

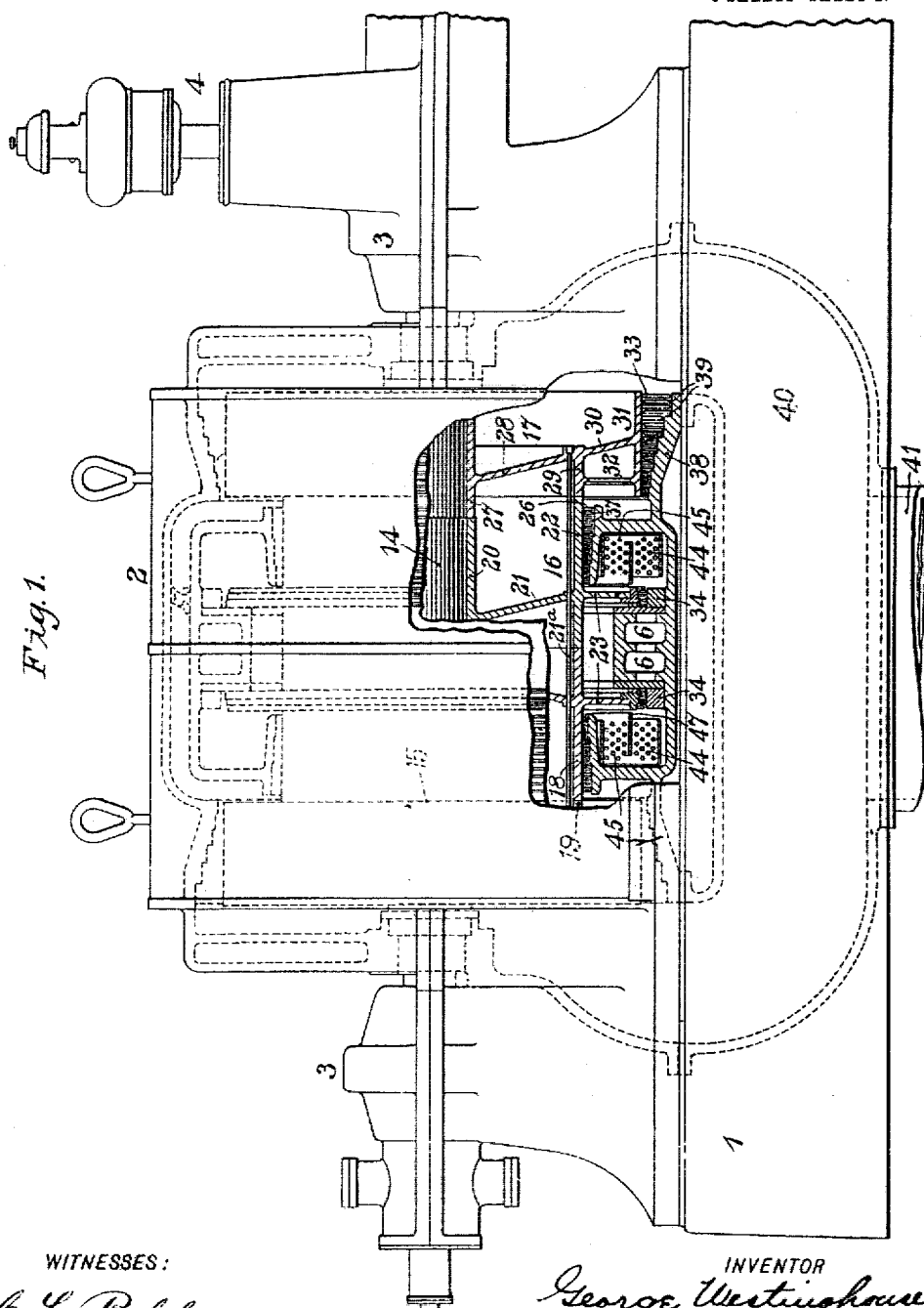
No. 816,516.

PATENTED MAR. 27, 1906.

G. WESTINGHOUSE.
FLUID PRESSURE TURBINE.

APPLICATION FILED MAY 5, 1902. RENEWED SEPT. 20, 1905.

