S. Z. DE FERRANTI.

GOVERNING MECHANISM FOR ELASTIC FLUID TURBINES.

APPLICATION FILED APR. 11, 1908.

916,944. Patented Mar. 30, 1909.

12 SHEETS—SHEET 1.

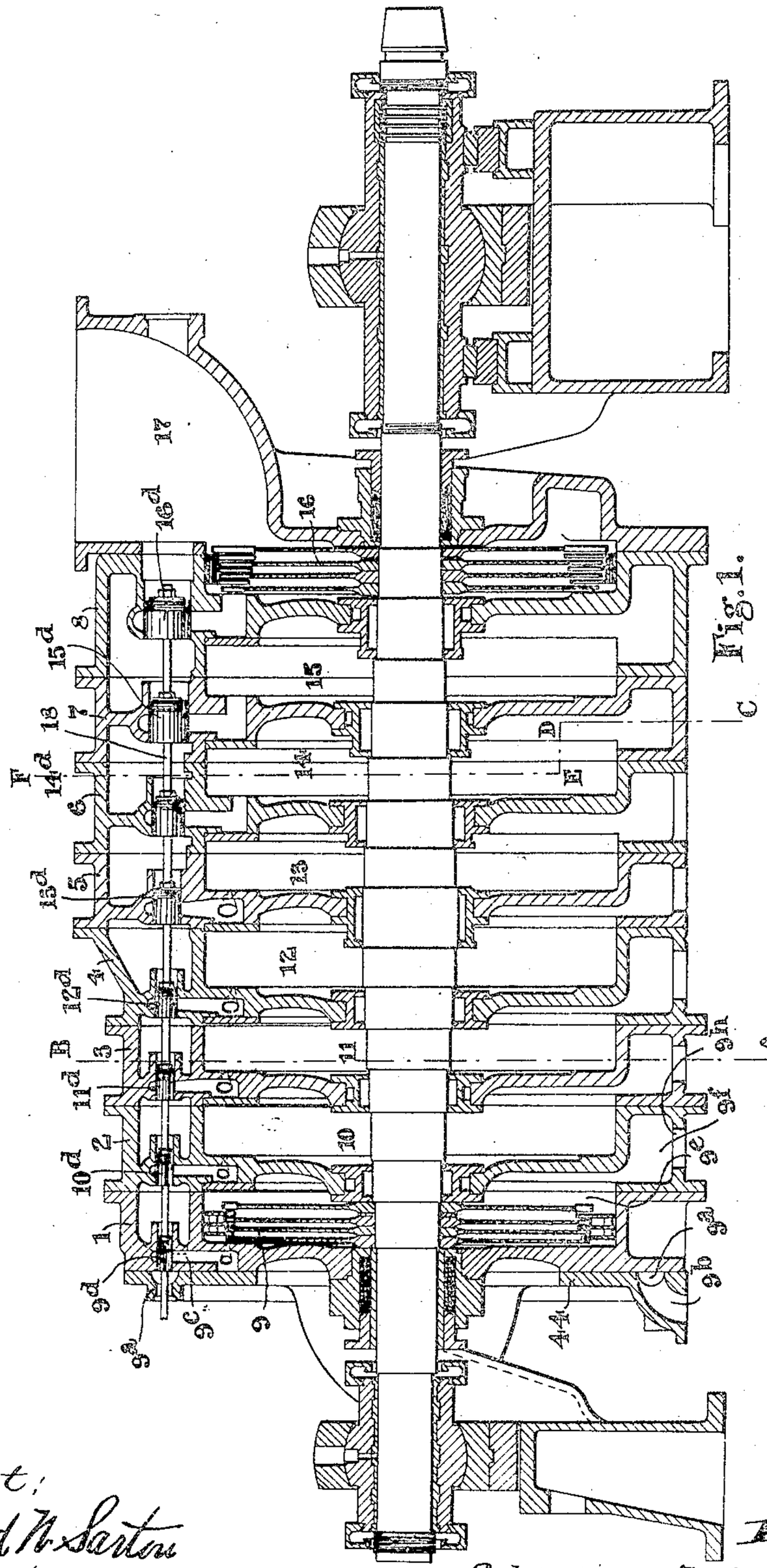

Fig. 1.

Attest:
Edward N. Sarton
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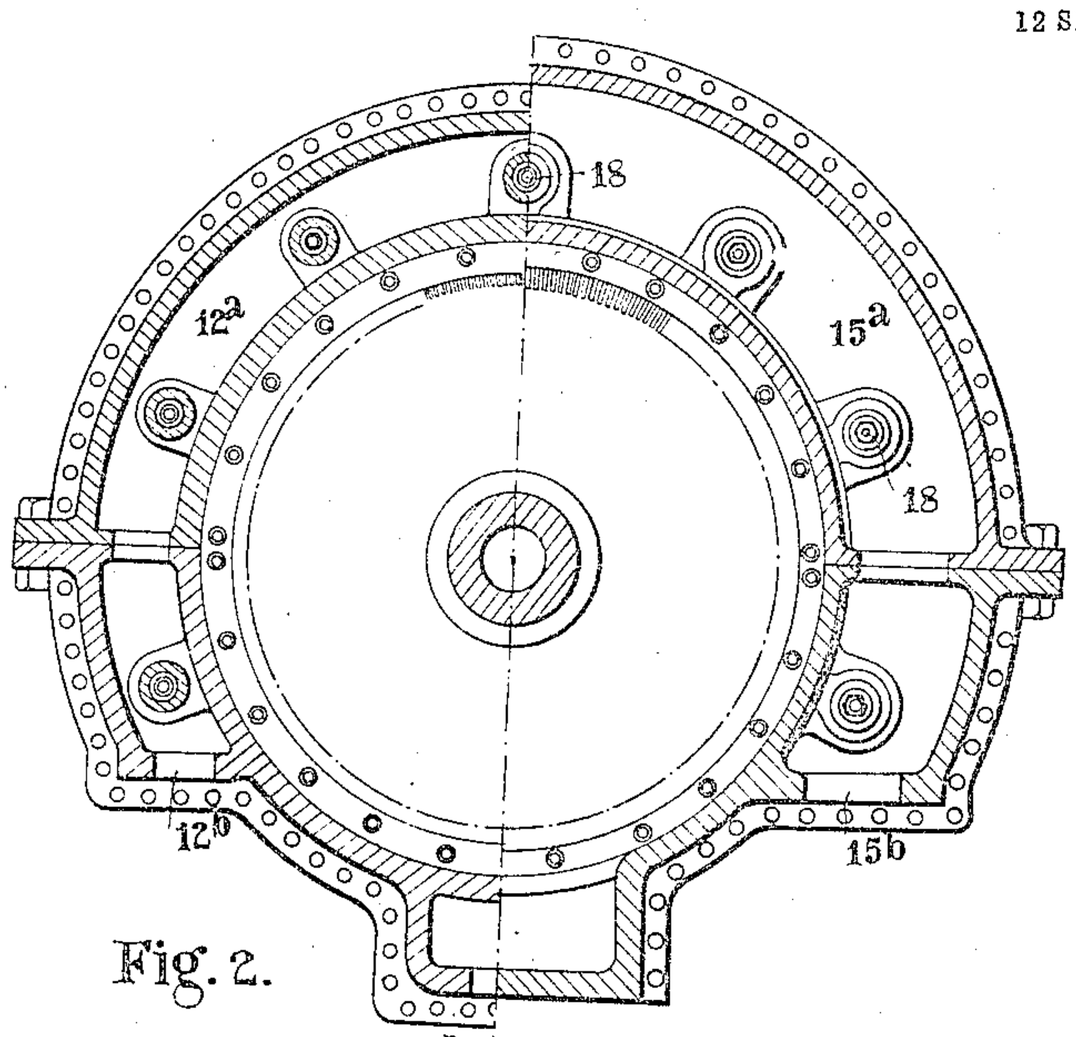

Fig. 2.

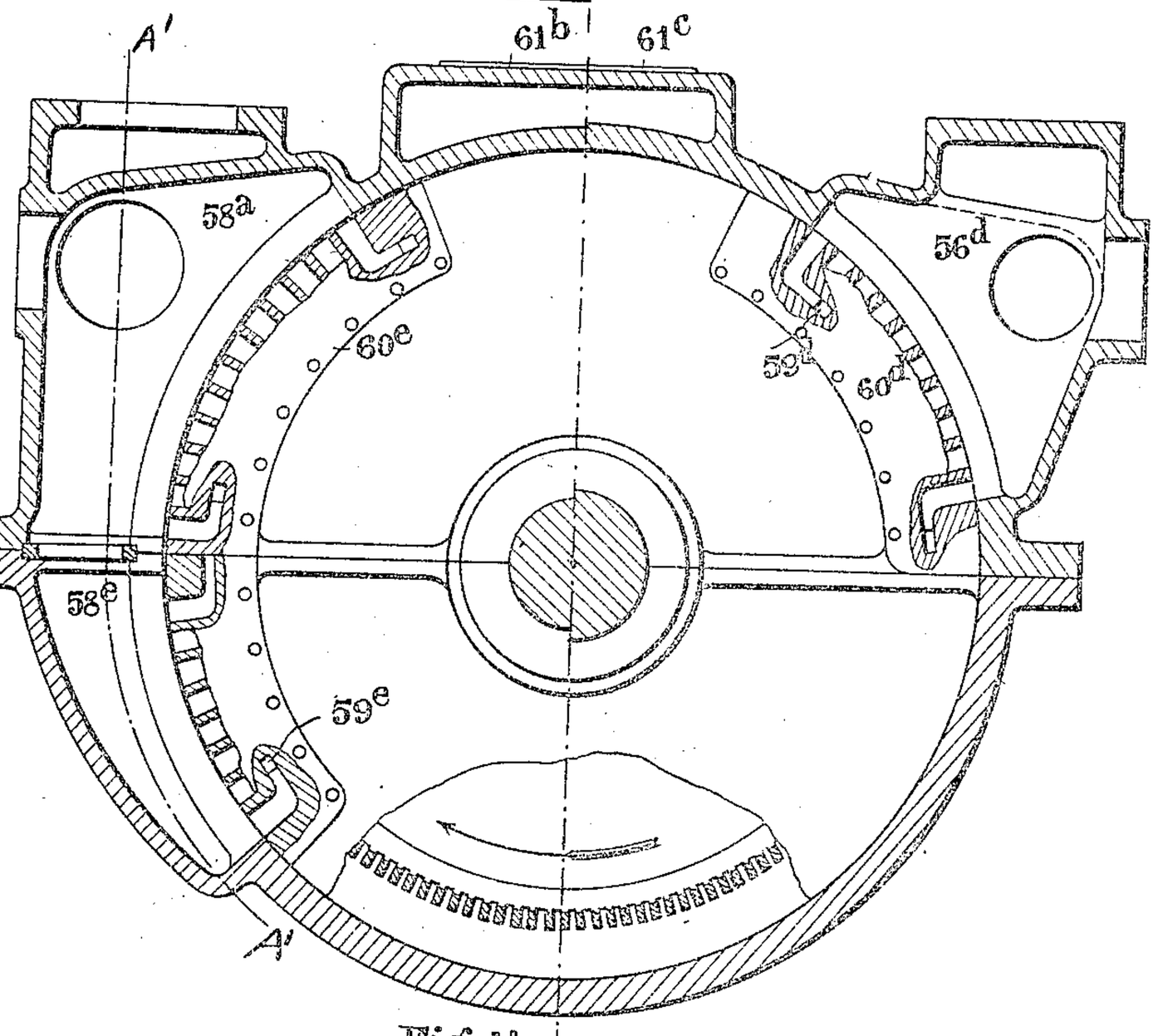

Fig. 11.

