W. G. DODD.

TURBINE.

APPLICATION FILED AUG. 7, 1909.

970,193. Patented Sept. 13, 1910.

2 SHEETS—SHEET 1.

Fig. 1.

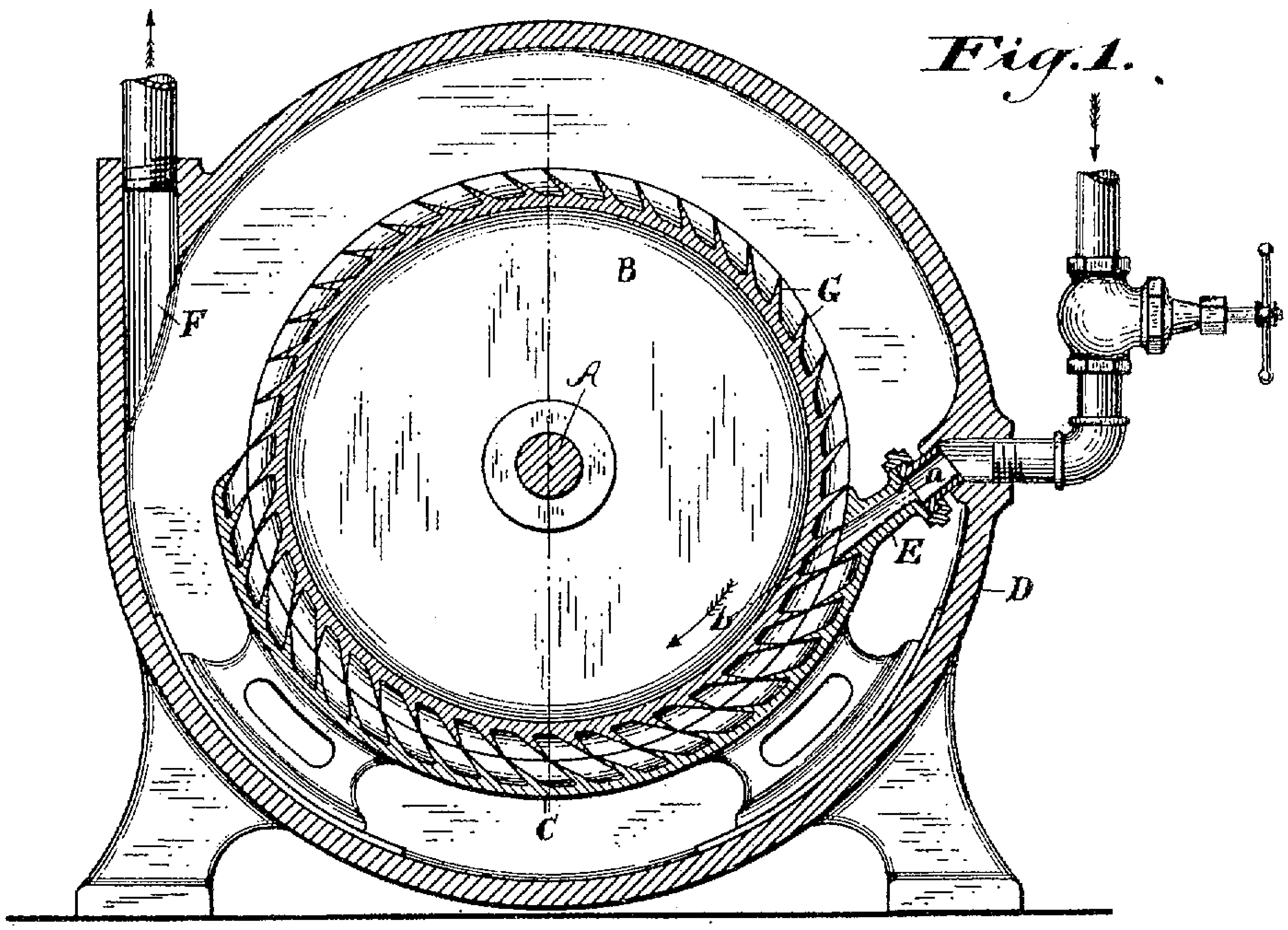


Fig. 2.

