W. J. A. LONDON.

ELASTIC FLUID TURBINE.

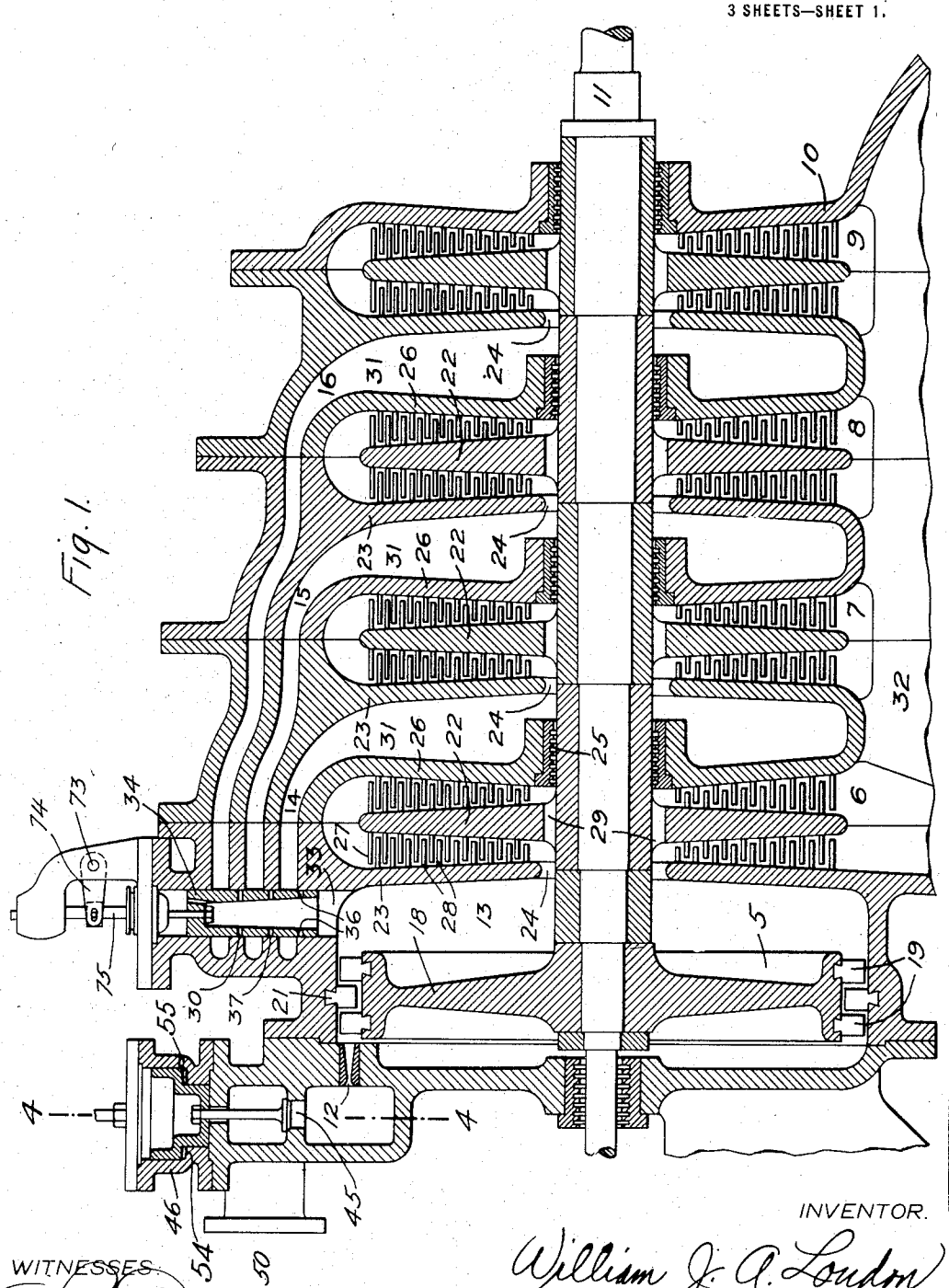
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1,223,342.

