(No Model.)

5 Sheets—Sheet 1.

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ELASTIC FLUID TURBINE.

No. 589,422.

Patented Sept. 7, 1897.

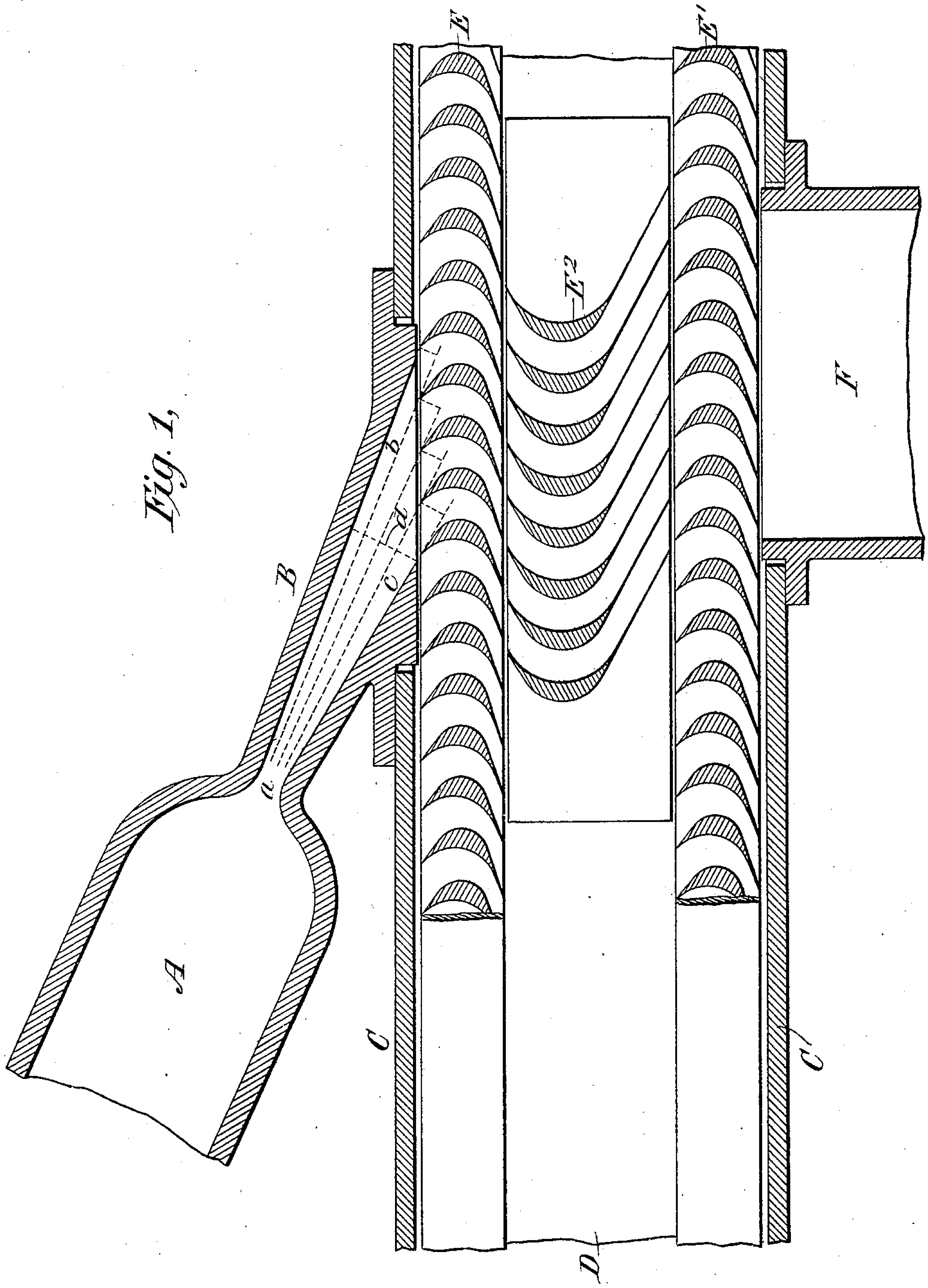

Fig. 1.