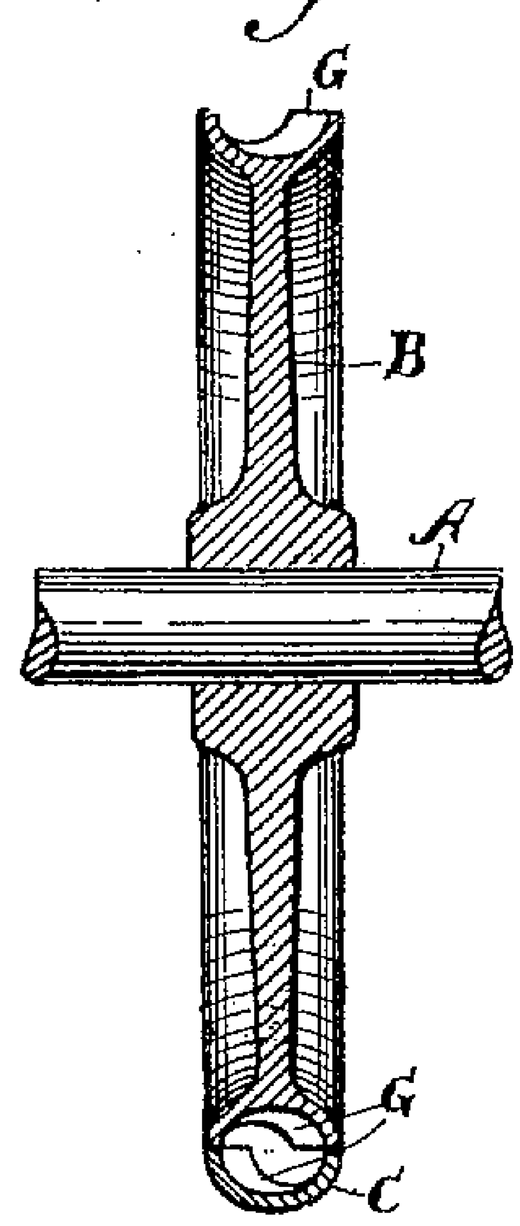
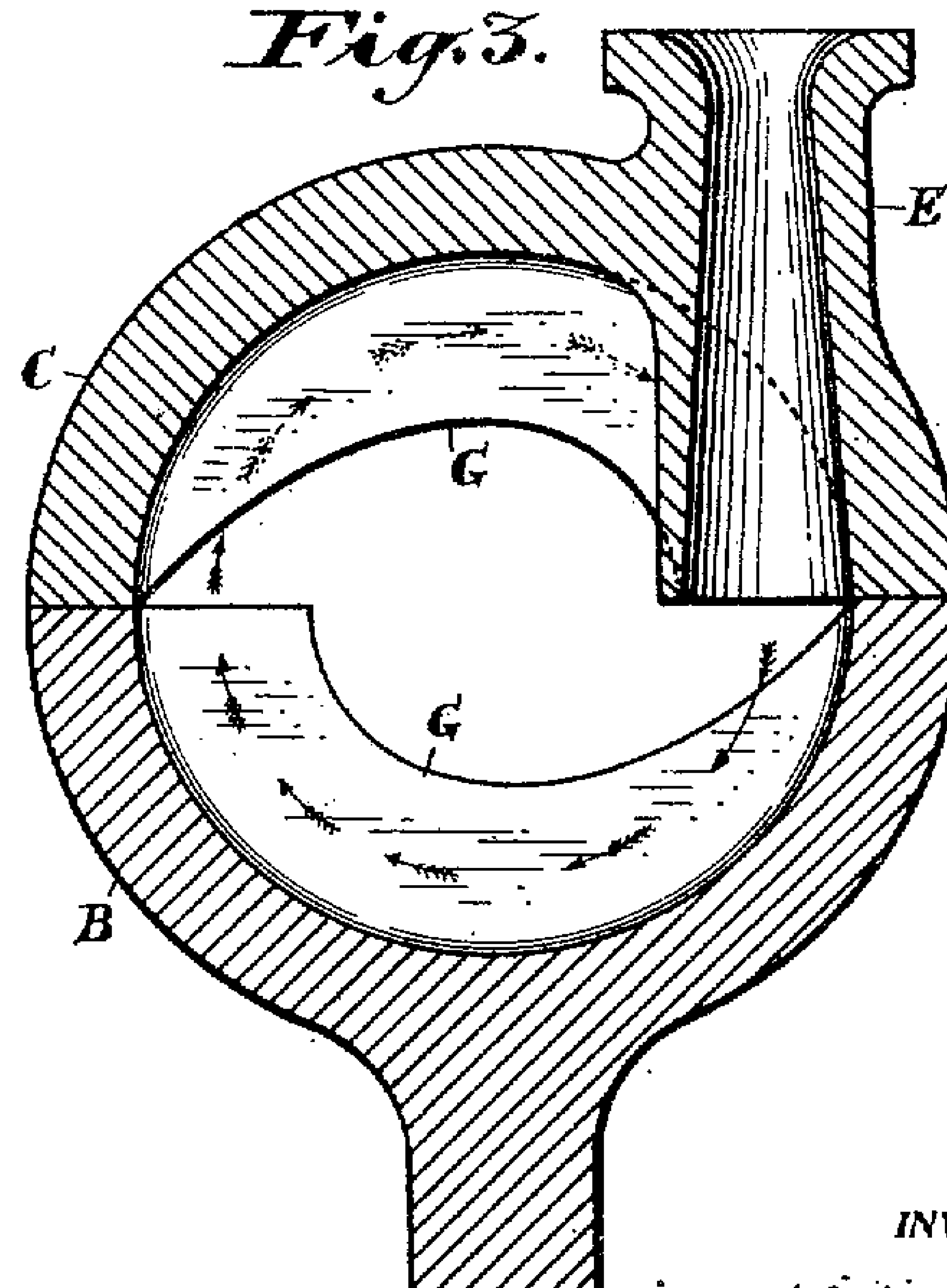