3 SHEETS—SHEET 1.



WITNESSES:

C. L. Belcher
B. B. Hines

INVENTOR

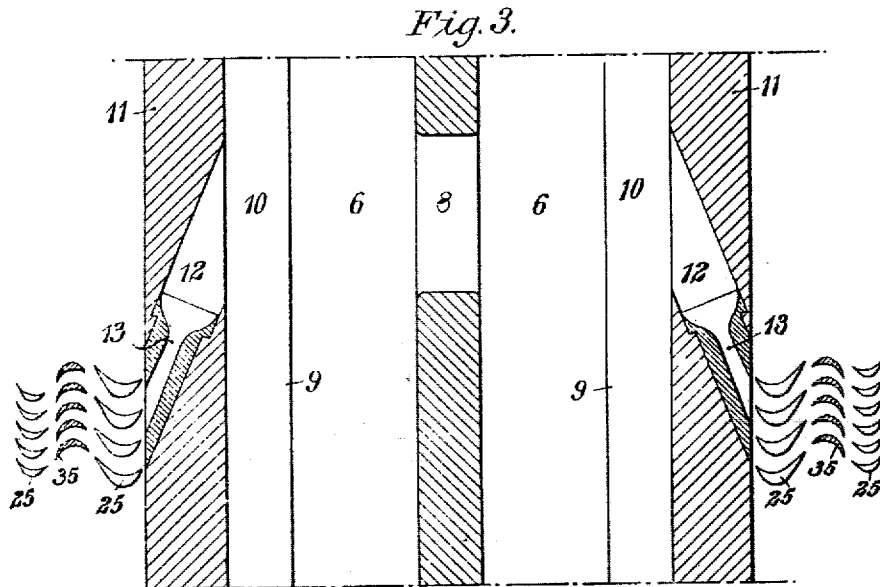
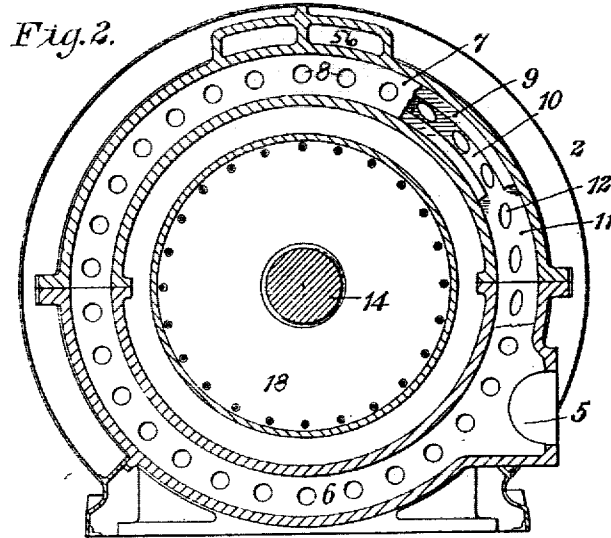
George Westinghouse
BY
Wesley E. Carr
ATTORNEY.

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3 SHEETS—SHEET 3.

Fig. 4.