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INVENTOR:

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Fig. 2,

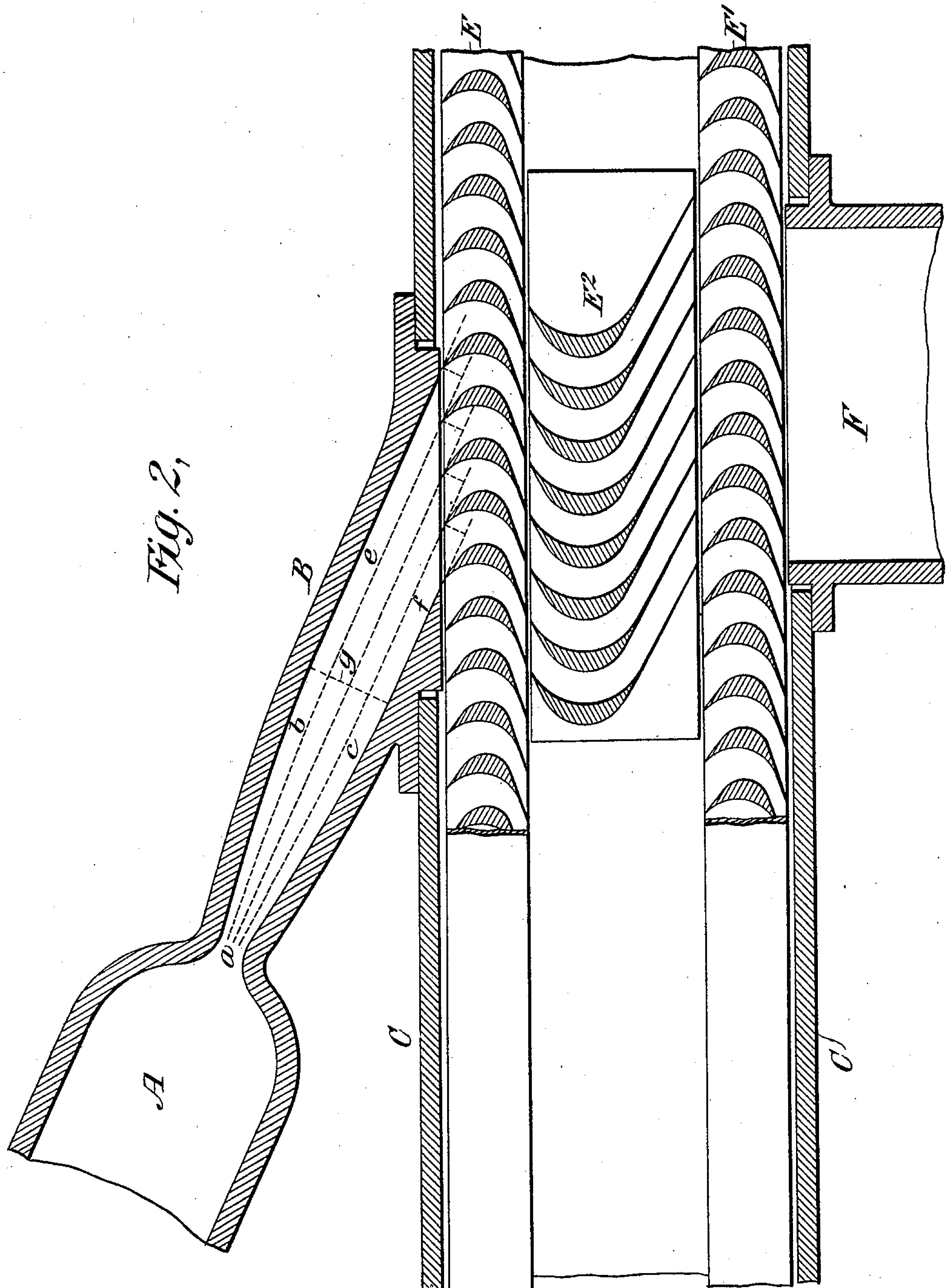

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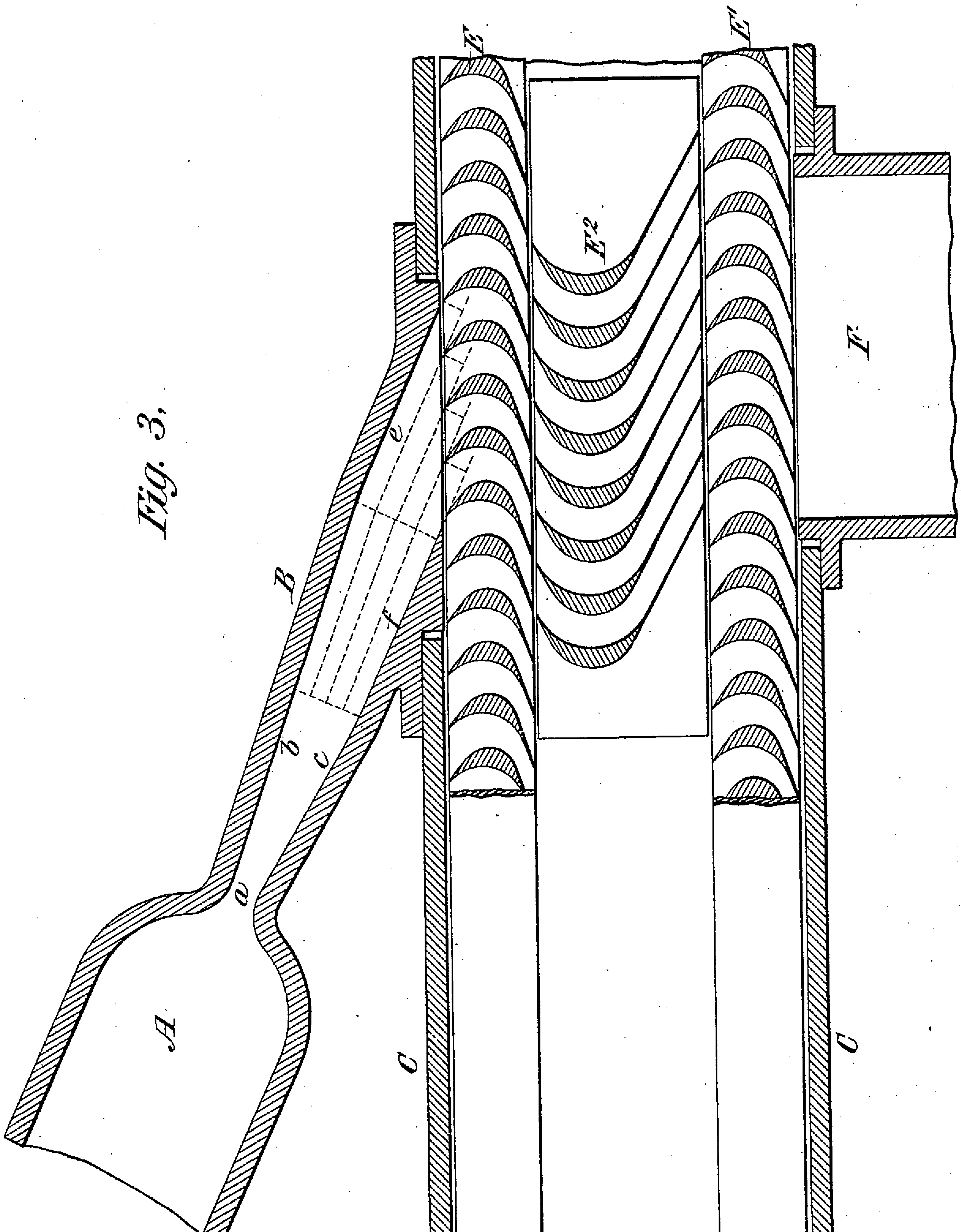
Fig. 3.