Fig. 3.



WITNESSES:

F. C. Fliedner

N. B. Keating

INVENTOR,

Willis G. Dodd,

BY

Francis M. Wright,

ATTORNEY

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2 SHEETS—SHEET 2.

Fig. 4.

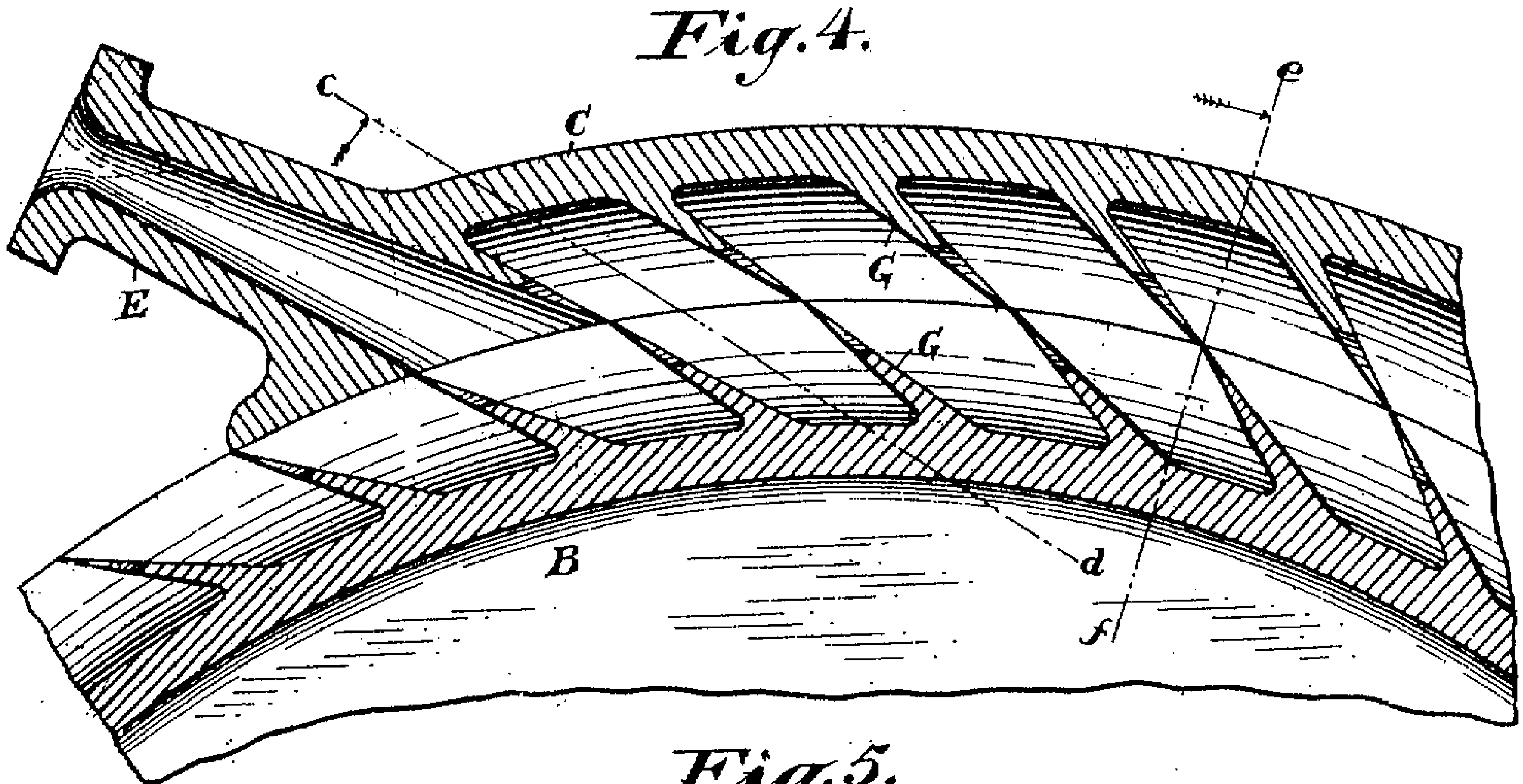


Fig. 5.

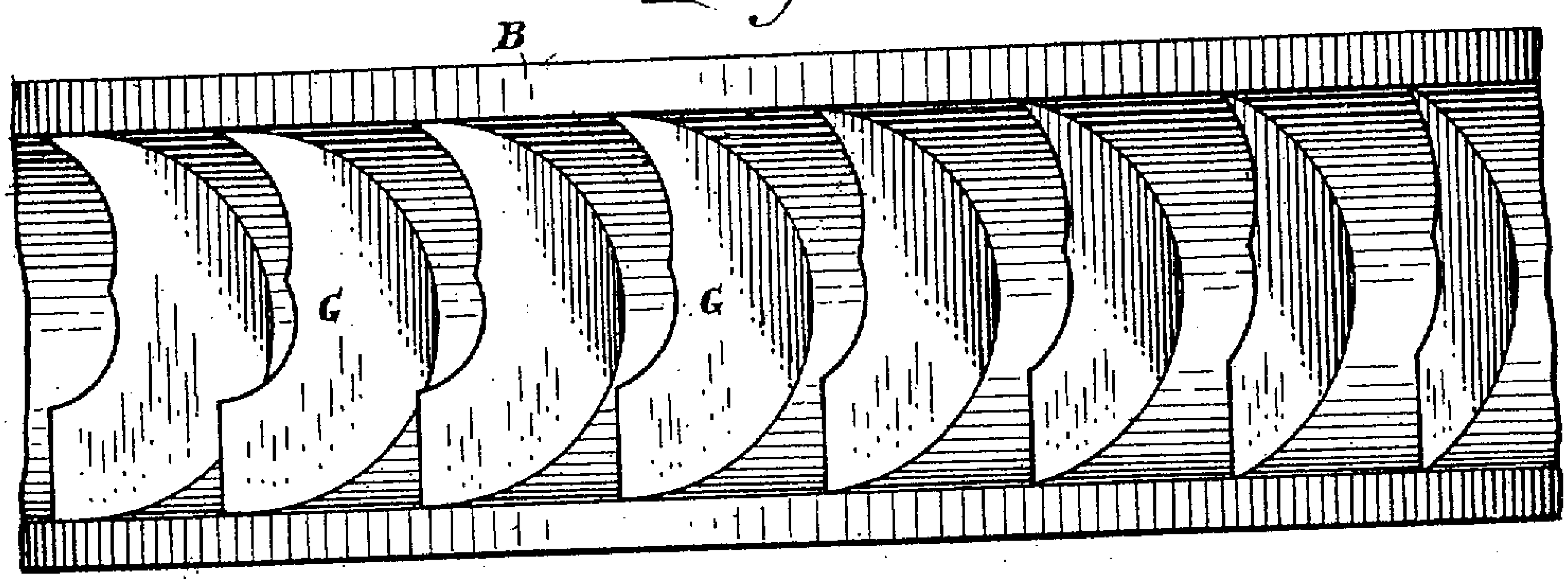


Fig. 6.

