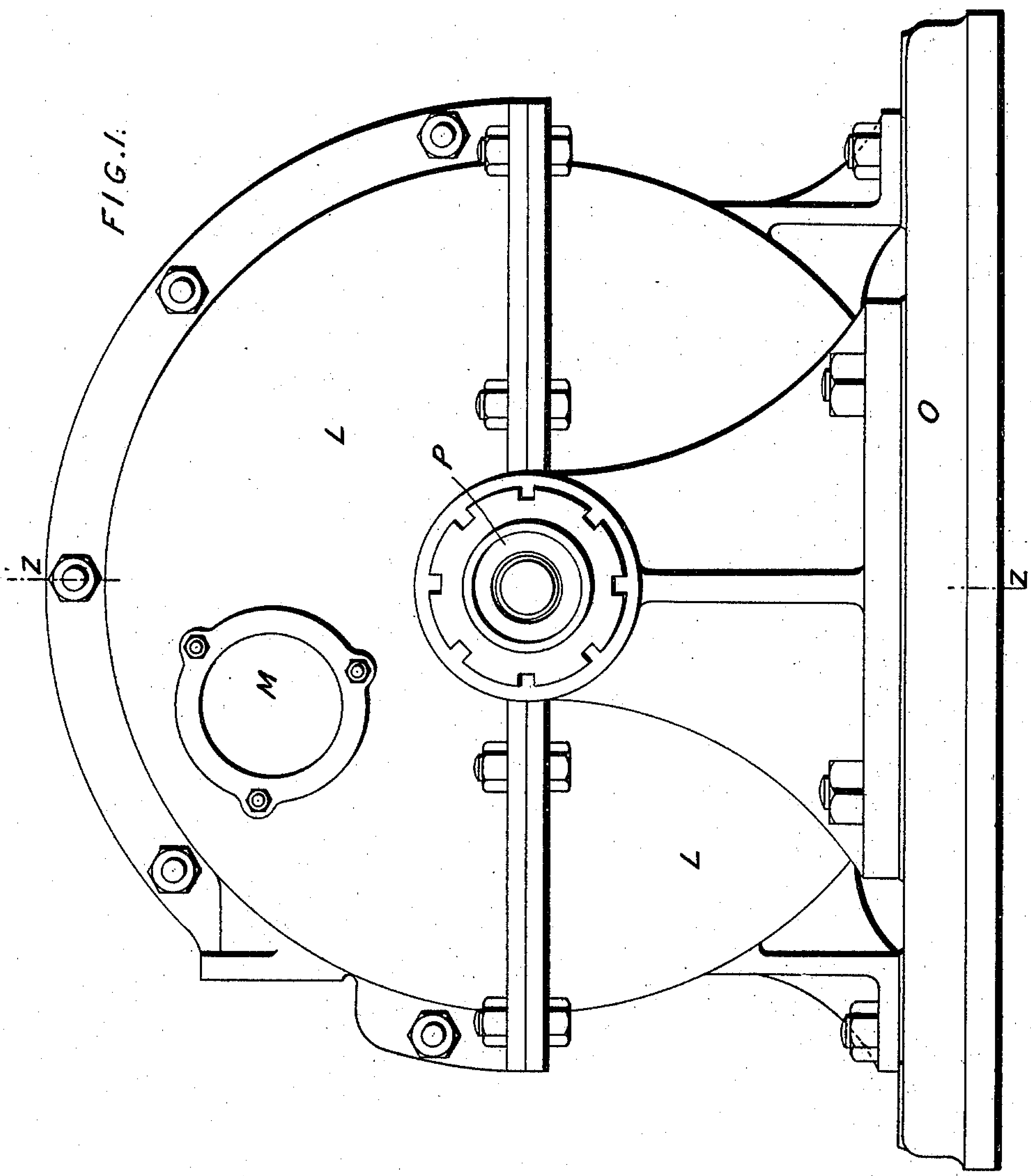
(No Model.) 6 Sheets—Sheet 1.

S. C. DAVIDSON.

TANGENTIAL IMPULSE TURBINE OR PELTON WHEEL.

No. 584,579. Patented June 15, 1897.

FIG. 1.



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(No Model.)