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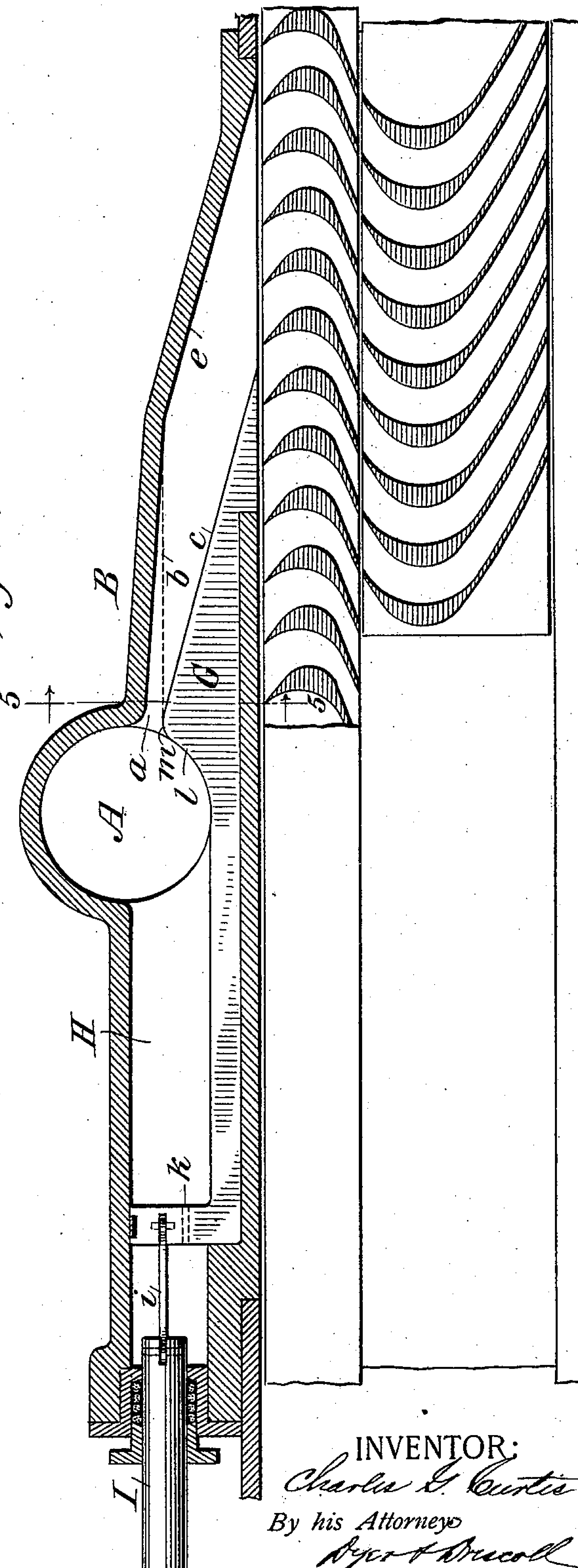

