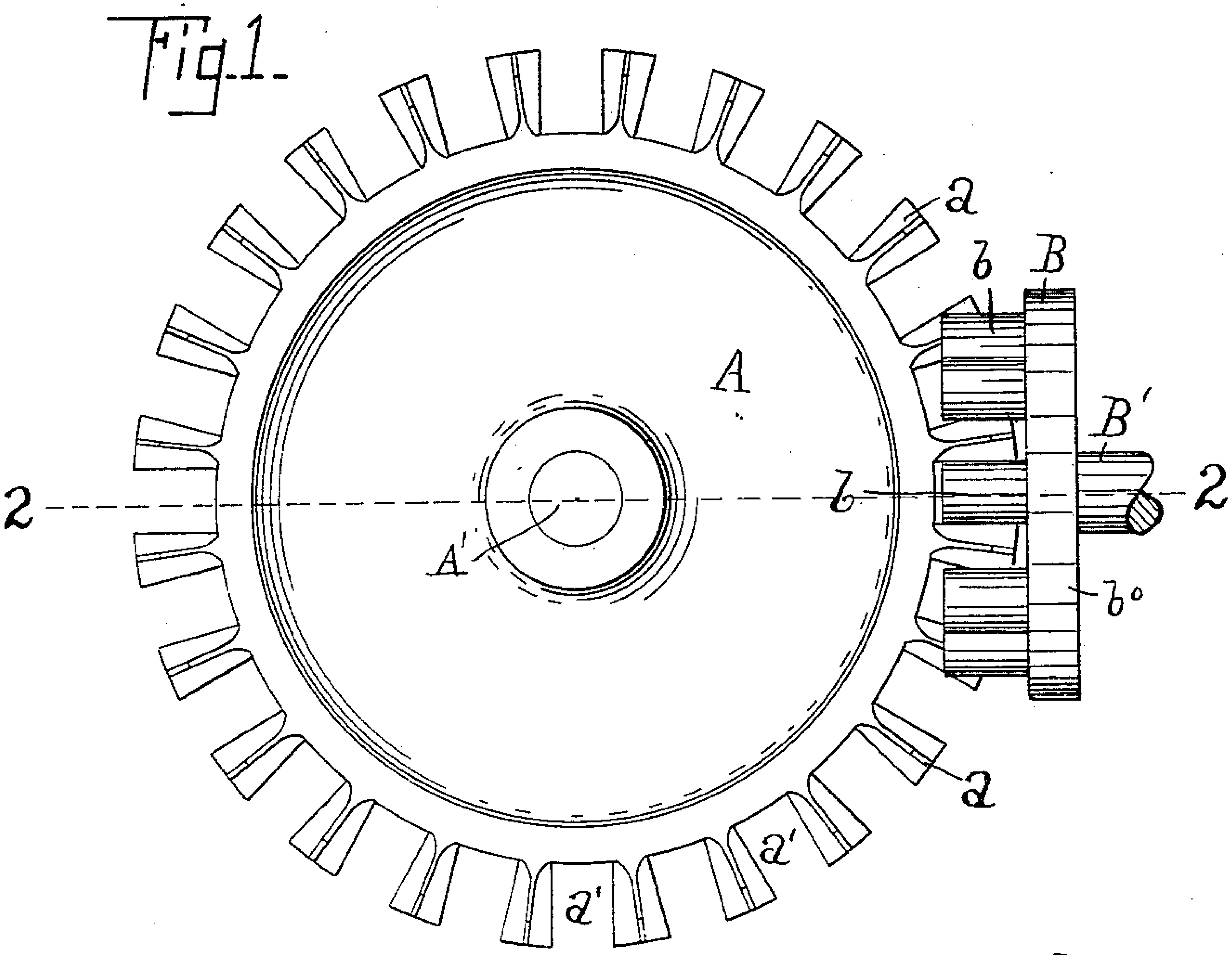
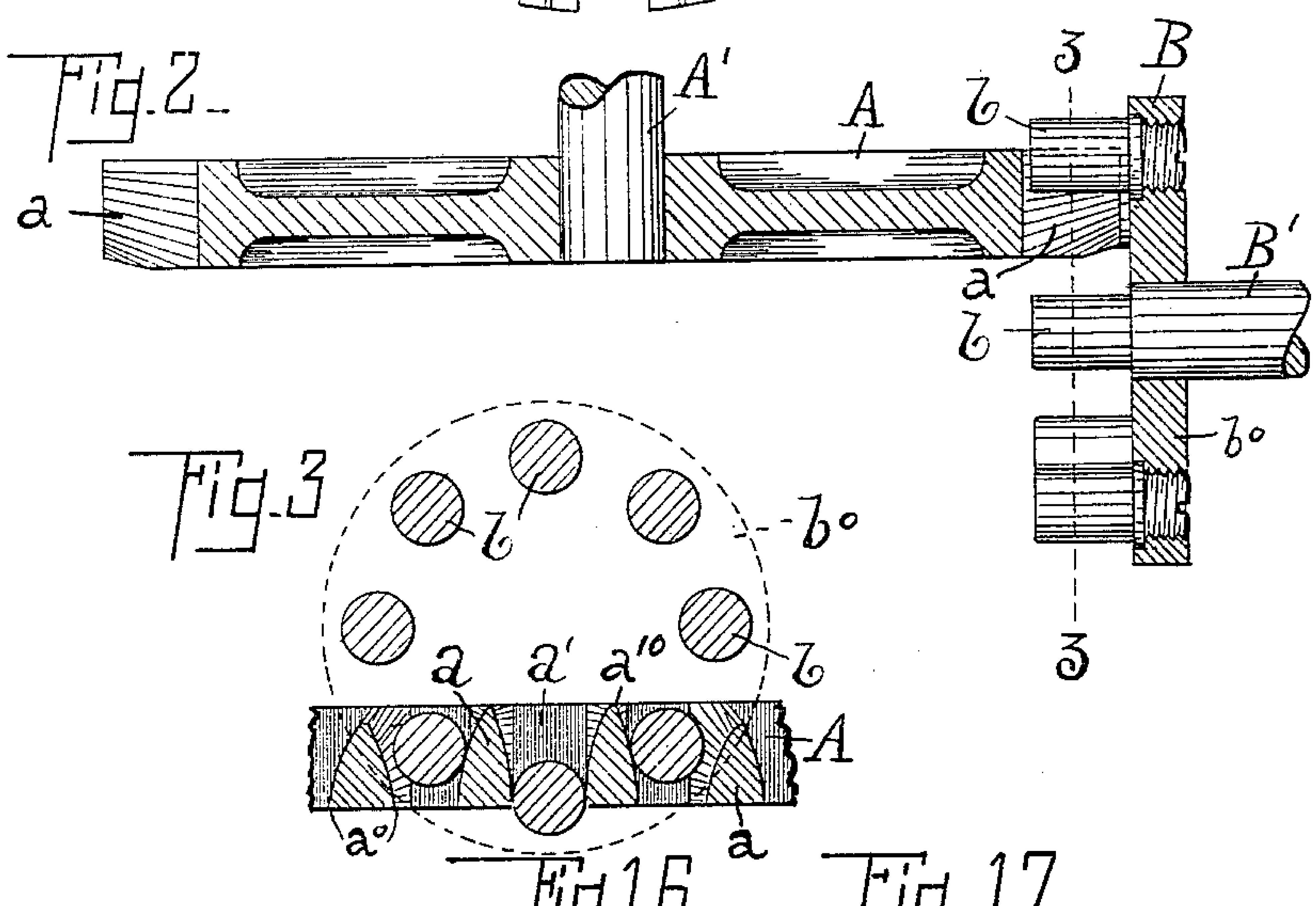