Attest:
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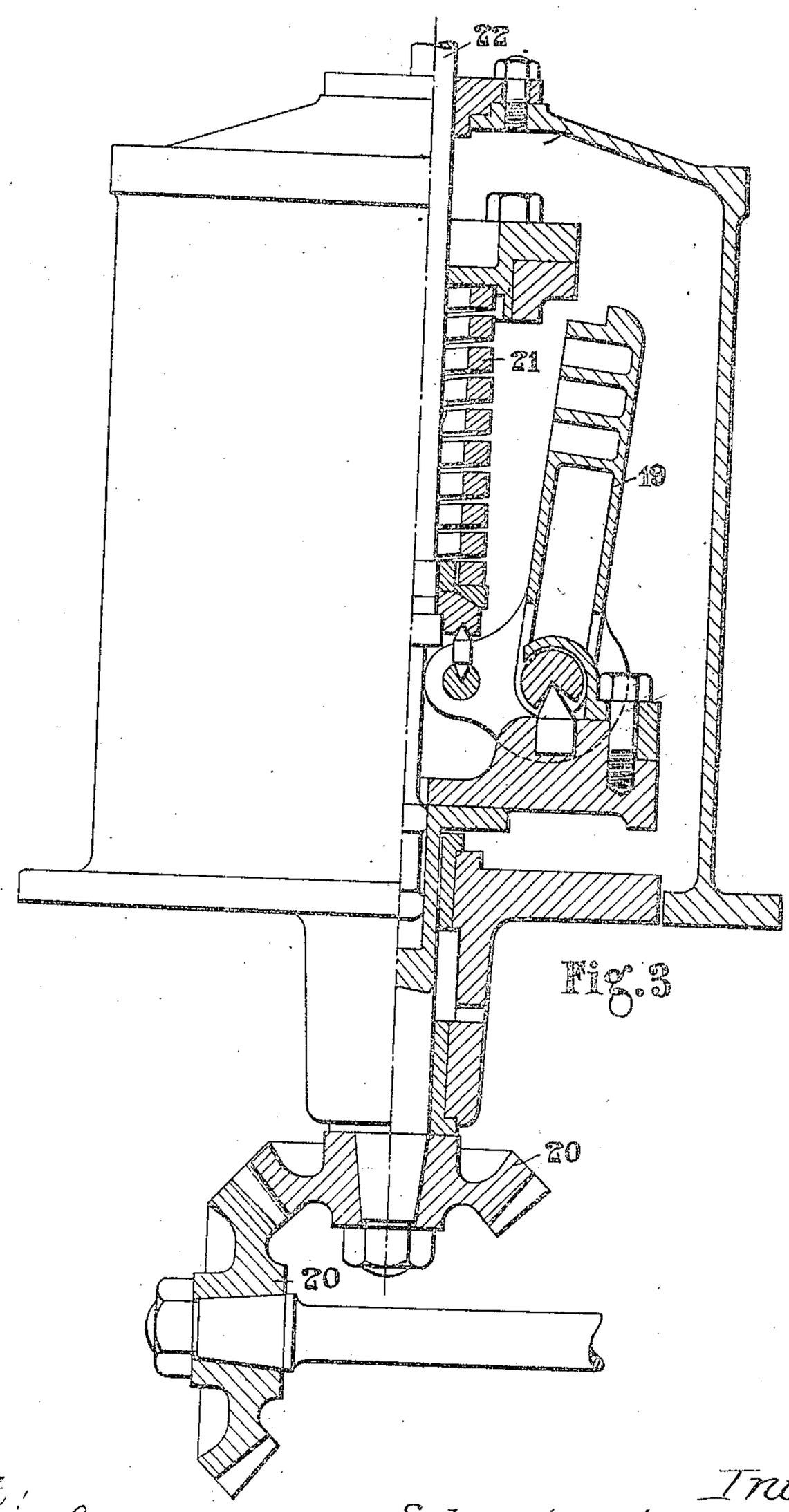

Fig. 3

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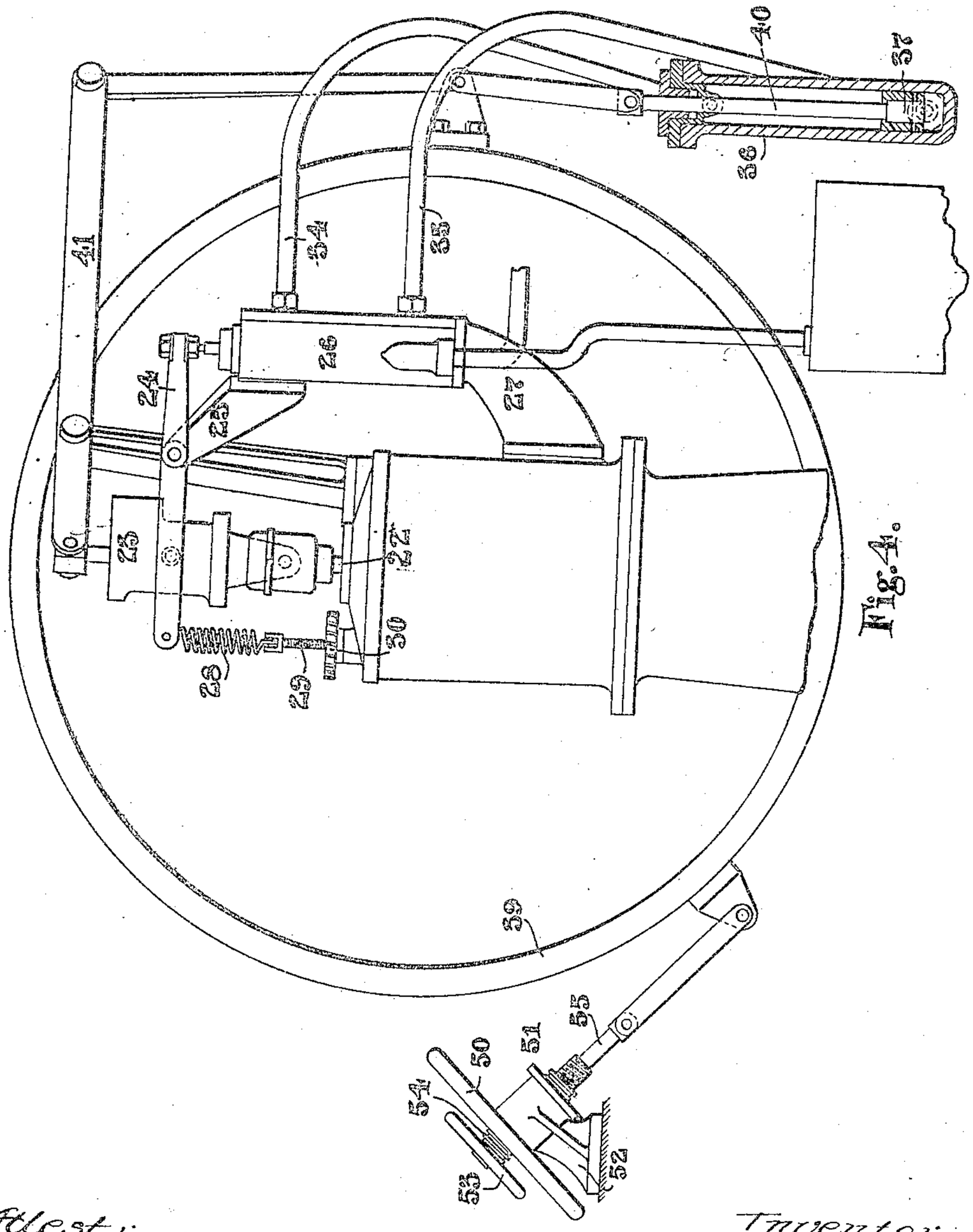

Fig. 4.

Attest:
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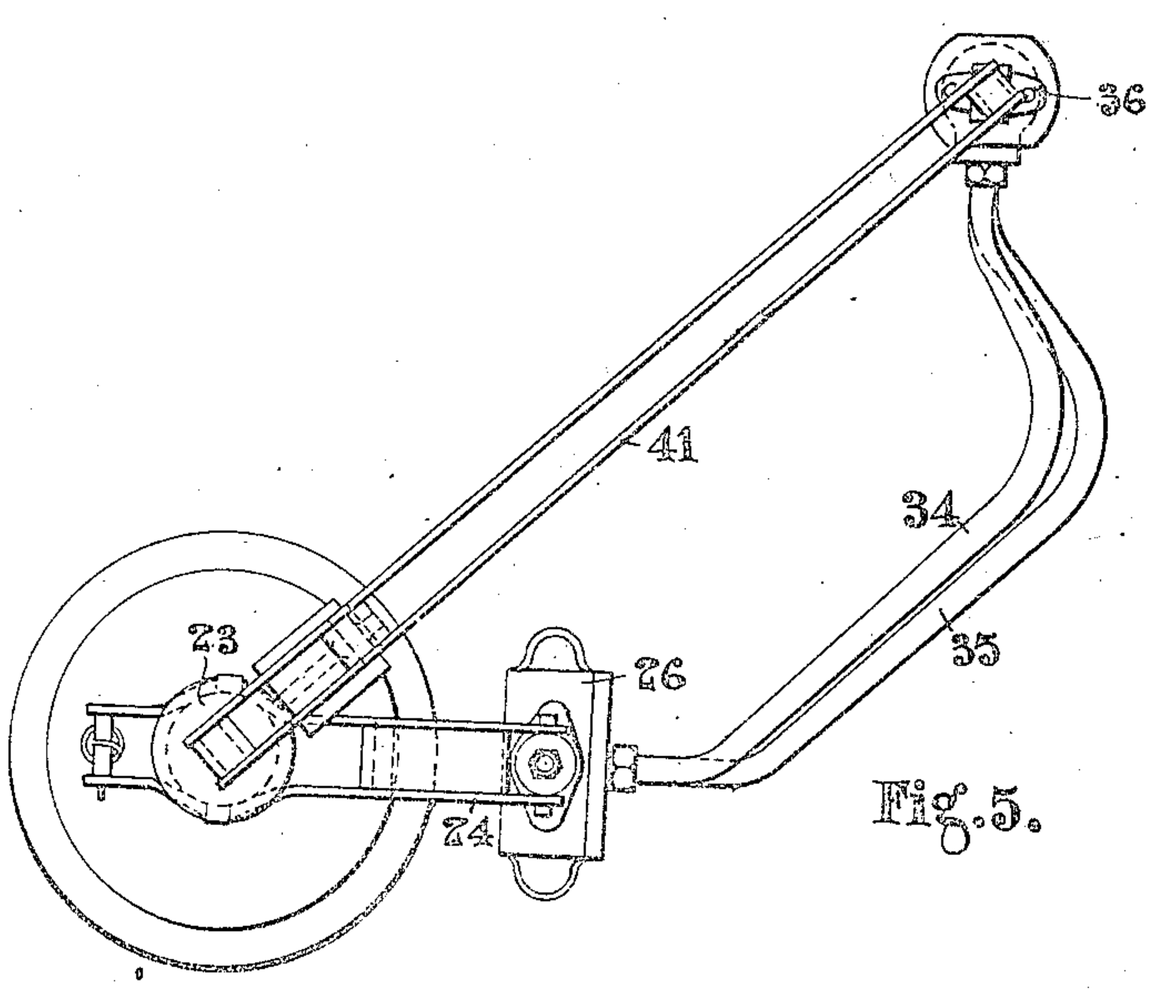

Fig. 5.