Fig. 4,

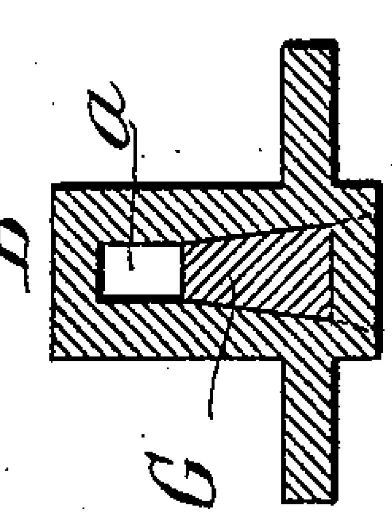

Fig. 6,

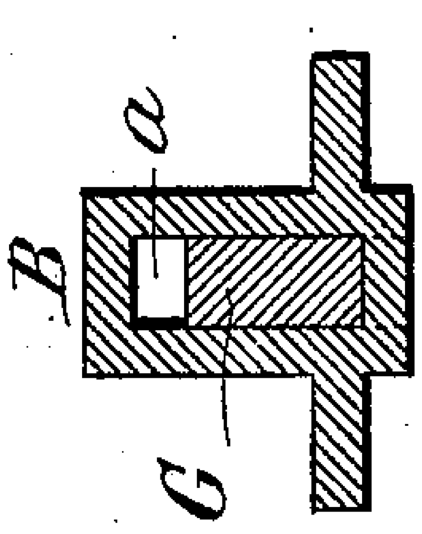

Fig. 5,

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(No Model.)

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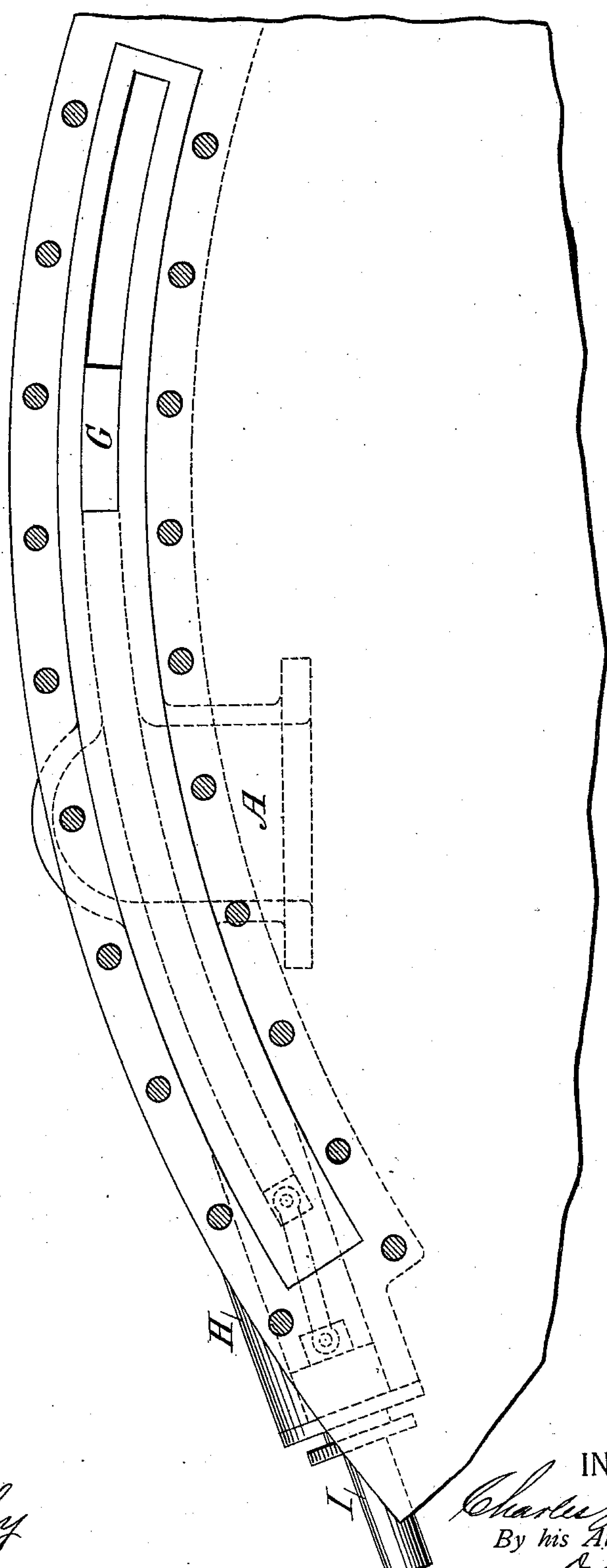

Fig. 7.