Patented Apr. 17, 1917.

3 SHEETS—SHEET 1.

Fig. 1.



INVENTOR.

William J. A. London

BY

Ino. Thorne.

HIS ATTORNEY IN FACT

WITNESSES.

Wm. Fiss.

Ada Romig

W. J. A. LONDON.

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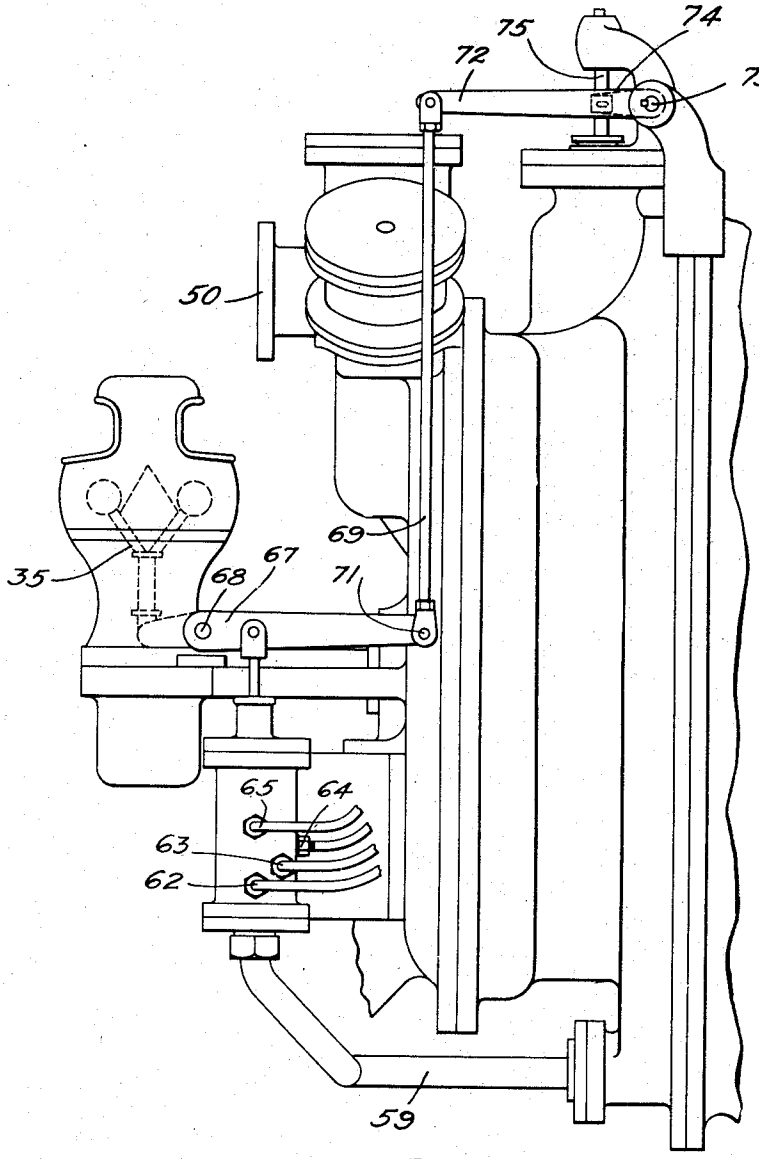


Fig. 2.

INVENTOR.