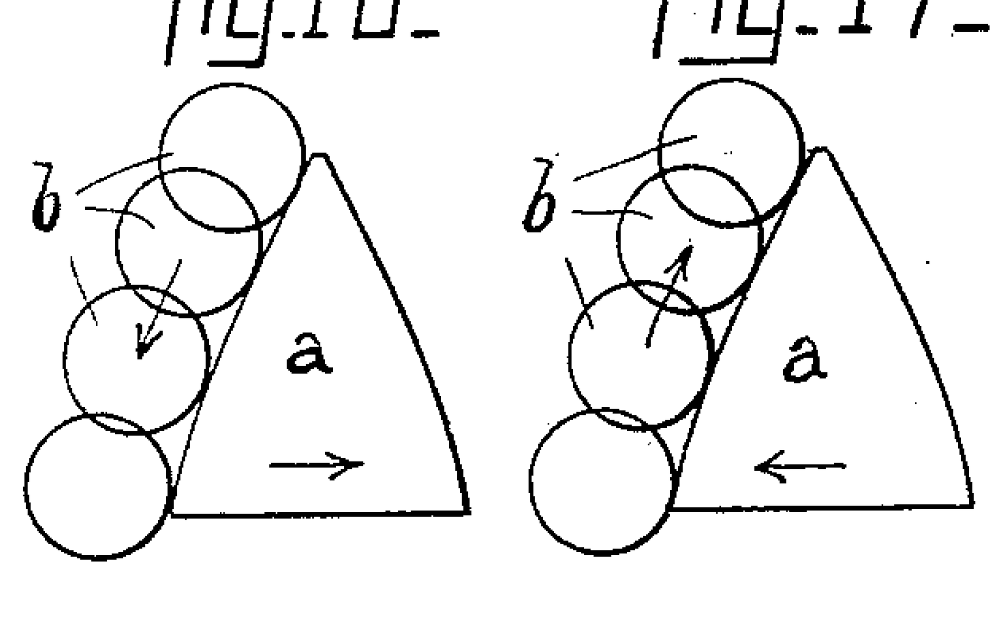
(No Model.) 3 Sheets—Sheet 1.