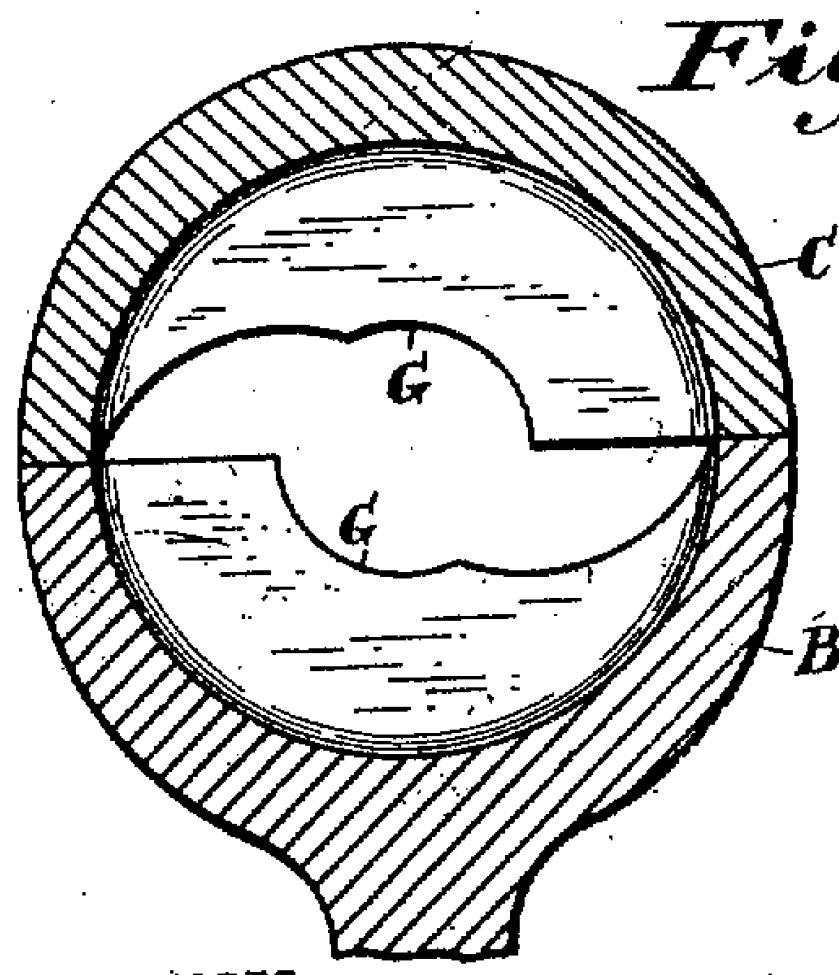
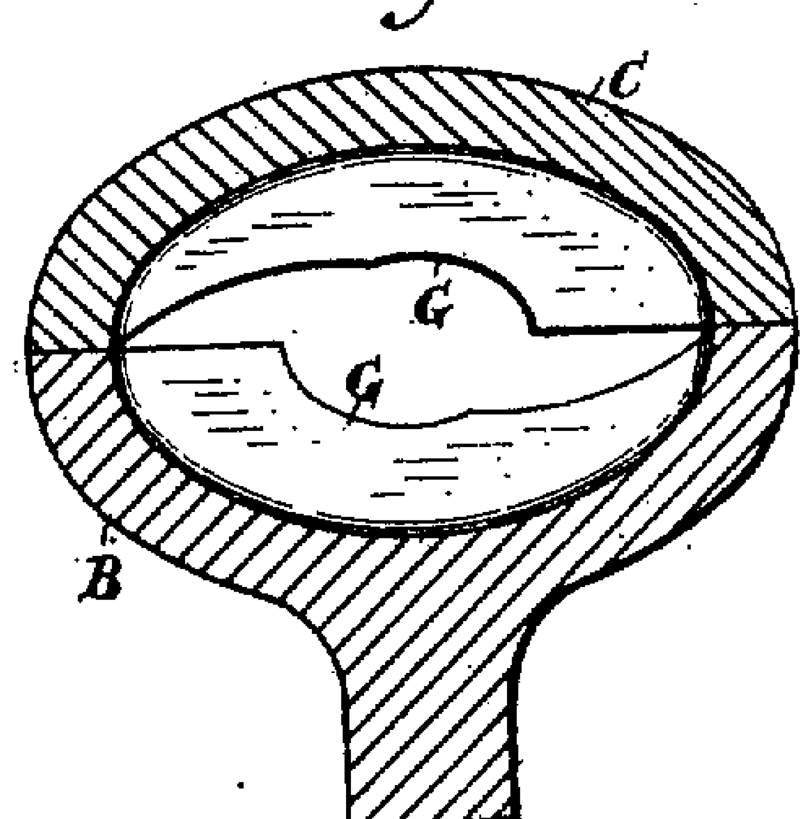