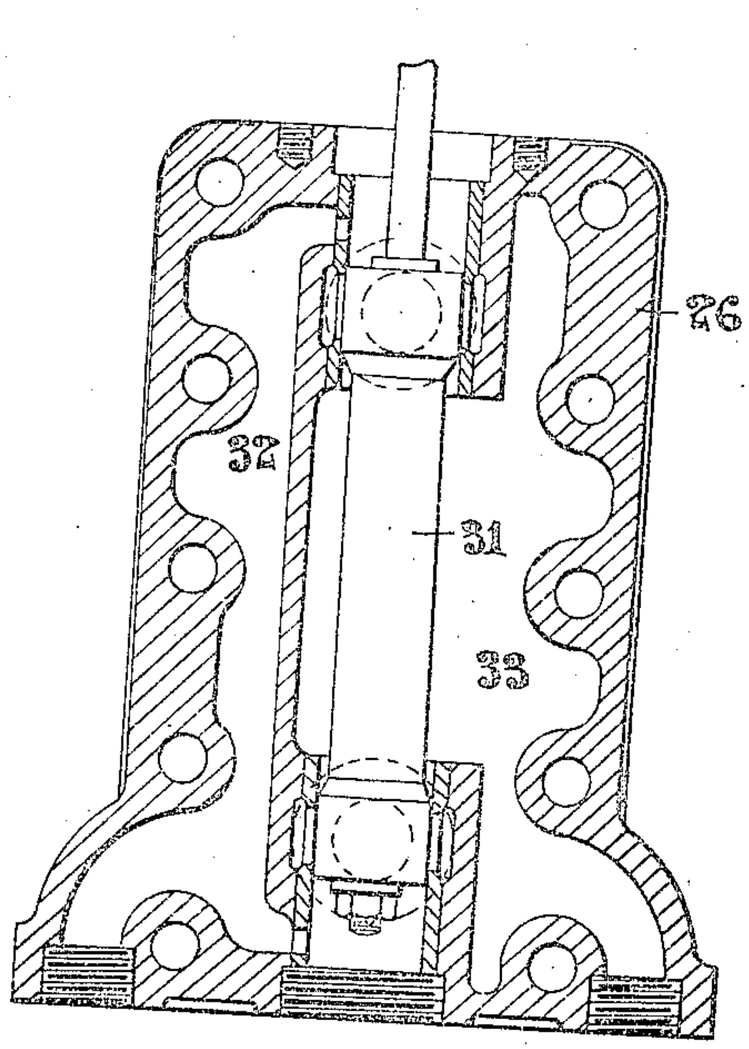

Fig. 6.

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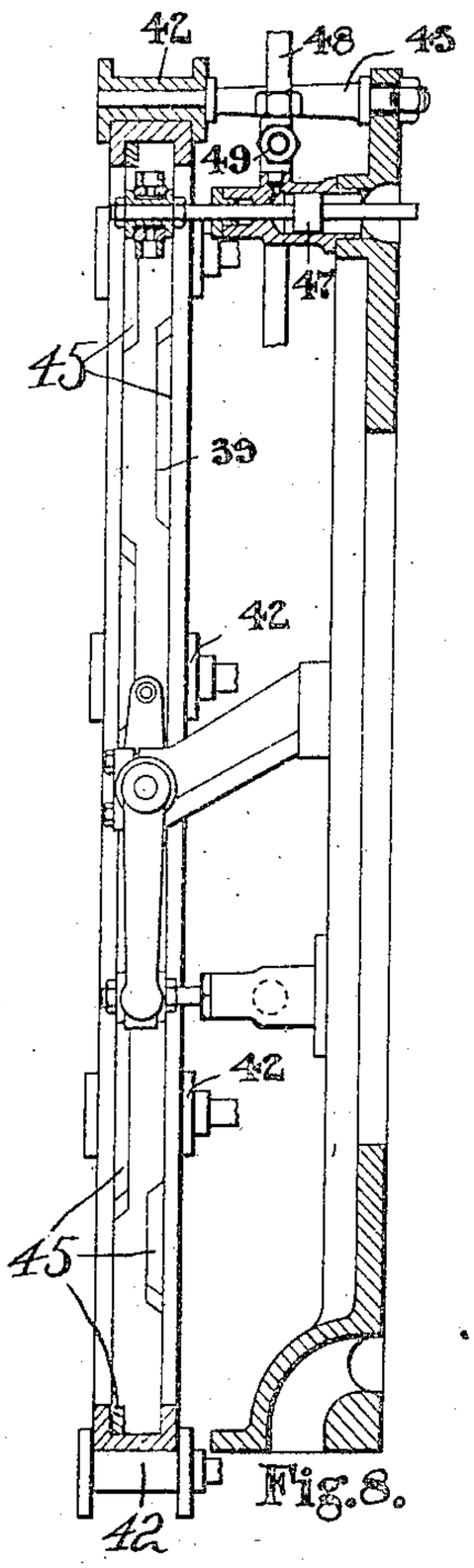

Fig. 8.

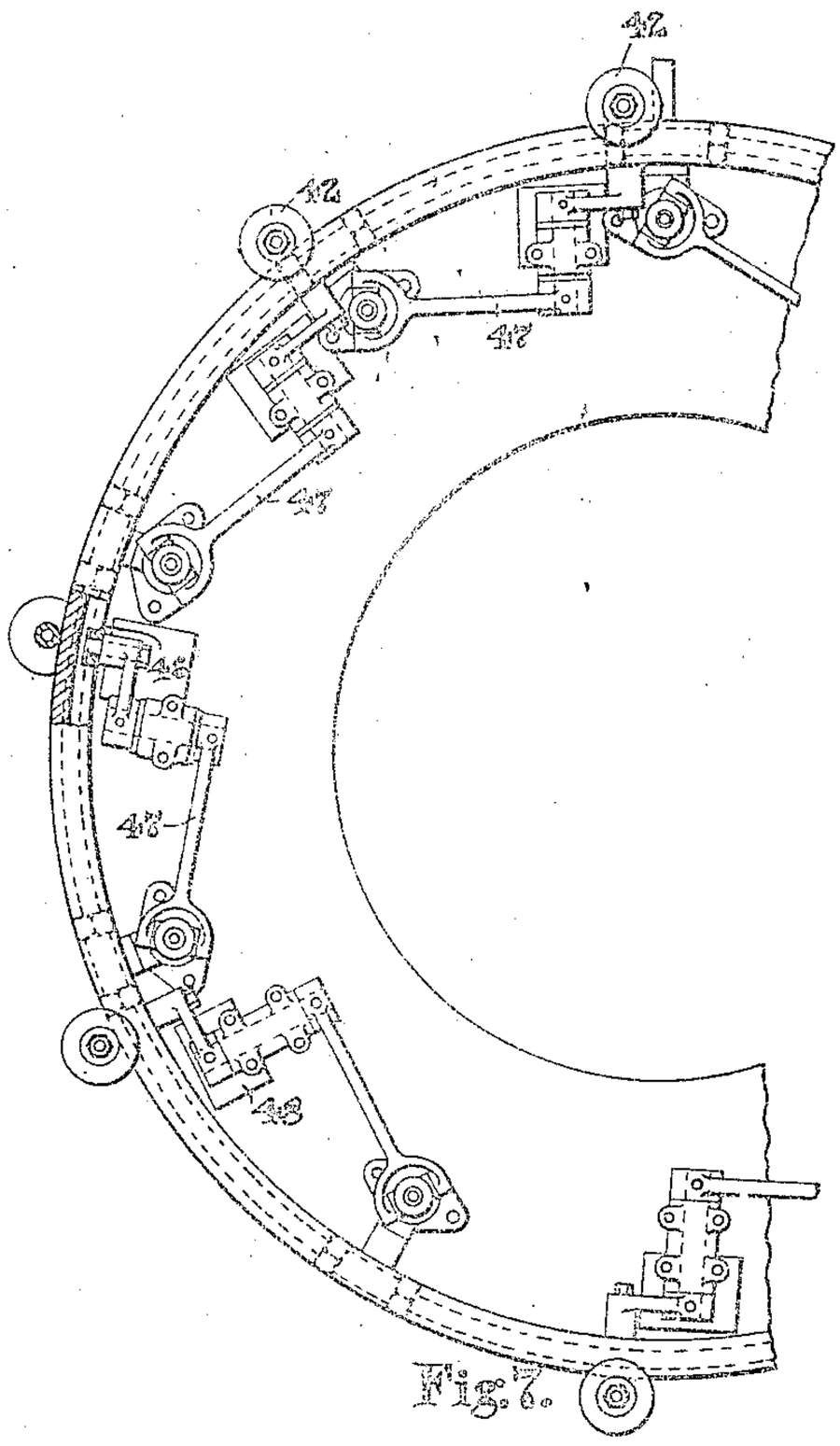

Fig. 7.

Witnesses:
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GOVERNING MECHANISM FOR ELASTIC FLUID TURBINES.