6 Sheets—Sheet 2.

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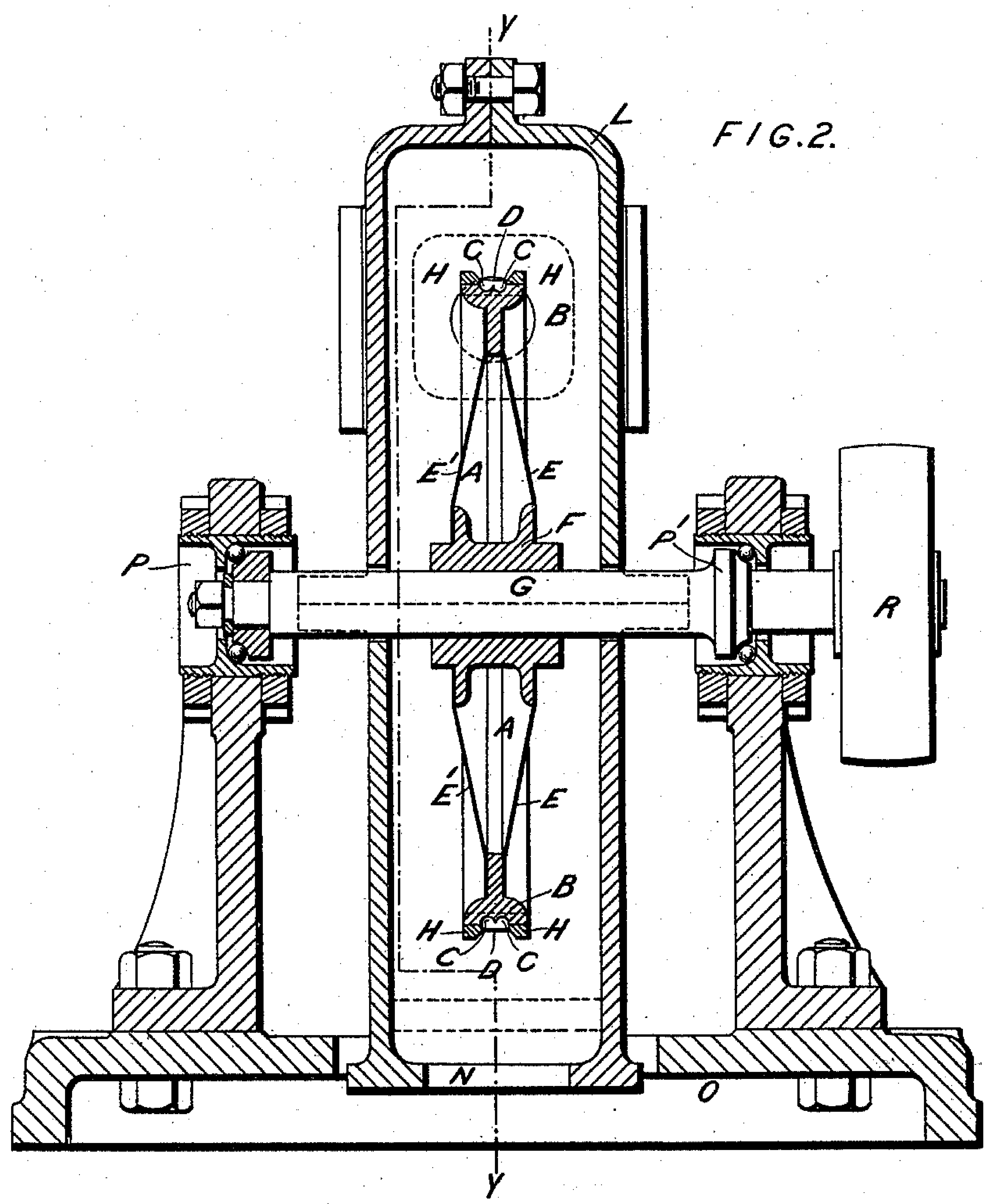

FIG. 2.

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(No Model.)

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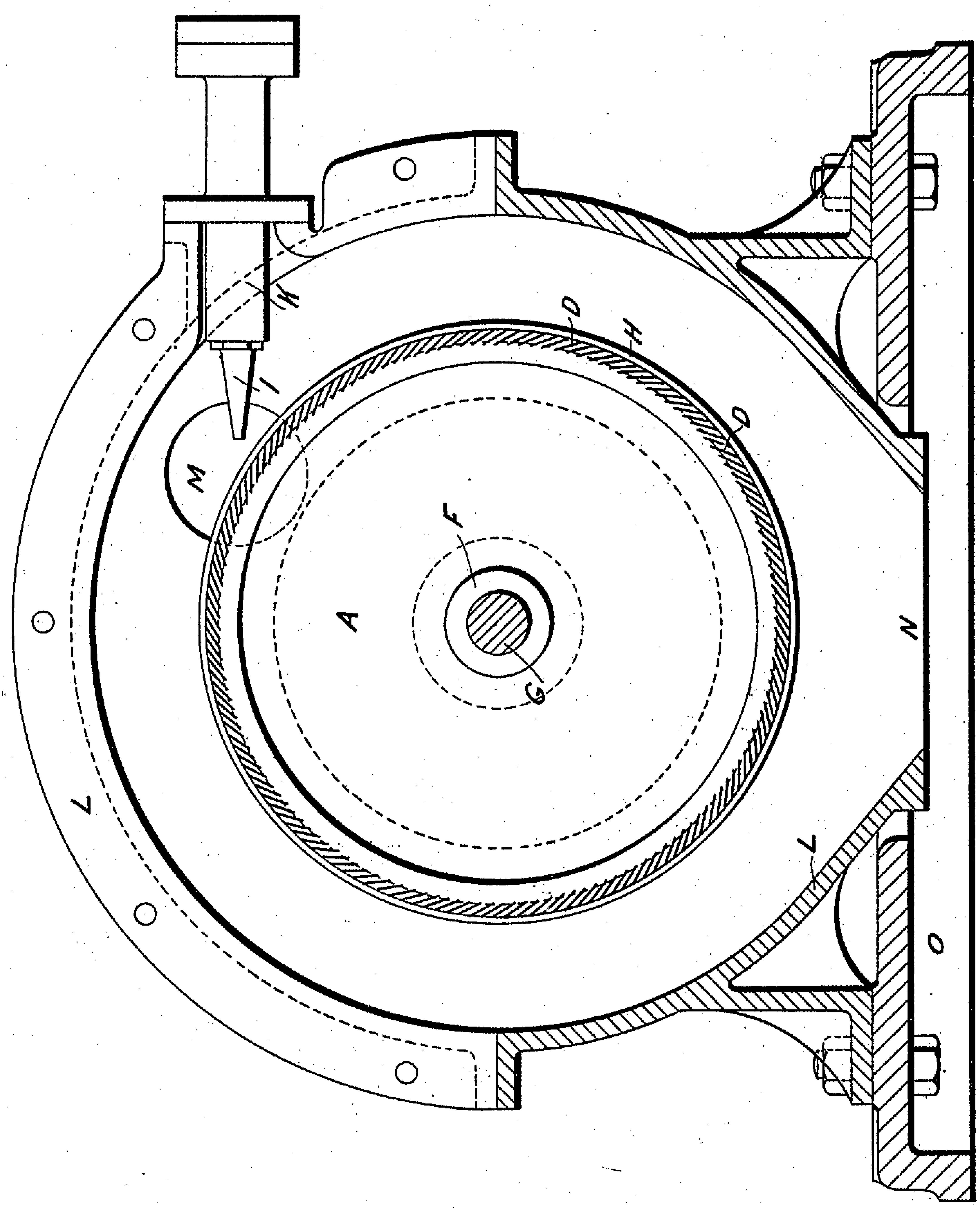
S. C. DAVIDSON.