Fig. 7.



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INVENTOR,
Willis G. Dodd.
BY
Francis M. Wright.
ATTORNEY

THE NORRIS PETERS CO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

WILLIS G. DODD, OF SAN FRANCISCO, CALIFORNIA.

TURBINE.

970,193. Specification of Letters Patent. Patented Sept. 13, 1910.

Application filed August 7, 1909. Serial No. 511,722.

To all whom it may concern:

Be it known that I, WILLIS G. DODD, a citizen of the United States, residing at San Francisco, in the county of San Francisco and State of California, have invented new and useful Improvements in Turbines, of which the following is a specification.

The object of the invention is to obtain a turbine of low rotative speed and high efficiency. This object is accomplished by transforming the potential energy of steam under high pressure into velocity by means of an expanding nozzle, and conducting this steam in a curvilinear path and compelling it to rotate in a plane tangential to the plane of rotation of the turbine wheel or rotor, and converting the resultant centrifugal force into useful work. The means employed for this purpose is described in the following specification, pointed out in the claim and illustrated in the accompanying drawings, similar letters referring to similar parts, in which,

Figure 1 is a vertical section of the turbine, showing the relative positions of the rotor, the housing and the casing. Fig. 2 is a vertical cross section of the rotor, showing the relative position of the housing. Fig. 3 is an enlarged cross section of the rotor and housing on the line *a*—*b*, showing the diverging nozzle, rotor and housing in their relative positions, and also indicating the curvilinear path of the steam. Fig. 4 is an enlarged sectional view of the rotor and housing with the diverging nozzle. Fig. 5 is a plan view of a portion of the rotor rim, showing the fins, guides or semi-partitions which confine or guide the steam in its curvilinear path. Fig. 6 is a sectional view of the rotor and housing in their relative positions on the line *c*—*d* of Fig. 4, showing the fins and circular chamber within which the motive fluid rotates. Fig. 7 is a vertical cross section through the rim of the rotor and housing, in their relative positions, on the line *e*—*f* of Fig. 4, showing the elliptical annular chamber formed by the tangentially inclined circular chambers.

Heretofore the practice has been, in turbine construction, to employ the kinetic energy of the steam, using the impulse or reaction principle, for the conversion of said energy into useful work. But in the present form of turbine there is utilized the centrifugal force generated by steam rotating at high velocity within a curvilinear path of small diameter, and the difference between the two methods may be illustrated as follows: If steam under one hundred pounds pressure is expanded, by means of a diverging nozzle, to atmospheric pressure, the resultant effective velocity is approximately 2244 feet per second, and the kinetic energy contained in one pound of this steam, employing the formula

$$\frac{1 \times V^2}{2.g.}$$

would be 77,773 pounds, as available for conversion into useful work. If this same pound of steam, under the same velocity, is forced to travel or rotate within a curvilinear path or circle, having a diameter of three inches, or a radius of one-eighth of a foot, the force developed would be approximately, employing the formula

