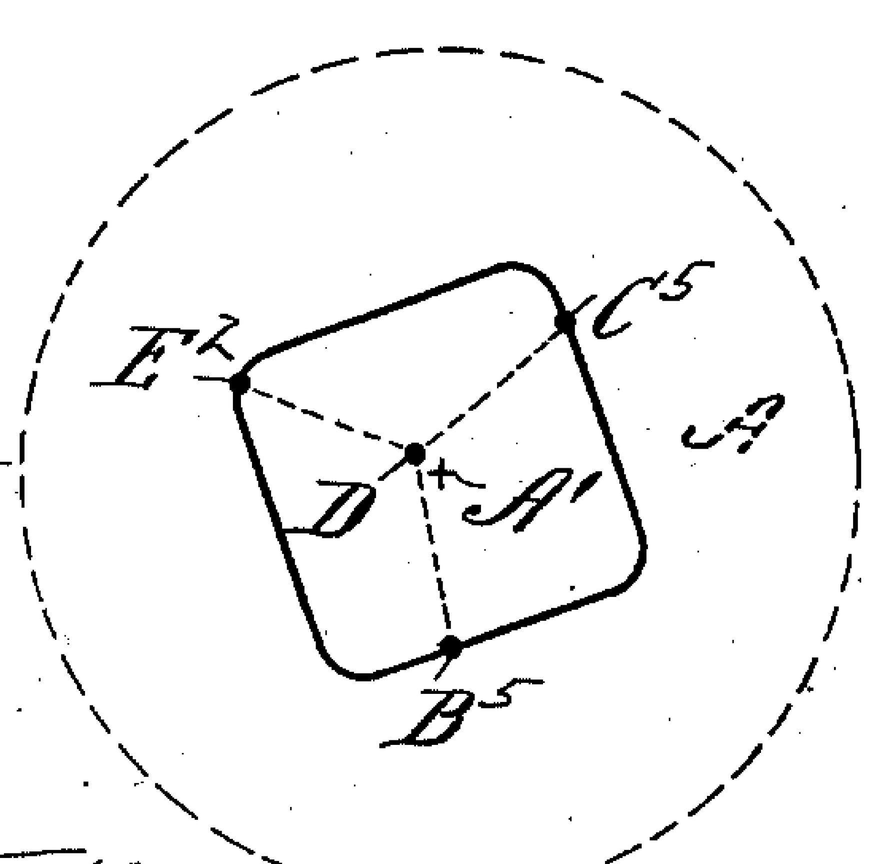
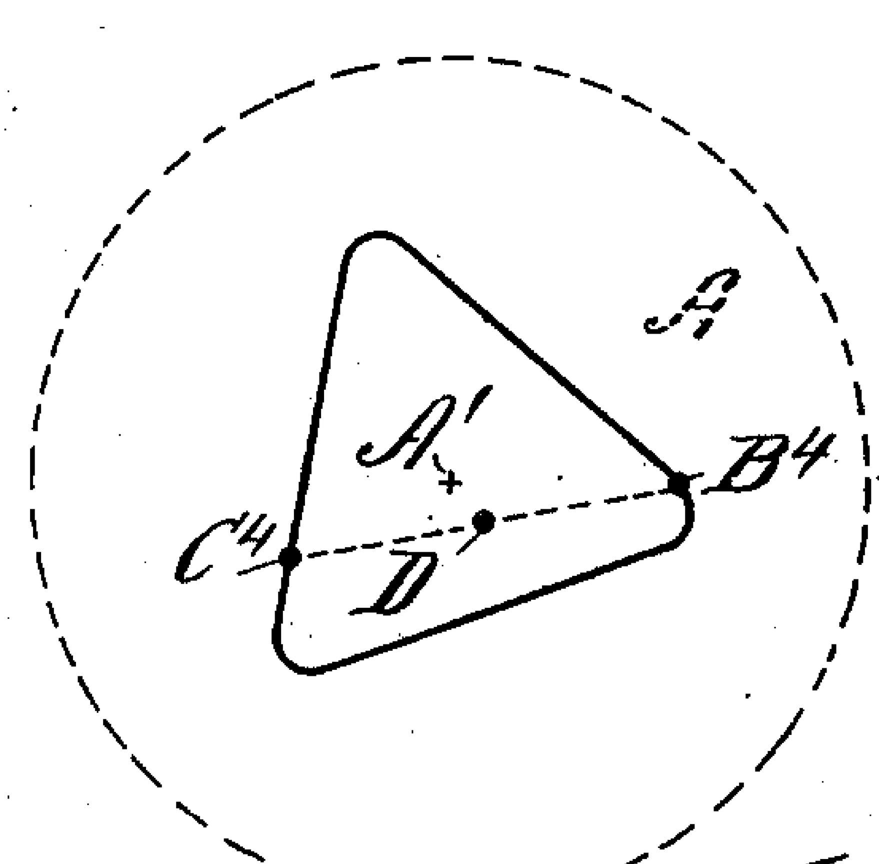