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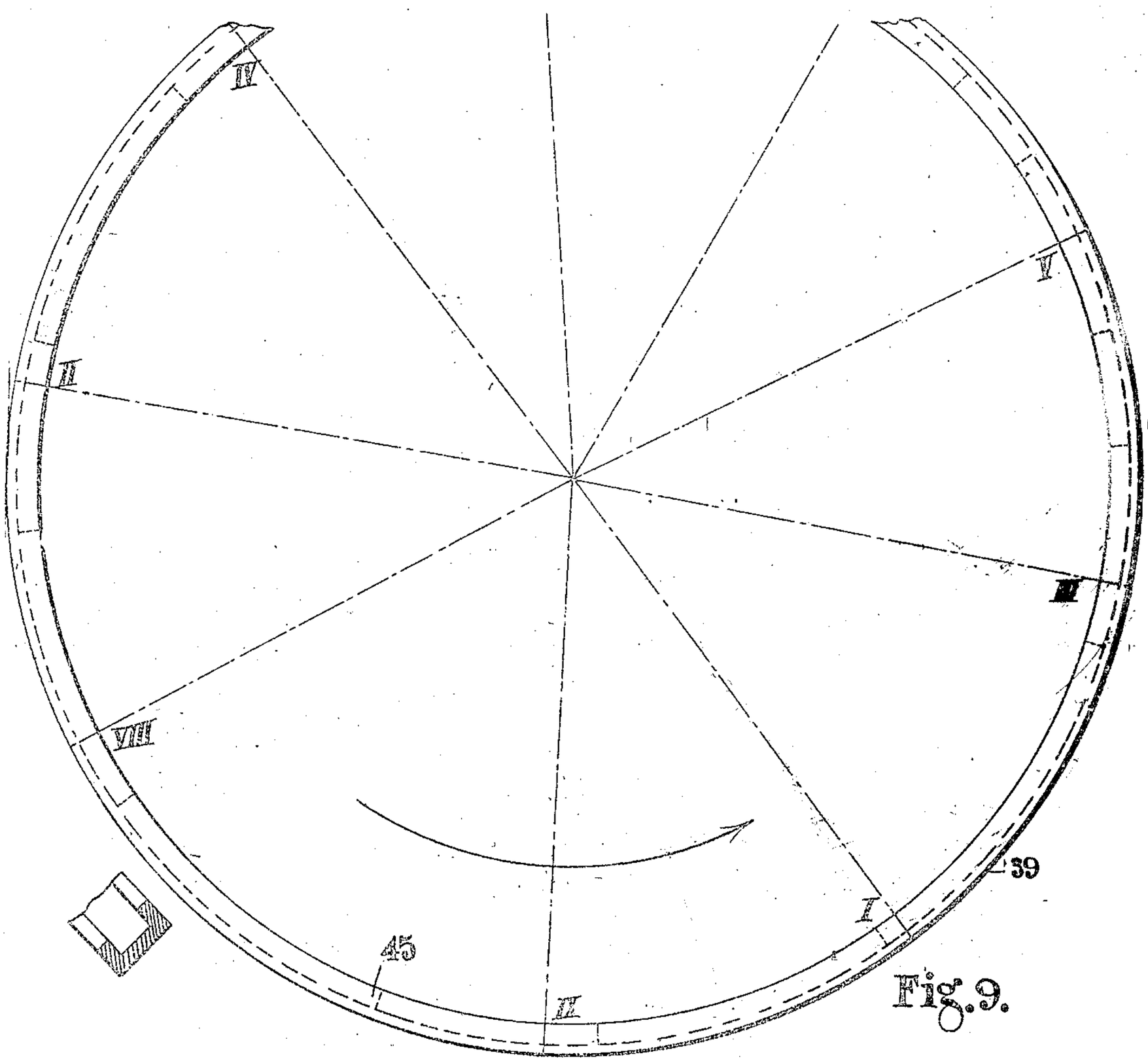

Fig. 9.

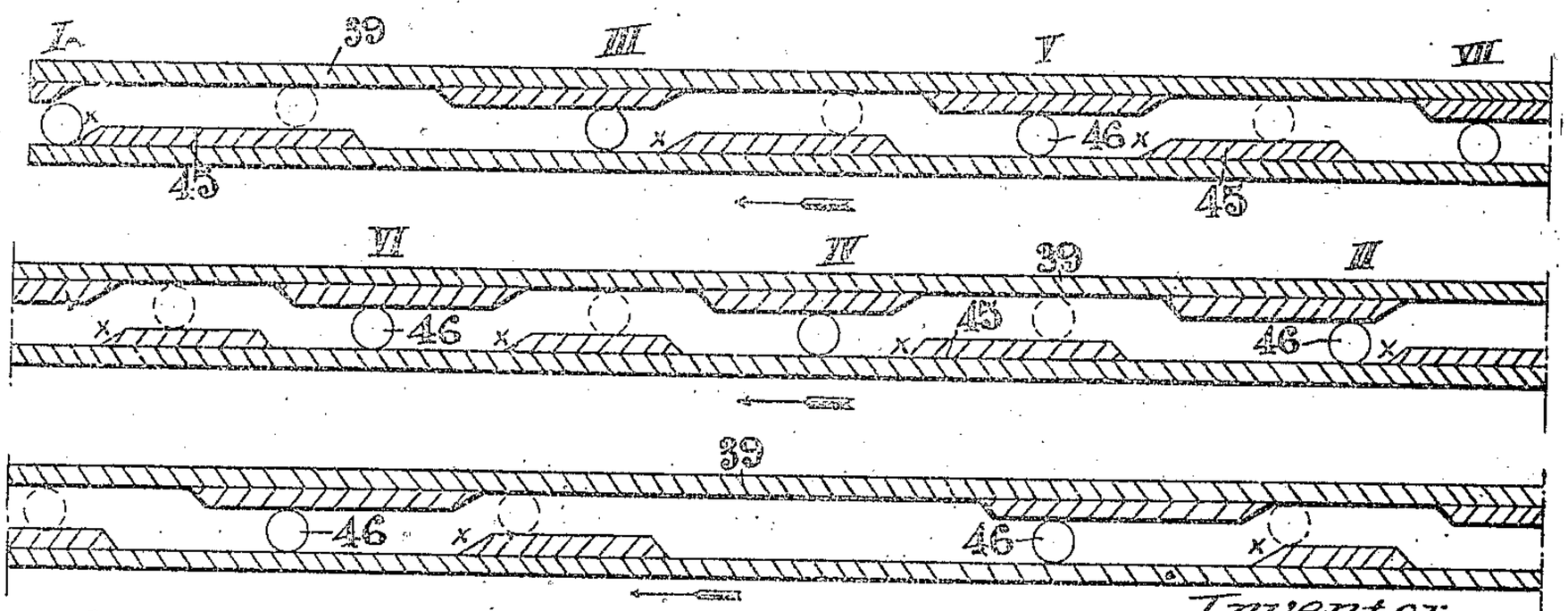

Fig. 10.

Attest:
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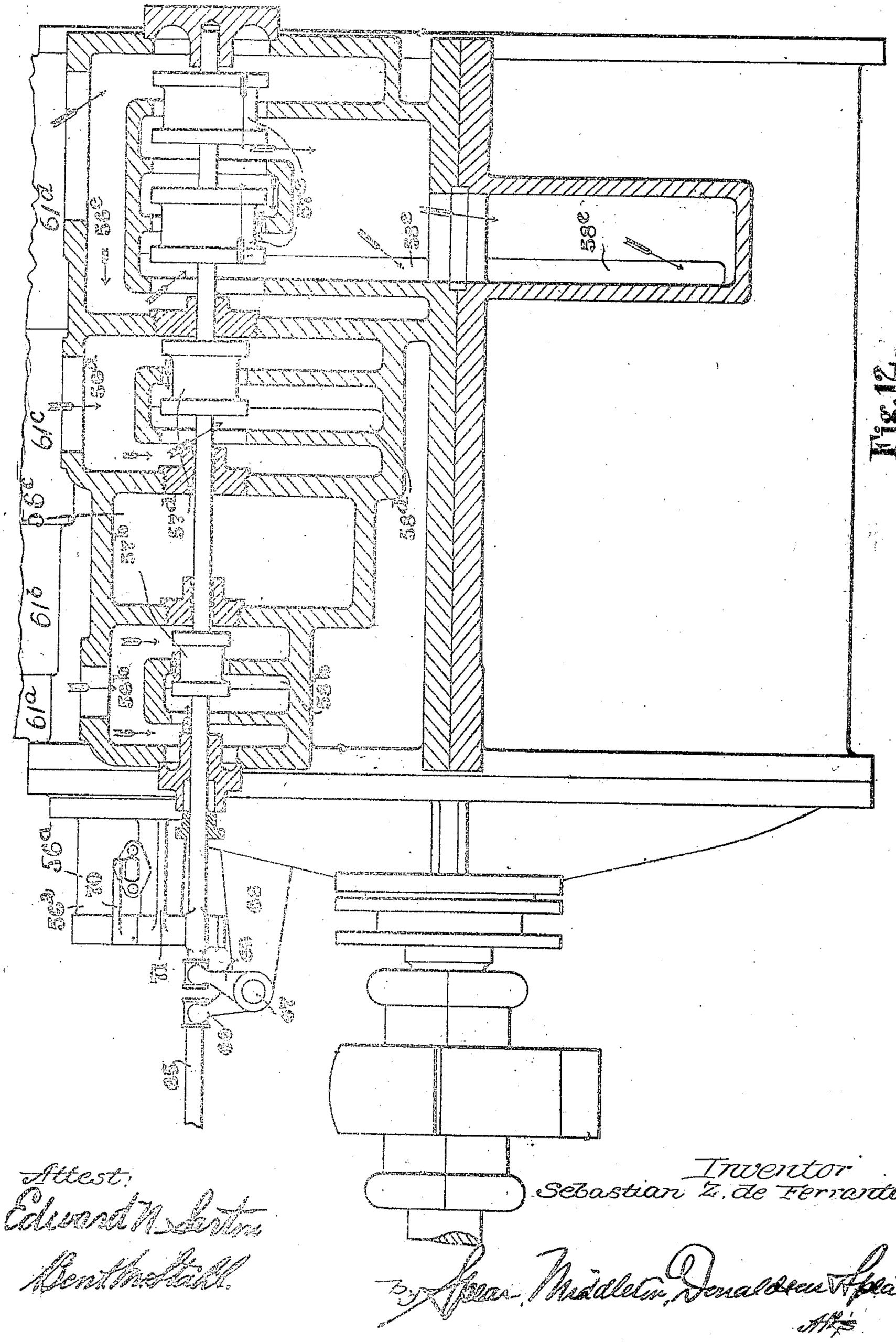

Fig. 12.

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GOVERNING MECHANISM FOR ELASTIC FLUID TURBINES.

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916,944. Patented Mar. 30, 1909.

