(No Model.) 9 Sheets—Sheet 1.

S. C. DAVIDSON.

MEANS OR APPARATUS FOR GOVERNING IMPULSE TURBINES.

No. 584,580. Patented June 15, 1897.

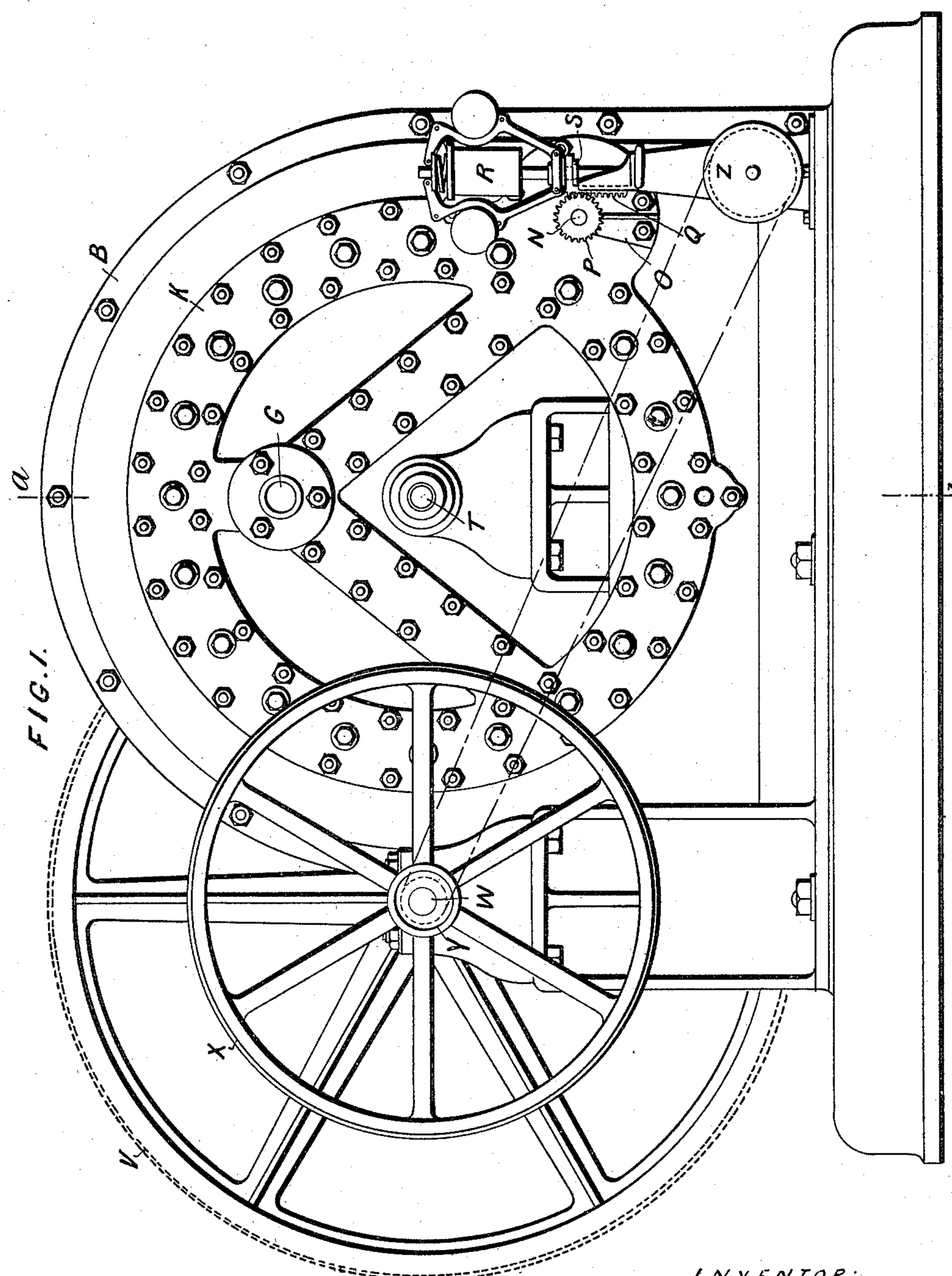

FIG. 1.

WITNESSES:
Fred White
C. K. Fraser.

INVENTOR:
Samuel Cleland Davidson,
By his Attorneys:
Allen C. Fraser & Co

(No Model.) 9 Sheets—Sheet 2.

S. C. DAVIDSON.

MEANS OR APPARATUS FOR GOVERNING IMPULSE TURBINES.