Fig. 20.



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J. F. COOLEY.

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NO MODEL.

4 SHEETS—SHEET 4.

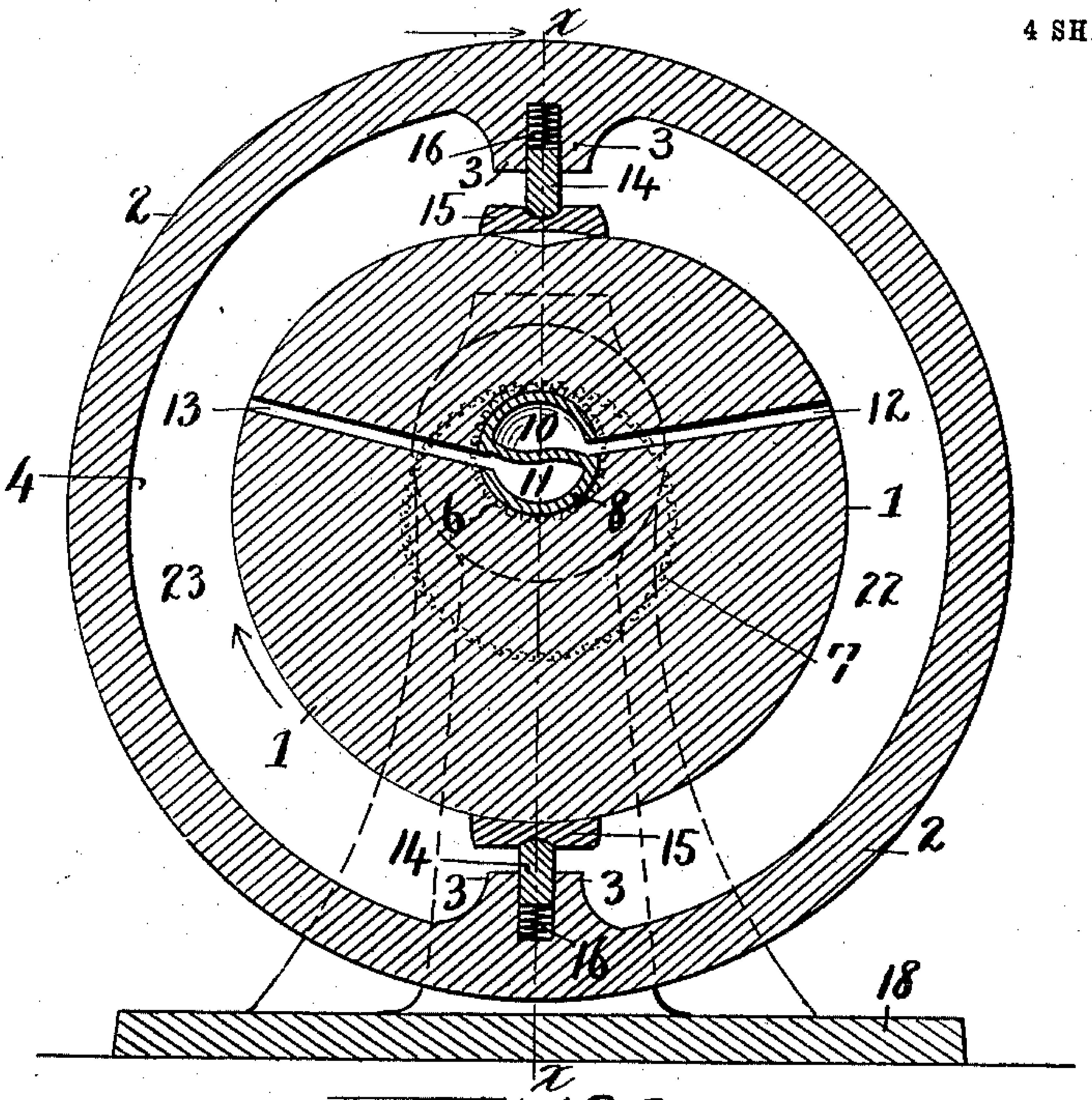

Fig. 25

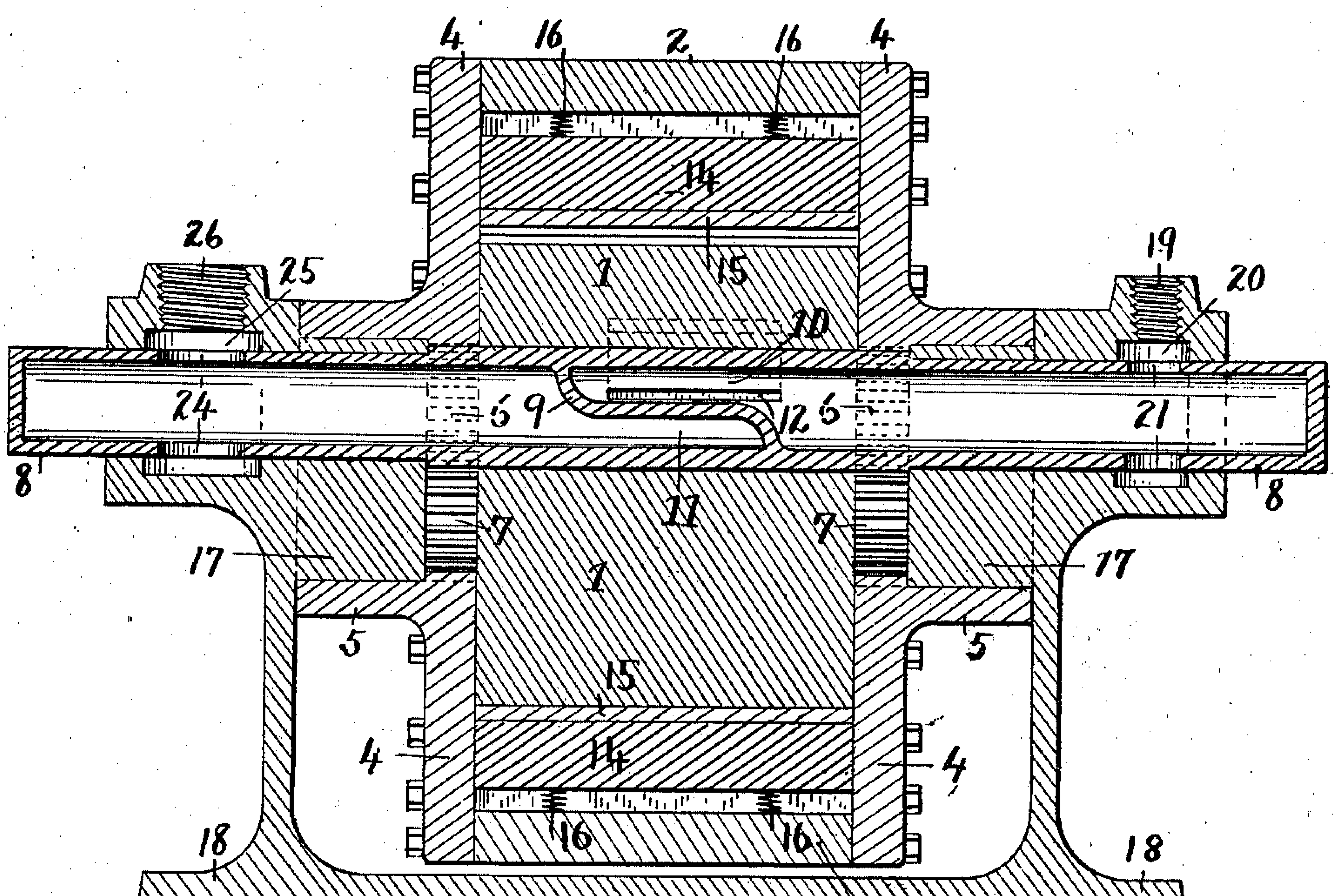

Fig. 26

Witnesses:
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A. L. Munn

Inventor:
John F. Cooley
By J. S. Rusk, Atty.

No. 731,283. Patented June 16, 1903.

UNITED STATES PATENT OFFICE.

JOHN F. COOLEY, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO COOLEY EPICYCLOIDAL ENGINE DEVELOPMENT COMPANY, OF JERSEY CITY, NEW JERSEY, AND BOSTON, MASSACHUSETTS, A CORPORATION OF NEW JERSEY.

MECHANICAL MOVEMENT.

SPECIFICATION forming part of Letters Patent No. 731,283, dated June 16, 1903.

Application filed January 17, 1902. Serial No. 90,116. (No model.)

To all whom it may concern:

Be it known that I, JOHN F. COOLEY, of Boston, (Allston,) in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Mechanical Movements, of which the following is a specification.