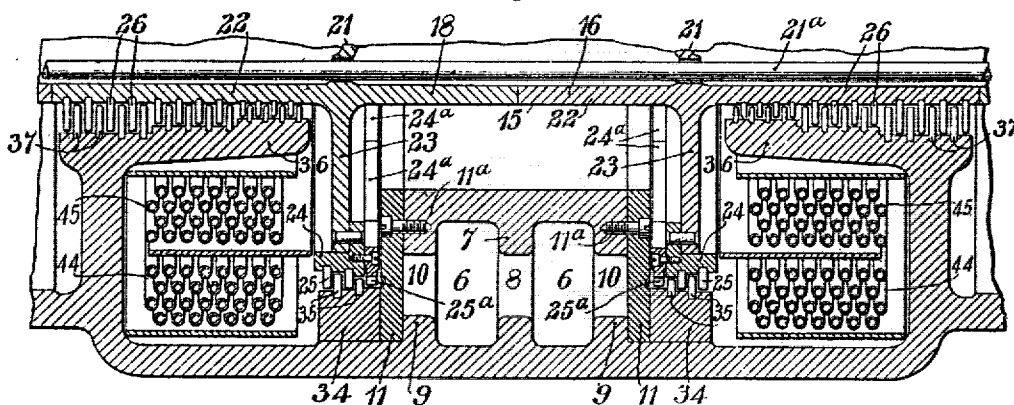
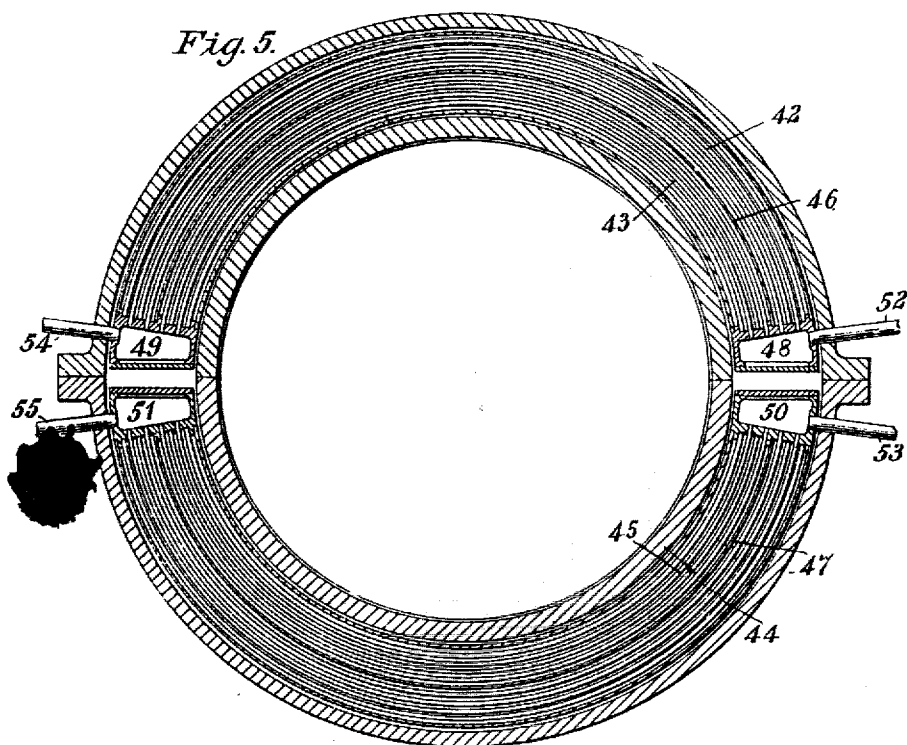


Fig. 5.



INVENTQR

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UNITED STATES PATENT OFFICE.

GEORGE WESTINGHOUSE, OF PITTSBURG, PENNSYLVANIA.

FLUID-PRESSURE TURBINE.

No. 816,516.

Specification of Letters Patent.

Patented March 27, 1906.

Application filed May 5, 1902. Renewed September 20, 1905. Serial No. 279,247.

To all whom it may concern:

Be it known that I, GEORGE WESTINGHOUSE, a citizen of the United States, residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented new and useful Improvements in Fluid-Pressure Turbines, of which the following is a specification.

This invention relates to elastic-fluid turbines, and has for an object the production of a multistage turbine of this class in the initial or primary stage of which velocity energy due to the conversion of thermal into kinetic energy in the form of velocity is absorbed or abstracted in a relatively small number of annular sets of moving blades and in the remaining stages of which the working fluid is fractionally expanded by means of alternate annular rows of stationary vanes and moving blades, whereby energy is derived both by impulse or impact and by reaction.

A further object has been to produce a compact and yet efficient double-flow turbine—that is, one which on opposite sides of the center, so far as the stages or sections are concerned, is bilaterally symmetrical.

These as well as other objects which are readily apparent to those skilled in this art, I have attained by means of the apparatus described in this specification and illustrated in the drawings forming a part of this application, and throughout the several views of which similar elements are denoted by like characters.

