No. 787,485.

PATENTED APR. 18, 1905.

G. WESTINGHOUSE.

FLUID PRESSURE TURBINE.

APPLICATION FILED JULY 3, 1903.

2 SHEETS—SHEET 1.

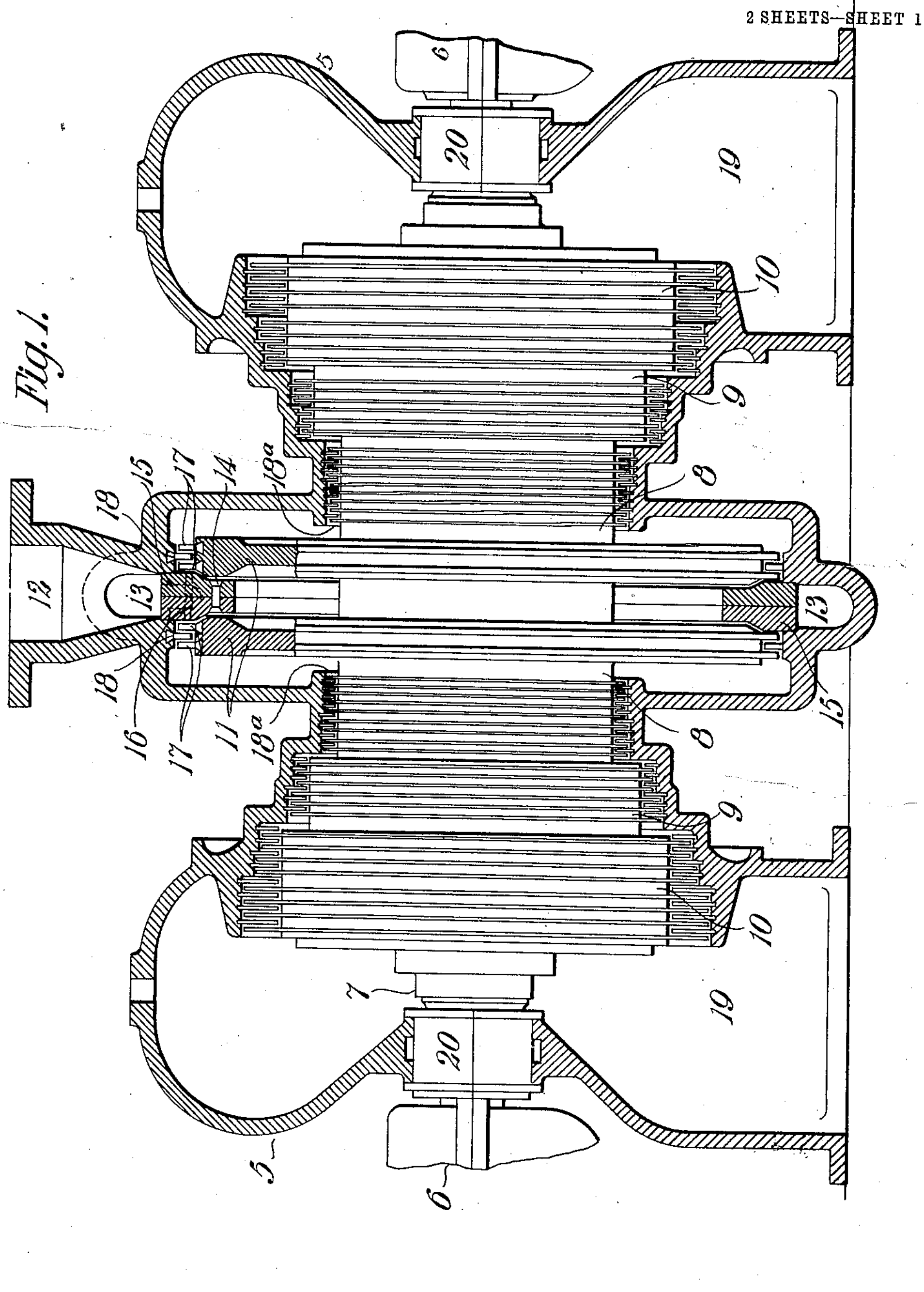


Fig. 1.