TANGENTIAL IMPULSE TURBINE OR PELTON WHEEL.

No. 584,579. Patented June 15, 1897.

FIG. 3.



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(No Model.) 6 Sheets—Sheet 4.

S. C. DAVIDSON.

TANGENTIAL IMPULSE TURBINE OR PELTON WHEEL.

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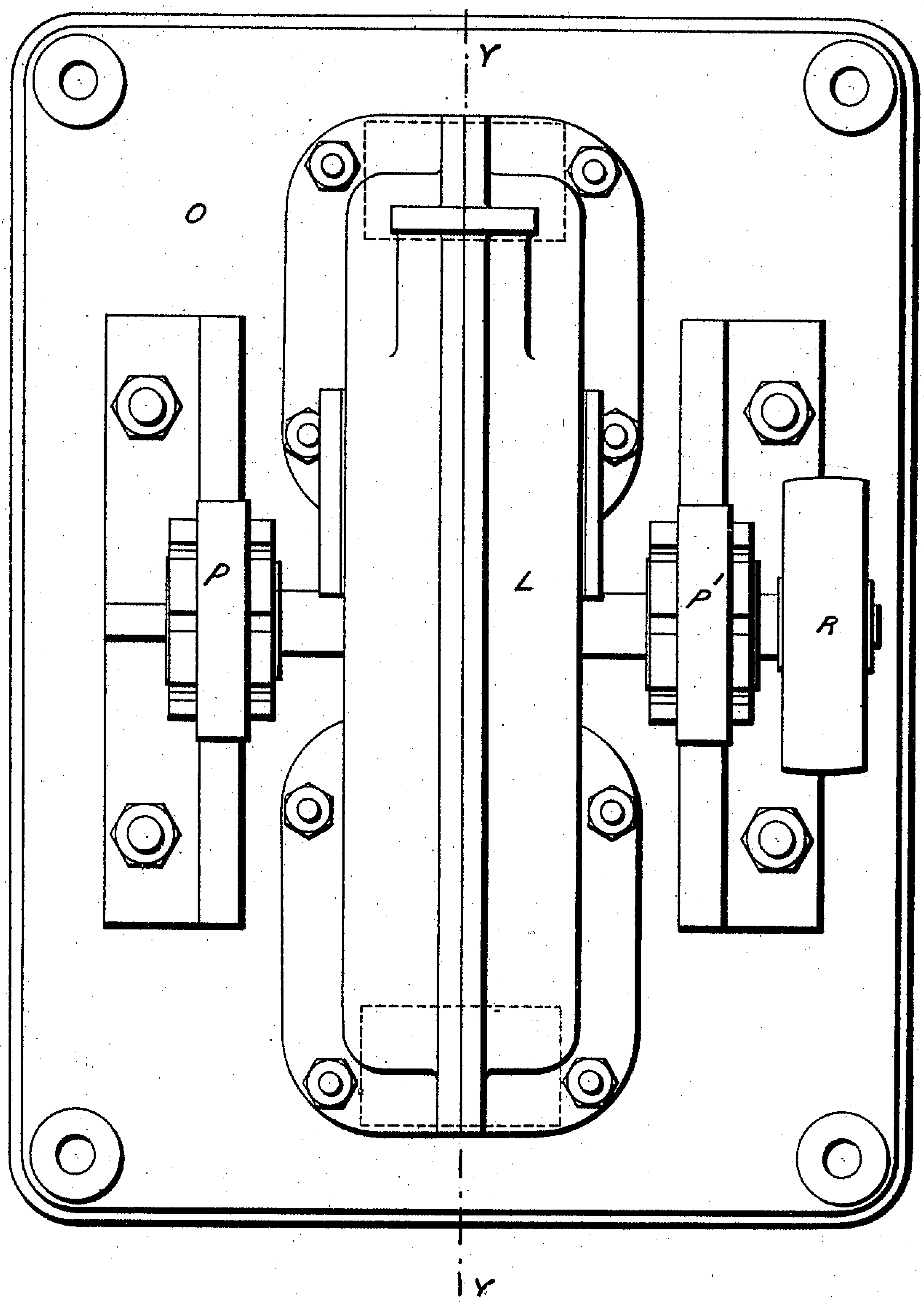
FIG. 4.



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(No Model.) 6 Sheets—Sheet 5.

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FIG. 6.