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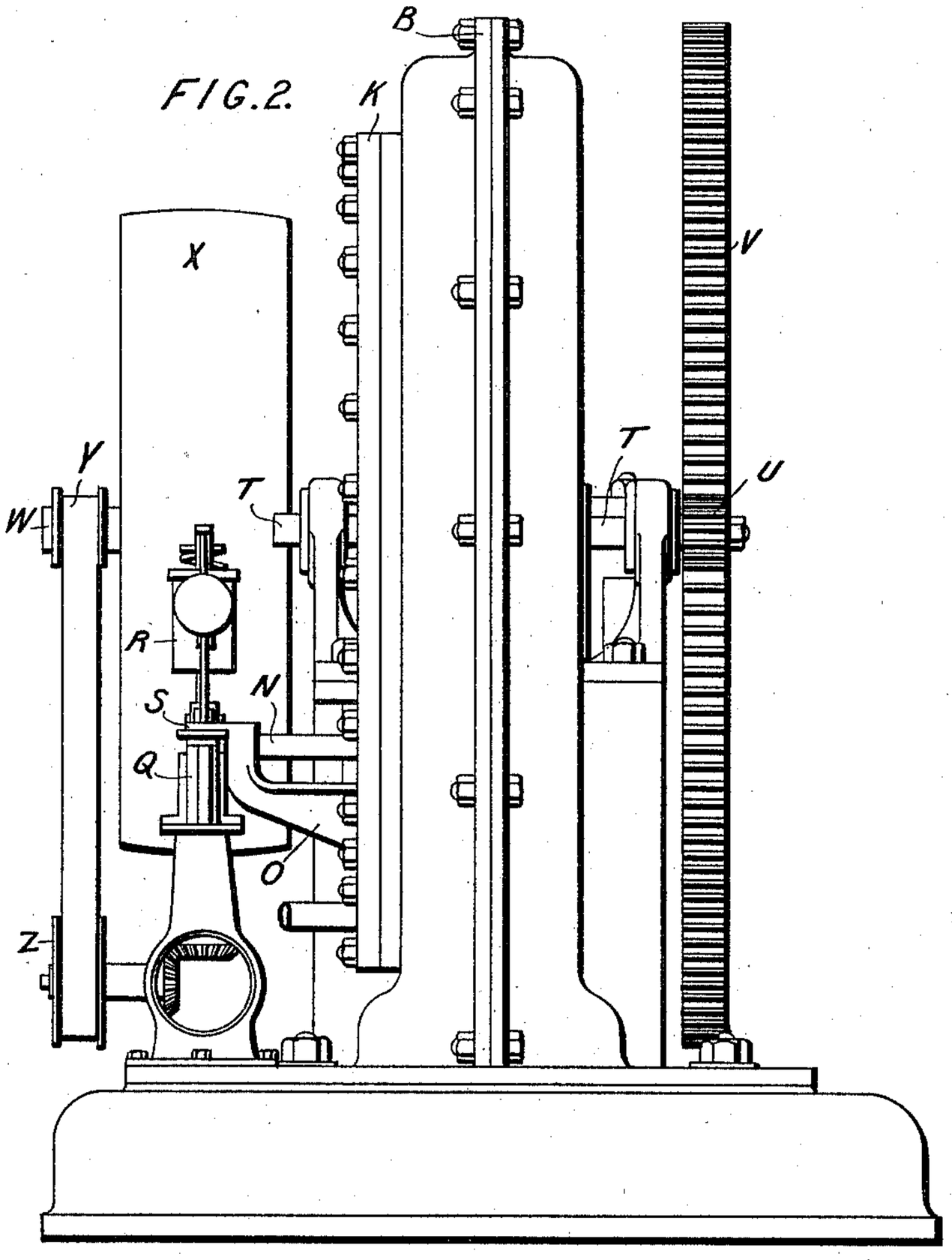
FIG. 2.



WITNESSES:
Fred White
C. K. Fraser.

INVENTOR:
Samuel Cleland Davidson,
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Arthur C. Fraser & Co.

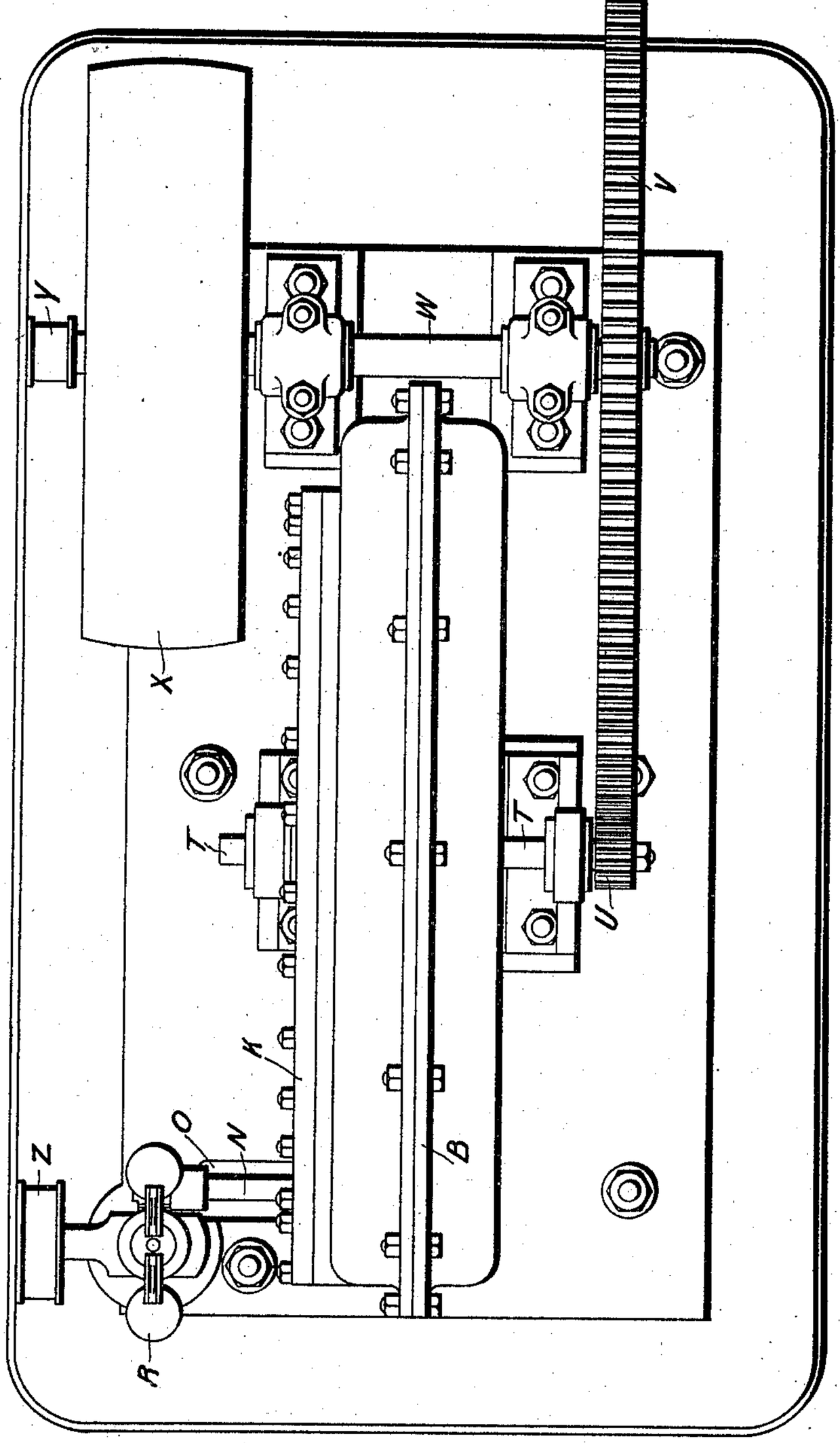
(No Model.) 9 Sheets—Sheet 3.