WITNESSES:

G. L. Ryder.

E. W. McCallister

INVENTOR

George Westinghouse

BY Jno. S. Green

ATTORNEY

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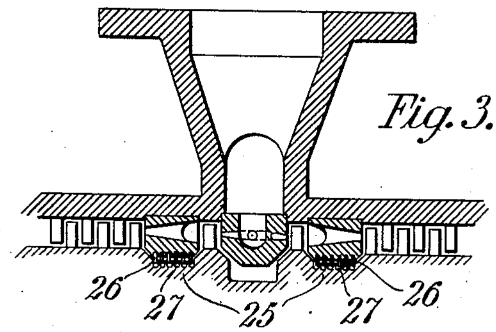
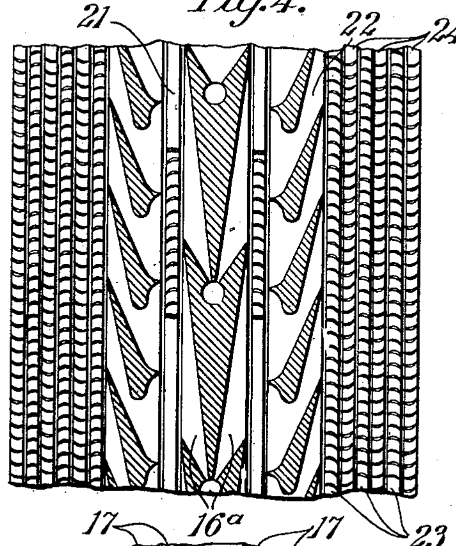



Fig. 3.

Fig. 4.



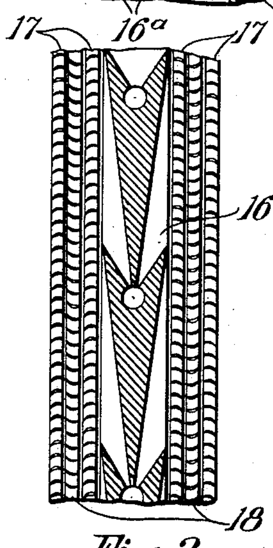




Fig. 2.

WITNESSES:

G. L. Ryder.

E. W. McCallister

INVENTOR

George Westinghouse

BY Jno. S. Green

ATTORNEY

No. 787,485. Patented April 18, 1905.

# UNITED STATES PATENT OFFICE.

GEORGE WESTINGHOUSE, OF PITTSBURG, PENNSYLVANIA, ASSIGNOR TO THE WESTINGHOUSE MACHINE COMPANY, A CORPORATION OF PENNSYLVANIA.

## FLUID-PRESSURE TURBINE.

**SPECIFICATION** forming part of Letters Patent No. 787,485, dated April 18, 1905.

Application filed July 3, 1903. Serial No. 164,143.

*To all whom it may concern:*

Be it known that I, George Westinghouse, a citizen of the United States, and a resident of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Fluid-Pressure Turbine-Engines, of which the following is a specification.

This invention relates to steam or other elastic-fluid turbines, and as an object has the production of relatively simple, compact, and efficient machines of this class.

A further object has been to produce a double-flow turbine—that is, one in which the working fluid flows in opposite directions, balancing the rotor end thrusts—in which the working fluid is initially expanded through nozzles down to the pressure at which it is desired to have it enter the intermediate turbine section or stage.

A still further object of this invention has been to produce an organized machine of this class comprising one or more purely impulse stages or sections with one or more "impulse and reaction" stages or sections having the rotor or running-wheels for the several sections or stages mounted on a common shaft, whereby I am enabled to obtain a highly-efficient turbine at a minimum cost.

With these as well as other objects in view, which will readily appear to one skilled in the art to which this invention pertains, and which objects I attain by means of the apparatus which, together with modified details of construction, is described and illustrated in the specification and drawings accompanying and forming a part of this application, I have produced a novel form of turbine, which may be broadly described as follows: The first or primary stage through which the working fluid passes consists of a single-stage impulse-section in which velocity energy of the working fluid, due to nozzle expansion, is wholly absorbed without further expansion in two rows of impulse-blades or wholly abstracted without further expansion in a single row of impulse-blades, as is desired, or said primary or initial stage or section in which it is desired to secure a relatively large drop in the working-fluid pressure may be subdivided into a plurality of subsections or stages, each of which may be similar in general formation to either of the ones just above described, or in one subsection the velocity energy may be fractionally abstracted and in another wholly absorbed in one moving row of impulse-blades. Combined with either this single or subdivided section or stage and utilizing the working fluid issuing therefrom at its reduced pressure and increased volume is an impulse and reaction section or stage comprising alternate annular rows of stationary vanes and moving blades, whereby the working fluid is fractionally expanded down to exhaust-pressure. The expansions, it will be understood, occur both between the stationary vanes comprised in the annular rows secured to the turbine-casing and the moving blades comprised in the annular rows secured to the rotor, as is now common in the purely Parsons type of turbine.