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UNITED STATES PATENT OFFICE.

CHARLES G. CURTIS, OF NEW YORK, N. Y., ASSIGNOR TO THE CURTIS COMPANY, OF SAME PLACE.

ELASTIC-FLUID TURBINE.

SPECIFICATION forming part of Letters Patent No. 589,422, dated September 7, 1897.

Application filed August 4, 1896. Serial No. 601,605. (No model.)

To all whom it may concern:

Be it known that I, CHARLES G. CURTIS, a citizen of the United States, residing at New York city, in the county and State of New York, have invented a certain new and useful Improvement in Elastic-Fluid Turbines, of which the following is a specification.

The expanding-nozzles which have heretofore been used or proposed for converting the pressure of steam or other elastic fluid into *vis viva* and delivering it obliquely to the curved vanes of rotating turbines, by means of which the velocity is converted into mechanical power, have been provided with sides diverging to the points of delivery. I have discovered that this construction involves a considerable loss of power, due to the fact that if the proper conditions of expansion and conversion of pressure into velocity are produced at the delivery-point of the shorter side of the nozzle there is a still further and considerable expansion of the fluid at the point of delivery on the longer side of the nozzle, and that if the nozzle is proportioned to give the desired conditions at the central point of delivery there will still be a sufficient divergence from those conditions at the ends of the shorter and longer sides to produce a substantial variation from the proper velocity of flow at these points and consequent loss of power. A further difficulty also arises from the fact that with the diverging nozzles as heretofore constructed or proposed the angle at which the moving stream of particles strikes the curved vanes is different on the two sides of the nozzle, being greater on the longer side, and hence the vanes to which the fluid-jet is delivered simultaneously receive a quantity of the fluid which diminishes from the shorter to the longer side of the nozzle, thus failing to deliver a sufficient quantity of fluid to some of the buckets to secure the maximum efficiency, and resulting in a further loss of power. It is especially important to overcome these difficulties in the case of compound turbines having long and complex passages, and that equal amounts of steam and at the same degree of expansion or pressure be delivered to all the passages through which the jet of steam flows, otherwise there may be very unequal velocities of flow through the different vane-passages.

The object I have in view is to improve the elastic-fluid turbine upon which I have already applied for patents, (Patents Nos. 566,967, 566,968, and 566,969, dated September 1, 1896) so as to avoid these difficulties.

In the accompanying drawings, forming a part hereof, Figure 1 is a horizontal section of the old form of nozzle with a plan view of a portion of the vanes of a compound rotating turbine. Fig. 2 is a similar view illustrating one form of my improved nozzle. Fig. 3 is a similar view showing a somewhat different construction of the nozzle. Fig. 4 is a similar view showing my improved means for varying the cross-sectional area of the nozzle without changing the ratio of expansion between its receiving and discharging ends. Fig. 5 is a cross-section on the dotted line 5 5 in Fig. 4, looking in the direction of the arrows which cross that dotted line. Fig. 6 is a similar cross-section showing a nozzle having diverging top and bottom walls; and Fig. 7 is an elevation from the inside of the turbine shell or case, looking toward the nozzle of Fig. 4.