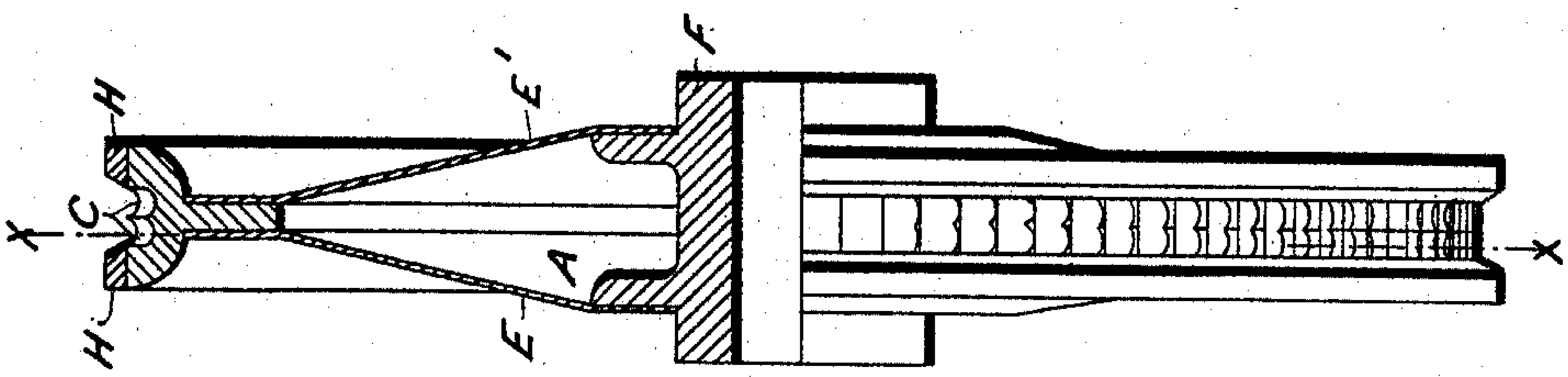
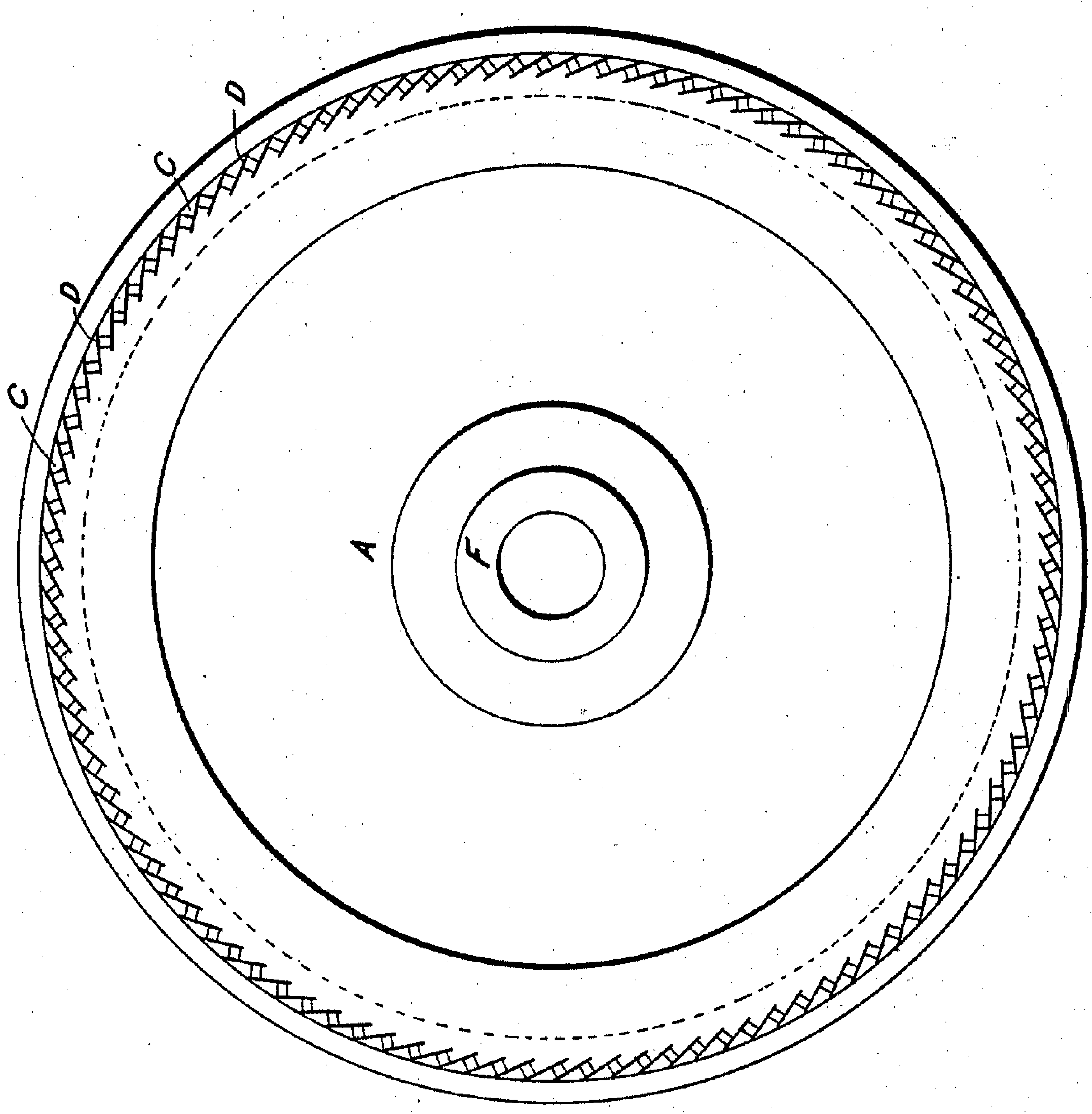


FIG. 5.



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(No Model.)

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S. C. DAVIDSON.

TANGENTIAL IMPULSE TURBINE OR PELTON WHEEL.

No. 584,579. Patented June 15, 1897.

FIG. 7.

