R. F. HALLIWELL.

ELASTIC FLUID TURBINE.

APPLICATION FILED NOV. 25, 1907.

963,142.

Patented July 5, 1910.

3 SHEETS—SHEET 1.

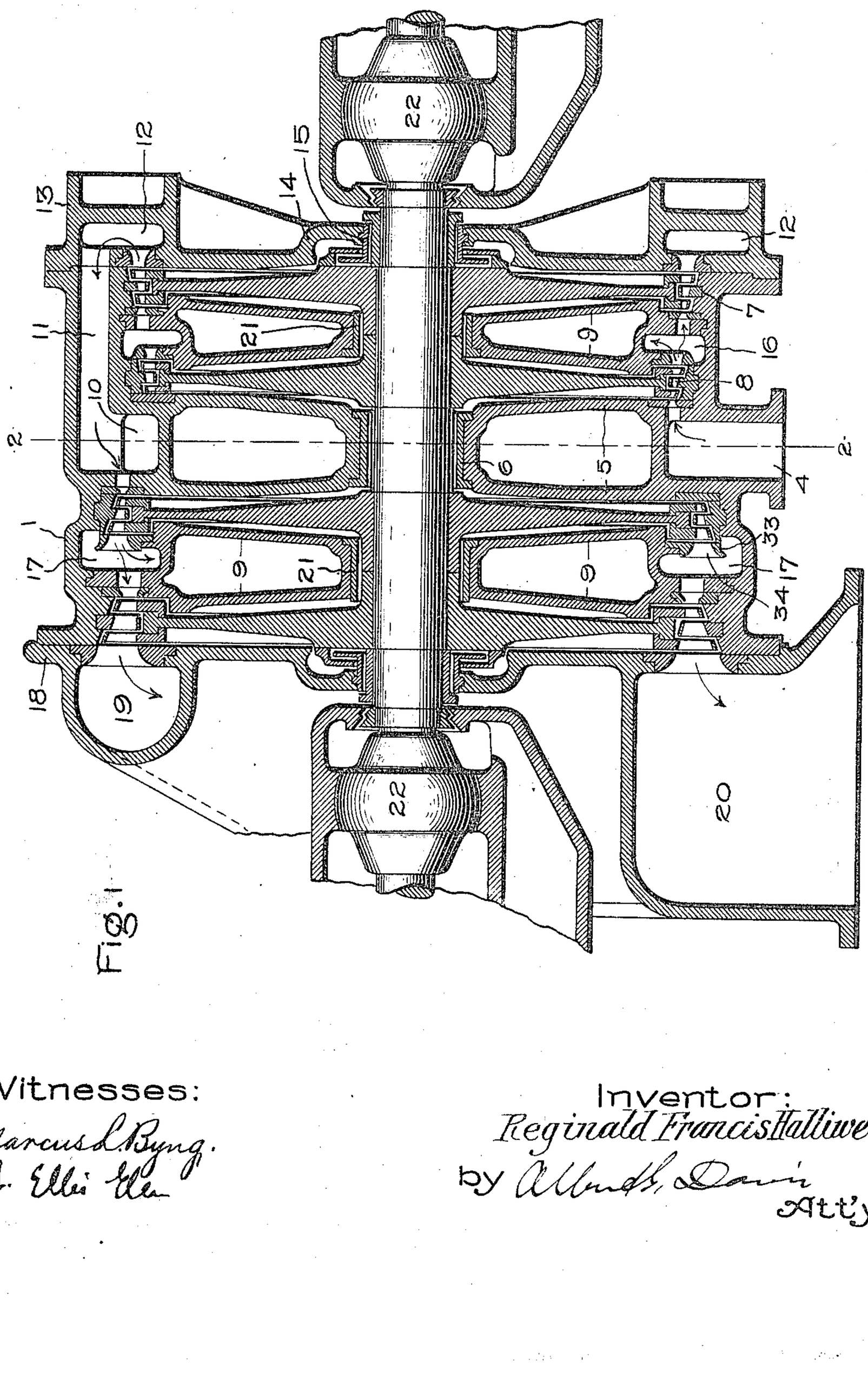

Fig. 1.