12 SHEETS—SHEET 9

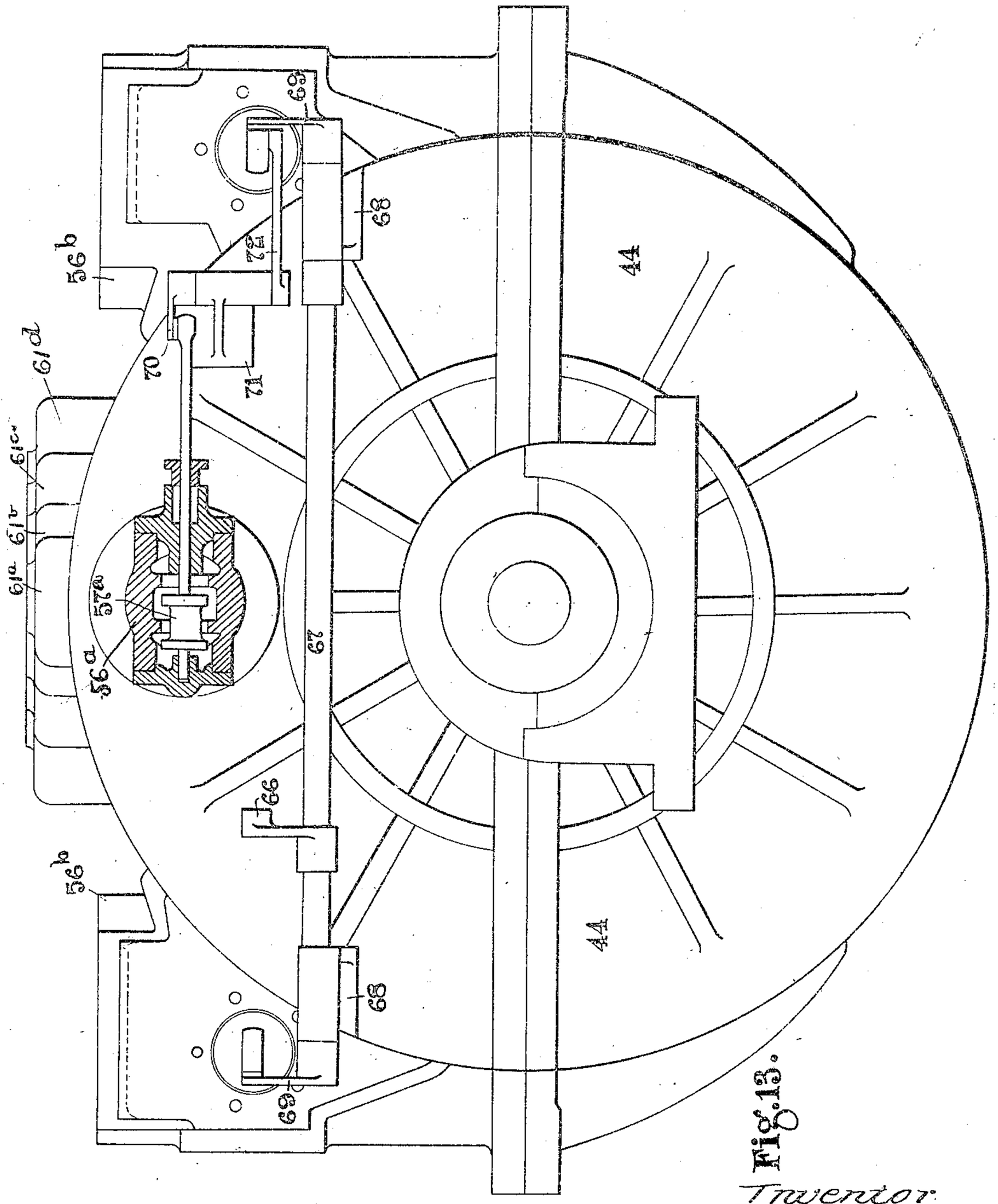

Fig. 13.

Witnesses:
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by Lee, Middleton, Davidson & Spear
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GOVERNING MECHANISM FOR ELASTIC FLUID, TURBINES.

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12 SHEETS—SHEET 10.

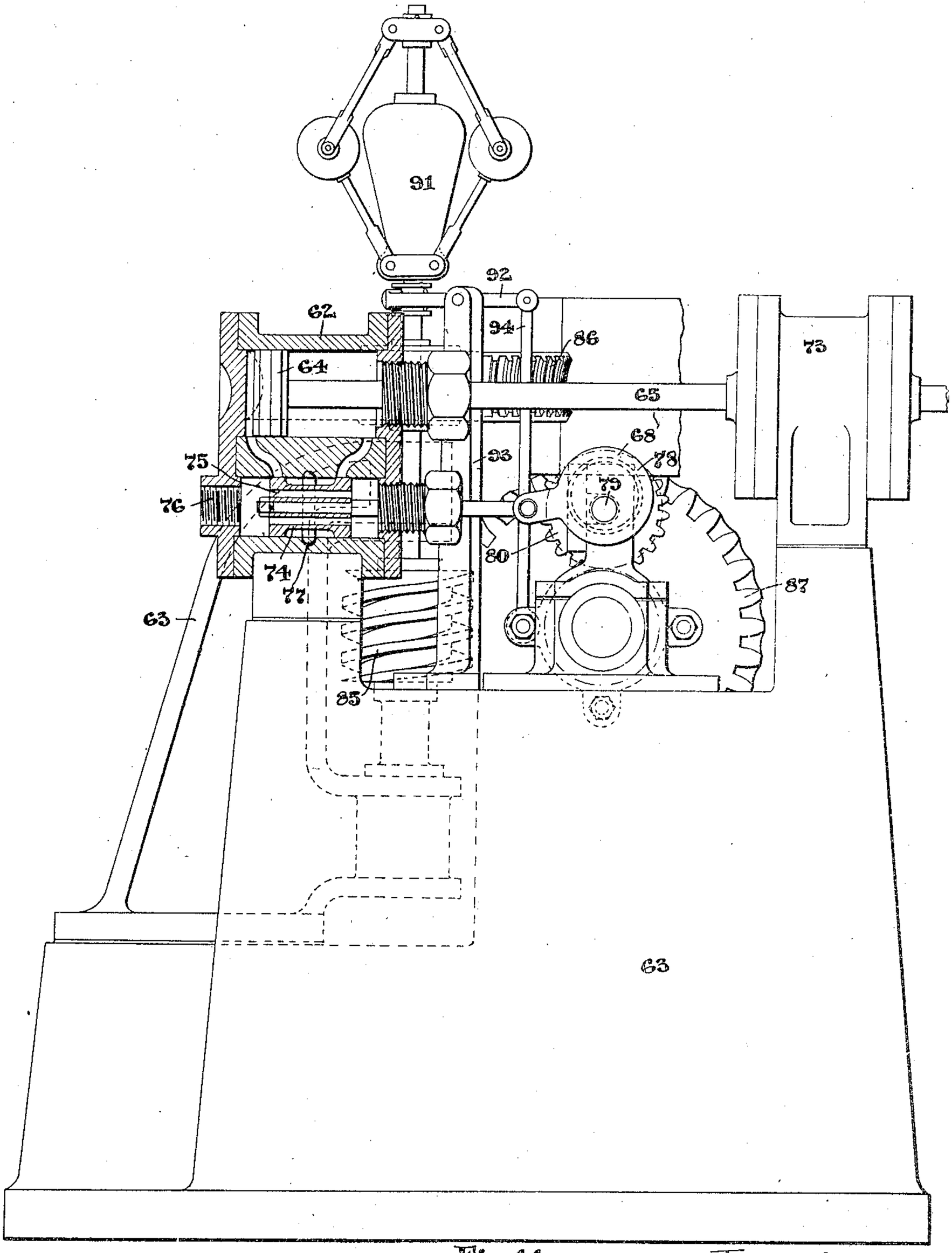

Fig. 14.

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APPLICATION FILED APR. 11, 1908.

916,944. Patented Mar. 30, 1909.

12 SHEETS—SHEET 1A.

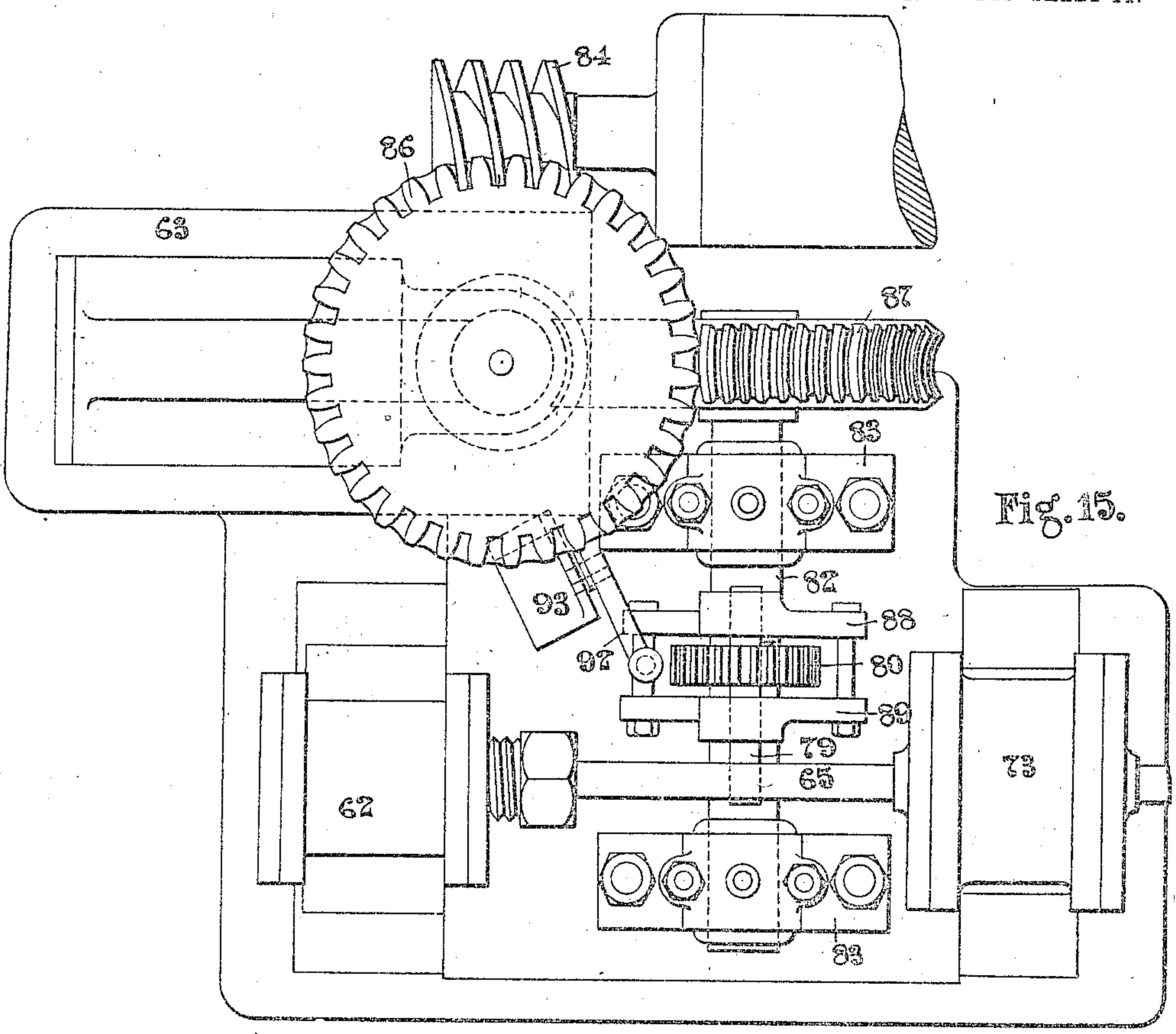

Fig. 15.