S. C. DAVIDSON.

MEANS OR APPARATUS FOR GOVERNING IMPULSE TURBINES.

No. 584,580. Patented June 15, 1897.

FIG. 3.



WITNESSES:
Fred White
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(No Model.) 9 Sheets—Sheet 4.

S. C. DAVIDSON.

MEANS OR APPARATUS FOR GOVERNING IMPULSE TURBINES.

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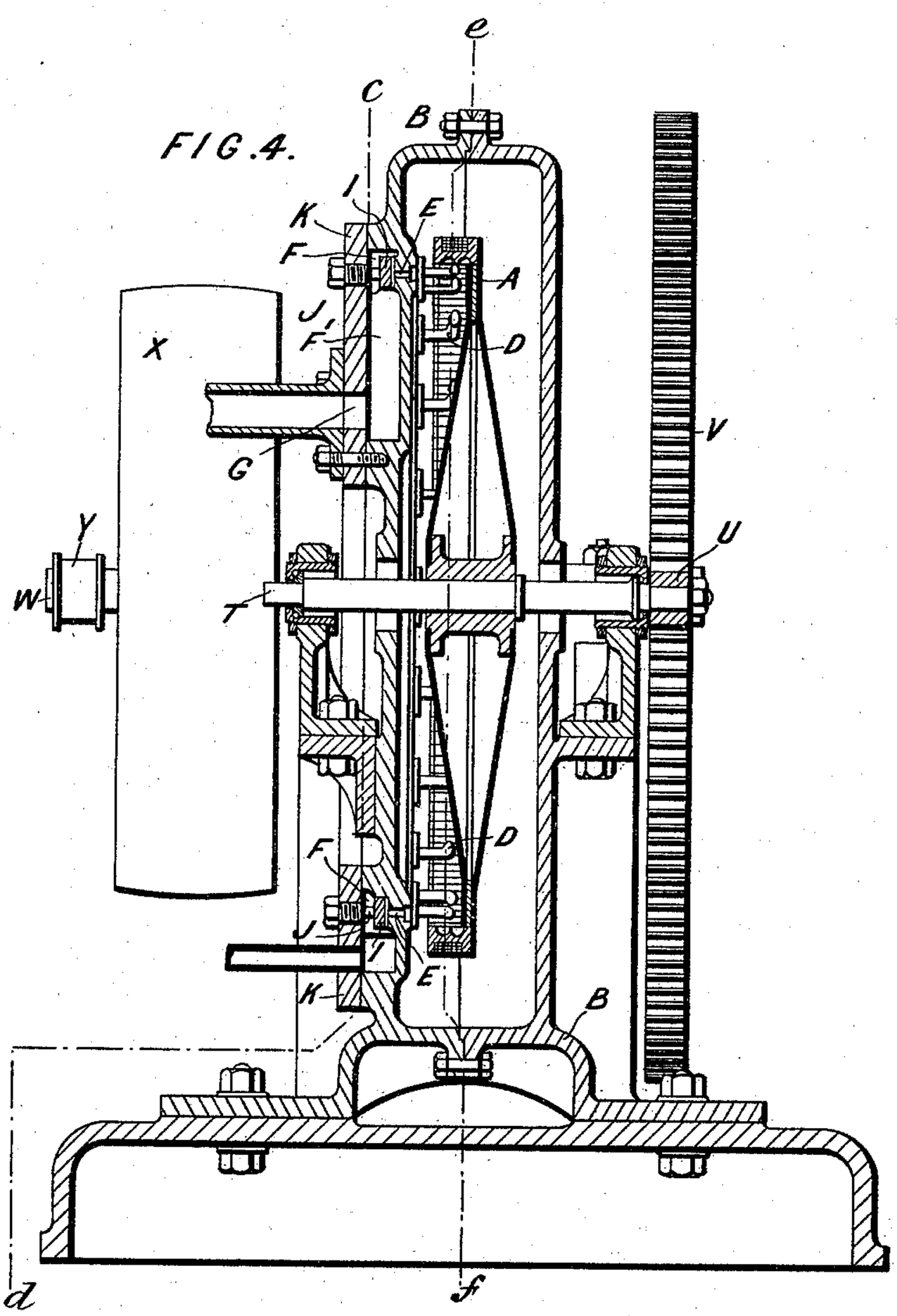
FIG. 4.



WITNESSES:
Fred Whitty
L. K. Fraser.

INVENTOR:
Samuel Cleland Davidson,
By his Attorneys:
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(No Model.)

9 Sheets—Sheet 5.

S. C. DAVIDSON.

MEANS OR APPARATUS FOR GOVERNING IMPULSE TURBINES.