This invention is equally applicable to single or double flow turbines and, as before said, as shown in the drawings, is applied to a double-flow machine. When utilized in a bilaterally-symmetrical machine, such as the one illustrated, all rotor end thrusts are cared for, as the thrusts in one direction counterbalance those in the other direction; but when utilized in a single-flow machine one of the many well-known end-thrust-counterbalancing methods may be made use of.

In the drawings which illustrate a practical embodiment of this invention in the shape of an organized turbine, as well as several modifications and structural details applicable thereto, Figure 1 is a longitudinal section of said machine. Fig. 2 is an enlarged view in section of the nozzles and velocity-energy-abstracting blades of the primary stage illustrated in Fig. 1. Figs. 3 and 4 are views in section of a modified form of the primary stage, which may be utilized, if desired, and in this modified form the velocity energy of the working fluid issuing from the first nozzles is wholly absorbed in one moving row of impulse-blades, is received from said impulse-blades and discharged through a second set of nozzles, and the velocity energy of the working fluid issuing from said second set of nozzles is fractionally abstracted by a plurality of moving rows of impulse-blades and intermediate guide-vanes.

The turbine-casing 5 is divided on the horizontal plane through its axis, as is now common, and the turbine being bilaterally symmetrical it is only believed necessary to describe one-half of the same.

Bearings 6 are provided, within which the shaft 7 of the turbine-rotor is journaled. The rotor is preferably built up of drum-sections 8, 9, and 10, respectively, increasing in diameters from the center of the turbine to the exhausts. The rotor at its center is formed in the nature of two running wheels 11 of relatively large diameter in comparison with either of the drum-sections 8, 9, or 10.

A working-fluid inlet 12 is in communication with an annular fluid-chamber 13, which extends around the turbine-casing, and secured to the casing in any suitable manner, and preferably formed in halves bolted together, as at 14, is a nozzle-block or a member 15, provided with oppositely-discharging divergent nozzles 16.

Each of the wheel portions 11 of the rotor is provided with two annular rows of impulse-blades 17, and between these rows is a row of intermediate guide-vanes 18, secured to the turbine-casing, as is now common in certain impulse types of turbines.

The velocity energy of the working fluid issuing from the expansion-nozzles 16 is fractionally abstracted by the two rows of impulse-blades 17 without further expansion, and the fluid issuing from the last of said row of impulse-blades 17 flows inwardly toward the rotor-axis to the annular inlet 18 between the rotor and the casing to the impulse and reaction section.

The casing exterior to drums, 8, 9, and 10 is stepped, as shown in Fig. 1, and of progressively-increasing internal diameter to provide suitable fluid-space for accommodating the fluid without restricting its expansion from the inlet of said section to the exhaust end 19. Suitable stuffing-boxes or packing-glands 20 are provided where the rotor-shaft passes through the turbine-casing.

The nozzles 16 may be so proportioned that the desired pressure drop is secured therein, and when constructed as shown in Figs. 1 and 2 the velocity energy of the working fluid obtained by converting the thermal energy of the working fluid into kinetic energy in the form of velocity in said nozzles is fractionally abstracted in the two moving rows of impulse-blades carried on each running-wheel.

As illustrated in Figs. 3 and 4, the primary stage on each side of the center may consist of a series of nozzles 16[a], in which the thermal energy of the working fluid is converted into kinetic energy in the form of velocity, a single row of impulse-blades 21 for absorbing the velocity energy without further expansion, a series of nozzles 22, receiving the fluid discharged from said impulse-blades and whereby a further portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity, and a plurality of rows of moving impulse-blades 23 and stationary guide-vanes 24, whereby the velocity energy of the fluid leaving said nozzles 22 is fractionally abstracted without further expansion.

When the intermediate nozzles 22 are employed, it will be desirable to pack the joints between said nozzles and the rotor, and a means for accomplishing this is illustrated in Fig. 3 at 25. This packing means, as illustrated, consists of a series of dummy rings 26, secured to the stator or casing and adapted to loosely fit with annular grooves 27, formed in the rotor for that purpose.