J. H. SAGER.
ANGLE GEARING.

No. 602,629. Patented Apr. 19, 1898.







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(No Model.) 3 Sheets—Sheet 2.

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Fig. 4.

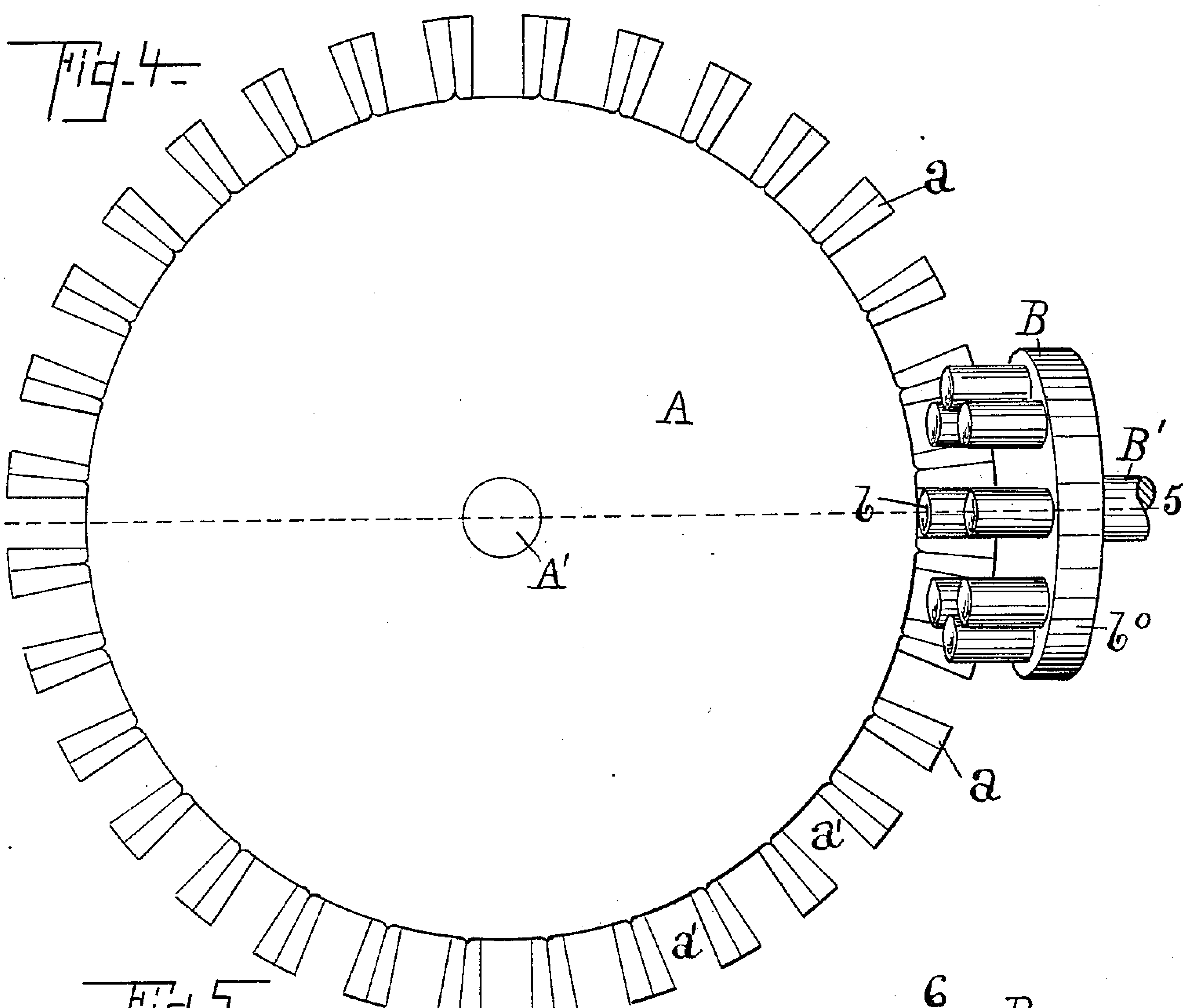


Fig. 5.

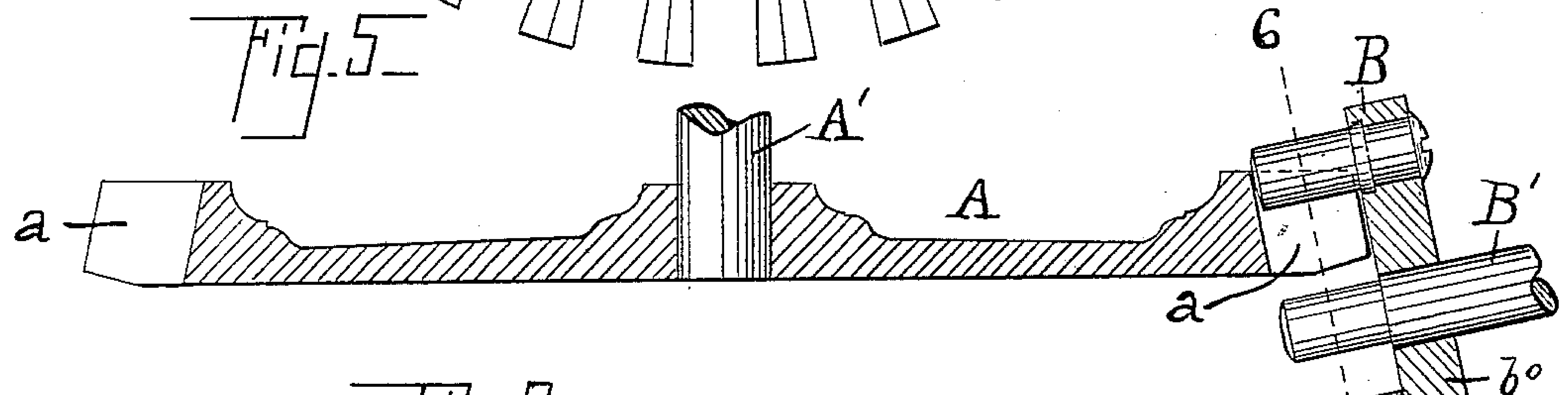
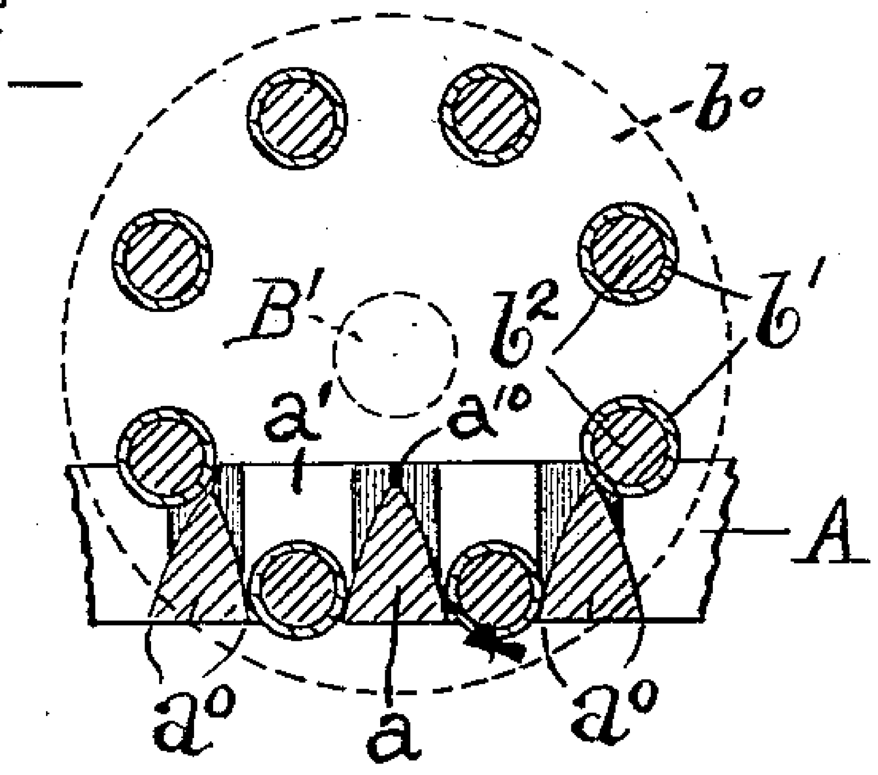


Fig. 6.