Referring to Fig. 1, A is the pipe or conduit connected with the steam-boiler or other source of elastic fluid under pressure. B is the expansion delivery-nozzle. C is the shell of the turbine, containing the rotating turbine D, provided with curved vanes E and E' and a divided intermediate stationary passage E^2, and F is the discharge-passage, which is the exhaust of the apparatus or is an intermediate passage connected with another turbine. The expanding delivery-nozzle has a contracted receiving end or throat *a* and is provided with side walls *b c*, which diverge uniformly to the discharging end of the nozzle. The dotted lines running lengthwise of the nozzle indicate the direction of movement of the flowing particles. If the nozzle is proportioned to give the proper expansion at the cross-section indicated by the dotted line *d*, passing through the discharging end of the shorter side of the nozzle, it will be seen that the fluid will be expanded farther to a considerable extent before it reaches the discharging end of the longer side of the nozzle, and it will also be observed that the angle at which the fluid impinges against the curved vanes is greater progressively from the shorter to the longer side of the nozzle at its discharging end. This results in the steam or other elastic fluid having a greater expansion and lower pressure where it strikes the vanes E progressively from the discharging end of the shorter side of the nozzle to the discharging end of the longer side of the nozzle, and not only will the steam entering the vane-spaces at the discharging end of the longer side of the nozzle have a lower pressure, but the steam will strike the vanes at a different angle and a smaller quantity of steam will be delivered to the vane-spaces than at the discharging end of the shorter side of the nozzle. Consequently if the nozzle is so proportioned and the angle at the receiving ends of the vanes E is such as to give the proper pressure and proper angle of delivery to the vanes at the shorter side of the nozzle the pressure will be too low and the vane-spaces will receive too little steam at the longer side of the nozzle. This is a matter of considerable importance in my compound turbine, because unless the vane-passages are completely filled with steam at the proper pressure in the first set of vanes this steam in passing into the vane-spaces of the intermediate stationary passage will expand to fill such vane-spaces and may largely or entirely lose its velocity and be without the necessary pressure to produce the flow through subsequent vane-passages. To overcome the objections to this construction, I construct the nozzle with diverging sides b c, so as to give the proper expansion and conversion of pressure into velocity, and beyond those diverging walls I extend the nozzle with parallel side walls $e f$, Fig. 2. In this way the proper expansion of the fluid, or approximately so, will be attained when the cross-section represented by the dotted line g at the junction of the diverging and parallel sides of the nozzle is reached, and beyond this cross-section the moving stream is guided for a sufficient distance between the parallel walls, so that the particles are given a parallel motion and will not only be delivered to all the vanes at the same angle, but without any material difference in expansion at the ends of the shorter and longer sides of the nozzle, or, as shown in Fig. 3, the parallel sides e f of the longer and shorter sides of the nozzle may be one in advance of the other, and when so arranged will produce the same effect.

Referring to Figs. 4 to 7, inclusive, A is the pipe or conduit leading to the boiler or other source of elastic fluid under pressure. The expansion-nozzle B has its sides b c diverging, its extended wall e being made parallel with the diverging wall c. It will be observed that the nozzle has a curved form, as illustrated in Fig. 7, and that the discharging end of the nozzle, which is shown to the right of the letter G in Fig. 7, is of curved oblong form, having parallel curved top and bottom edges and straight radial side edges. The width of this discharging end vertically is the height of the vanes E, so that the nozzle will conform in shape precisely to the space afforded by the vane-passages at any time in line with it. The diverging wall c is carried by a sliding tongue G, which slides between the top and bottom walls of the nozzle and also in a groove formed in an extended passage H. The piece G has a curved form and slides in a curved seat, as shown in Fig. 7. Through the end of the passage H passes a plunger I, connected by a link i with the extension of the piece G. A hole k (shown in dotted lines) permits the steam-pressure from the pipe A to act upon the inner end of the plunger I, thus balancing approximately the piece G in its movement. This piece would otherwise be unbalanced, because the pressure upon its side l next to the inlet A is greater than the pressure upon its diverging face c. The plunger I may be connected with means for moving it by hand, but is preferably moved automatically by connection with a suitable speed-governing mechanism or with other means responsive to variations in speed or load. In the movement of the piece G the point m of that piece which forms one side of the throat a of the nozzle moves, as is shown by the dotted line, toward the angle formed between the diverging wall b of the nozzle and the extended parallel wall e. This movement varies the cross-sectional area of the nozzle at its throat and at its discharging end approximately to the same extent, so that the volume of the fluid-jet can be changed without changing substantially the ratio of expansion which takes place in the nozzle, and hence without changing substantially the velocity of the fluid-jet. In this way the fluid-turbine can be governed and will operate approximately at the same efficiencies under variations in load, as described in my application, Serial No. 574,031, before referred to.