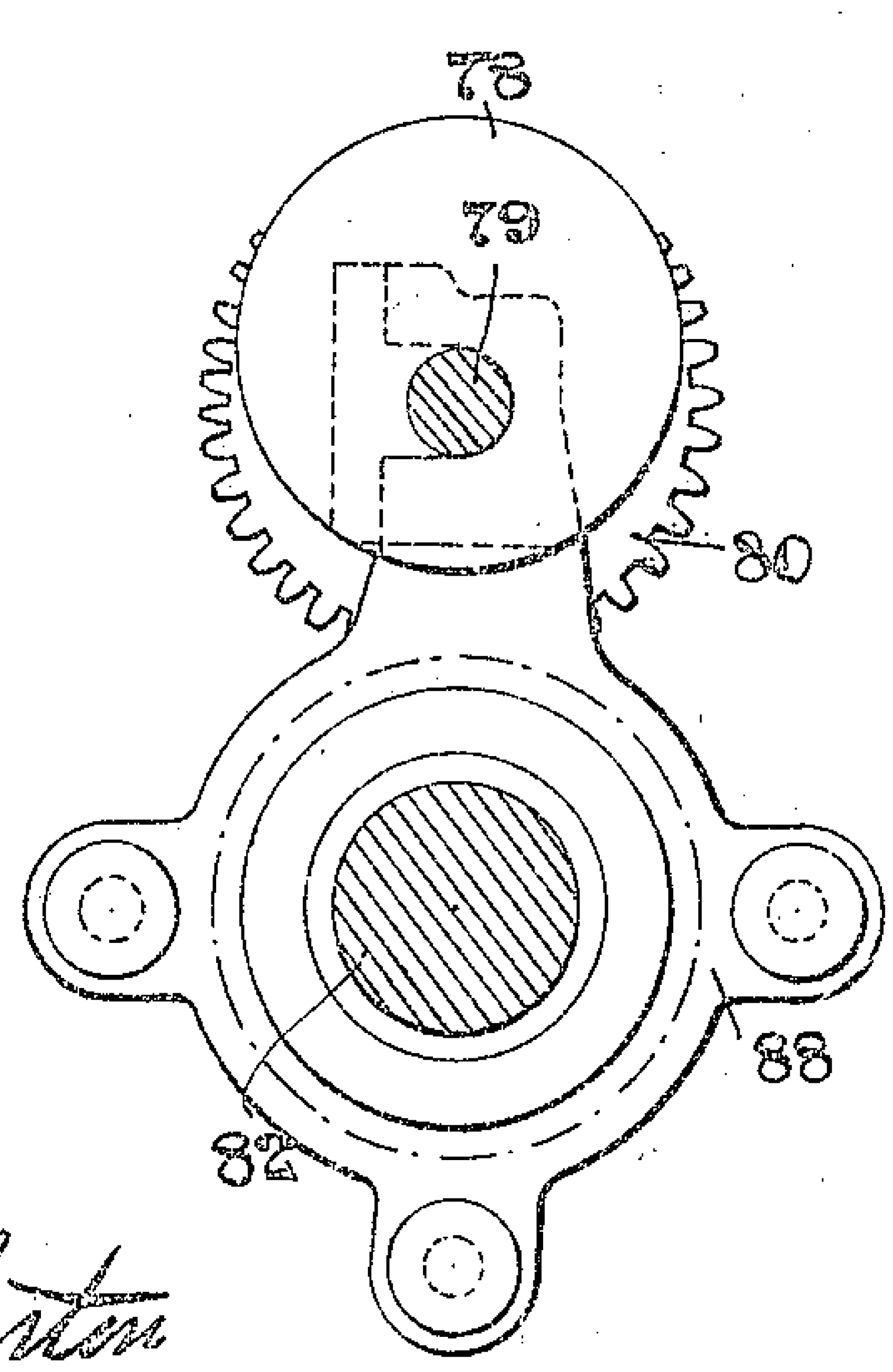

Fig. 19.

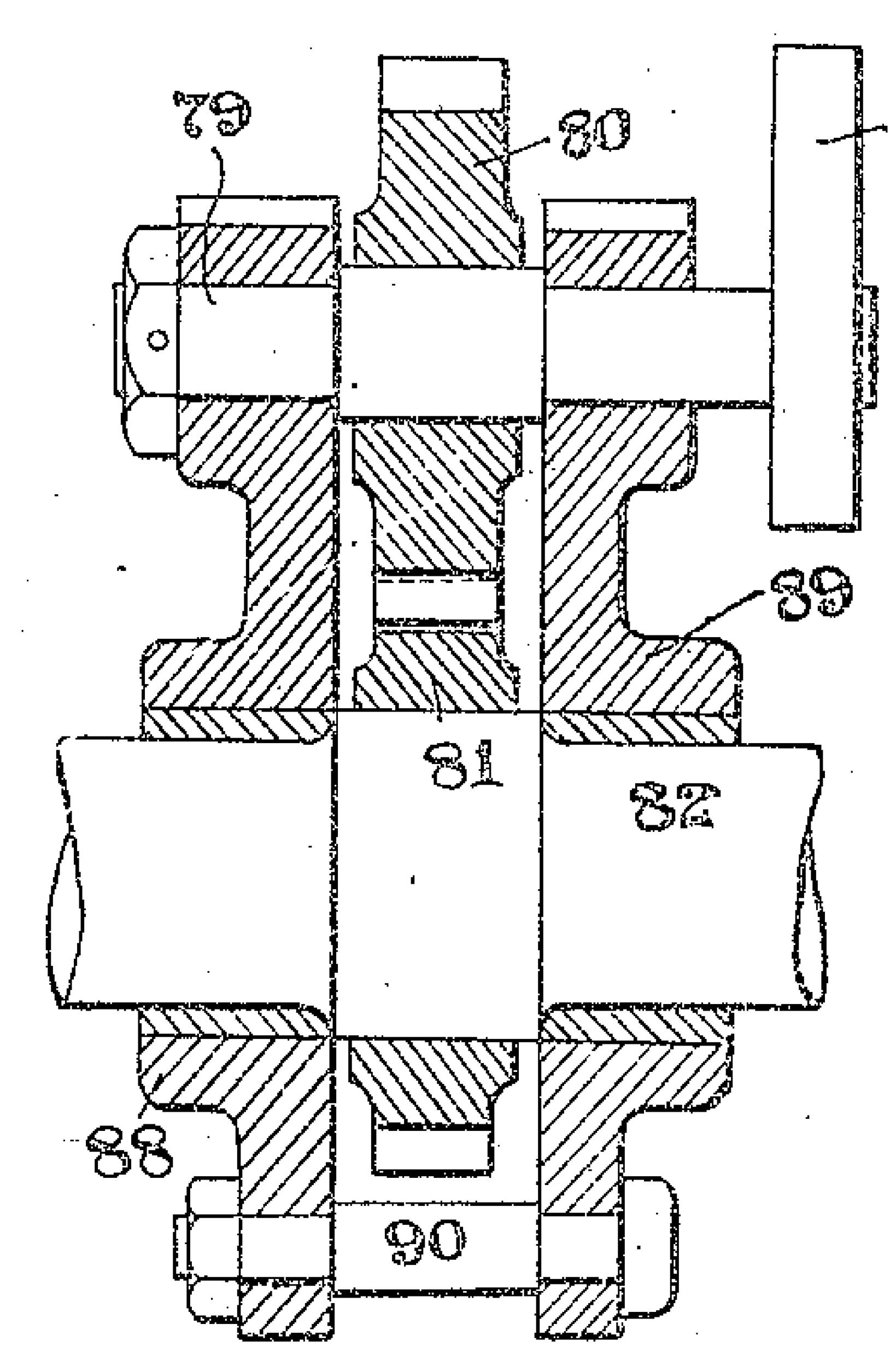

Fig. 20.

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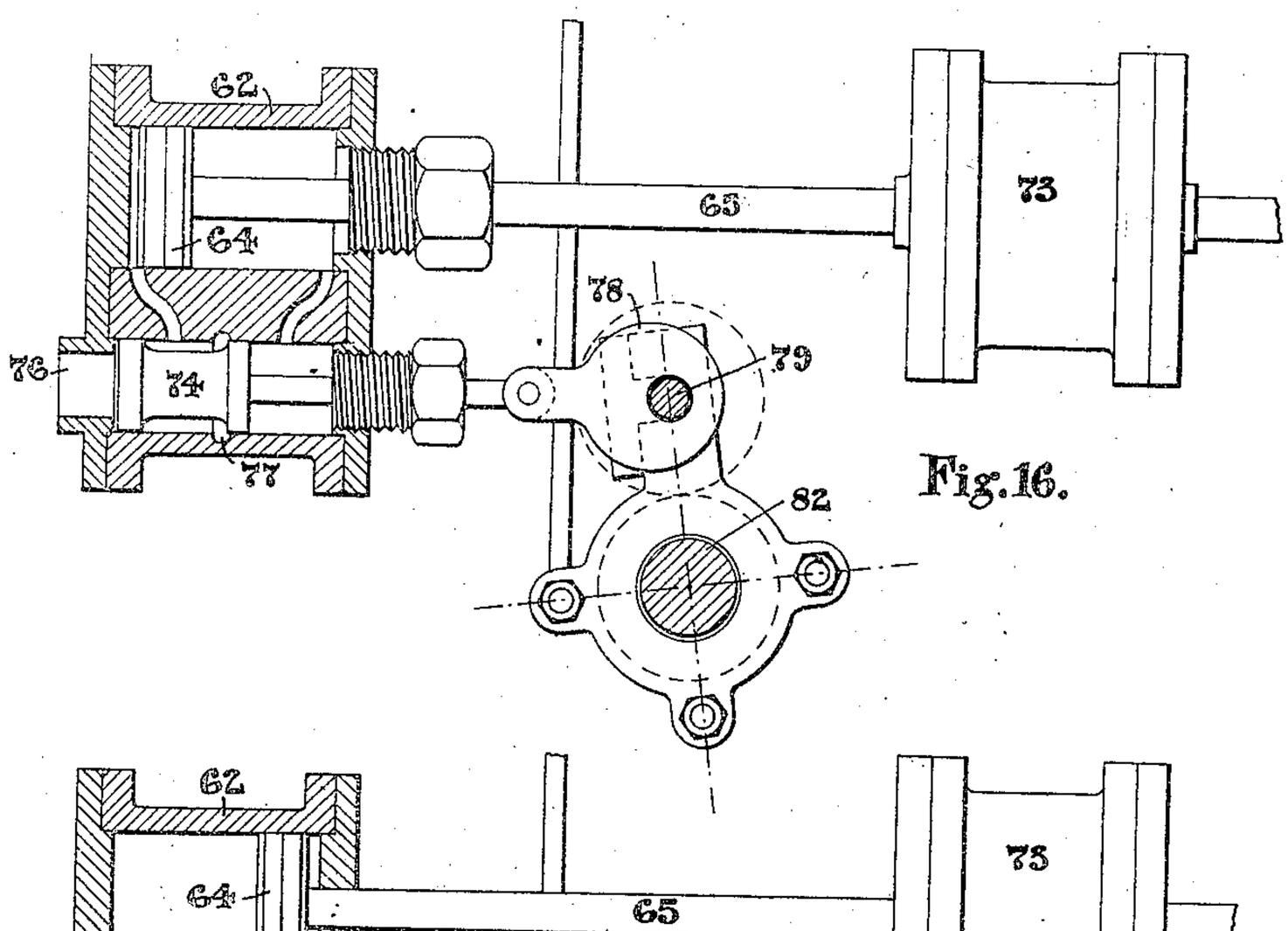

Fig. 16.