William J. A. London

BY

HIS ATTORNEY IN FACT

WITNESSES:

D. M. Siro.

Ada Romig

W. J. A. LONDON.

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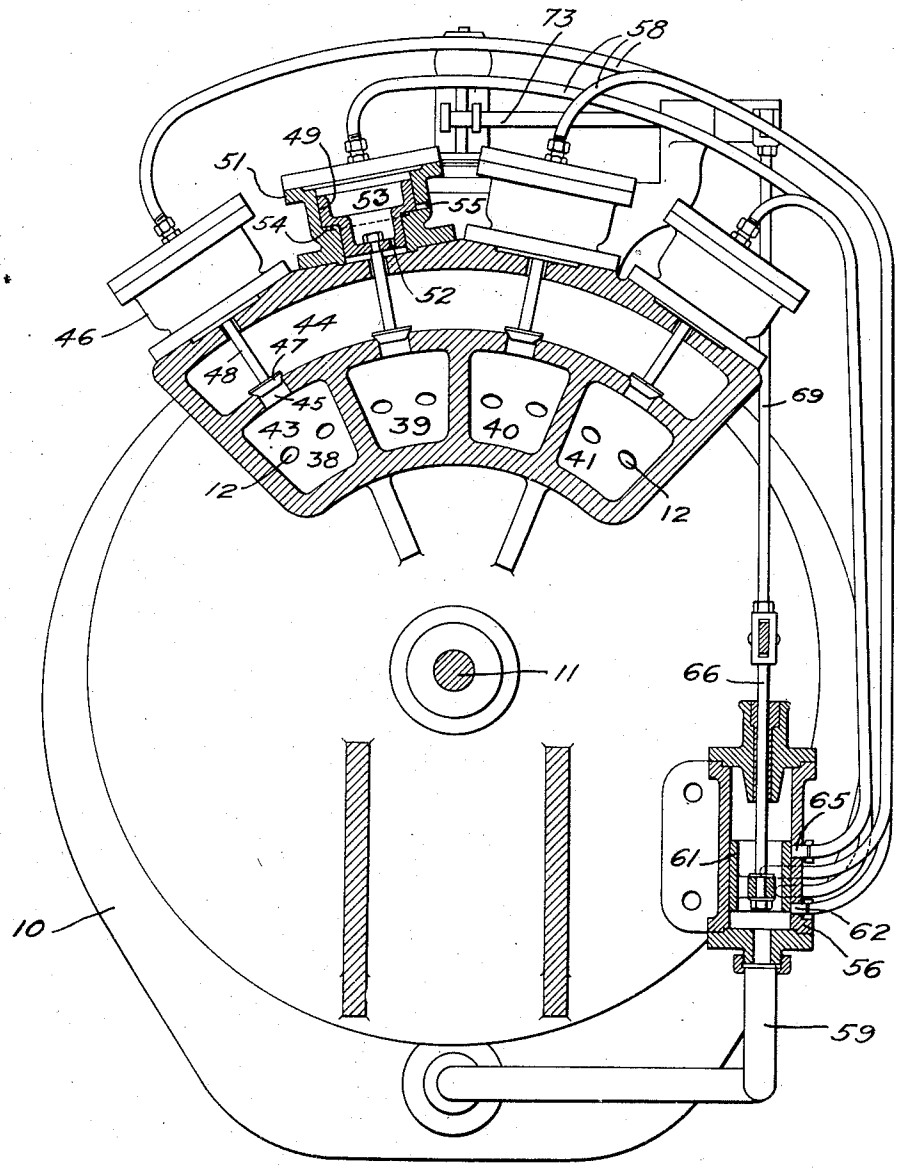


Fig. 3.

INVENTOR.

William J. A. London.

BY

Ino. Schumm.

HIS ATTORNEY IN FACT

WITNESSES:

W. M. Ser Jr.

Ada Romig

UNITED STATES PATENT OFFICE.

WILLIAM JAMES ALBERT LONDON, OF HARTFORD, CONNECTICUT, ASSIGNOR TO THE WESTINGHOUSE MACHINE COMPANY, A CORPORATION OF PENNSYLVANIA.

ELASTIC-FLUID TURBINE.

1,223,342. Specification of Letters Patent. Patented Apr. 17, 1917.

Original application filed April 13, 1906, Serial No. 311,482. Renewed October 30, 1912, Serial No. 728,733. Divided and this application filed March 25, 1913. Serial No. 756,725.