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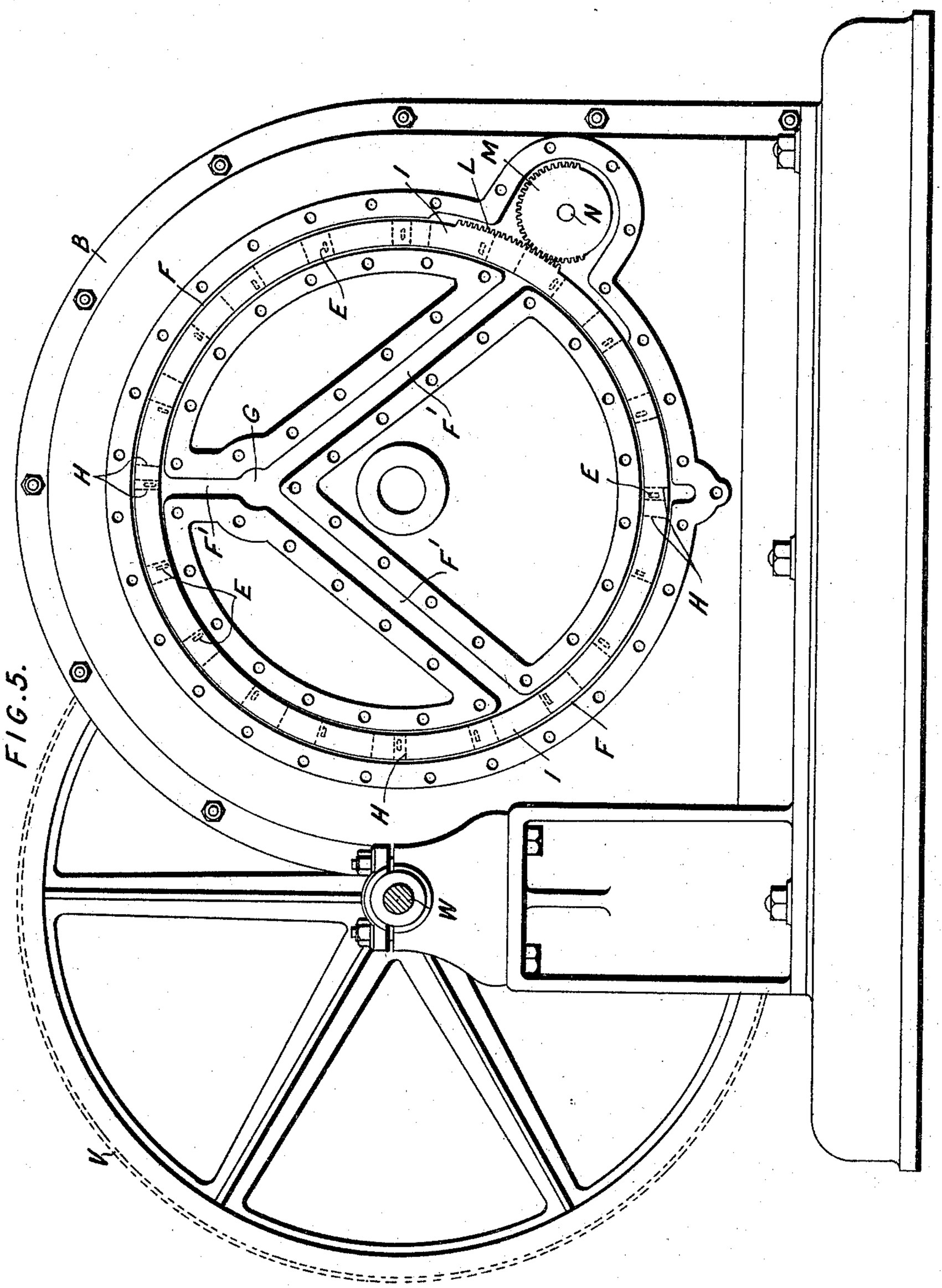

FIG. 5.

WITNESSES:
Fred White
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INVENTOR:
Samuel Cleland Davidson,
By his Attorneys:
Arthur C. Fraser & Co.

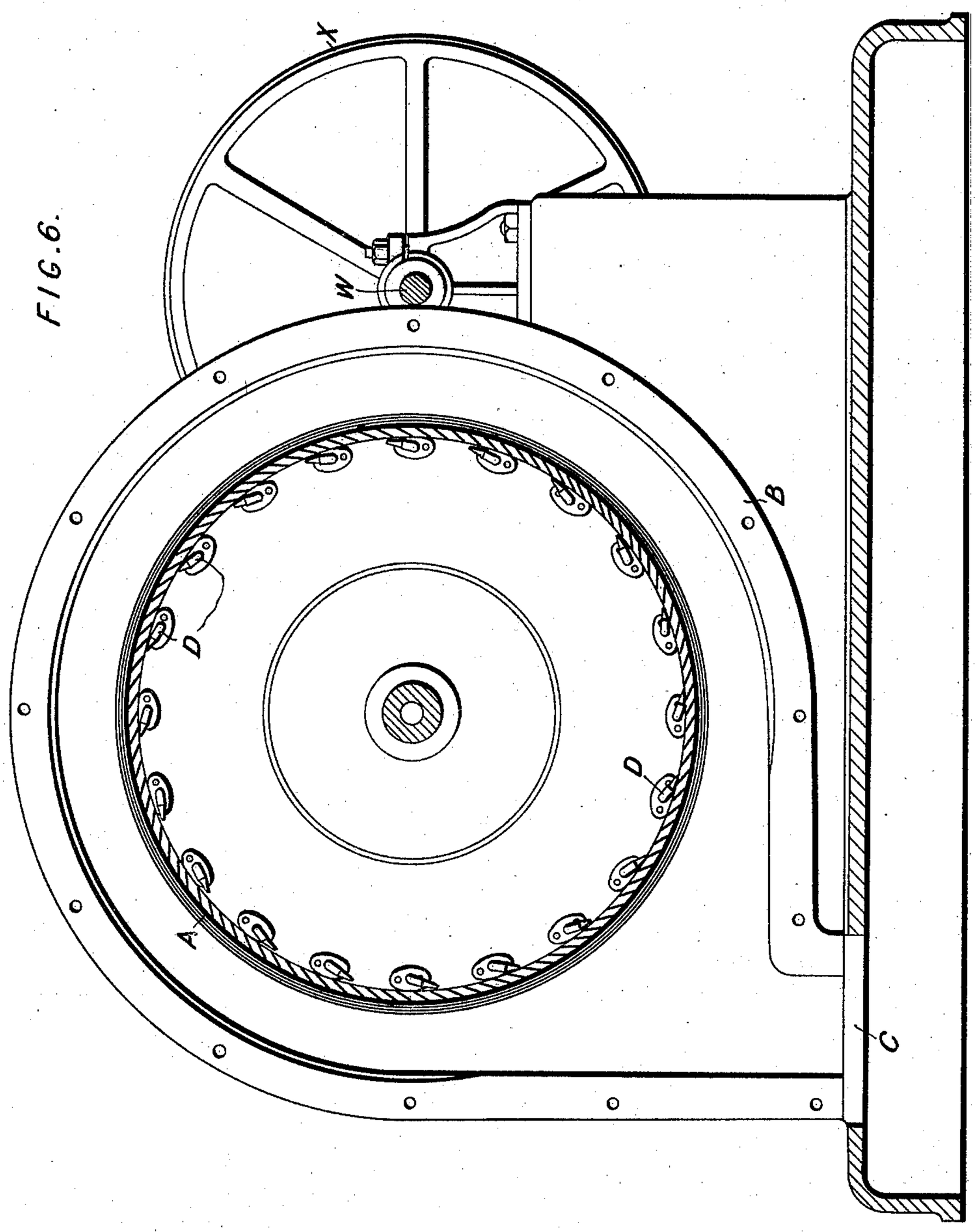
(No Model.) 9 Sheets—Sheet 6.