$$\frac{1 \times V^2}{r.g.} = 1{,}246{,}600 \text{ pounds.}$$

All of this enormous quantity of energy is not available, however, for useful work. The loss due to changing the direction of the steam from linear to curvilinear, including friction etc., is, as near as can be ascertained 20%, or one-fifth, leaving a balance of 997,280 pounds. This pressure is exerted in all directions radially from the center of the circular path within which the steam is traveling, and it is obvious that, in only a relatively small part of the whole of this circular path, can this force be effectively utilized, this being, in practice, approximately one eighth of the entire circumference. This furnishes 124,672 pounds of energy available for conversion into useful work, which shows a theoretical difference in favor of the application of centrifugal force, as compared with the direct conversion of the kinetic energy, as 100 is to 63. This statement would appear to be erroneous, were it not capable of demonstration that, should the diameter of the curvilinear path be doubled or increased from three inches to six inches in diameter, giving a radius of three inches, or one quarter of a foot, then, by the application of the same formula,

$$\frac{1 \times V^2}{r.g.}$$

there would be obtained 627,200 pounds. Deducting 20% for change from a linear to a curvilinear path, there would be left 501,760 pounds, which, divided by 8, gives 62,720 pounds of energy as available for conversion into useful work, an amount less than the kinetic energy available by the direct method, whic hresult clearly points out the limits within which the centrifugal method of conversion of the energy is more effective than the direct conversion thereof, which limits may be summarized as follows: The greatest efficiency will be obtained when the circular path of the steam has a radius as small as possible, leaving a neutral axis around which the strata or jet of steam can revolve. The neutral axis referred to should be approximately twice the diameter of the jet.

By referring to the drawings, the construction of the turbine will be readily understood, and is briefly as follows: As only a small portion of the circumference of the tangentially inclined circular path is available for the absorption of energy the guide vanes may be cut away more or less leaving an open space in the center of the annular chamber, which serves as a neutral axis around which the jet of steam revolves, and also provides means for the exit of any dead steam, due to the provision of any excess in the number of chambers actually required as will be explained hereafter.

While it is possible to operate this type of turbine at any low rate of speed desired, it may be observed that the lowest speed at which the turbine should be operated to obtain the highest efficiency is when the peripheral speed of the rotor is approximately twelve and a half per cent. of the velocity of the steam leaving the jet, and the number of chambers in the housing required to give the number of cycles, or rotations of the steam, requisite for the absorption of the available energy, by the rotor, is determined in the following manner. For the purpose of illustration, steam under 100 pounds gage pressure may be taken, and it is desired to operate a wheel or rotor two feet in diameter at a speed of 2670 revolutions per minute, equivalent to a peripheral speed of the rotor of 280 feet per second, and exhausting against a pressure of one pound above atmosphere. Steam at 100 pounds gage pressure contains 1184.4 heat units per pound and has a temperature of 337.8 degrees F., and at one pound pressure has a temperature of 216.3 degrees. This temperature drop gives us a thermal efficiency of 15.24% or in other words, only 15.24% of the total heat units contained in a pound of this steam is available viz: 180.5 for conversion into useful work, and, as each heat unit is equal to 778 foot pounds, the available potential energy contained in one pound of steam, under the conditions given, would be $1184.4 \times .1524 \times 778$ or 140,429 potential foot pounds. The available velocity at which this steam flows from a diverging nozzle would be

$$\sqrt{140{,}429} \times 6 = 2244 \text{ feet per second,}$$

and the energy of this pound of steam under a velocity of 2244 feet per second, converted into centrifugal force, using a curvilinear path of three inches having a radius of one-eighth of a foot, would be equal to

$$\frac{1 \times 2244^2}{.125 \times 32.2} = 1{,}246{,}600 \text{ pounds.}$$

Deducting 20% loss due to change from a linear to a curvilinear path, we have left 997,280 pounds, one-eighth of which, or 124,672 pounds, is available for conversion into useful work.

In the table No. 1, given below, the column N indicates the number of cycles or revolutions of the steam necessary to enable the rotor to absorb the available energy. The column FAV indicates the available pounds of energy at each cycle or revolution of the steam. The column V indicates the square root of the number of available pounds of energy, which, multiplied by six, gives the available velocity in feet per second and is designated in column marked V^1. The column marked V^2 indicates the peripheral speed, or velocity, in feet per second of the rotor's rim. The column marked FAB, indicates the amount of energy in pounds absorbed or converted into work by the rotor at each cycle or revolution of the steam between the rotor and housing. The column Y indicates the percentage of energy absorbed at each cycle. The column Z indicates the total percentage of energy which has been absorbed by the rotor at any particular cycle. For instance, at cycle No. 8, theoretically, .7604% of the total available energy which has been put into the turbine has been absorbed and converted into useful work. Upon inspection, the table indicates that, with a rotor two feet in diameter, making 2670 R. P. M. or a peripheral speed of 280 feet per second, it requires, to absorb all the available energy possible, sixteen cycles, showing a recovery of the available energy put into the turbine of ninety-seven per cent., with a residual loss of approximately three per cent.