To all whom it may concern:

Be it known that I, WILLIAM JAMES ALBERT LONDON, a subject of the King of Great Britain, residing at 23 Girard avenue, Hartford, Connecticut, United States of America, have made a new and useful Invention in Elastic-Fluid Turbines, of which the following is a specification, this application being a division of an application originally filed by me on April 13, 1906, serially numbered 311,482, renewed October 30, 1912, serially numbered 728,733.

This invention relates to elastic fluid turbines.

The invention, broadly, consists in combining with a primary or initial turbine a plurality of independent turbines, each of which is adapted to operate in series with and receive motive fluid from the primary turbine to which motive fluid is supplied in automatically regulable amounts.

The embodiment of my invention as illustrated in the drawings accompanying this application comprises a turbine provided with an initial or high pressure stage or section to which motive fluid is supplied through governor-controlled nozzles, and a plurality of secondary or low pressure sections, each of which communicates with the initial section and, as illustrated, is adapted to fractionally expand in successive stages, the motive fluid delivered from the initial section and to abstract the available energy due to the said expansion by impulse and reaction. The rotor element of each section is mounted on the turbine shaft and a valve is provided between the initial section and the secondary sections which is employed to vary the number of secondary sections in communication with the high pressure or initial stage or section.

The object of this invention is the production of a turbine that will operate efficiently under a wide range of loads.

A further object is the production of a turbine in which the number of operating low pressure working sections may be varied, as for example, in accordance with the load demand.

A still further object is the production of a turbine in which means are utilized for increasing the effective working passages in accordance with the amount of motive fluid supplied.

These and other objects I attain in a turbine embodying the features herein described and illustrated.

In the drawings accompanying this application and forming a part thereof, Figure 1 is a partial longitudinal section of a turbine embodying my invention;

Fig. 2 is a partial side elevation of the turbine shown in Fig. 1; and

Fig. 3 is a transverse section along the line 4—4 of Fig. 1.

The turbine consists of an initial stage or section 5 and secondary or low pressure sections 6, 7, 8 and 9 inclosed within a stationary casing 10, and adapted to operate in parallel on motive fluid discharged from the initial section 5. The rotor element of each section is located within one of a number of chambers formed within the casing 10 and is rigidly mounted on a shaft 11 which is journaled outside of the casing 10. The initial stage 5 receives motive fluid from a group of fluid delivery nozzles 12 and communicates with a receiving chamber 13. The section 6 communicates directly with the receiving chamber 13 and the sections 7, 8 and 9 communicate therewith through the respective passages 14, 15 and 16, formed within the casing 10.

The initial stage comprises a wheel 18, mounted on the shaft 11 and provided with two rows of peripherally mounted impulse blades 19. A row of stationary directing vanes 21 is mounted on the casing 10 intermediate of the two rows of moving blades 19 and is adapted to receive motive fluid discharged from one row of blades and deliver it to the other row. The motive fluid supply nozzles 12 are arranged at one end of the turbine and supply motive fluid to the initial stage 5 and are arranged to convert a portion of the pressure energy of the motive fluid into kinetic energy in the form of velocity by expanding the fluid from the initial pressure to a predetermined lower pressure and the impulse blades 19 are adapted to convert the fluid velocity into available energy. Throughout this specification and in the appended claims I have used the term "stage" to mean a working

section of a turbine in which the motive fluid is expanded or reduced in pressure and in which approximately all of the velocity or kinetic energy occasioned by the expansion is abstracted. The initial section of the turbine is illustrated as including a single stage, which as described includes expansion nozzles, and two rows of moving blades. Each of the independent full peripheral admission turbine elements or sections 6, 7, 8 and 9 includes a plurality of stages, but each stage includes but one row of moving blades whether the section is of the impulse and reaction or some other type. The motive fluid discharged from the initial stage enters the receiving chamber 13, which is formed within the casing between the initial stage and an inclosing wall of the section 6. The section 6 and each of the sections 7, 8 and 9 comprise a rotor element 22, rigidly mounted on the shaft 11 and inclosed within a chamber formed within the casing 10. A wall 23 of the section casing or chamber extends inwardly toward the shaft 11 and a port 24 is maintained around the shaft and between it and the inner periphery of the wall. A packing 25, which consists of interleaving grooves and ridges formed on the shaft and stationary casing, seals the joint between the shaft and a wall 26 of the section casing.