S. C. DAVIDSON.

MEANS OR APPARATUS FOR GOVERNING IMPULSE TURBINES.

No. 584,580. Patented June 15, 1897.

FIG. 6.



WITNESSES:
Fred White.
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INVENTOR:
Samuel Cleland Davidson,
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Wilkinson & Fraser & Co

(No Model.) 9 Sheets—Sheet 7.

S. C. DAVIDSON.

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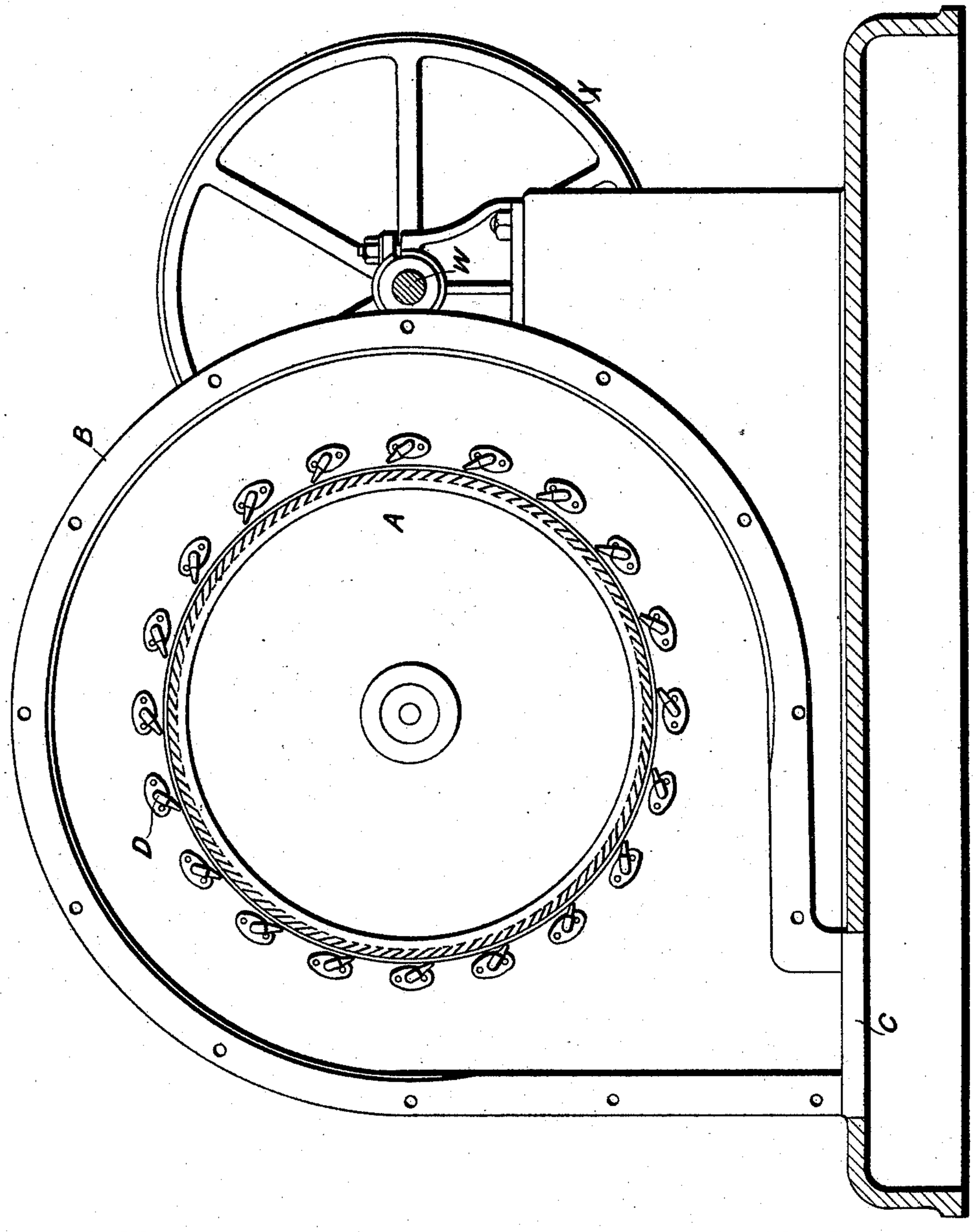
FIG. 7.



WITNESSES:
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C. K. Fraser.

INVENTOR:
Samuel Cleland Davidson,
By his Attorneys:
Wilkinson & Fraser & Co.