Centrifugal turbine—2 ft. wheel—100 pounds steam to 1.3 atmospheres—2670 R. P. M.=280 ft. per second.

TABLE No. 1.

N	FAV	V	V^1	V^2	FAB	% absorbed.	
						Y	Z W/E
1	124672	....	2244	280	17047	.1367	.1367
2	107625	328	1968	"	14651	.1175	.2542
3	92974	304	1824	"	13402	.1075	.3617
4	79572	282	1692	"	12256	.0983	.4600
5	67316	260	1560	"	11110	.0891	.5491
6	56206	237	1422	"	9912	.0799	.6290
7	46294	215	1290	"	8767	.0703	.6993
8	37424	193	1158	"	7621	.0611	.7604
9	29803	172	1032	"	6527	.0523	.8127
10	23276	152	912	"	5485	.0440	.8567
11	17787	133	798	"	4496	.0360	.8927
12	13281	115	690	"	3559	.0265	.9192
13	9722	98	588	"	2683	.0215	.9407
14	7039	84	504	"	1944	.0156	.9563
15	5059	71	426	"	1261	.0101	.9664
16	3834	62	372	"	798	.0063	.9727
0	3036	55	330	"	....	....	....

If the steam at 100 pounds pressure is exhausted into a vacuum of 26 inches and the same wheel is run at the same peripheral speed, the results would be somewhat changed, as indicated in table No. 2 as given below. The velocity of the steam would be increased to 2970 feet per second and the number of cycles required to absorb the available energy would be increased to nineteen.

Centrifugal turbine—100 pounds to 26 in. vac.—2 ft. wheel—2679 R. P. M.—280 S. F.

TABLE No. 2.

N	FAV	V	V^1	V^2	FAB	% absorbed.	
						Y	Z W/R
1	233042	....	2970	280	23349	0.1001	......
2	209693	458	2748	"	21422	.0919	1920
3	188271	432	2592	"	20099	.0862	2782
4	168172	410	2460	"	18922	.0812	3604
5	149250	386	2316	"	17672	.0758	4362
6	131578	363	2178	"	16475	.0707	5069
7	115103	339	2034	"	15572	.0678	5747
8	99531	316	1896	"	14027	.0602	6349
9	85504	293	1758	"	12829	.0550	6899
10	72675	269	1614	"	11579	.0517	7416
11	61096	247	1482	"	10433	.0447	7863
12	50663	225	1350	"	9287	.0398	8261
13	41376	203	1218	"	8142	.0349	8610
14	33134	182	1092	"	7048	.0302	8912
15	26086	161	966	"	5954	.0255	9167
16	20132	142	852	"	4965	.0213	9380
17	15167	123	738	"	3975	.0170	9550
18	11192	105	630	"	3038	.0130	9680
19	8154	90	540	"	2257	.0097	9777
	5897	76	456	"	....	....	......

The efficiencies here shown are not attainable in actual practice, due to losses which occur, in the way of radiation, windage, leakage, and so forth, but it is no detriment to the machine to provide the number of cycles indicated, as the expended steam readily discharges through the openings between the guide blades of the rotor and the housing.

The construction and application of the device here disclosed produces a simple and reliable prime mover, which requires little attention, and, when intelligently operated, will convert into useful work a high percentage of the energy available.

I do not wish to be understood as confining myself to the specific construction here shown, but reserve the right to make such changes and modifications as properly come within the spirit and scope of my invention.

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

A steam turbine comprising a rotating element and a stationary element, said elements between them forming an annular elliptical chamber, within which are located a series of guide vanes, constituting a series of tangential chambers, forming paths of constant deflection for the impelling medium, an expanding nozzle located within the first chamber of the series, a neutral axis or annular space between the stationary and rotating elements, formed by cutting away the guide vanes as and for the purpose specified.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

WILLIS G. DODD.

Witnesses:

FRANCIS M. WRIGHT,

D. B. RICHARDS.