Each rotor 22 is provided on both sides with rows of suitably mounted radially-arranged blades 27 alternately arranged with annular rows of stationary directing vanes 28, suitably mounted on the walls 23 and 26 of the casing. The alternate rows of blades and vanes receive motive fluid from the port 24 and communication is provided between each side of the rotor by a series of openings 29 arranged at the base of the rotor 22, adjacent to the shaft of the turbine. The port 24 of the section 6 communicates directly with the receiving chamber 13 while each port of the sections 7, 8 and 9 communicate with an annular chamber 31, formed between the rear wall 26 of one section casing and the forward wall 23 of an adjacent section. Each section 6, 7, 8 and 9 communicates with a common exhaust passage 32, which is formed within the casing 10 and communicates with the exhaust port (not shown).

The chamber 31 of the respective sections 7, 8 and 9 communicates with a valve chamber 33 through the corresponding passages 14, 15 and 16. The valve chamber 33 communicates with the receiving chamber 13 and is provided with a piston valve 34, which is actuated by a governor 35, with which the turbine is provided. Ports 36, 37 and 30 are arranged in the piston valve 34 and are adapted to communicate with the respective passages 14, 15 and 16 for certain positions of the piston valve and to admit motive fluid from the receiving chamber 13 to the corresponding section. The piston valve is adapted to open the passages 14, 15 and 16 successively and to admit motive fluid to the secondary sections in accordance with the load demand of the turbine.

As illustrated the nozzles 12 are divided into groups 38, 39, 40 and 41 of a suitable number each and each group is inclosed within a chamber 43, which communicates with a motive fluid supply passage 44 through a port 45. The motive fluid supply passage 44 communicates with a motive fluid inlet port 50, formed in the casing 10. A valve mechanism 46, adapted to regulate the flow of motive fluid through the port 45, comprises a valve disk 47, mounted on a valve stem 48, which is connected to a differential piston 49 of the valve-operating mechanism. The piston 49 is located in the cylinder 51, which is bored to two diameters to correspond to the different diameters of the piston 49. A restricted port 52 extends through the piston 49 and admits motive fluid to a chamber 53 above the piston, and the lower and smaller face of the piston is exposed to the fluid pressure of the supply passage 44. An annular chamber 54 is formed in the casing of the cylinder 51 adjacent to the shoulder formed by the different diameters of the differential piston 49 and communicates with the atmosphere through a port 55. Under such conditions the disk 47 is normally held to its seat on the walls of the port 45 by the fluid pressure in the chamber 53, which acts above the piston 49 in opposition to the fluid pressure of the passage 44 on the lower face of the piston. The annular chamber 54 together with its port 55 operates as a dash pot and exerts a controlling effect on the piston 49.

The top portion of the chamber 53 communicates with a cylinder 56 of a governor-controlled relay device through a tube 58. The cylinder 56 communicates with the exhaust passage 32 through a pipe or passage 59 and is provided with a governor-operated piston 61, which is adapted to open and close ports 62, 63, 64 and 65 to the exhaust pipe 59. The valve chamber 53 of the valve-operating mechanism of each of the groups 38, 39, 40 and 41 respectively communicate with the ports 62, 63, 64 and 65 through the separate tubes or passages 58. The piston 61 is provided with a piston rod 66, which extends through a suitable gland in the end wall of the cylinder 56 and connects with a lever 67 which is fulcrumed at 68 on the casing 10 of the turbine and which is attached to a governor-actuated sleeve on the governor standard.