By employing either of the forms of primary stage illustrated it will be seen that the turbine is materially shortened over a purely Parsons type of turbine of the same capacity.

It will be understood that various changes may be made in the apparatus without departing from the spirit of this invention. The running-wheels 11 may be reduced in diameter and, in fact, may be of the same diameter as drums 8, if desired, and, in fact, may be omitted, and the impulse-blades 17 or 21 and 24 may be mounted directly on the drums 8. The length of the blades in the impulse and reaction section may be varied to suit operating conditions, and the number of rows of such blades may be varied.

Having thus described my invention, what I claim as new and useful, and desire to secure by Letters Patent, is—

1. In an elastic-fluid turbine, agents whereby a portion of the fluid-pressure is converted into velocity and translated without further expansion into rotary motion, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said agents is fractionally expanded and converted into rotary motion.

2. In a parallel-flow elastic-fluid turbine, agents whereby a definite proportion of the fluid-pressure is converted into velocity, fractionally abstracted without further expansion and translated into rotary motion, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said agents is fractionally expanded and converted into rotary motion.

3. In an elastic-fluid turbine, agents whereby a portion of the fluid-pressure is converted into velocity and fractionally translated without further expansion into rotary motion, and a plurality of alternate rows of stationary

vanes and moving blades whereby the fluid received from said agents is fractionally expanded and converted into rotary motion.

4. In an elastic-fluid turbine, agents whereby a portion of the fluid-pressure is converted into velocity and translated without further expansion into rotary motion, and instrumentalities receiving the fluid from said agents whereby it is fractionally expanded and converted into rotary motion.

5. In an elastic-fluid turbine, a plurality of stationary nozzles whereby a portion of the fluid-pressure is converted into velocity, agents whereby the energy due to said velocity is fractionally abstracted without further expansion, and a plurality of moving rows of blades and stationary vanes whereby the fluid received from said agents is fractionally expanded.

6. In an elastic-fluid turbine, divergent nozzles whereby a portion of the fluid-pressure is converted into velocity, agents whereby the energy due to said velocity is fractionally abstracted without further expansion and converted into rotary motion, and instrumentalities receiving the fluid from said agents whereby it is fractionally expanded and converted into rotary motion.

7. In an elastic-fluid turbine, a plurality of annularly-disposed nozzles whereby a portion of the fluid-pressure is converted into velocity, agents receiving the fluid from said nozzles whereby the energy due to said velocity is fractionally abstracted without further expansion, and instrumentalities receiving the fluid from said agents whereby it is fractionally expanded and converted into rotary motion by impact and reaction.

8. In an elastic-fluid turbine, oppositely-discharging nozzles, agents whereby the velocity energy of the fluid due to nozzle expansion is fractionally abstracted without further expansion and converted into rotary motion, and a plurality of alternate rows of moving blades and stationary vanes receiving the fluid from said agents whereby it is fractionally expanded and converted into rotary motion.

9. In an elastic-fluid turbine, agents whereby the fluid-pressure is converted into velocity, fractionally abstracted without further expansion and translated into rotary motion, instrumentalities whereby the fluid received from said agents is fractionally expanded and converted into rotary motion and means whereby the energy so obtained is applied to a shaft common to said agents and said instrumentalities.

10. In an elastic-fluid turbine, instrumentalities whereby a portion of the pressure of the working fluid is transformed into velocity, agents whereby the energy due to said velocity is fractionally abstracted without further expansion, and alternate rows of moving blades and stationary vanes whereby the fluid leaving said agents is fractionally expanded both in said moving and stationary rows and rotary motion obtained both by impulse and reaction.

11. In a double-flow elastic-fluid turbine, oppositely-discharging nozzles whereby a portion of the fluid-pressure is converted into velocity, agents whereby the energy due to said velocity is fractionally abstracted without further expansion, and instrumentalities receiving the fluid from said agents whereby it is fractionally expanded and converted into rotary motion by impact and reaction.

12. In a double-flow elastic-fluid turbine, oppositely-discharging agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity and fractionally abstracted without further expansion, and alternate rows of stationary vanes and moving blades receiving the fluid from each of said agents whereby said fluid is fractionally expanded and converted into rotary motion.

13. In a double-flow elastic-fluid turbine, oppositely-discharging agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity and fractionally abstracted without further expansion, and alternate rows of stationary vanes and moving blades receiving the fluid from each of said agents whereby said fluid is fractionally expanded both in said stationary and moving rows and converted into rotary motion.