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(No Model.)

3 Sheets—Sheet 3.

J. H. SAGER.

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Fig. 7.

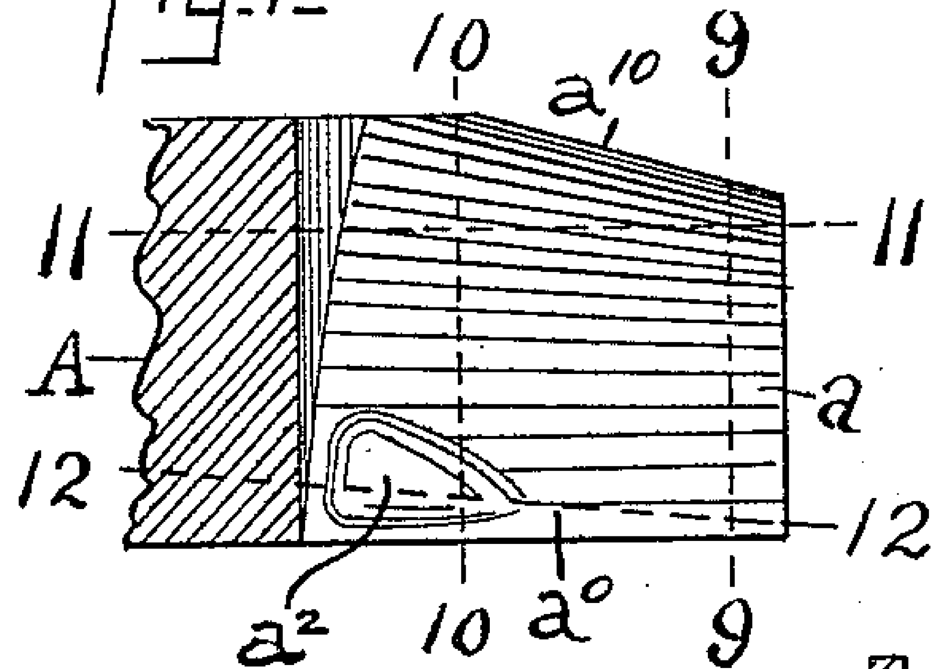


Fig. 8.

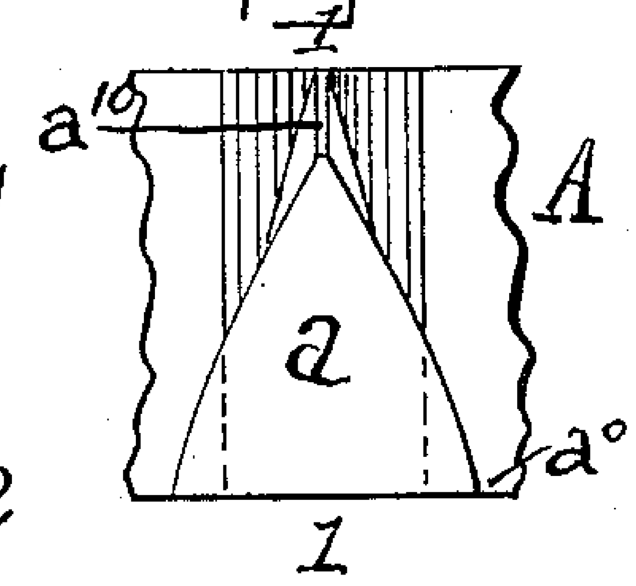


Fig. 9.

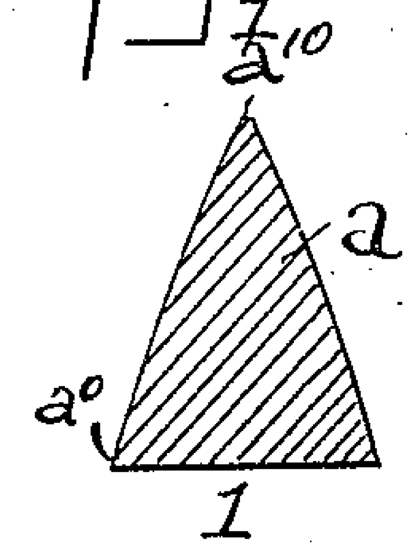


Fig. 10.

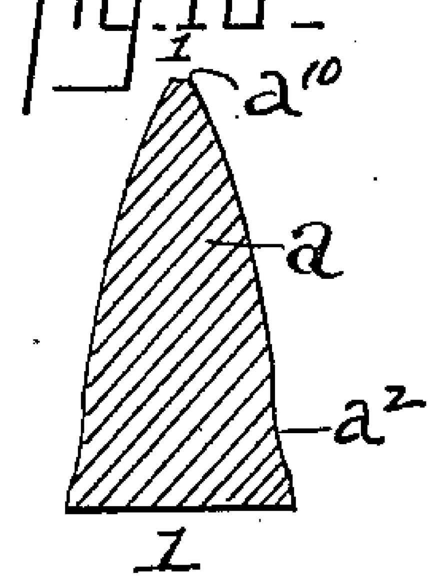


Fig. 11.

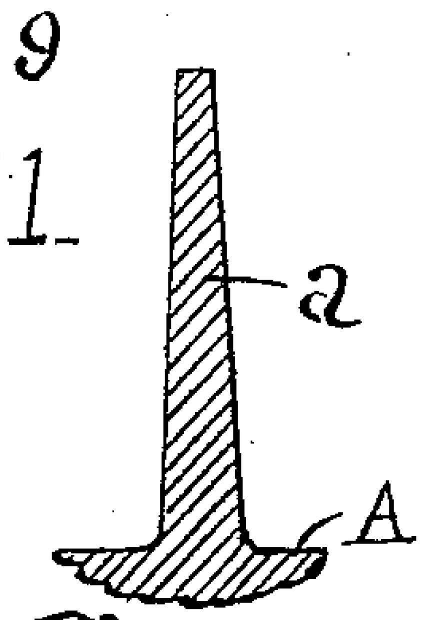


Fig. 12.