As shown in Fig. 5, the top and bottom walls of the nozzle B are parallel, but they may be made somewhat diverging, as shown in cross-section in Fig. 6, in which case a less divergence will be necessary between the walls b and c, or such walls may be actually parallel and the divergence obtained entirely between the top and bottom walls.

What I claim is—

1. In a compound elastic-fluid turbine, the combination with movable vanes and means for causing the elastic fluid to act upon such vanes two or more times in succession, of a delivery-nozzle having a contracted throat and permitting the expansion of the fluid beyond the contracted throat and provided with extended parallel sides to transform the motion of the particles into a parallel motion before discharging them from the nozzle, substantially as set forth.

2. In a compound elastic-fluid turbine, the combination with movable vanes and means

for causing the elastic fluid to act upon such vanes two or more times in succession, of a delivery-nozzle having a contracted throat, a diverging portion beyond the throat, and parallel delivery-walls at the sides of the nozzle, substantially as set forth.

3. In an elastic-fluid turbine, an obliquely-arranged expansion-nozzle having a contracted throat, a diverging portion beyond the throat, and parallel delivery-walls at the sides of the nozzle, the parallel delivery-walls being produced by changing the angle of the longer outer side wall at its delivery end so as to make it substantially parallel with the inner or shorter side wall of the nozzle, substantially as set forth.

4. In an elastic-fluid turbine, a delivery-nozzle having a curved discharging end with parallel top and bottom edges, substantially as set forth.

5. In an elastic-fluid turbine, an expansion-nozzle having parallel side walls at the discharging end of the nozzle, in combination with means for varying the cross-sectional area of the nozzle throughout its length simultaneously and proportionately, substantially as set forth.

6. In an elastic-fluid turbine, the combination with an expansion-nozzle having two opposite parallel walls at its discharging end, of an adjustable piece forming one of such parallel walls, substantially as set forth.

7. In an elastic-fluid turbine, an obliquely-arranged expansion-nozzle having the angle of its longer outer side wall changed at the delivery end of the nozzle so as to be parallel with the shorter or inner side of the nozzle, in combination with a sliding piece which forms the inner or shorter side wall of the nozzle, substantially as set forth.

8. In an elastic-fluid turbine, a curved delivery-nozzle, in combination with a curved slide for adjusting said nozzle simultaneously and proportionately at its receiving and discharging ends, substantially as set forth.

9. In an elastic-fluid turbine, an obliquely-arranged expansion-nozzle having a straight inner or shorter side wall and having the angle of its longer or outer side wall changed intermediate between its ends so that its delivery end is made substantially parallel with the inner side wall, in combination with a sliding piece which forms the inner side wall and which by its adjustment is caused to approach toward or recede from the parallel portion of the outer side wall and thereby vary the cross-sectional area of the nozzle simultaneously and proportionately from its receiving to its discharging end, substantially as set forth.

10. In an elastic-fluid turbine, the combination with a jet-expansion delivering-nozzle, of means for varying the cross-sectional area of the nozzle, and a plunger or piston for balancing any excess of pressure on the movable parts, substantially as set forth.

11. In an elastic-fluid turbine, the combination with the inlet A and nozzle B, of the passage H, sliding piece G and plunger I, substantially as set forth.

This specification signed and witnessed this 30th day of July, 1896.

CHARLES G. CURTIS.

Witnesses:
EUGENE CONRAN,
JNO. R. TAYLOR.