14. In an elastic-fluid turbine, agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity, fractionally abstracted without further expansion and translated into rotary motion, and instrumentalities receiving the fluid from said agents whereby it is fractionally expanded and converted into rotary motion.

15. In an elastic-fluid turbine, agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity, fractionally abstracted without further expansion and translated into rotary motion, and a plurality of moving and stationary instrumentalities receiving the fluid from said agents whereby it is fractionally expanded in both said moving and stationary instrumentalities and converted into rotary motion.

16. In an elastic-fluid turbine, a primary stage employing nozzles whereby a definite proportion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity, and impulse-blades whereby the energy due to said velocity is abstracted without further expansion, and a secondary stage employing alternate rows of stationary vanes and moving blades whereby the fluid received from said primary stage is fractionally expanded both between the vanes in the

stationary rows and the blades in the moving rows.

17. In an elastic-fluid turbine, agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity and fractionally translated into rotary motion without further expansion, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said agents is fractionally expanded and converted into rotary motion.

18. In an elastic-fluid turbine, agents whereby a portion of the thermal energy of the working fluid entering it is converted into kinetic energy in the form of velocity and abstracted without further expansion, and a plurality of movable and stationary instrumentalities receiving the fluid from said agents whereby it is fractionally expanded in both said moving and stationary instrumentalities and converted into rotary motion.

19. In an elastic-fluid turbine, a primary stage comprising agents whereby a portion of the fluid-pressure is converted into velocity and translated into rotary motion without further expansion, a secondary stage comprising agents whereby a portion of the fluid-pressure is converted into velocity and the energy due to said velocity is fractionally abstracted, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said secondary stage is fractionally expanded and converted into rotary motion.

20. In an elastic-fluid turbine, a primary stage comprising agents whereby a portion of the fluid-pressure is converted into velocity and a row of movable impulse-blades whereby the energy due to said velocity is translated into rotary motion, a secondary stage comprising agents whereby a portion of the fluid-pressure is converted into velocity and the energy due thereto is fractionally abstracted, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said secondary stage is fractionally expanded and converted into rotary motion.

21. In a parallel-flow elastic-fluid turbine, a primary stage comprising agents whereby a definite proportion of the fluid-pressure is converted into velocity abstracted without further expansion and translated into rotary motion, a secondary stage comprising agents whereby a definite proportion of the fluid-pressure is converted into velocity fractionally abstracted without further expansion and translated into rotary motion, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said secondary stage is fractionally expanded and converted into rotary motion.

22. In a parallel-flow elastic-fluid turbine, a primary stage comprising agents whereby a definite proportion of the fluid-pressure is converted into velocity and a moving row of impulse-blades whereby the energy due to said velocity is absorbed, a secondary stage comprising agents whereby a definite proportion of the fluid-pressure is converted into velocity, fractionally abstracted without further expansion and translated into rotary motion, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said secondary stage is fractionally expanded and converted into rotary motion.

23. In an elastic-fluid turbine, a primary stage comprising agents whereby a definite proportion of the fluid-pressure is converted into velocity, absorbed without further expansion and translated into rotary motion, a secondary stage comprising agents whereby a definite proportion of the fluid-pressure is converted into velocity, fractionally abstracted without further expansion and translated into rotary motion, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said secondary stage is fractionally expanded and converted into rotary motion.

24. In an elastic-fluid turbine, a primary stage comprising agents whereby a definite proportion of the fluid-pressure is converted into velocity and a moving row of impulse-blades whereby the energy due to said velocity is absorbed without further expansion and translated into rotary motion, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a definite proportion of the pressure of said fluid is converted into velocity, fractionally abstracted without further expansion and translated into rotary motion, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said secondary stage is fractionally expanded and converted into rotary motion.

25. In an elastic-fluid turbine, a primary stage comprising agents whereby a portion of the fluid-pressure is converted into velocity absorbed without further expansion and translated into rotary motion, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a portion of the pressure of the fluid received is converted into velocity and fractionally translated into rotary motion, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said secondary stage is fractionally expanded and converted into rotary motion.

26. In an elastic-fluid turbine, a primary stage comprising agents whereby a portion of the fluid-pressure is converted into velocity and translated into rotary motion, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a portion of the pressure of said fluid is converted

into velocity and fractionally translated without further expansion into rotary motion, and instrumentalities receiving the fluid from said secondary stage whereby it is fractionally expanded and converted into rotary motion.