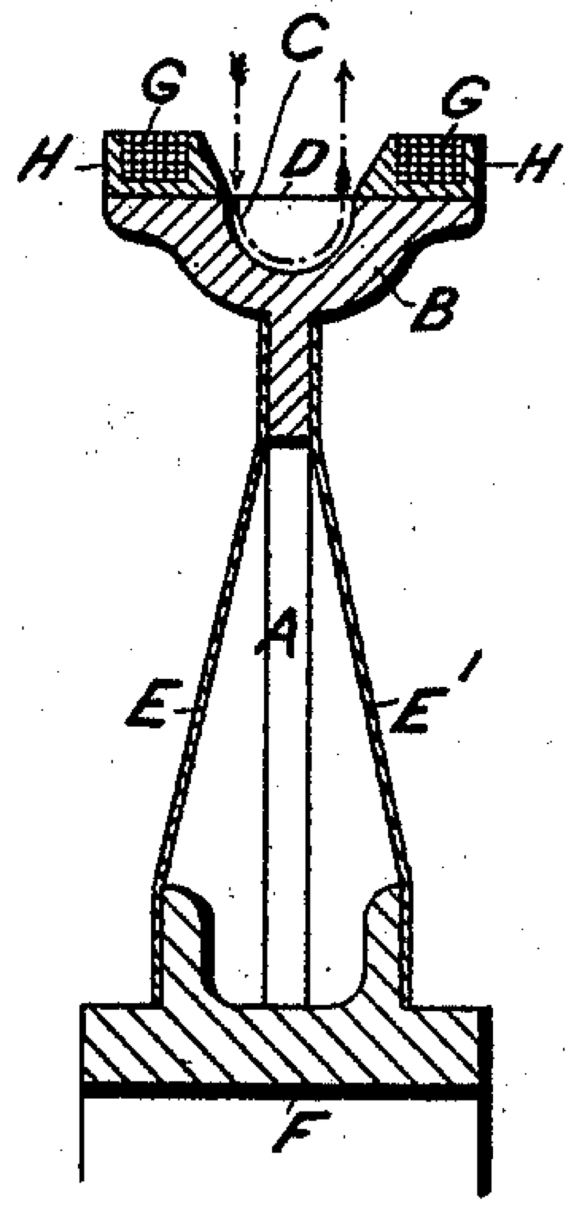


FIG. 8.

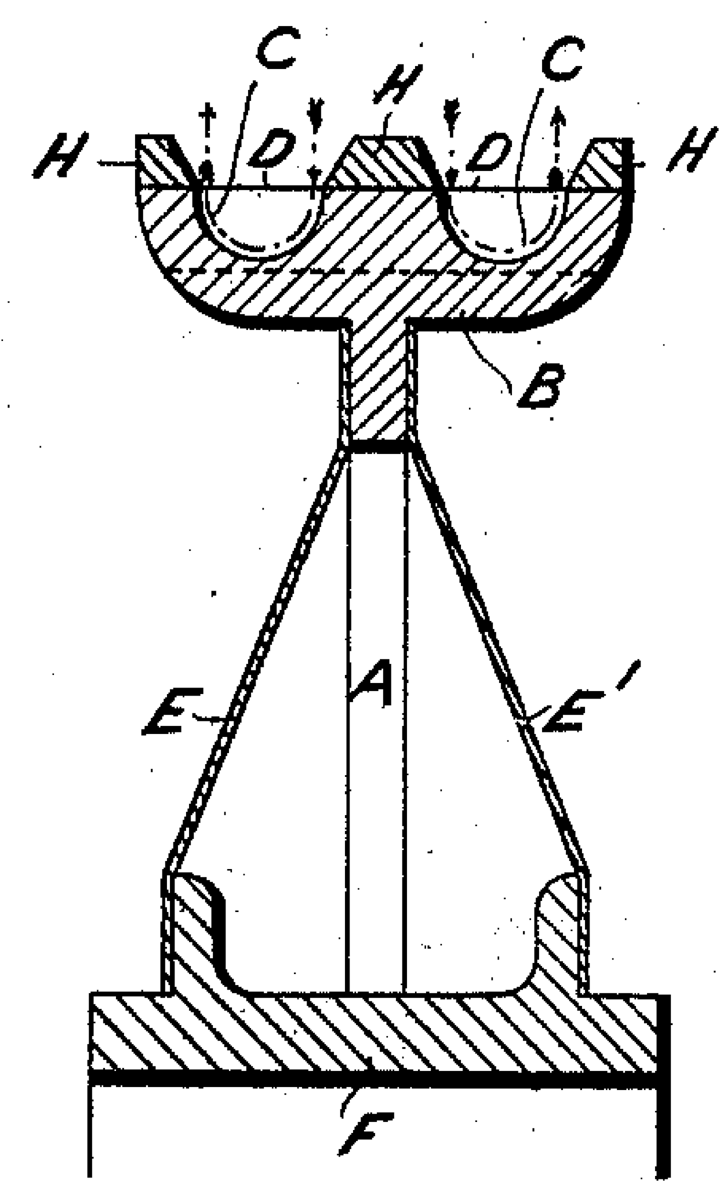
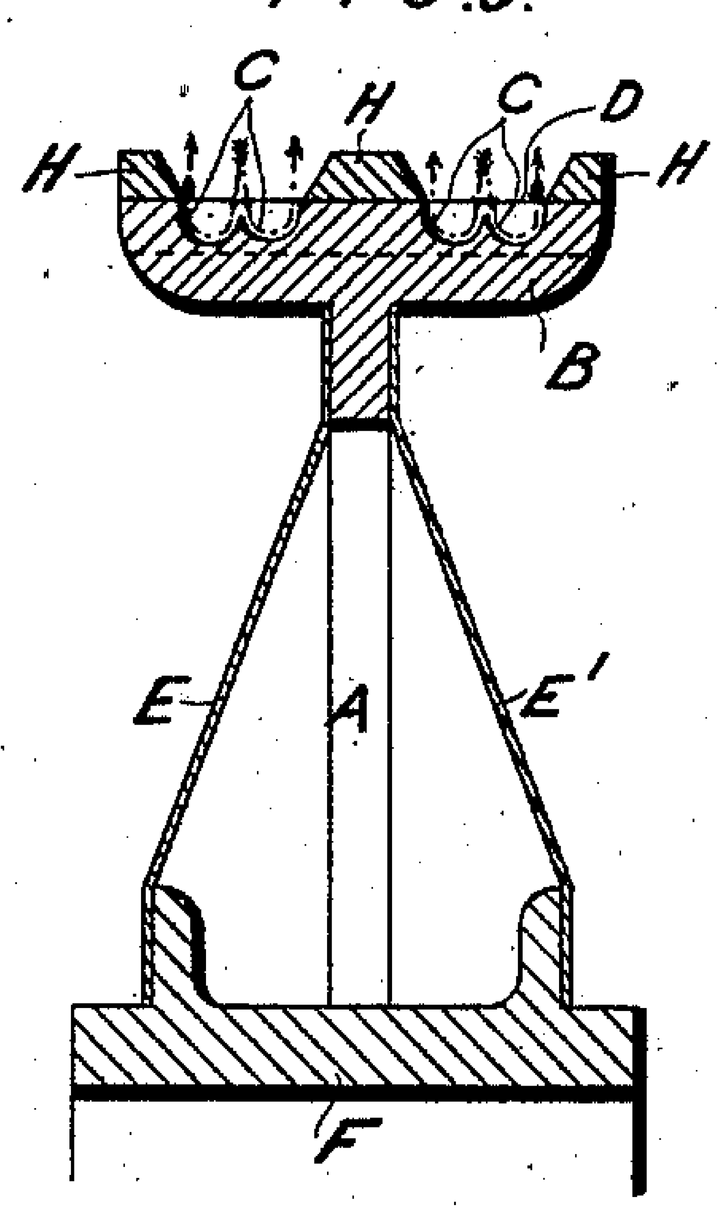