Fig. 17.

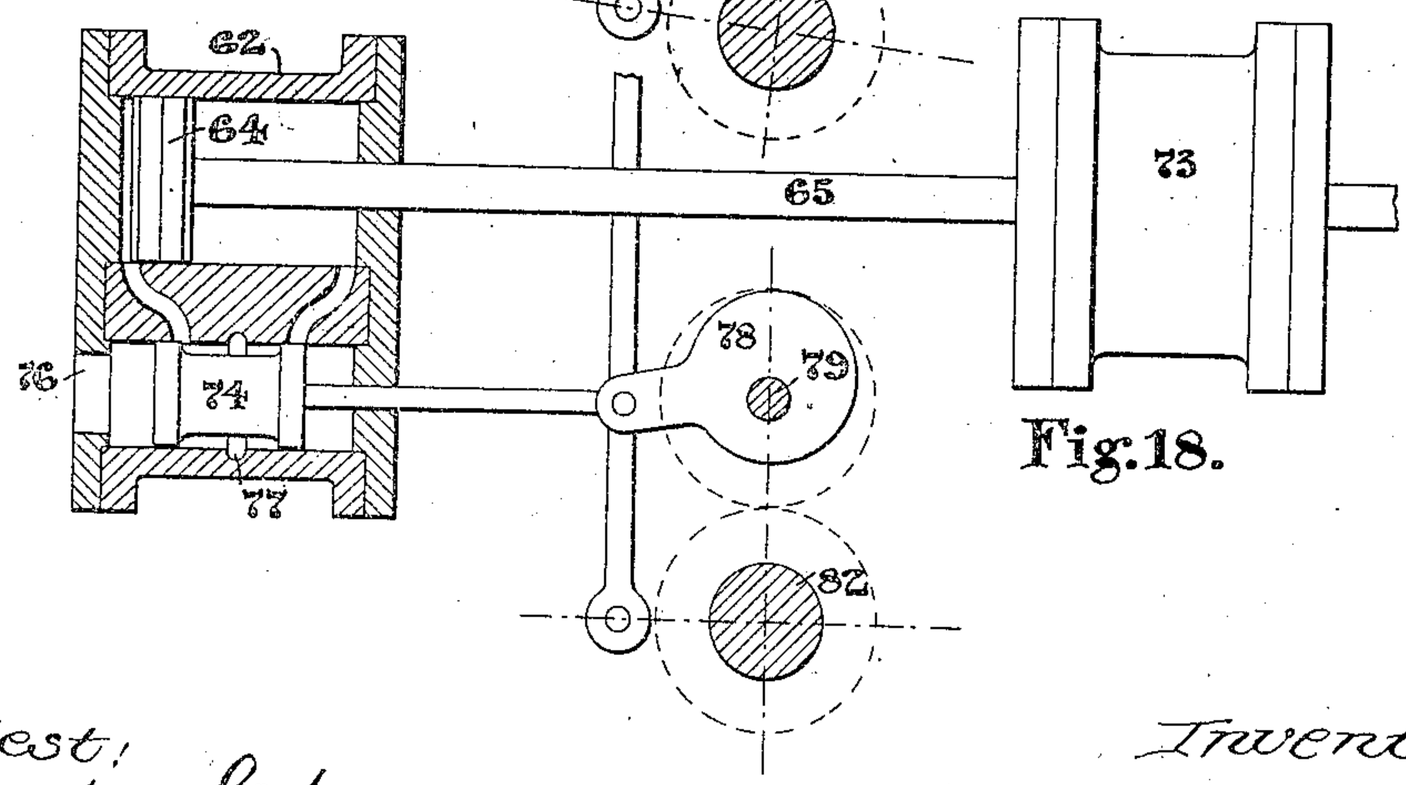

Fig. 18.

Attest:
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Benth. Stahl.

Inventor
Sebastian Z. de Ferranti.
by Spear, Middleton, Donaldson & Spear
Att'ys.

UNITED STATES PATENT OFFICE.

SEBASTIAN ZIANI DE FERRANTI, OF GRINDLEFORD, ENGLAND.

GOVERNING MECHANISM FOR ELASTIC-FLUID TURBINES.

No. 916,944. Specification of Letters Patent. Patented March 30, 1909.

Original application filed October 31, 1903, Serial No. 179,407. Divided and this application filed April 11, 1908. Serial No. 426,499.

To all whom it may concern:

Be it known that I, SEBASTIAN ZIANI DE FERRANTI, a subject of the King of Great Britain and Ireland, and resident of Grindleford, in the county of Derby, C. V. D., England, have invented certain new and useful Improvements in Governing Mechanism for Elastic-Fluid Turbines, of which the following is a specification.

My invention relates to the governing of multiple stage elastic fluid turbines, and more particularly to the kind known as "isothermal" wherein the temperature of the turbine is maintained practically uniform from end to end by means of reheaters disposed between the turbine stages.

Difficulties arise in the governing of turbines of the hereinbefore described types.

My new method of governing consists in maintaining the pressure in each stage practically constant, independent of the work being done by the turbine. To effect this, in a multiple stage impact turbine I either control simultaneously the number of jets operating at each stage of the turbine from inlet to exhaust, or I control the areas of these jets simultaneously in such a way as not to interfere with their action by causing wasteful eddies. I also mechanically connect the controlling devices corresponding to each stage so that all act simultaneously under the control of a mechanical or electrical governor of any suitable type.

In cases in which I employ, instead of the impact type of turbine, a reaction turbine, in which the fall of pressure takes place more or less in the buckets or passages of the moving elements, I maintain the pressure at each stage of the compound turbine for governing purposes by means of throttle valves disposed between the stages of the expansion and simultaneously operated. Where, however, considerable ranges of power have to be dealt with to maintain the economy at light loads I apply the principle of puff governing or governing by blasts, that is to say I arrange quick opening valves to deliver steam to each section of the turbine in periodical blasts, similar valves of suitable area being provided for each stage of the expansion, and I further couple the mechanism operating all these valves so that they act preferably simultaneously under the control of a mechanical or electrical governor of any well known type.

My invention differs from the puff governing or governing by blasts, as used heretofore in providing puff governing at several stages or sections at which stages or sections the steam pressure is kept practically constant irrespective of load. I may apply my invention for example by providing intermittent governed admission from each reheater to each turbine element.

Referring now to the accompanying drawings:—Figure 1 shows a longitudinal section of the turbine as a whole. Fig. 2 is, as regards its left hand half, a section on the line A B of Fig. 1 and as regards its right hand half, a section on the line C D E F of the same figure. Fig. 3 is an elevation, half in section, of a form of centrifugal governor. Figs. 4 and 5 are elevation and plan respectively of the gear intermediate between the governor and relay cylinder while Fig. 6 is a section through the control valve; Fig. 7 shows an end view of parts of the governing gear looking on the high pressure end of the turbine, Fig. 8 is a corresponding side elevation but with many of the parts shown in the previous figure omitted for clearness; Fig. 9 is an elevation of the cam ring and Fig. 10 a sectional development of the same the total length of the developed ring being divided into three sections for convenience in drawing. Fig. 11 is, as to its left hand half, a section through a modified form of turbine, and, as to its right hand half, a similar section through a different plane, of the same. Fig. 12 is a section through the valve chests taken on the line A′—A′ of Fig. 11. Fig. 13 is an end view of the high pressure end of the turbine showing part of the governing gear. Figs. 14 and 15 are elevation and plan respectively of a general arrangement of puff-governing gear. Figs. 16, 17 and 18 are views showing the action of the gear and Figs. 19 and 20 detail views of the levers on which the eccentric spindle is journaled.

According to one modification of my invention, I take, for example, a turbine as shown in Figs. 1 and 2 wherein the casing is constructed of a number of sections 1–8, bolted steam tight to each other in such a manner as to provide a set of chambers 9–16, in which the turbine wheels revolve.

The passage of the steam is as follows:—Entering 9^b at high pressure it passes to an annular space 9^a and is distributed by valve 9^d, to the wheel chamber 9. It then exhausts through 9^c to a reheater by way of 9^f and 9^h and afterward enters the next section, and finally exhausts at 17. In the particular turbine shown, there is no reheater between sections 9 and 10. The piston valves 9^d—16^d controlling corresponding parts *c*, in the different sections are all mounted on one spindle such as 18.

Figs. 3 to 9 illustrate one form of governing gear suitable for a turbine of the nature described above having nine sets of valves but it will be evident that by obvious mechanical alterations such a gear can be applied to a similar turbine having any number of sets of valves. The broad scheme according to which the governing gear is constructed according to this form, is as follows:—A governor, driven by gearing from the turbine shaft operates a control valve, admitting oil under pressure above or below a relay piston which in turn moves a cam ring and operates the steam valves of the turbine.

Referring to Figs. 3 to 10, Fig. 3 shows a suitable form of centrifugal governor, weighted arms, 19, being driven by gear, 20, from the turbine shaft; the necessary force controlling the outward movement of the arms, 19, is supplied by the spring, 21. It will be seen that the action of the governor as a whole is to raise or lower the rod, 22.