27. In a parallel-flow elastic-fluid turbine, a primary stage comprising agents whereby a certain portion of the fluid-pressure is converted into velocity and wholly absorbed without further expansion in one moving row of impulse-blades, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a certain portion of the pressure of said fluid is converted into velocity, fractionally abstracted without further expansion and translated into rotary motion, and instrumentalities receiving the fluid from said secondary stage whereby it is fractionally expanded and converted into rotary motion.

28. In an elastic-fluid turbine, a primary stage comprising a plurality of stationary nozzles whereby a portion of the fluid-pressure is converted into velocity and agents whereby the energy due to said velocity is absorbed without further expansion, a secondary stage receiving the fluid from said primary stage and comprising a plurality of stationary nozzles whereby a portion of the pressure of said fluid is converted into velocity and agents whereby said velocity is fractionally abstracted without further expansion, and a plurality of alternate rows of moving blades and stationary vanes receiving the fluid from said secondary stage whereby it is fractionally expanded.

29. In an elastic-fluid turbine, a primary stage comprising a plurality of stationary nozzles whereby a portion of the fluid-pressure is converted into velocity and a moving row of impulse-blades whereby the energy due to said velocity is absorbed without further expansion, a secondary stage receiving the fluid from said primary stage and comprising a plurality of stationary nozzles whereby a portion of the pressure of said fluid is converted into velocity and agents whereby the energy due to said velocity is fractionally abstracted without further expansion, and a plurality of rows of moving blades and stationary vanes receiving the fluid from said secondary stage whereby it is fractionally expanded.

30. In an elastic-fluid turbine, a primary stage comprising divergent nozzles whereby a portion of the fluid-pressure is converted into velocity and agents whereby the energy due to said velocity is absorbed without further expansion and converted into rotary motion, a secondary stage receiving the fluid from said primary stage and comprising divergent nozzles whereby a portion of the fluid-pressure is converted into velocity and agents whereby the energy due to said velocity is fractionally abstracted and converted into rotary motion, and instrumentalities receiving the fluid from said secondary stage whereby it is fractionally expanded and converted into rotary motion.

31. In an elastic-fluid turbine, a primary stage comprising divergent nozzles whereby a portion of the fluid-pressure is converted into velocity and a moving row of impulse-blades whereby the energy due to said velocity is absorbed, a secondary stage receiving the fluid from said primary stage and comprising divergent nozzles whereby a portion of the pressure of said fluid is converted into velocity and agents whereby the energy due to said velocity is fractionally abstracted and converted into rotary motion, and instrumentalities receiving the fluid from said secondary stage whereby it is fractionally expanded and converted into rotary motion.

32. In an elastic-fluid turbine, a primary stage comprising a plurality of annularly-disposed nozzles whereby a portion of the fluid-pressure is converted into velocity and agents receiving the fluid from said nozzles whereby the energy due to said velocity is absorbed without further expansion, a secondary stage comprising a plurality of annularly-disposed nozzles whereby a portion of the fluid-pressure is converted into velocity and agents receiving the fluid from said nozzles whereby the energy due to said velocity is fractionally abstracted, and instrumentalities receiving the fluid from said secondary stage whereby it is fractionally expanded and converted into rotary motion by impact and reaction.

33. In an elastic-fluid turbine, a primary stage comprising oppositely-discharging nozzles and agents whereby the energy due to fluid velocity received from said nozzles is absorbed without further expansion and converted into rotary motion, a secondary stage comprising oppositely-discharging nozzles and agents whereby the energy due to fluid velocity received from said nozzles is fractionally abstracted and converted into rotary motion, and a plurality of alternate rows of moving blades and stationary vanes receiving the fluid from said secondary stage whereby it is fractionally expanded and converted into rotary motion.

34. In an elastic-fluid turbine, two primary stages having common oppositely-discharging nozzles, a moving row of impulse-blades in each primary stage whereby the energy due to fluid velocity received from said nozzles is absorbed and converted into rotary motion, two secondary stages each receiving the fluid from one primary stage and comprising nozzles and agents whereby the energy due to fluid velocity received therefrom is fractionally abstracted and converted into rotary motion, and a plurality of alternate rows of moving blades and stationary vanes receiving the fluid from each of said secondary stages whereby it is fractionally expanded and converted into rotary motion.