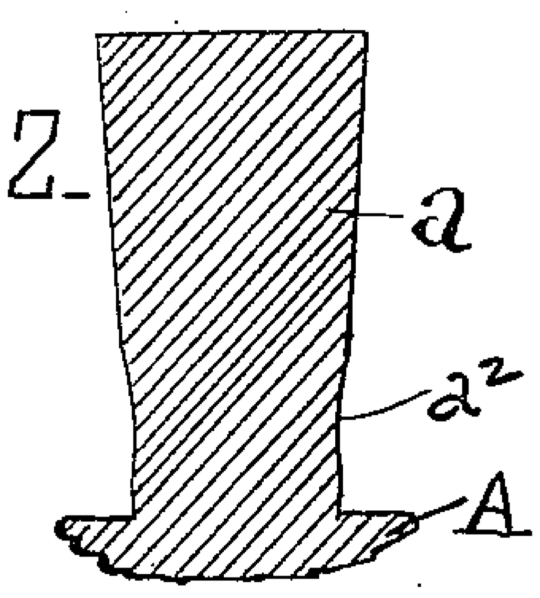


Fig. 13.

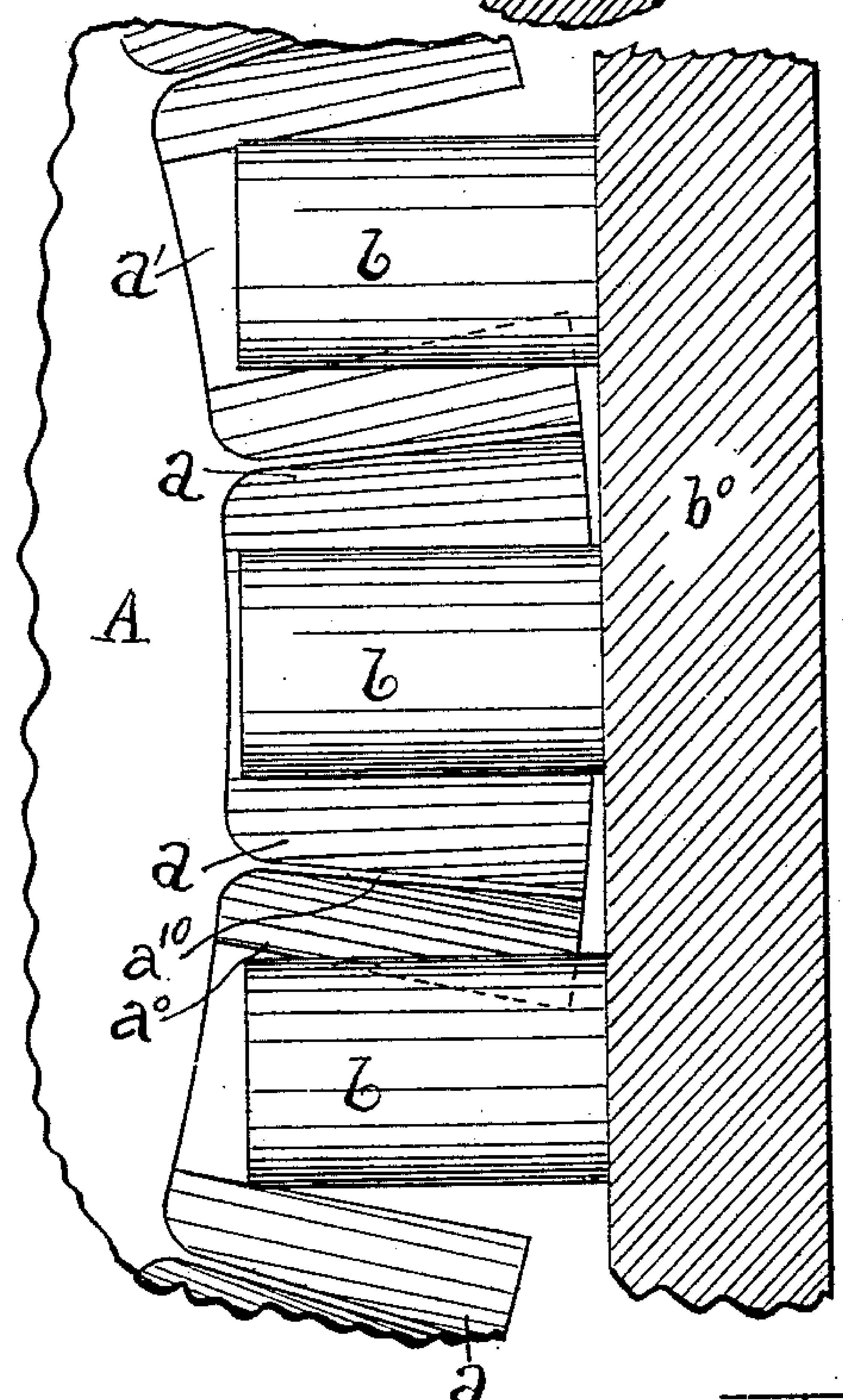


Fig. 14.