This my invention in its broad scope relates to a new mechanical movement wherein a point may operate or a plurality of points may simultaneously operate to produce epicycloidal or hypocycloidal curves or forms corresponding to those generated by a point in the circumference of a moving circle or disk which rolls on the inside or outside of the circumference of a fixed circle as commonly understood in certain branches of mathematics.

The essence of this invention is expressed by a combination of two like directionally-rotating elements connected to revolve around separate fixed axes at correlatively constant speed rates differing by such an amount that the terms of their ratio when reduced to their lowest integral numbers differ by unity, one element having one or more fixed points set at equal radial distances from its axis and equally spaced along their circular path of travel and moving in contact with the other element, forming epicycloidal or hypocycloidal curves thereon, which will be the common path of said fixed points when they are numerically equal to the greater or lesser of the two terms of the correlative speed ratio of the elements when expressed in their smallest integral numbers and the points are borne by the element differing therefrom.

This invention demonstrates that when a point revolves around and at a set distance from an axis and moves at a given rate of motion upon a plane which revolves in like direction around an axis offset from the axis of revolution of the point and with a comparative rate of revolution of the plane to the point, as two to one, three to two, four to three, &c., or one to two, two to three, three to four, &c., then the point will delineate upon the plane epicycloidal or hypocycloidal forms such as are produced by the point-bearing disk of cyclometry when rolling upon the inside or outside of the circumference of the stationary circle.