35. In a double-flow elastic-fluid turbine,

two primary stages each of which comprises nozzles whereby a portion of the fluid-pressure is converted into velocity and agents whereby the energy due to said velocity is absorbed without further expansion, two secondary stages each comprising nozzles whereby a portion of the fluid-pressure is converted into velocity and agents whereby the energy due to said velocity is fractionally abstracted, and two sets of instrumentalities each receiving the fluid from one of said secondary stages whereby it is fractionally expanded and converted into rotary motion.

36. In a double-flow elastic-fluid turbine, a primary stage comprising agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity and absorbed without further expansion, two secondary stages each comprising agents whereby a portion of the thermal energy of the working fluid received from said primary stage is converted into kinetic energy in the form of velocity and fractionally abstracted without further expansion, and two series of alternate rows of stationary vanes and moving blades each of which series receives the fluid from one of said secondary stages whereby said fluid is fractionally expanded and converted into rotary motion.

37. In a double-flow elastic-fluid turbine, a primary stage comprising agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity and absorbed without further expansion, two secondary stages each of which comprises agents whereby a portion of the thermal energy of the working fluid received from said primary stage is converted into kinetic energy in the form of velocity and fractionally abstracted without further expansion, and two series of alternate rows of stationary vanes and moving blades each of which series receives the fluid from one of said secondary stages whereby said fluid is fractionally expanded and converted into rotary motion both in said stationary and moving rows.

38. In an elastic-fluid turbine, a primary stage comprising agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity, absorbed without further expansion and translated into rotary motion, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a portion of the thermal energy of said fluid is converted into kinetic energy in the form of velocity, fractionally abstracted and translated into rotary motion, and instrumentalities receiving the fluid from said secondary stage whereby it is fractionally expanded and converted into rotary motion.

39. In an elastic-fluid turbine, a primary stage comprising agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity, absorbed without further expansion and translated into rotary motion, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a portion of the thermal energy of said fluid is converted into kinetic energy in the form of velocity, fractionally abstracted without further expansion and translated into rotary motion, and a plurality of movable and stationary instrumentalities receiving the fluid from said secondary stage whereby it is fractionally expanded in both said moving and stationary instrumentalities and converted into rotary motion.

40. In an elastic-fluid turbine, a primary stage comprising agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity and a moving row of impulse-blades whereby the energy due to said velocity is absorbed without further expansion and translated into rotary motion, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a portion of the thermal energy of said fluid is converted into kinetic energy in the form of velocity, fractionally abstracted without further expansion and translated into rotary motion, and a plurality of movable and stationary instrumentalities receiving the fluid from said secondary stage whereby it is fractionally expanded in both said moving and stationary instrumentalities and converted into rotary motion.

41. In an elastic-fluid turbine, a primary stage comprising agents whereby a portion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity and a moving row of impluse-blades whereby the energy due to said velocity is absorbed without further expansion and translated into rotary motion, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a portion of the thermal energy of said fluid is converted into kinetic energy in the form of velocity absorbed without further expansion and translated into rotary motion, and a plurality of movable and stationary instrumentalities receiving the fluid from said secondary stage whereby it is fractionally expanded in both said moving and stationary instrumentalities and converted into rotary motion.

42. In an axial-flow elastic-fluid turbine, a primary stage comprising agents whereby a definite proportion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity and absorbed without further expansion, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a definite proportion of the thermal energy of said fluid is converted into kinetic energy in the form of velocity and fractionally abstracted without

further expansion, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said agents is fractionally expanded and converted into rotary motion.

43. In an axial-flow elastic-fluid turbine, a primary stage comprising agents whereby a definite proportion of the thermal energy of the working fluid is converted into kinetic energy in the form of velocity and absorbed without further expansion, a secondary stage receiving the fluid from said primary stage and comprising agents whereby a definite proportion of the thermal energy of said fluid is converted into kinetic energy in the form of velocity and fractionally abstracted, and a plurality of alternate rows of stationary vanes and moving blades whereby the fluid received from said secondary stage is fractionally expanded and converted into rotary motion; said expansions occurring both between the vanes in the stationary rows and the blades in the moving rows.

In testimony whereof I have hereunto subscribed my name this 15th day of June, 1903.

GEO. WESTINGHOUSE.

Witnesses:
WESLEY G. CARR,
BIRNEY HINES.