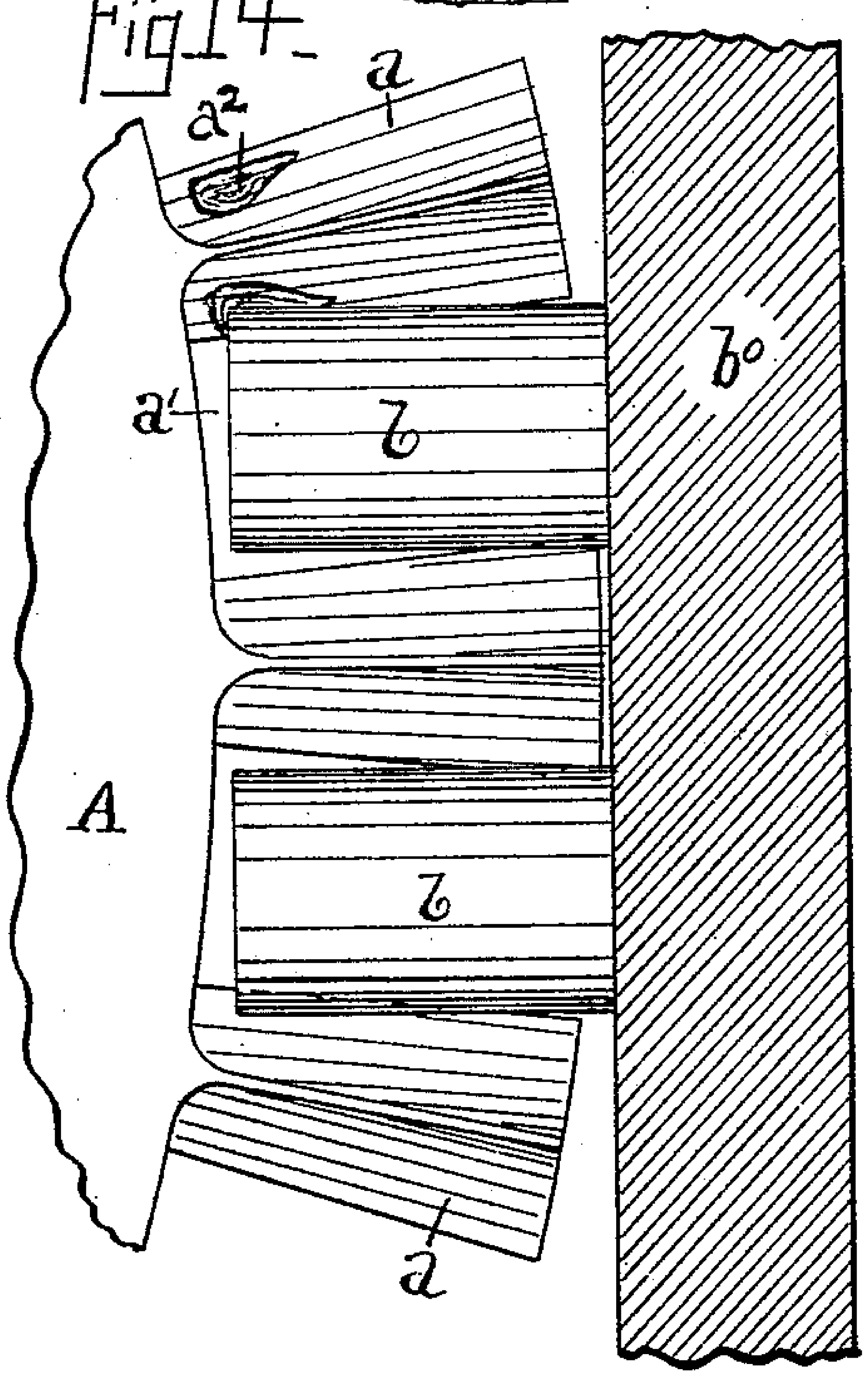
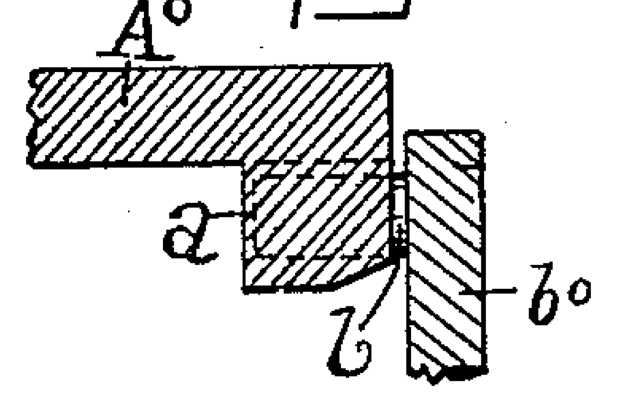


Fig. 15.



WITNESSES

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UNITED STATES PATENT OFFICE.

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ANGLE-GEARING.

SPECIFICATION forming part of Letters Patent No. 602,629, dated April 19, 1898.

Application filed December 30, 1897. Serial No. 664,693. (No model.)

To all whom it may concern:

Be it known that I, JAMES H. SAGER, a citizen of the United States, and a resident of Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Angle-Gearing, of which the following is a specification.

This invention relates to angle-gearing; and it consists in the mechanism and arrangement of parts hereinafter set forth.

The object of the invention is to provide an angle-gearing having certain advantages due to its construction, as hereinafter described.

In the drawings, Figure 1 is a front elevation of a pair of gears embodying my invention having axes at right angles and having twenty-four teeth in the larger member. Fig. 2 is a transverse section on the line 2 2 of Fig. 1. Fig. 3 is a section on the line 3 3 of Fig. 2, a portion only of the larger gear being shown. Fig. 4 is a front elevation of a pair of my gears with axes set at an obtuse angle and having thirty-two teeth in the larger member, the smaller member being the same as shown in Fig. 1. Fig. 5 is a section on the line 5 5 of Fig. 4. Fig. 6 is a section on the line 6 6 of Fig. 5, a portion only of the larger gear being shown and showing the parts in different positions from those shown in Fig. 3. Fig. 7 is an enlarged side elevation of a single tooth of the larger gear shown in Fig. 4. Fig. 8 is an end view of the same tooth shown in Fig. 7. Figs. 9 to 12 are sections taken, respectively, on the lines 9 9, 10 10, 11 11, and 12 12 of Fig. 7. Figs. 13 and 14 are each an enlarged elevation of a portion of the edge of the larger gear and a portion of the pin-disk with the pins thereon, the parts being shown in positions corresponding to Figs. 3 and 6. Fig. 15 is a partial view of a pair of my gears, showing a modification; and Figs. 16 and 17 are diagrams illustrating the action of the gear.