In the accompanying drawings, Figure 1 is a view, partially in front elevation and partially in section, of a turbine constructed in accordance with this invention, one end of the frame being broken away. Fig. 2 is a transverse sectional view of the turbine, parts being broken away. Fig. 3 is a detail sectional view showing a portion of the inlet-chambers and two of the nozzles leading therefrom to the blades of the primary stage. Fig. 4 is an enlarged sectional view of a portion of the turbine that is shown in section in Fig. 1. Fig. 5 is a vertical section through the reheating apparatus shown in Figs. 1 and 4.

The turbine here shown is double flow, the two ends of which are exact duplicates of each other and are so disposed in alinement that the working fluid is introduced at the center and is exhausted at the outer ends.

While the invention is intended for utilization with any suitable elastic fluid, steam is

generally employed, and for convenience and simplicity of description steam will be hereinafter referred to as the fluid utilized without any intention of limiting the invention to the use of this specific fluid.

The frame 1 of the turbine comprises a casing 2 for the steam-using parts, bearings 3 for the shaft, and a casing and support 4 for the governor. (Not shown.) The inlet-chamber, with which the inlet-port 5 communicates, is indicated as comprising two annular chambers 6, separated by a rib or flange 7, having openings 8, which enable the steam to pass freely between the two chambers 6. This flange is employed for strengthening purposes only, and so far as the utilization of the steam is concerned it obviously might be omitted. The outer walls 9 of the chambers 6 are severally provided with annular channels or spaces 10, and adjacent to and in contact with the walls 9 are annular plates 11, provided with inclined passages 12, which terminate in removable nozzles 13, the internal diameters of which are small as compared with the diameters of the passages 12, and, if desired, may be made divergent to provide the desired degree of steam expansion. The casing 2 and each of the annular plates 11 are made, as shown, in two parts, though they might be further subdivided, if desired, and the segments of the rings 11 are removably fastened to the corresponding walls 9 by means of screws 11^a or otherwise.

Rigidly mounted upon the main shaft 14 of the turbine is a drum 15, which may be made in various ways, but is herein shown as consisting of four sections 16, 17, 18, and 19, the sections 16 and 18 being exact duplicates of each other and the sections 17 and 19 being also of like form and dimensions. Each of the sections 16 and 18 consists of a sleeve 20, which is closely fitted to the shaft 14, a dish-shaped disk 21 surrounding the sleeve and forming an integral part of it, a cylinder 22 surrounding the disk 21, and an annular flange 23 surrounding the cylinder 22, the sleeve 20, disk 21, cylinder 22, and the flange 23 all constituting parts of a single casting. These drum-sections are all clamped together by means of bolts 21^a. Mounted upon the periphery of each of the flanges 23 and riveted thereto is a ring or short cylinder 24, the periphery of which is provided with annular sets of blades 25, arranged side by side and fastened in position by any suitable means. A plurality of ring-segments

24^a, in which blades 25^a are cut, are bolted or otherwise removably fastened to the inner side of each ring or cylinder 24, thus forming a built-up ring having an annular set of blades. This segmental construction permits of ready and comparatively inexpensive repair in case any of the blades 25^a become broken. The blades of the several sets may vary in length, as shown, so that the velocity energy of the steam issuing from the nozzles will be fractionally abstracted by blades 25^a and 25. The portion of each cylinder 22 beyond the flange 23 and toward the end of the drum is provided with a series of annular rows of blades 26, the lengths of which increase progressively from the inner to the outer end of the series. Each of the drum-sections 17 and 19 comprises also a sleeve 27, a dish-shaped disk 28, a short cylinder 29, an extension-flange 30, a cylinder 31 surrounding and supported by flange 30, and one or more plates 32, the parts 27, 28, 29, 30, and 31 all constituting a single casting. The cylinder 31 is provided with a series of annularly-disposed sets of blades 33, which vary in length from the inner to the outer set, the rate of variation being preferably greater than the rate of variation in the series of blades 26 in the cylinders 22.