A link 69 is attached to the lever 67 at 71 and to a lever 72 fulcrumed on a rod 73 which is journaled in suitable brackets formed integrally with the casing 10. A lever 74 is rigidly mounted on the rod 73

and operates the piston valve 34 through a valve stem 75.

The governor 35, the controlling valves of the nozzle groups 38, 39, 40 and 41 and the piston valve 34 are so arranged, in the illustrated embodiment of my invention, that the number of nozzle groups effective in delivering motive fluid to the turbine and the number of secondary sections communicating with the receiving chamber 13 of the turbine is varied in accordance with the load demand or the speed of the turbine.

During the normal operation of the turbine, the nozzle-controlling relay device is so arranged that the port 62, which extends through the casing of the cylinder 56 and which communicates with the chamber 53 of the valve-controlling mechanism of the groups 39 is opened to the exhaust. The port 52, through which steam is admitted to the chamber 53 from the fluid supply passage 44 is of such size, relative to the exhaust port 62, that the flow of motive fluid through the chamber will be unrestricted and the pressure will consequently drop and permit the valve disk 47 to be raised by the fluid pressure on the under side of the piston 49, thereby admitting steam to the turbine through the nozzles of the group 38. As the load increases and the speed of the turbine decreases, the governor 35 will move the piston 61 to such a position that the port 63 will also communicate with the exhaust and the controlling mechanism of the nozzles of the group 39 will raise the valve disk 47 and admit motive fluid to the turbine through the nozzles of the group 39. The piston valve 34 and its operating links and levers are so arranged that the passage 14 will communicate with the receiving chamber 13 and admit motive fluid to the secondary section 7 when the nozzles of the group 39 are admitting motive fluid to the turbine. As the turbine continues to decrease in speed, the nozzle groups 40 and 41 are successively opened to the motive fluid supply passage 44 and the ports 37 and 38 of the piston valve 34 successively open the passages 15 and 16 respectively and admit motive fluid from the receiving chamber 13 to the corresponding secondary sections. Finally at a predetermined reduction in speed of the turbine, all the nozzles are open and supplying motive fluid to the turbine and all the secondary sections are in communication with the receiving chamber and operating under full pressure.

The ports 24 of the secondary sections are of such a size that each will effectively convey the expanded motive fluid admitted to the turbine by one group of nozzles and since an additional section is rendered effective as a working agent of the turbine as each group of nozzles is opened, it is apparent that the turbine will have a wide range of efficient operation. Each secondary section is directly connected to the exhaust passage 32 and will, therefore, add substantially no resistance while running idle, as the rotor element will be revolving in a vacuum.

A number of separate valves, either directly operated by the governor or an auxiliary relay device, may be substituted for the piston valve 34 and various methods may be utilized for controlling the valves of the separate nozzle groups and, while I have illustrated my invention as embodied in a turbine utilizing an impulse section as an initial stage and a plurality of secondary sections in which the motive fluid is fractionally expanded throughout a number of alternate rows of moving blades and stationary vanes, I wish it to be specifically understood that I do not limit myself to the arrangement shown and described, and that any type, or any combination of types, may be utilized and still fall within the spirit and scope of my invention.

What I claim as new and useful and desire to secure by Letters Patent is:

1. In combination in a turbine, an initial stage comprising at least one row of impulse blades, and a plurality of nozzles for delivering steam to said blades, less than the entire number of nozzles at times delivering steam to said blades, and a plurality of full annular admission low pressure sections adapted to operate in parallel on steam discharged from the initial stage and each comprising a plurality of working stages having a single row of moving blades per stage, said initial stage at times delivering steam to less than the whole number of low pressure sections.

2. A turbine having a high pressure section comprising a multiple drop impulse stage, expansion nozzles for delivering motive fluid to said stage, and at least three independent full annular admission low pressure turbine elements adapted to operate on the same terminal pressure and in parallel on fluid discharged from the impulse stage, said impulse stage at times delivering motive fluid to less than the whole number of said low pressure turbine elements.