I have produced the gear hereinafter set forth in order to avoid many of the difficulties found in prior angle-gears and to produce an easy-running and efficient mechanism, and I accomplish this result by the mechanism now to be described.

In the drawings, A is a wheel carried by a suitable shaft A′, which of course is set in proper bearings.

B is a pin face-gear carried by a suitable shaft B′, which turns in proper bearings. The shafts A′ and B′ may be set at various angles, acute or obtuse, or at right angles to each other.

In Figs. 1 and 2 the shafts are set at right angles, while in Figs. 4 and 5 the shafts are set at an angle of about eighty degrees.

The member B of a pair of my gears consists, as herein shown, of the disk b^0, set transversely upon the shaft B′ and having upon said disk a series of equidistant pin-teeth b, arranged in a circle around the center of revolution of the disk, with their axes projecting from said disk. I prefer to use cylindrical pins whose axes are at right angles to the face of the disk, and therefore are parallel to the axis of the shaft B′; but it is highly preferable, and perhaps essential, that each pin should have no diameter of its working portion smaller than that of the working portion or the pin nearest its outer end. These pins may be solid or, as shown in some of the drawings, may consist of rollers b', set upon a central pin b^2. The roller b' may be hardened and may revolve upon the pin b^2, while the pin itself may be of softer and tougher material. The pin is rigidly fixed to the disk in any suitable manner. For easy construction, as shown in Fig. 5, the pin b^2 is set into the disk b^0 and is fixed thereon by means of a set-screw b^{20}, extending into the pin from the back of the disk, and in order to retain the roller b' upon the pin the outer end of the pin has a flange b^{21}, which overlaps the outer end of the roller and retains it between the flange and the disk. Another arrangement is shown in Fig. 2, in which the pin is merely screwed into the disk. If one of the hardened rollers b' should be cracked, worn, or otherwise damaged, a new roller may be placed upon the pin b^2, and in case the gear should be subjected to severe shock in use the roller would crack; but the tougher pin b^2 would bend rather than break, and thus insure greater safety in the use of the device. As above stated, I prefer the use of the hardened rollers b' upon softer pins b^2; but my device is practicable and under some circumstances is better if the whole pin b is solid.

The wheel A bears a series of equidistant teeth a for engagement with the pins b and of the same pitch as the pins. These teeth may be set either upon the face of the wheel A, as shown in Fig. 15, or they may be formed upon the periphery of the wheel, as shown in the other figures. When the teeth are formed upon the periphery of the wheel, the mechanism occupies less space than when the teeth are on the face of the wheel. The teeth *a* are of a modified wedge shape, having the medial plane of each tooth transverse to or across the plane of rotation of the wheel, and the apex of the wedge (whether truncated or not) points or is directed transversely to said plane. When the teeth are not skew-teeth, nor the wheel a skew-wheel, the medial plane of each tooth is perpendicular to the plane of rotation of the wheel. The interdental spaces a' at the base-lines a^0 of the teeth have sides which are not radial as to the wheel, but which are at said base-lines parallel to each other and are separated by a distance only slightly greater than the diameter of the cylinder *b*. This difference in width between the teeth is for the purpose of permitting clearance of the pins without binding in the interdental spaces. The contour of the side faces of the teeth *a* and the pitch are generated by the moving pins *b* upon the revolving disk b^0 when the velocity of the gear-wheel on the tooth-circle equals the speed of rotation of the circle in which the bases of the pins are set. In other words, when the two members of the gear have a uniform ratio of velocity the contour of the side faces of the teeth and the pitch of said teeth will vary according to the size of the two members of the gear and of the pins upon the member bearing them and upon the angle at which the two members are set, as the case may be. The side surfaces of the teeth *a*, as shown best in Figs. 4 to 9, are warped or twisted surfaces, upon which the pin *b*, if on the driving member, has always a line-contact from the position of the first engagement at the entrance into the interdental space with an approaching action to the root or base of the tooth at the position of deepest entrance into said space; but if the pin-gear is the follower the pin engages a tooth at the root of the latter and moves outward along the side of the tooth with a receding action. Figs. 16 and 17 illustrate, respectively, the approaching and receding action. This line-contact is due to the fact that the side surface and hence the tooth form and the interdental spaces are the result of being formed as if generated by the movement of the pin entirely across the face of the tooth.

Inasmuch as in the embodiment of my invention herein shown each pin is cylindrical, any surface generated by the motion of the surface of the pin must be either a plane or a surface which may be considered as a bent plane, according as the motion of the axis of the pin is in a right line or in a curve, and it follows that the side surfaces of the teeth of the gear are bent planes whereon the pins always bear with line-contact. The axis of the pin in a pair of my gears upon analysis will be found to describe upon a tooth of the wheel a regular curve, which if the gears run at right angles is a cycloid, but which at all other angles appears to be an unnamed curve intermediate between a cycloid and any epicycloid. The rotation of the wheel A, however, in combination with the movement of the pin, generates still another curvature of the side surface of the tooth, which warps or twists the plane, bent into the curve above mentioned, from the front edge-line a^{10} of the tooth to the base-line a^0 thereof and through an angle whose arc is subtended by two planes, one passing through the front edge a^{10} and the other passing through the side base-line a^0 of the tooth. In this statement the side base-line is considered as the line which is the last line of contact of the pin with the tooth and nearest to the base of the tooth.

Each tooth is symmetrical with reference to the medial plane 1 1, Figs. 8, 9, and 10.

In short, the side surfaces of each tooth in my device are generated by a body circular in cross-section (whether cylindrical, conical, or otherwise) whose plane of rotation is at an angle to the plane of rotation of the revolving toothed wheel.

As illustrated in Figs. 9 and 10, when the pins are cylindrical the side surfaces of the teeth are cycloidal or have curvatures intermediate between cycloids and epicycloids in planes perpendicular to the axes of the pins; but these curves, in fact, deviate from true cycloids or epicycloids to an extent related to and dependent upon the thickness of the pin. The mathematical axis only of the pin can describe a true cycloid or epicycloid or a true curve of the intermediate form above described. In transverse planes parallel to the axes of the pins the side surfaces of the teeth are composed of straight lines, which on the two sides of a tooth form angles varying from the front edge to the base or root of the tooth, as shown in Figs. 11 and 12.