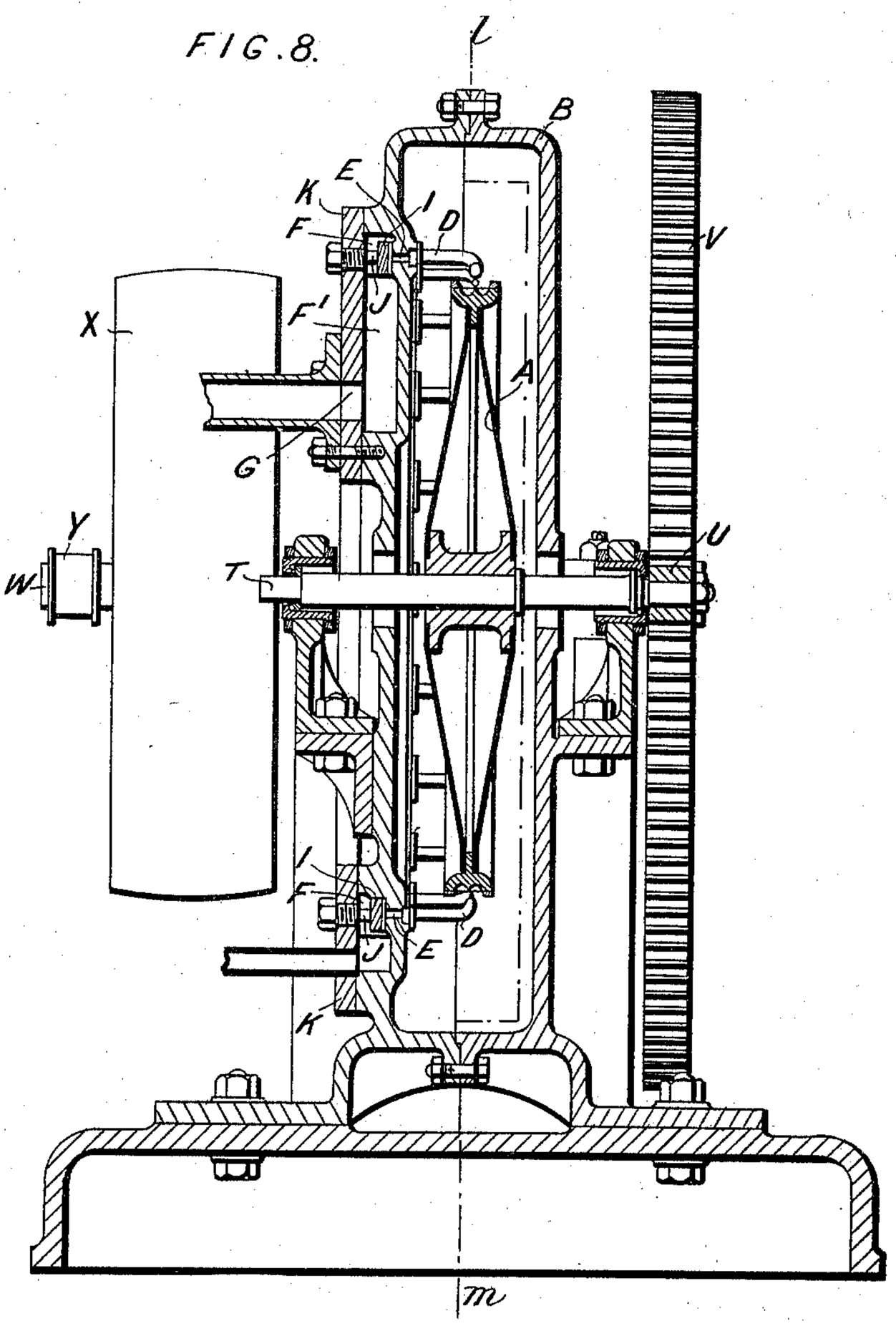
(No Model.) 9 Sheets—Sheet 8.

S. C. DAVIDSON.

MEANS OR APPARATUS FOR GOVERNING IMPULSE TURBINES.

No. 584,580. Patented June 15, 1897.

FIG. 8.



WITNESSES:

Fred Whitg

C. K. Fraser.

INVENTOR:

Samuel Cleland Davidson,

By his Attorneys:

Arthur C. Fraser & Co

(No Model.)

9 Sheets—Sheet 9.

S. C. DAVIDSON.

MEANS OR APPARATUS FOR GOVERNING IMPULSE TURBINES.

No. 584,580. Patented June 15, 1897.

FIG. 9.