When the conditions of my invention are complied with, the movement two of the point to one of the plane will produce the well-known cardioid, the movement three to two produces the nephroid, four to three the tricuspid form, &c., and it also shows that the cardioid is the common path of two points revolving at the same radial distances around the same axis at the same time when their position equally spaces their circular path of travel. The nephroid is the common path of three such points at the same time and the tricuspid of four, &c., and when the speed rates are reversed then a reversal of the curves and cusps takes place corresponding to curves generated by the describing-point on a rolling circle or disk when rolling upon the inside of a stationary circle, the simplest form being the ellipse, whose extremes are the straight line and the circle. In my invention for this form only one point can be used—the tricuspid form—in consecutive order and is the common path of two points, the four cusp is the common path of three, &c. When the point or points are given an axially-longitudinal movement while rotating, it or they will spirally describe the surface of epicycloidal or hypocycloidal cylindrical forms, depending upon whether they have the slower or faster movement. Alternations of longitudinal and rotary movements will describe the surface of said cylindrical forms by parallel lines extending longitudinally or circumferentially, or both. When said points are replaced by a line or lines of equal length longitudinally extended axially, the path of said line or lines relative to the other element will form cylindroids whose section profile will be true epicycloidal or hypocycloidal forms. When disks or cylinders are used or other forms instead of points or lines and they are located upon the element bearing them in conformity to the rule governing angular position of said points, useful modifications of said forms will be produced.

My invention consists of certain novel features hereinafter described, and particularly pointed out in the claims.

In the accompanying drawings, which illustrate constructions embodying my invention, Figures 1, 2, 3, and 4 are diagrammatic views illustrating the cardioid form of epicycloid. Figs. 5, 6, 7, and 8 are diagrammatic views illustrating the nephroid or bicuspid form or epicycloid. Figs. 9, 10, 11, and 12 are diagrammatic views illustrating the tricuspid form of epicycloid. Figs. 13, 14, 15, and 16 are diagrammatic views representing the simplest form of hypocycloid, starting with a circle and showing two elliptical shapes and ending with a straight line. Figs. 17, 18, 19, and 20 are diagrammatic views representing a tricuspid form of hypocycloid. Figs. 21, 22, 23, and 24 are diagrammatic views showing the four-cusp shape or form of hypocycloid. Fig. 25 represents a rotary fluid-motor pump or meter in vertical section through the center thereof. Fig. 26 is a longitudinal vertical section through a rotary fluid-motor pump or meter on the line X X, Fig. 25.

Like characters of reference refer to like parts throughout the several views.

Referring to Figs. 1, 2, 3, and 4, A represents the evolute element, whose axis is A′. B and C represent two points of the evolver, whose axis is D. The dotted lines between B and C and drawn through D represent the equal radii, which limit the distance of B and C from the axis D. In the operation of forming the cardioid epicycloid the two evolver-points B and C rotate around the axis D at the given rate of rotation upon the evolute element A, which is also moving in the same direction of evolution around its axis A′, but at a different rate of speed from that of the evolver element. The speed ratio of the two elements in this case when reckoned in complete revolutions of both elements and reduced to their lowest integral numbers differ by unity, there being one revolution of the evolver to two revolutions of the evolute element.

When using the nomenclature of cyclomatics, Figs. 1 and 2 may be described as prolate epicycloids, Fig. 3 as the curtate epicycloid, and Fig. 4 as the common epicycloid.

Referring to Figs. 5, 6, 7, and 8, A is the evolute element, and A′ its axis of revolution. B′, C′, and E are the points of the evolver element. A, the evolute element, is revolved around A′, its axis, at a given rate of speed. B′, C′, and E, the points of the evolver element, revolve in the same direction and upon the evolute element A at a slower speed ratio and in this case when reckoned in complete revolutions of both elements differ by unity when reduced to their lowest integral numbers, being three of the evolute to two of the evolver element. Fig. 5 is a prolate bicuspid epicycloid. Fig. 6 is the common epicycloid, and Fig. 7 is a curtate form. Fig. 8 is another modification of prolate. (Shown in Fig. 5.)