FIG. 9.



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By his Attorneys:

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UNITED STATES PATENT OFFICE.

SAMUEL CLELAND DAVIDSON, OF BELFAST, IRELAND.

TANGENTIAL IMPULSE-TURBINE OR PELTON WHEEL.

SPECIFICATION forming part of Letters Patent No. 584,579, dated June 15, 1897.

Application filed August 7, 1896. Serial No. 602,006. (No model.)

To all whom it may concern:

Be it known that I, SAMUEL CLELAND DAVIDSON, of Belfast, Ireland, have invented certain new and useful Improvements in Tangential Impulse-Turbines or Pelton Wheels, of which the following is a specification.

My improvements have reference to the class or type of turbines known as "tangential impulse" or more commonly as "Pelton wheels," which as hitherto ordinarily constructed consist of a number of separately-made buckets bolted or otherwise secured upon or around the periphery of a wheel at equal distances apart, and into which buckets jets of the motive fluid (usually water) employed for driving same are directed from outside the periphery of the wheel. Turbine wheels of such construction are not suitable for driving with steam as the motive fluid, as their separately-attached buckets are liable to become bent out of proper position or break away from the wheel, owing to the excessively powerful centrifugal force developed by the enormously high velocities at which steam-propelled turbines must necessarily revolve when running at efficient working speed. Further, as there are open spaces between the buckets their advancing sides act like fan-vanes on the surrounding atmosphere and cause a loss in their working efficiency equivalent to the power absorbed thereby, and the amount of open space that exists between the buckets also equivalently diminishes the number that can be mounted on the wheel. Again, the efficiency of impulse-turbines is enhanced by having as many buckets as possible around the periphery consistent with the pitch between their dividing-vanes, being sufficient to avoid any undue friction in the passage of the motive fluid through the buckets, and by having the dividing diaphragms or vanes as thin as practicable.

The objects, among others, of my invention are to so construct tangential impulse-turbines that they may be driven with one or more jets of steam, vapor, air, or gases, or of water, which may be used at extra high pressures, such as one thousand pounds and upward per square inch, (hereinafter called the "motive fluid,") without danger of the buckets breaking away from the wheel or twisting out of position thereon and without the divisional vanes between the buckets operating with fan action on the surrounding atmosphere to any appreciable extent, while a maximum number of buckets may be employed around the periphery of the wheel in which the dividing-vanes are formed of very thin sheet metal.

In constructing my improved impulse-turbines I preferably make the central part of the wheel (hereinafter called the "turbine wheel") either as a disk annulus mounted on arms or spokes of a wheel or between a pair of disks diverging at the center and there riveted to a central hub keyed on the turbine shaft or as a solid disk similarly mounted on the said shaft or spindle, with a flange or rim around the periphery of the said disk annulus or solid disk, as the case may be, in which rim the buckets are formed by a combination of one or more circumferential and suitably-shaped concave grooves (hereinafter called the "rim-grooves") formed, preferably, by turning them in the central part of the outer face of said rim with thin sheet-metal vanes or diaphragms (hereinafter called the "bucket-vanes") inserted as a firm fit into slits or cuts (hereinafter called "cross-cuts") incised across its outer face to the bottom of said rim groove or grooves, whereby same is divided into a series of buckets; and I preferably set the bucket-vanes at such an angle with the rim of the wheel that when they come opposite any of the jets of motive fluid driving the turbine they are approximately in parallel line therewith, and the cross-section of the concave curve in the rim-groove is such that the line of junction between it and the bucket-vanes inserted across the same forms axially-directed semicircular or semielliptical curvatures which constitute the back of the buckets and around which the path of the motive fluid is directed in passing through the buckets. The diameter of this curvature I preferably make equal to about four to six times the diameter of the jet of motive fluid at the time of its entry thereto, in practice, however, commencing with a minimum diameter of at least half an inch for the smallest sizes of jets used therewith. The distance apart between the bucket-vanes constitutes the pitch or length of the bucket as measured around the rim, and this length I preferably adjust so that the clear width of entrance for the jets of motive fluid between the bucket-vanes is equal to about one-half the cross-sectional diameter of the motive-fluid jets at the time of their entry into the buckets, in practice, however, commencing with a minimum space of at least one-eighth of an inch between the bucket-vanes for the smallest sizes of jets of motive fluid used therewith. I may also alternatively construct my herein-described improved impulse-turbines with two of said rim-grooves so located side by side in the rim that when each is turned out to its proper concave curvature in the outer face of the wheel-rim their curves meet or cut into one another at their inner edges, whereby a sharp wedge-like projection is formed between them, and which edge is preferably a little below the exposed edge of the bucket-vanes when inserted, as hereinbefore described, across the double groove thus formed. The jets of motive fluid on being directed upon the said sharp wedge-like dividing edge between the grooves are split thereby to right and left into the axially-directed curvatures forming the back of the buckets in each of the rim-grooves, so that a double-acting bucket is formed by this combination of double rim-grooves with the bucket-vanes from which the return-current of the motive fluid is discharged outwardly in approximately equal parts from its opposite ends, and on the marginal edges of the said rim-grooves a sufficient width of the wheel-rim is left flat for a metal ring to be shrunk on over it, with or without the addition of a coil of wire wound tightly into a groove around it, so as to bind the bucket-vanes and the divided parts of the rim between them sufficiently firmly and strongly together to withstand the centrifugal force developed by the enormously high velocities at which these turbines necessarily revolve when working with steam or high-pressure hydraulic jets of about one thousand pounds and upward as motive fluid.