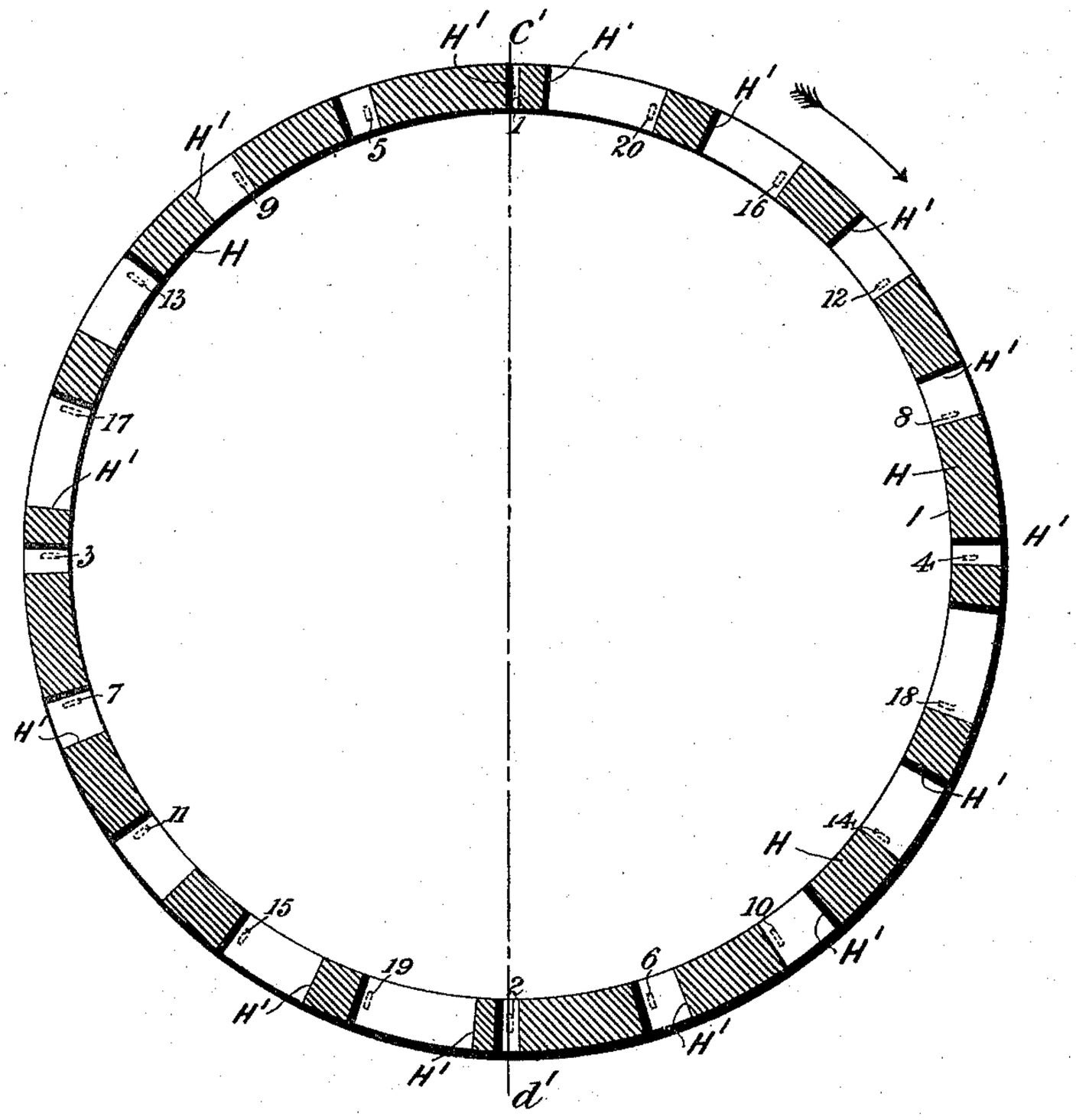
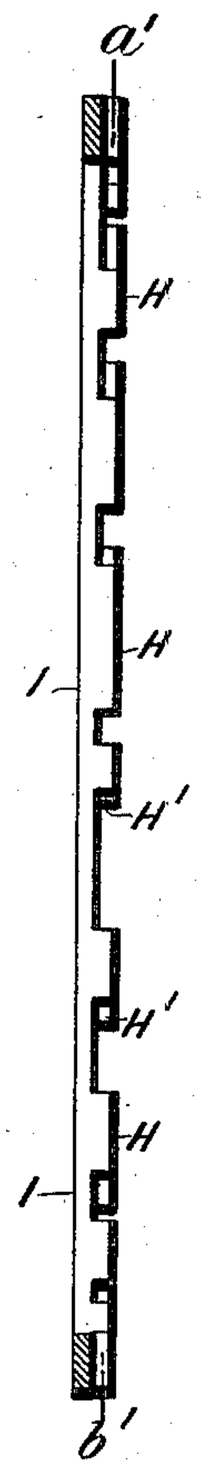


FIG. 10.



WITNESSES:
Fred White
C. K. Fraser.

INVENTOR:
Samuel Cleland Davidson,
By his Attorneys:
Arthur C. Fraser & Co

UNITED STATES PATENT OFFICE.

SAMUEL C. DAVIDSON, OF BELFAST, IRELAND.

MEANS OR APPARATUS FOR GOVERNING IMPULSE-TURBINES.

SPECIFICATION forming part of Letters Patent No. 584,580, dated June 15, 1897.

Application filed August 7, 1896. Serial No. 602,007. (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 Means or Apparatus for Governing Impulse-Turbines, of which the following is a specification.

My improvements refer to the governing of impulse-turbines in which more than one jet-nozzle is employed for directing the motive fluid into the buckets thereof, and more especially to the turbines described in the two other applications for Letters Patent, Serial Nos. 602,005 and 602,006, both filed by me of equal date herewith.

The objects of my improvements are to maintain the initial pressure and force of the motive fluid employed for driving the turbine in full operation through such of the jet-nozzles as are in active work and to regulate the volume of motive fluid operating on the turbine by cutting it off from or admitting it to the jet-nozzles one by one, so as to drive the turbine at approximately any required speed under varying loads.

My improvements consist in the employment in or upon the side casing of the turbine wheel of an annular pipe or tube (hereinafter called the "annular" supply-pipe) for the main supply of the motive fluid to the jet-nozzles, which direct the motive fluid into the buckets of the turbine, and which nozzles are connected thereto on the side next the turbine and suitably curved therefrom to give the motive fluid its required direction, and I preferably construct the said annular supply-pipe as an outwardly open trough in the turbine casing and inclose its open side by a steam-tight or water-tight cover which may be fitted with plugs arranged opposite each jet-nozzle, so that if any obstruction should get into any of the nozzles it is only necessary to undo the plug opposite said nozzle and after pushing a wire through the nozzle replace the plug without the cover as a whole having to be removed for this purpose. The inlet ends of the nozzles from the said trough are each formed in the center of a slightly-elevated surface in the bottom of said trough, all of which surfaces are turned or milled to a uniformly-level facing, upon which I apply a flat ring or annulus which acts as a valve (hereinafter called the "valve-annulus") with a number of elevated surfaces each of suitable length and space from each other, or with holes or slits in it, so arranged in respect of the inlet-orifice to each nozzle that when said valve-annulus is in a certain position all the jet-nozzles are in communication with the annular supply-pipe, and by the movement of the valve-annulus to or fro, as the case may be, one jet-nozzle after another gets cut off from or reopened to the motive fluid supply. By this arrangement the motive-fluid operates on the turbine through each nozzle with the full force due to its initial pressure up to the time of its being cut off therefrom by the valve-annulus. I preferably arrange the cutting off or reopening of the nozzles so that those opposite to or half-way round from the last nozzle acted upon by the valve-annulus are successively cut off or reopened, as the case may be, and I operate this valve-annulus preferably by means of a rack-and-pinion movement acting on its side, and which may either be operated by hand or by a governor driven in any convenient way, either directly by the turbine shaft or by the shaft driven therefrom. It will be obvious that this method of governing the supply of motive fluid to the various jets insures the initial pressure of the motive fluid remaining in full operation through each jet-nozzle until it is itself cut off therefrom by the valve-annulus, and consequently whether the turbine is running with full or partial supply of motive fluid to suit varying loads the jets act with undiminished efficiency so long as they are in actual operation.