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Fig. 4.

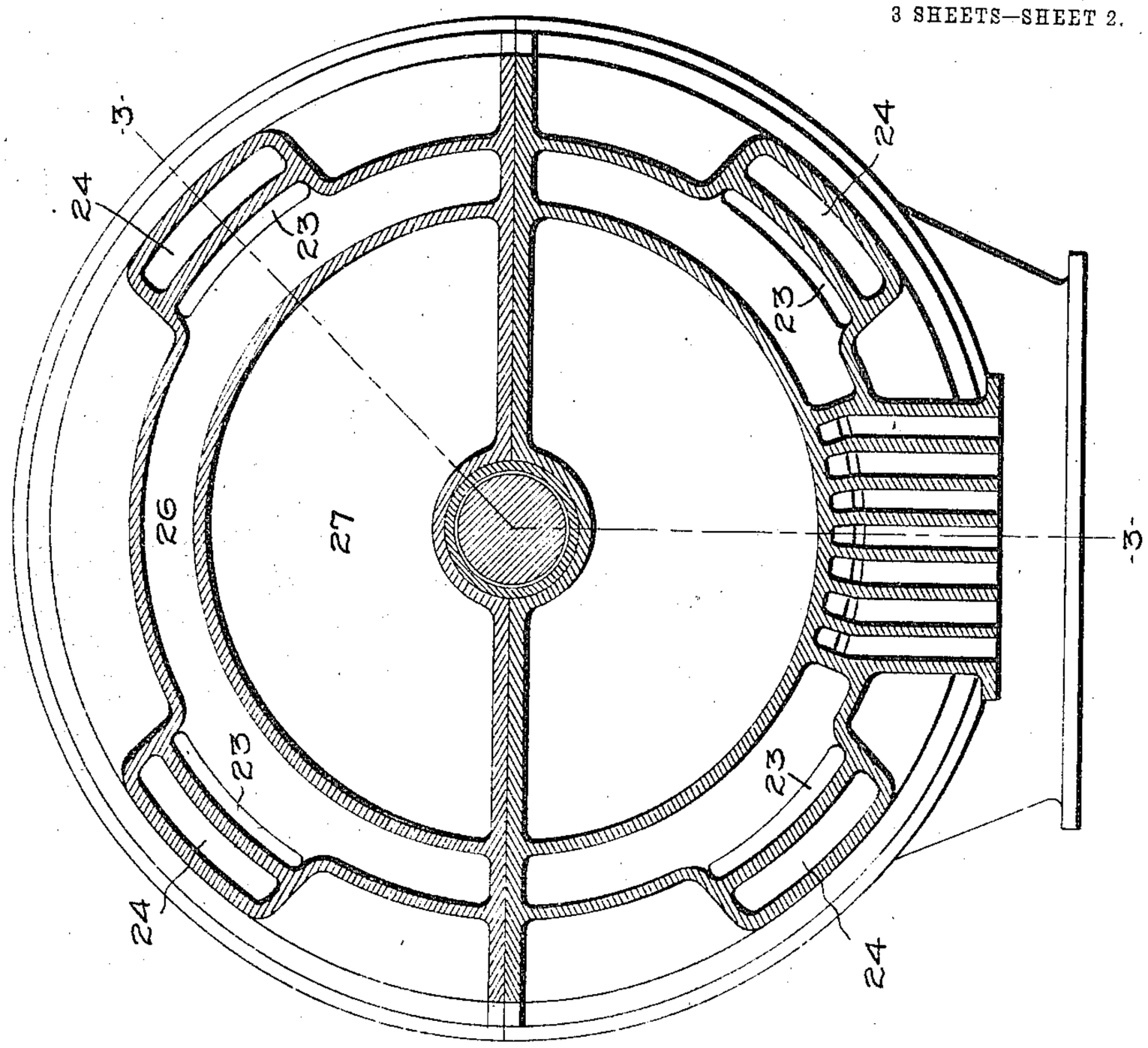