Referring to Figs. 9, 10, 11, and 12, Fig. 9 shows the tricuspid form of epicycloid, in which a four-pointed evolver element revolves in the same direction, but at slower speed, upon the evolute element A, the speed ratio in this case being four to three—that is, four of the evolute to three of the evolver element. The tricuspid epicycloid described by the points is the common path of all of them. Fig. 9 is the curtate form, Figs. 10 and 11 the prolate form, and Fig. 12 is the common form.

Referring to Figs. 13, 14, 15, and 16, these are hypocycloidal forms. Fig. 13 shows a one-pointed evolver element moving in the same direction and upon the evolute element A, wherein the center D of the evolver and the center A′ of the evolute coincide, which produces in this, as in all cases where the centers of both elements coincide, a true circle, the evolver element rotating in the same direction but at a higher rate of speed than the evolute element, the ratio of the two elements when reduced to their lowest integral numbers being one to two—that is, two of the evolver to one of the evolute—this speed ratio with slightly-offset centers, as in Fig. 14, producing an ellipse. Fig. 15 showing a greater offset of the centers of the axes of both elements produces an elongated ellipse. Fig. 16, wherein the offset between the axes exactly equals the radial distance of the evolver-point from its axis of rotation, produces a straight line.

Referring to Figs. 17, 18, 19, and 20, Fig. 17 shows the tricuspid form of hypocycloid, which is the common form of the two points B^4 C^4 of the evolver element when they revolve around their axes D upon the evolute element A, which is revolving in the same direction and around its axis A′ and at a slower rate of speed. This hypocycloidal form is the common path of two points, the speed ratio of the two elements when reduced to their lowest integral numbers being two to three. Fig. 17 is the curtate form, Fig. 18 the common form, Figs. 19 and 20 being the prolate forms.

Referring to Figs. 21, 22, 23, and 24, these are also hypocycloidal forms. Fig. 21 shows a three-pointed evolver element describing a four-cusp hypocycloidal form, the evolver element revolving in the same direction but faster than the evolute element and the speed ratio of the elements in this case when reduced to their lowest integral numbers being three to four. Figs. 21 and 24 are prolate forms, Fig. 22 the curtate form, and Fig. 23 the common form.

Figs. 1 to 24, inclusive, are a few examples of a point or points upon one element correlative to the other, as shown in dotted lines. The fixed radial distance is shown also in dotted lines. The path of the point relatively to the other element is shown as a complete, closed, curved, and full line within the outer circles, which forms a possible limitation of the other element.

Figs. 1 to 12, inclusive, illustrate by full-line curves the path of the points when they are mounted upon the slower element.

Figs. 13 to 24, inclusive, illustrate by full-line curves the path of the points when they are mounted upon the faster element.

Figs. 25 and 26 illustrate this mechanical movement, which is the subject of this invention, as applied to a rotary fluid engine, pump, or meter in one of the possible forms under this principle and may be used with suitable gases, vapors, or liquids as operative fluid mediums; but it is self-evident that this is a mere example, and this invention is broader than its mere application to such uses. In this example the cardioid form, which is herein the piston 1, is the path of the extremities of the two partitions 3 3 of the part 2, which operative conditions require to be provided with yielding and wearing elements 14 and 15, said partitions, with their yielding parts, being mounted upon the element 2, which corresponds with the point-bearing element of this invention, which in this example is called the "spacer" of this engine, pump, or meter and is mounted upon a separate axis than that of the cardioid part 1 and parallel thereto, and in correlative speed rates the movement of both parts rotating in the same direction is as two of part 1 to one of part 2 in this example. As a more full explanation of the operative principle of this invention in relation to its usefulness and facilitating the extending of the operative conditions of this example I give the following detailed description of the construction and operation thereof: The cardioid piston 1 is fixed on the hollow shaft 8, which by a partition 9 is divided into two chambers 10 and 11 and is closed at each end. The chamber 10 connects with a port 12, and the chamber 11 connects with the port 13. The mantle or cylinder 2 or, as it may be termed, the "spacer" has two partitions or abutments 3 toward the interior, where they are provided with shoes which can adjust themselves radially in order to make a practically fluid-tight moving contact with the piston 1, even in case of the piston or the shoes having suffered from wear or other irregularities. The spline 14 abuts against the rocking shoe 15, which glides on the surface of the piston and divides it. The splines are adjusted automatically by the springs 16. The shaft is provided with a geared surface 6, which engages with a corresponding geared surface 7 in circular openings in the spacer-heads 4 4. The bosses 17 on the standards 18 form eccentric parallel bearings for the spacer and for the shaft.