3. In combination a high pressure live steam turbine and an exhaust steam turbine divided into at least three separate parts, and each of said parts receiving steam direct from said first mentioned turbine, said high pressure turbine at times discharging into less than the whole number of parts of the exhaust steam turbine, and that part or those parts into which the high pressure turbine exhausts being designed to accommodate the steam entering from the high pressure turbine.

4. In combination a high pressure live

steam turbine and an exhaust steam turbine divided into at least three parts operating separately and supplied with exhaust steam direct from said first mentioned turbine, said live steam turbine at times discharging into less than the whole number of parts of said exhaust steam turbine, and that part or parts into which the live steam turbine exhausts being designed to accommodate the steam from the live steam turbine.

5. In combination a high pressure live steam turbine, and an exhaust steam turbine divided into more than two parts, a single casing for both of said turbines, means controlling communication between all of the several parts of the exhaust steam turbine and the live steam turbine, said live steam turbine at times discharging into less than the whole number of parts of the exhaust steam turbine, and that part or those parts of the exhaust steam turbine into which the live steam turbine discharges being designed to accommodate the steam entering from said live steam turbine.

6. A turbine comprising a high pressure impulse section, and at least three annular admission low pressure sections, adapted to operate in parallel on motive fluid discharged from the high pressure section, and in which a single row of moving blades is employed in each stage.

7. A turbine comprising a high pressure turbine element and a divided low pressure turbine element having at least three sections designed to operate at the same terminal pressure and to receive motive fluid exhausted from said high pressure section, said high pressure section at times discharging into less than the whole number of low pressure sections.

8. In combination a high pressure live steam turbine, three or more exhaust steam turbines, said high pressure turbine at times discharging into less than the whole number of said exhaust steam turbines, and that exhaust steam turbine or those exhaust steam turbines into which the high pressure turbine exhausts being designed to accommodate the steam entering from the high pressure turbine.

9. A power developing apparatus comprising an impulse turbine section having a plurality of nozzles for delivering motive fluid thereto, a plurality of full annular admission low pressure turbine sections operating in parallel on the fluid discharged from said impulse section, each of the low pressure sections having substantially the same range of expansion and comprising a plurality of working stages having a single row of moving blades to each stage, the number of low pressure sections being proportional to the number of fluid delivery nozzles of the impulse section, means for cutting off the supply of motive fluid to one or more of said nozzles and means for shutting off communication between one or more of said low pressure sections and the impulse section.

10. In an organized turbine apparatus, a turbine element adapted to partially expand the motive fluid delivered to it, a divided flow low pressure turbine element communicating directly with the first mentioned turbine element and comprising at least three separate sections, each of which communicates directly with the exhaust of the organized apparatus and is provided with a separate set of rotating blades, and means communicating with the exhaust of said first mentioned element for delivering separate streams of fluid to said divided flow turbine element.

11. In combination in an organized turbine unit, an initial turbine section, comprising at least one row of blades and a plurality of nozzles for delivering motive fluid from the same source of fluid supply to the initial row of blades of said section, means for cutting off communication between one or more of said nozzles and the source of fluid supply, a plurality of full annular admission low pressure turbine sections operating in parallel on fluid discharged from the initial section, each low pressure section having substantially the same range of expansion and expanding the fluid traversing it to exhaust pressure, and comprising a plurality of working stages having a single row of moving blades to each stage, and means for cutting off communication between one or more of the low pressure sections and the initial section.

12. In an organized turbine apparatus, a high pressure turbine element adapted to partially expand motive fluid delivered thereto, at least three low pressure turbine sections operating in parallel on fluid discharged from the high pressure turbine element and having substantially the same range of expansion and expanding the fluid to final or exhaust pressure, and means for dividing fluid discharged from the high pressure element into at least two streams and for delivering it to the low pressure sections.

In testimony whereof, I have hereunto subscribed my name this 19th day of March, 1913.

WILLIAM JAMES ALBERT LONDON.

Witnesses:
ROBERT C. ALLEN,
T. B. BOWNE.