The casing 2 is provided adjacent to each of the rings 11 with a ring 34, having annular sets of guide-vanes 35 that alternate with the corresponding blades 25 on the cylinder or ring 24, there being two sets, as here indicated. The internal configuration of the casing is made to conform to the various drum-sections provided with blades, a portion 36 corresponding to that portion of the cylinder 22 which is provided with the blades 26, and this portion 36 is provided with a series of guide-vanes 37, disposed in annular sets which alternate in position with the sets of blades and which vary in length from the inner to the outer end of the series. The casing also comprises at each end a length 38 of varying diameter from its inner to its outer end and provided with a series of guide-vanes 39, arranged in annular sets that alternate with the sets of blades 33 and are of increasing length from the inner to the outer end of the series.

The several sets of blades and corresponding vanes may be located and fastened in grooves or otherwise rigidly supported in position by any suitable means.

The steam which enters the inlet-port 5 and passes in both directions through the turbine is exhausted at the ends of the cylinders 22 and passes out of the engine through a chamber 40 and an exhaust-port 41.

In order to increase the efficiency of the turbine, I propose to reheat the steam during its progress through the turbine and for this purpose I provide the casing adjacent to each cylinder 24 with sets of approximately semi-

circular pipes 42, 43, 44, and 45, the sets of pipes 42 and 43 being separated by a partition 46, and the sets of pipes 44 and 45 being also separated by a partition 47, the partitions 46 and 47 extending nearly across the chambers in which the pipes are located. The corresponding ends of the sets of pipes 42 and 43 are connected by manifolds 48 and 49, and the corresponding ends of the sets of pipes 44 and 45 are connected by manifolds 50 and 51. As will be seen by reference to Figs. 1 and 4, the arrangement of these sets of pipes is such that as the steam leaves the primary stage or section it will pass between and around the pipes 42 and 44, being guided by the partition-plates 46 and 47, and will then pass between and around the pipes 43 and 45 before entering the spaces between the blades 26 and guide-vanes 37. In order to reheat the steam at this point, either superheated steam or a superheated liquid—such, for example, as water or oil—is supplied to two of the manifolds, say to those marked “48” and “50,” through pipes 52 and 53 and withdrawn from the manifolds 49 and 51 through pipes 54 and 55. Other means may of course be employed for reheating the steam, if desired.

In order to equalize the pressure of the steam in corresponding intermediate parts of the two ends of the turbine and in order that the steam leaving the outlets to the intermediate stage will be equally distributed to both sections of the low-pressure stage, I provide a passage 56, located outside of the turbine proper, and which extends from the space between the adjacent ends of the cylinders 22 and 32 at one end of the corresponding space in the other end of the turbine.

The operation of the turbine is as follows: The steam, which is admitted to the chamber 6 through the inlet-port 5, passes through the openings 10 and passages 12 and through the nozzles 13, where a portion of its thermal energy is converted into kinetic energy in the form of velocity. The energy due to this velocity is abstracted in rows of blades comprised in this initial or high-pressure stage. The steam issuing from the primary stage passes around and between the reheating-coils before entering the intermediate or secondary stage, comprising blades 26 and vanes 37. The gradually-increasing length of these blades and vanes provides progressively-increasing space for expansion, and the same are so formed and spaced apart that the expansions occur both between the blades in the working rows as well as the vanes in the stationary rows, whereby energy is derived both by impulse and by reaction. The steam then passes between the blades 33 and vanes 39, constituting the low-pressure stage and which are formed and arranged as are those of the intermediate stage, but of course of greater size and length.

It will be understood that my invention might be embodied in a turbine which would be substantially represented by what is shown at either side of the center of Fig. 1, with the addition of a suitable balancing means, in which case the steam would be introduced at one end and exhausted at the other. It will also be understood that the relation of diameters of the different drum and casing sections may be materially varied from what is shown, provided such a relation is secured as will provide a necessary strength of parts and a proper utilization of steam.

The exact structure and relation of parts here shown and described are obviously not essential to my invention, and I therefore desire it to be understood that variations as to form and dimensions may be made without departing from the spirit and scope of the invention.