The action of the machine when used as a motor is as follows: The gas, steam, or other fluid or liquid enters by the opening 19 into the annular space 20 and from thence by the openings 21 into the chamber 10 of the hollow shaft 8 and then by the port 12 into the space 22 between the spacer or cylinder and the piston. If the fluid is under pressure and the machine works as an engine or motor, then it exerts a pressure on the surface of the spacer confined by the limitations 3 3 and exerts a counter-pressure on the part of the piston-surface between the said limitations bearing thereon. As the larger portion of the piston-surface exposed to the pressure lies below the axis of the shaft 8, the pressure fluid will cause the piston to turn in the direction of the arrow, and the spacer 2 will in consequence of the geared surface 7 intermeshing with the geared surface 6 of the shaft 8 rotate in the same direction. The speeds of rotation of the piston and of the spacer are in this cardioid example as two to one. When the piston 1 has made half a revolution in the direction of the arrow, the partitions 3 are at right angles to their initial position and cover the ports 12 and 13. If the cardioid piston works as a motor, it will in this case be on the dead-center and must be carried along so much farther by its momentum or by outer power (such as a fly-wheel) that the ports 12 and 13 are no longer covered by the shoes 15. When this position has been reached, the pressure fluid can enter the space 23 by the port 12. Then the mean pressure exerted on the piston is tangential to the axis of rotation of the shaft 8 and the movement in the direction of the arrow ensues as before. Assuming that in the beginning of the rotation the space 23 between the spacer 2 and the piston 1 be filled with a fluid medium and that then the aforesaid movement of the parts takes place, then the pressure will be produced in the medium, which will find outlet through the port 13 into the chamber 11 of the power-shaft 8, thence through the openings 24 into the annular space 25, finally exhausting through the opening 26 in the support 18.

Having thus described the nature of my invention and set forth a construction embodying the same, what I claim as new, and desire to secure by Letters Patent of the United States, is—

1. A mechanical movement characterized by two elements caused to rotate in like direction upon separate parallel and positionally-fixed axes at a correlatively constant speed ratio whose lowest integral terms are consecutive numbers, there being a point located upon one element and moving in a cycloidal path upon the other element.

2. A mechanical movement characterized by two elements caused to rotate in like direction upon separate parallel and positionally-fixed axes at a correlatively constant speed ratio whose lowest integral terms are consecutive numbers, there being a plurality of points located upon one element and at equiradial distances from and equiangular positions around its axis and in number equal to the lowest integral speed-ratio term of the other element, and each moving in a cycloidal path thereon which is the common path of all.

3. A mechanical movement characterized by two elements rotating in the same direction around separate parallel and positionally-fixed axes at speeds, which, when they are reduced by a common divisor to the lowest term expressible by whole numbers (which may be termed the integral speed numbers)

will differ by one or unity, any point in the element of lower speed then describing a circle around its own axis and an epicycloid relatively to the element of higher speed, and any point in the element of higher speed describing a circle around its own axis and a hypocycloid relatively to the element of lower speed, there being two or more points in one of the said circles which may occupy equidistant positions therein and move in a cycloidal curve which is the common path of said two or more points when the number of points in that element is equal to the integral speed number of the other element.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 9th day of January, A. D. 1902.

JOHN F. COOLEY.

Witnesses:
A. L. MESSER,
J. S. RUSK.