Passing now to Figs. 4 and 5, the rod, 22, is pivotally connected to the cylindrical element, 23, of a dash-pot which in turn is similarly connected to a lever, 24, fulcrumed on the bracket, 25; this bracket, according to the form illustrated is secured to the control valve casing, 26, which itself may be conveniently carried on the bracket, 27, projecting from the governor casing. A prolongation of the lever, 24, serves for the attachment of a spring, 28, the strength of which may be adjusted by the screw, 29, and nut, 30. The lever, 24, in accordance with the movements imparted to it by the governor, operates the control valve, 31, (see Fig. 6). The control valve chest is divided into two parts 32 and 33, the former being connected to a reservoir of oil under pressure while the latter is connected to the oil exhaust. These connections are shown in Fig. 4 of the drawings. The motion of the valve, 31, admits the oil under pressure to one of the pipes, 34, the other one, 35, being put into connection with the exhaust. These pipes connect respectively to either end of the relay cylinder, 36, in which works the piston, 37; the piston thus moving up or down as the case may be and operating the cam-ring, 39, which will be described hereafter. The piston rod, 40, in addition to being operatively connected to the cam-ring, is also linked to one end of the lever, 41, conveniently fulcrumed on a bracket fixed to the governor casing the other end of the lever being connected to the piston element of the dash-pot. It is found that the connecting of the relay-piston to the piston of the dash-pot assists materially in the prevention of hunting.

It will be obvious that the gear just described may be disposed in any convenient position the oil pipes, 34, 35, and the gearing, 20, between the turbine shaft and the governor being arranged accordingly.

The cam-ring, 39, shown in section in Fig. 8, is adapted to turn on rollers, 42, carried by pillars, 43, fixed to the high pressure turbine cover, 44, (see Figs. 1, 7, and 8). To the inside of the cam-ring are secured cam-pieces, 45, having beveled ends, each cam-piece being adapted to engage with a roller, 46, mounted on the end of one arm of a double lever, 47, fulcrumed on a bracket, 48, the end of the other arm being connected to one of the rods carrying the valves which serve to distribute steam to the different sections of the turbine.

The relative positions of the cam pieces, 45, and rollers, 46, are such that the rollers are operated successively as the cam-ring, 39, turns thus opening (or closing) only one set of steam valves at a time. This is well shown in Figs. 9 and 10. In the latter figure the opening surfaces of the cam-pieces are indicated by crosses the full circles showing the cam-rollers, 46, when just about to open successively the different series of valves while the dotted circles show the positions of the cam rollers when all the valves have been opened. The direction in which the cam ring moves to open the valves is shown by arrows in Figs. 9 and 10, while the order in which the cam-rollers are successively operated is indicated by the Roman numerals from I to IX placed against them, the corresponding numerals in Fig. 9 showing their true position in the ring.

To assist in the easy working of the valves a balance piston, 47, is fitted to each line of valves (see Fig. 8) the areas of the piston and piston rods being so adjusted as to give practically no resultant thrust along the line of valves; steam is supplied to the backs of all the balance pistons by means of the pipe, 48, and couplings, 49.

Apart from the mechanism described above for automatically regulating the steam supply, hand gear may also be provided. This may preferably be of the differential screw type shown in Fig. 4 and according to one form consists of a handwheel, 50, having an internally threaded boss and collar, 51, to prevent end motion in the bracket, 52, together with a second handwheel, 53, secured to a sleeve, 54, threaded both externally and internally with threads of different pitches and a threaded rod, 55, linked to the cam-

ring, the different parts being arranged as shown in the drawing. By holding one handwheel and operating the other, it will be seen that both a coarse and a fine adjustment may be given to the cam-ring.

Referring now to Figs. 11 to 13, a modified construction of turbine is illustrated, in which the principle of puff governing or governing by blasts is applied, the steam inlet valves and ports being suitably arranged for this purpose. The turbine illustrated is of the same general type as that already described in detail and where possible the same reference letters have been used to denote corresponding parts. Steam enters by way of the valve chambers, 56[a], 56[b], etc. disposed on each side of the turbine,—the chambers as shown increasing in size from the high pressure to the low pressure end. (See Figs. 11 and 12.) In the drawings the valve, in the chamber 56[c], is omitted because at the high pressure end a valve is sometimes arranged on one side only. Two sets of valves running the whole length of the turbine are shown, their action being controlled by the governor gear hereinafter to be described. Steam leaving the valve chests passes through passages, 58[a], etc. to the nozzles, 59, which in the example are separately cast, and bolted to partitions 60. Exhaust outlets, 61[a], 61[b], &c. to the reheaters are shown. The valve, 57[a], for distributing steam to the first stage is, for convenience, placed at right angles (see Fig. 13) to the two main lines of valves, its action, however, being in all respects essentially similar.

The course of the steam through the turbine will, in view of the above remarks and the arrows on the drawings, be readily followed without further description.

According to one form of governing gear in which the principle of puff governing or governing by blasts is embodied, as applied to the turbine just described, a cylinder, 62, (see Figs. 14 to 18) supported on any convenient bed-plate, 63, is arranged to operate a set of valves admitting steam to the different sections of the turbine. A piston, 64, working in this cylinder, and piston-rod, 65, are connected, in the arrangement shown, to the lever, 66, keyed to the shaft, 67. This shaft (see Fig. 13) passes across the end of the turbine, supported by suitable brackets, 68, and carries other levers, 69, each adapted to operate its respective line of valves. The valve, 57[a], which is placed for convenience at right angles to the main lines of valves, is operated by means of the lever, 70, keyed to a vertical shaft journaled in the bracket, 71, a second lever, 72, also keyed to this shaft, being suitably connected to a point of one of the main valve spindles. An air buffer, 73, is preferably arranged on some suitable portion of the mechanism to avoid shock. Admission of steam to the cylinder, 62, is controlled by the piston valve, 74, having through passages, 75; the steam enters the valve chest through the opening, 76, and exhausts by the passage, 77. It will be obvious that other types of slide valve may be adopted. The valve, 74, is operated by an eccentric, 78, keyed to the shaft, 79, (see Figs. 19 and 20) a spur-wheel, 80, being also mounted on the shaft. The wheel, 80, gears with another spur-wheel, 81, mounted on the shaft, 82, carried in bearings, 83. This shaft 82, is driven from the main turbine shaft by means of gearing such as the worms, 84, 85 and the worm wheels 86 and 87. The spur wheel and eccentric shaft, 79, is journaled on the levers, 88, 89 secured together by the bolts, 90, and turning loosely on the shaft, 82. The position of these levers is controlled by a governor, 91, acting through the lever, 92 (fulcrumed on any convenient bracket 93) and link, 94.

The operation of the mechanism is as follows:—Supposing, while running normally, that the load is removed, the speed of the turbine will increase and the outward movement of the governor balls will cause the gear to assume the position shown in Fig. 16. The valve, 74, can then admit steam to the right hand side of the piston only, the piston consequently being held in the extreme position shown at the left hand end of the cylinder and the line of valves closed. The opposite case to this is shown in Fig. 17; with full load the governor balls will approach each other as nearly as possible throwing the gear into the position shown. The action of the valve, 76, is then such as to admit steam to the left hand of the piston only, the piston being held at the extreme right hand end of the cylinder and the line of valves being fully open. In some intermediate state of working the eccentric shaft will assume its mid-position as shown in Fig. 18, the valve, 76, will then operate as in an ordinary engine, the piston and consequently the line of valves reciprocating bodily and causing the steam to be admitted to the turbine in puffs or blasts. Although in the example illustrated the number of puffs per minute is kept practically constant while the governing is accomplished by varying the duration of the individual puffs, I may in a modified form of governing gear, vary this in such a manner as to accomplish the governing by varying the number of puffs per minute while keeping the duration of the puffs constant. It will also be seen that the puffs to the different stages need not necessarily be simultaneous so long as the pressure at each stage is kept practically constant by providing intermittent openings from stage to stage. As an alternative ar-

rangement I may take a number of turbines of the pressure flow type arranged so that the steam passes through them successively with intermediate re-heaters, each separate turbine being provided with a puffing valve actuated by a piston moving in a cylinder and all the pistons being controlled by a single relay valve the puffs to each turbine being thus practically simultaneous. Or again, the puffing valves to each separate turbine may be arranged in lines on spindles operated in the manner already described with reference to Figs. 14 to 18.

This case is a division of that filed October 31, 1903, Serial Number 179,407 and which matured into a patent July 7, 1908, #892,818.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:—

1. In combination, a plurality of turbine stages; valves controlling the flow of working fluid through said stages; mechanical interconnecting means for grouping corresponding valves in different stages together; together with means for successively operating said valve groups.

2. In combination, a plurality of turbine stages; valves controlling the flow of working fluid through said stages; mechanical interconnecting means for grouping corresponding valves in different stages together; a speed responsive device together with means coacting with said speed responsive device for successively operating said valve groups.

3. In combination, a plurality of turbine chambers; means for controlling the flow of working fluid through said chambers; means for mechanically interconnecting said controlling means in sets, each set including controlling means standing in the same operative relation to different chambers together with means for successively operating said sets.

4. In combination, a plurality of turbine chambers; means for controlling the flow of working fluid through said chambers; means for mechanically interconnecting said controlling means in sets, each set including controlling means standing in the same operative relation to different chambers; a speed responsive device together with means coacting with said speed responsive device for successively operating said sets.

5. In combination, a plurality of turbine stages; a plurality of spindles extending through a plurality of said stages; a plurality of valves on each of said spindles together with means for successively operating said spindles.

6. In combination, a plurality of turbine stages; a plurality of spindles extending through a plurality of said stages; a plurality of valves on each of said spindles; a speed responsive device together with means coacting with said speed responsive device for successively operating said spindles.

7. In combination, a plurality of turbine stages; a plurality of lines of valves controlling the passage of the working fluid through said stages, each line comprising a plurality of valves mounted on a common spindle together with means for automatically varying the number of the operative lines of said valves.

8. In a turbine, means for automatically regulating the supply of working fluid, comprising in combination, a plurality of lines of valves, running through the turbine parallel to its axis from end to end; a centrifugal governor driven by the turbine; a control valve operated by said governor; a relay cylinder and piston actuated by fluid under pressure admitted by said control valve; a rotatable ring carrying cam-segments, together with a plurality of rocking levers equal in number to the lines of valves, the one end of each of said rocking levers carrying rollers adapted to engage with said cam-segments and the other end being operatively connected to a line of said valves, substantially as described.

9. In a turbine, means for automatically regulating the supply of working fluid, comprising in combination a plurality of lines of valves running through the turbine parallel to its axis from end to end; a governor driven by the turbine; a control valve operated by said governor; a relay cylinder and piston, the latter being actuated by fluid under pressure admitted by said control valve together with means whereby said relay piston serves to operate the lines of valves, substantially as described.

10. In a turbine, means for automatically regulating the supply of working fluid, comprising in combination, a plurality of lines of valves, running through the turbine parallel to its axis from end to end; a centrifugal governor driven by the turbine; a control valve operated by said governor; a relay cylinder and piston actuated by fluid under pressure admitted by said control valve; a rotatable ring carrying cam-segments, together with a plurality of rocking levers equal in number to the lines of valves, the one end of each of said rocking levers carrying rollers adapted to engage with said cam-segments and the other end being operatively connected to a line of said valves, and said cam segments being so disposed that said line of valves are successively operated, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

SEBASTIAN ZIANI DE FERRANTI

Witnesses:

LUTHER J. PARR,

CHAS. N. DANIELS.