I claim as my invention—

1. In a fluid-pressure turbine, the combination with a shaft and a drum comprising a plurality of sections mounted thereon and having annular sets of blades, the first and last of said sections being of materially greater diameter than the intermediate section or sections, of a cylinder comprising a plurality of sections having annular sets of vanes and means for supplying the propelling fluid to the first set of blades in jets at a given velocity.

2. In a steam-turbine, the combination with two drum-sections having radial blades, corresponding cylinder-sections having radial guide-vanes, and an inlet-chamber having nozzles arranged to expand the steam and project it from said chamber in jets against the working faces of said blades, of drum and cylinder sections of lesser diameter having sets of radial blades and guide-vanes of increasing length longitudinally of the turbine between which the steam is progressively expanded, and drum and cylinder sections which receive the steam from the intermediate sections and are of greater diameter than the intermediate sections.

3. In a steam-turbine, the combination with an inlet-chamber, drum-sections at the opposite sides thereof provided with blades, and nozzles through which the steam is expanded to increase its impact velocity and by which it is directed against the working faces of the blades, and drum-sections having sets of blades against which the steam acts as it is progressively expanded, the first and last drum-sections being of greater diameter than the intermediate section or sections.

4. In a steam-turbine, a drum-section provided with annular sets of blades and a ring comprising a plurality of segments removably attached to one end of said drum-section and provided with an annular set of blades.

5. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage divided into two symmetrical sections having separated inlets, and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

6. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage divided into two sections having separated inlets and through which sections the working fluid flows in opposite directions, and a fluid conduit or passage separated from the interior of the turbine for placing the inlets to said sections in communication one with the other.

7. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage divided into two symmetrical sections having separated inlets and through which sections the fluid flows in opposite directions, and a fluid conduit or passage separated from the interior of the turbine for placing the inlets to said sections in communication one with the other.

8. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage divided into two sections having separated inlets and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

9. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two symmetrical sections having

separated inlets and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

10. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two symmetrical sections having separated inlets and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage for placing the inlets to said sections in communication one with the other.

11. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for fractionally abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two symmetrical sections having separated inlets and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

12. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for fractionally abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two symmetrical sections having separated inlets and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage for placing the inlets to said sections in communication one with the other.

13. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure

stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two sections having separated inlets and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

14. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two sections having separated inlets and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage for placing the inlets to said sections in communication one with the other.

15. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for fractionally abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two sections having separated inlets and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

16. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for fractionally abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two sections having separated inlets and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage for placing the inlets to said sections in communication one with the other.

17. In a multistage turbine, a high-pres-

sure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two symmetrical sections located at opposite ends of the turbine and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

18. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two symmetrical sections located at opposite ends of the turbine and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage for placing the inlets to said sections in communication one with the other.

19. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for fractionally abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two symmetrical sections located at opposite ends of the turbine and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

20. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for fractionally abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-

pressure stage being divided into two symmetrical sections located at opposite ends of the turbine and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage for placing the inlets to said sections in communication one with the other.

21. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two sections located at opposite ends of the turbine and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

22. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two sections located at opposite ends of the turbine and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage for placing the inlets to said sections in communication one with the other.

23. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of velocity and moving rows of blades for fractionally abstracting the energy due to said velocity, a low-pressure stage employing alternate annular rows of stationary vanes and moving blades whereby the working fluid is fractionally expanded and energy derived both by impulse and by reaction; said low-pressure stage being divided into two sections located at opposite ends of the turbine and through which sections the working fluid flows in opposite axial directions, and a fluid conduit or passage separated from the interior of the turbine proper for placing the inlets to said sections in communication one with the other.

24. In a multistage turbine, a high-pressure stage employing expansion-nozzles for converting thermal energy of the working fluid into kinetic energy in the form of veloc-

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conduit or passage for placing the inlets to
said sections in communication one with the
other.

In testimony whereof I have hereunto sub- 15
scribed my name this 25th day of April, 1902.

GEO. WESTINGHOUSE.

Witnesses:

WM. H. CAPEL,
H. C. TENER.