According to another alternative modification in the construction of the buckets in my improved impulse-turbines instead of turning out the rim groove or grooves forming the axially-directed back curvatures of the buckets as a continuous concave groove around the outer face of the wheel-rim, whereby the circumferential line of the same is at an acute angle to the face of the bucket-vanes and an obtuse angle to the back thereof, I form the axially-directed back curvature of the buckets substantially at right angles to the back of each bucket-vane by substituting for the said continuous rim-grooves a series of equidistant (and preferably milled-out) semicylindrical-faced steps around the central part of the exterior face of the rim, each of which steps is of a depth equal to about one-half the diameter of the jet of motive fluid employed with the same at the time of its entry into the buckets, but in practice commencing with a minimum of at least one-eighth of an inch for the smallest jets used therewith. In front of each step there is a flat plane the line of which is at such an angle with the rim of the wheel that it is approximately parallel with that of the jets of motive fluid when opposite the same, so that the said jets may impinge direct into the upright concave curvature formed by the semicylindrical face of each step without any material deflection thereof by said plane, upon the face of which a thin sheet-metal vane is closely fitted by inserting it into cross-cuts incised across the face of the rim from edge to edge in corresponding line with said planes and extended sufficiently back past the face of each step for the inserted edge of the vane to be quite covered thereby. I may also alternatively form the back concave curvatures of each step in pairs located sufficiently closely together that their inner curves meet in a sharp wedge-like projection, whereby double return-buckets are formed between each pair of vanes, similar to those hereinbefore referred to, and the outer ends of the vanes and the divided parts of the rim between them are also similarly bound in firmly together by shrunk-on metal rings with or without the addition of a coil of wire wound tightly into a groove around it.

In any of the above-described modifications in the construction of the buckets it will be evident that as there is no interior or side entrance for the surrounding atmosphere to get into or between the buckets there can consequently be no free discharge of air therefrom, and the vanes being sloped backward from the direction in which the wheel is running have a minimum fan action upon any air that may be drawn in as an eddy over the edges of the wheel-rim, and as only a very small volume of air could get at the vanes by such eddies this form of bucket has practically no fan action to reduce its efficiency in work. It will also be obvious that as the path of the motive fluid through the buckets is deflected around a semicircular or semielliptical curvature it necessarily returns therefrom in a line practically parallel with and in opposite direction to that of the initial flow of the jet, provided the turbine is held stationary, but when it is working at its most efficient speed the bucket of course moves away from its position between the time that the jet first enters it and its return therefrom. Consequently the angle of the return-current must necessarily open outward to some extent, so that its return is not altogether parallel with that of its initial flow; but as the thin sheet-metal bucket-vanes in any of the forms of construction above described can with facility be efficiently and securely inserted at very short distances apart and as the semicircular curvature round which the motive fluid passes is also very short its return out of the buckets takes place so quickly that the buckets have not time to move so far forward that the angle of the return flow can open outwardly from a parallel line with its initial flow to such an extent as to materially reduce its operative efficiency, and as my herein-described improved turbines may be driven by jets of steam or by extra-high-pressure hydraulic jets delivered from nozzles exterior to their periphery into buckets formed on the exterior face of their rims by the combination of concave grooves or curvatures therein with thin sheet-metal dividing vanes or diaphragms inserted across the same and bound so rigidly therein that they are capable of withstanding the enormous centrifugal force developed when they are revolving at efficient working speed they may appropriately be termed "extra-impulse" turbines.

It will be obvious that if more power be desired from a given diameter of turbine wheel than can be obtained by multiplying the jets of motive fluid two separate sets of rim-grooves and buckets may be constructed on the one wheel.

It will also be obvious that when my improved extra-impulse turbines are required to impart motion in reverse directions, as in the case of their employment for driving locomotives or steamships, two wheels may be mounted on the one shaft and the vanes inserted therein at opposite angles to one another and the motive-fluid jets arranged to act thereon in opposite directions.