The result of the use of the form of tooth generated by the movement of the pins, cylindrical or otherwise, on the rotary support or disk is that thereby I produce the lowest possible angularity of face of the tooth, and by this form, aided, if desired, by the use of an antifriction-roller, I avoid thrust to the greatest degree. The pitch of the teeth on the wheel A being also generated by the rotation of the pin-gear results in close meshing of the pins and the teeth and the minimum of backlash for free-working gears. It also follows that with a single pin-gear a number of interchangeable wheels A may be used having different numbers of teeth. In Figs. 1 and 4 an identical pin-gear is shown meshing with wheels having twenty-four and thirty-two teeth. While there is a minimum limit for the number of teeth which may be practically employed on a toothed wheel-gearing with a pin-gear, wheels of any number of teeth above said minimum may be used with the same pin-gear. Thus different ratios of angular gears can be obtained by change of one member only of the pair, while at the same time preserving accurate and close meshing.

In the forms and proportions of teeth and pins shown in the drawings some undercut is provided in order to prevent binding of the pin between two adjacent teeth when near the bases of the teeth. This undercut is shown in Figs. 7 and 12 at a^2; but it is limited in extent and does not prevent a sufficient and efficient line-contact between the pin and tooth for driving purposes while preserving a close meshing between the two members of the gear.

It is found in practice that my gear is operative even when the shafts of the two members of the gear are not set exactly at the angle at which they were intended to be set and that a slight deviation from the true angle does not prevent effective operation.

As shown in the drawings, the interdental spaces are cut entirely across the periphery of the wheel and the centers of the pins pass nearly through the interdental spaces, and since the pins fit said spaces closely at and near the roots of the teeth dirt and objects entangled in said spaces are pushed out. It will be seen from Figs. 3 and 6 that in the form of my device shown therein the driving strains are principally exerted by or on the teeth *a* at and near their bases, thus bringing the driving strains nearer the bearings and lessening the tendency to bend or buckle the wheel A.

The line-bearing of the pins upon the faces of the teeth tends to produce long life of the parts and the minimum of wear, which result may be aided by the use of the antifriction-roller *b'*. The roller or pin when in operative position does not for an instant lose an ample bearing on the tooth and has line-contact throughout its roll or passage across the same. The length of this line of contact at any instant depends only upon the length of the tooth and the amount of the tooth allowed to extend outside the pitch circle of the gear-wheel. Hence the pin-gear does not require delicate end adjustment as to the length of the contact-line between its pins and the teeth with which they engage, and, further, the pin-gear may be shifted longitudinally on its axis and with reference to the axis of the toothed gear-wheel without losing efficient contact, and as long as there is some contact possible between the pins and the teeth of the wheel the mechanism remains operative.

The working faces of the teeth of the gear-wheel and the interdental spaces have limiting-surfaces whose curvatures are those generated by the moving pins when the pin-gear and gear-wheel revolve together; and it is clear that this construction involves line-contact and close meshing as between one of my gear-wheels and its pin-gear and the various adjustabilities and results herein mentioned.

I wish it to be understood that I do not intend to limit my claims to any greater extent than the state of the art and a broad construction of their terms may require.

What I claim is—

1. In angle-gearing, a pin-gear having pins with parallel axes, in combination with a gear-wheel having an axis at an angle to that of the pin-gear and provided with interdental spaces and with teeth whose working faces have warped limiting-surfaces whose positions and curvatures are those generated by the surface lines of the moving pins when the pin-gear and gear-wheel revolve together, whereby the contact between the pins and the teeth of the gear-wheel is line-contact.

2. In angle-gearing a pin-gear having a series of cylindrical pins having parallel axes arranged in a circle about the axis of rotation of said pin-gear and parallel thereto, in combination with a gear-wheel having an axis at an angle to that of the pin-gear and provided with interdental spaces and with teeth whose working faces have warped limiting-surfaces whose positions and curvatures are those generated by the surface lines of the moving pins when the pin-gear and gear-wheel revolve together, whereby the contact between the pins and the teeth of the gear-wheel is line-contact.

3. In angle-gearing a face pin-gear having pins with parallel axes, in combination with a gear-wheel having an axis at an angle to that of the pin-gear and provided with interdental spaces and with peripheral teeth whose working faces are warped surfaces generated by the surface lines of the moving pins when the pin-gear and gear-wheel revolve together and the pins of said pin-gear cross the periphery of the gear-wheel, whereby the contact between the pins and the teeth of the gear is line-contact.

4. In angle-gearing, a face-gear having a series of parallel cylindrical pins, in combination with a gear-wheel having an axis set at an angle to that of the pin-gear and provided with wedge-like teeth set transverse to the plane of rotation of the gear-wheel and whose working faces are warped surfaces which are curved in planes perpendicular to the axes of the pins when in contact therewith and which are straight lines in planes parallel to the axes of the pins when in contact therewith.

5. In angle-gearing, a face-gear, having a series of parallel cylindrical pins, in combination with a gear-wheel having an axis set at an angle to that of the pin-gear and provided with peripheral wedge-like teeth, set transverse to the plane of rotation of the gear-wheel and whose working faces are warped surfaces which are curved in planes perpendicular to the axes of the pins when in contact therewith, and which are straight lines

in planes parallel to the axes of the pins when in contact therewith, and antifriction-rollers on said pins.

6. In angle-gearing, a face-gear, having a series of parallel cylindrical pins, in combination with a gear-wheel having an axis set at an angle to that of the pin-gear and provided with peripheral wedge-like teeth set transverse to the plane of rotation of the gear-wheel and whose working faces are warped surfaces which are curved in planes perpendicular to the axes of the pins when in contact therewith and which are straight lines in planes parallel to the axes of the pins when in contact therewith, and having the axes of the pin-gear and gear-wheel set to cause the pins to cross the periphery of the wheel, and antifriction-rollers on said pins.

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