The accompanying drawings illustrate my invention applied by way of example to two impulse-turbines forming, respectively, the subjects of two other applications for Letters Patent of even date herewith, one of which turbines is in the specification termed the "intro-impulse turbine" and the other in the specification the "extra-impulse turbine."

In the accompanying drawings, Figure 1 is a front elevation of my hereinbefore-referred-to intro-impulse turbine in which, according to my present invention, the flow of the mo-

tive fluid into the nozzles is controlled and regulated by my herein-described annular valve operating inside an annular duct or pipe to which the jet-nozzles are attached and the movement of which annular valve is actuated by a centrifugal governor mounted on and driven by said intro-impulse turbine. Fig. 2 is a side elevation of the turbine. Fig. 3 is a plan. Fig. 4 is a cross-section through line *a b*, Fig. 1. Fig. 5 is a sectional elevation through line *c d* of Fig. 4. Fig. 6 is a sectional elevation through line *e f* of Fig. 4. Fig. 7 is a sectional elevation on line *l m* of Fig. 8; and Fig. 8 is a cross-section of my hereinbefore-referred-to extra-impulse turbine in which, according to my present invention, the flow of the motive fluid into the nozzles is controlled and regulated by my herein-described annular valve operating inside an annular duct or pipe to which the jet-nozzles are attached and the movement of which annular valve is actuated by a centrifugal governor mounted on and driven by said extra-impulse turbine. Figs. 9 and 10 are a sectional elevation and a cross-section, respectively, of a valve-annulus in which the edges of elevated surfaces are employed to cut off or admit the supply of motive fluid to the jet-nozzles, Fig. 9 being a section taken through line *a' b'* of Fig. 10 and Fig. 10 a cross-section taken through line *c' d'* of Fig. 9.

Referring, first, to Figs. 1 to 8, A is the turbine wheel, inclosed in the casing B, with a discharge-outlet C, and D D are jet-nozzles, attached to the inner side of one face of the casing B with their inlet ends and opening immediately over and communicating with the orifices of ports E. F is the annular duct, from which the ports E lead. This duct F communicates with the motive-fluid supply-pipe G by the branch ducts F'. I is the flat ring or valve-annulus, and H H are the elevated surfaces, and H' H' the cutting-off edges of the said flat ring or valve-annulus. These elevated surfaces rest upon the bottom surface of the duct F and are kept in position by having springs J attached to the back surface of the valve-annulus I and bearing against the inner side of the cover K. On part of the outer circumference of the annulus-valve or ring I teeth L are formed, which gear with a pinion M, mounted on a spindle N, passing through the cover K and carried by the bracket-bearing O. On the outer end of the spindle N another toothed pinion P is fixed, gearing into a rack Q, supported in guides attached to the standard of the centrifugal governor R, the rack Q being operated by the raising or lowering of the sleeve S of the governor R. T is the turbine shaft, on which the turbine wheel A is fixed and mounted, on one end of which a small pinion U is attached, gearing into the spur-wheel V, fixed and mounted on the second shaft W, upon which shaft a driving-pulley X is fixed, and also the small pulley Y, from which the governor-pulley Z is driven by means of a belt, or sprocket wheels and chain may be suitably used for this purpose, such as are fitted to bicycles.

The action is as follows: The motive fluid first enters the turbine by the pipe G and passes through the branch ducts F' to the annular duct F and from there through the openings or ports E to the nozzles D, from which it issues in the form of jets, which play into the buckets of the turbine wheel A and cause it to revolve, the motion being transmitted to the pulley Y through the shaft T, pinion U, spur-wheel V, and the second shaft W. A belt connecting the pulley Y with the pulley Z of the governor R transmits the motion thereto, the governor-balls flying farther out or falling inward as the speed of the turbine is increased or diminished, which raises or lowers the sleeve S and correspondingly operates the rack Q and pinion P, transmitting the rotary to-and-fro movement, as the case may be, of the pinion P through spindle N and pinion M to the valve-annulus I, which movement brings one valve-face after another over or off the inlet-orifices to the nozzles, whereby the supply of motive fluid is shut off or opened to the nozzles one by one and its volume thereby regulated, so as to maintain in the turbine an approximately equal speed of rotation under varying loads, provided the maximum load is not in excess of the power for which the turbine is designed.

In Figs. 9 and 10, I is the valve-annulus. H H are the elevated surfaces of varying lengths with cutting-off edges H'. The inlet-orifices to the nozzles are shown in dotted lines and indicated by numbers 1 to 20, the figures being in the order in which the supply of motive fluid to said orifices would be cut off one after another by the edges H' of the valve-annulus I when rotated in the direction of the arrow.

What I claim, and desire to secure by Letters Patent, is—

1. In impulse-turbines in which the motive fluid driving the same is directed into the buckets from a plurality of jet-nozzles, the combination with said nozzles, of an annular motive-fluid-supply pipe having a valve-face, and orifices at one side of said pipe with which the inlet ends of the respective jet-nozzles are connected, an annular slide-valve within and movable on the face of said pipe and having on its face toward such face of said pipe elevated valve-faced surfaces closing said orifices one by one, and intermediate transverse ports of less depth than the thickness of the valve, and means for imparting movement to said slide-valve, substantially as and for the purpose set forth.

2. In impulse-turbines in which the motive fluid driving the same is directed into the buckets from a plurality of jet-nozzles, the combination with said nozzles of an annular

motive-fluid-supply pipe having a valve-face, and orifices at one side of said pipe with which the inlet ends of the respective jet-nozzles are connected, an annular imperforate slide-valve within and movable on the face of said pipe and having on its face toward such faces of said pipe elevated valve-faced surfaces closing said orifices one by one, and intermediate transverse ports of less depth than the thickness of the valve, and means for imparting movement to said slide-valve, 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 C. DAVIDSON.

Witnesses:
GEORGE GOOLD WARD,
HUGH TAYLOR COULTER.