In the accompanying drawings, Figure 1 is a side elevation, and Fig. 2 a cross-section on the line *z z* of Fig. 1, of a turbine constructed according to one modification of my invention in which two adjoining and intersecting circumferential rim-grooves form, in conjunction with vanes inserted therein, double-acting buckets in circuit around the wheel. Fig. 3 is a longitudinal section on line *y y* of Figs. 2 and 4. Fig. 4 is a plan. Fig. 5 is a sectional elevation on line *x x* of Fig. 6, and Fig. 6 a half cross-section and half elevation, of a turbine constructed according to another modification in which two intersecting concave curves are milled out in the face of each of a successive series of steps around the outer face of the rim-annulus and form the buckets in conjunction with inserted vanes between each step. Fig. 7 is a half cross-section of another modification in which there is one single circumferential rim-groove forming the buckets and a groove or channel formed in the outer circumference of the two shrunk on metal rings, into which coils of wire are wound to give the rings greater tensile strength. Fig. 8 is a half cross-section of another modification in which there are two independent sets of single circumferential rim-grooves and sets of buckets, so that with double nozzles twice the power may be developed on the wheel. Fig. 9 is a half cross-section of another modification in which there are two independent sets of double circumferential rim-grooves and sets of buckets for use with double nozzles.

Referring first to Figs. 1 to 4, A is the turbine wheel, B the disk annulus, and C C the circumferential grooves therein. D D are the vanes inserted across the grooves C C, thereby forming the buckets. E and E′ are the dished plates, and F the hub, of the wheel which is keyed or otherwise secured to the spindle G. H H are the shrunk-on rings. I is the nozzle for the jet of motive fluid, and K the supply-pipe for same. L is the casing of the turbine, with inspection-doors M, fitted with plate-glass. N is the waste-motive-fluid outlet from the casing. O is the bed-plate with ball-bearings P P′ mounted thereon. R is the driving-pulley.

In Figs. 5 and 6, A is the turbine wheel, B the disk annulus with milled-out concave semicircular-faced steps C C, and D the vanes inserted across same. E and E′ are the dished plates, and F the hub, of the wheel; H H, the shrunk-on rings.

In Figs. 7, 8, and 9, A is the turbine wheel; B, the disk annulus with circumferential rim-grooves C C D D, the vanes across same forming the buckets. E and E′ are the dished plates, and F the hub; of the wheel H, the shrunk-on rings. In Fig. 7, G G are the coils of wire wound into the channel formed in the shrunk-on rings H H.

It is also intended that in the modifications shown in Figs. 7, 8, and 9 the back curvatures may, if desired, be alternatively formed according to the way represented in Figs. 5 and 6.

In the accompanying drawings, as above described, only one jet-nozzle is illustrated for directing the motive fluid into the buckets of the turbine wheel, and from a point in the outer casing which is in line with the plane of revolution of the turbine, but more than one may be applied in a similar manner, or the jets may be led from a motive-fluid-supply duct attached to or forming part of the side of the turbine-casing, as may be preferred, and which latter arrangement is shown and described in my specification for the governing of turbines, the application for which is Serial No. 602,007, filed of equal date herewith.

Having now described the nature of my invention and illustrated how the same is carried into effect by the several modifications hereinbefore described, and represented in the accompanying drawings, I do not, however, limit myself to the particular methods of construction as therein set forth, and accordingly claim as my invention—

1. In tangential impulse-turbines in which the initial flow of the motive fluid driving the same is directed into the buckets from one or more jet-nozzles exterior to the periphery of the turbine wheel, the combination with the body of the turbine wheel of a flanged rim revolving therewith an axially-directed approximately semicircular circumferential groove in the outer periphery of said rim, thin sheet-metal vanes dividing said

groove into buckets said vanes being inserted into transversely-incised slits across the face of said rim to the full depth of said groove at such an angle to the periphery of the wheel that when said vanes come opposite the jets of motive fluid driving the turbine they are approximately in parallel line therewith, and a band around said rim compressing and holding together the said vanes and the divided portions of said rim, substantially as and for the purpose set forth.

2. In tangential impulse-turbines in which the initial flow of the motive fluid driving the same is directed into the buckets from one or more jet-nozzles exterior to the periphery of the turbine wheel and in which the turbine wheel has a flanged rim with an axially-directed circumferential concave groove of approximately semicircular cross-section in its outer periphery as and for the purpose set forth, the combination with said rim and its said circumferential groove of a second similar groove in said rim parallel with the first-described groove and in sufficiently close proximity to it that their curves meet in a sharp edge and form a wedge-like projection between the two grooves, and thin sheet-metal vanes dividing both of said grooves into buckets, said vanes being inserted across said grooves into slits cut transversely across said rim to the full depth of said grooves and at an angle as described whereby when the jets of motive fluid are directed upon the edge between the two grooves said edge divides it between the two grooves and it is discharged from the opposite ends of the double buckets thereby formed in a line approximately parallel with and in opposite direction to that of its initial flow, and a band around said rim compressing and holding together the divided portions of said rim substantially as and for the purpose set forth.

3. In tangential impulse-turbines in which the initial flow of the motive fluid driving the same is directed into the buckets from one or more jet-nozzles exterior to the periphery of the turbine wheel, the combination with the body of the turbine wheel of a flanged rim revolving therewith, a successive series of semicylindrical concave-faced steps around the outer periphery of said rim the concave face of each step forming a back curvature thereof, and each of which steps is at right angles to the line of motive fluid when opposite the same, thin sheet-metal vanes inserted into transverse cuts across the face of said rim and dividing the concave-faced steps and therewith constituting buckets the said vanes coming into approximately parallel line with the jets when opposite the same, whereby the motive fluid is deflected around the concave face of each step in its traverse through the bucket and is discharged in a line approximately parallel with and in opposite direction to that of its initial flow and a band around said rim compressing and holding together the divided portions of said rim substantially as and for the purpose set forth.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

SAMUEL CLELAND DAVIDSON.

Witnesses:
GEORGE GOOLD WARD,
HUGH TAYLOR COULTER.