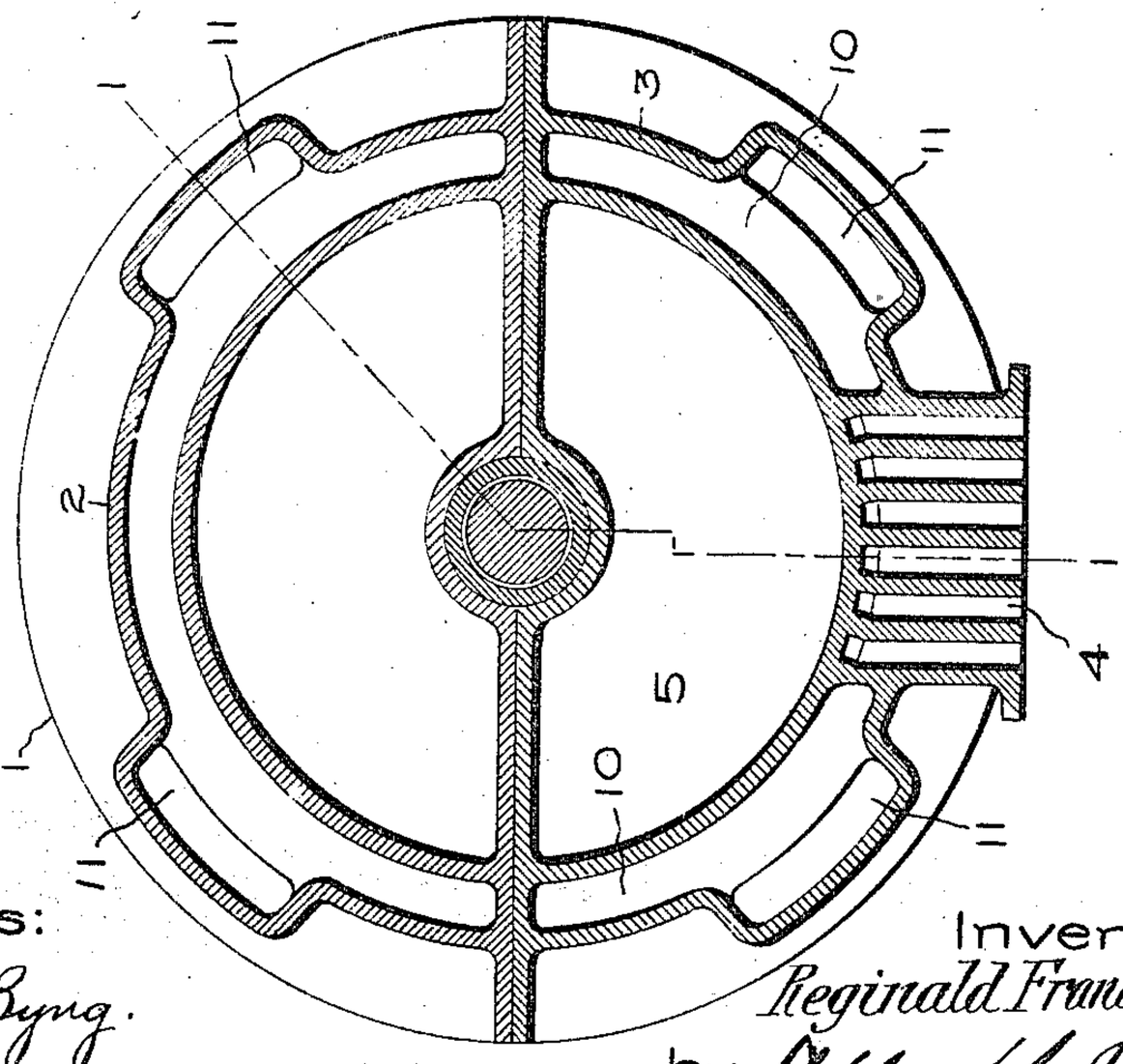


Fig. 2.



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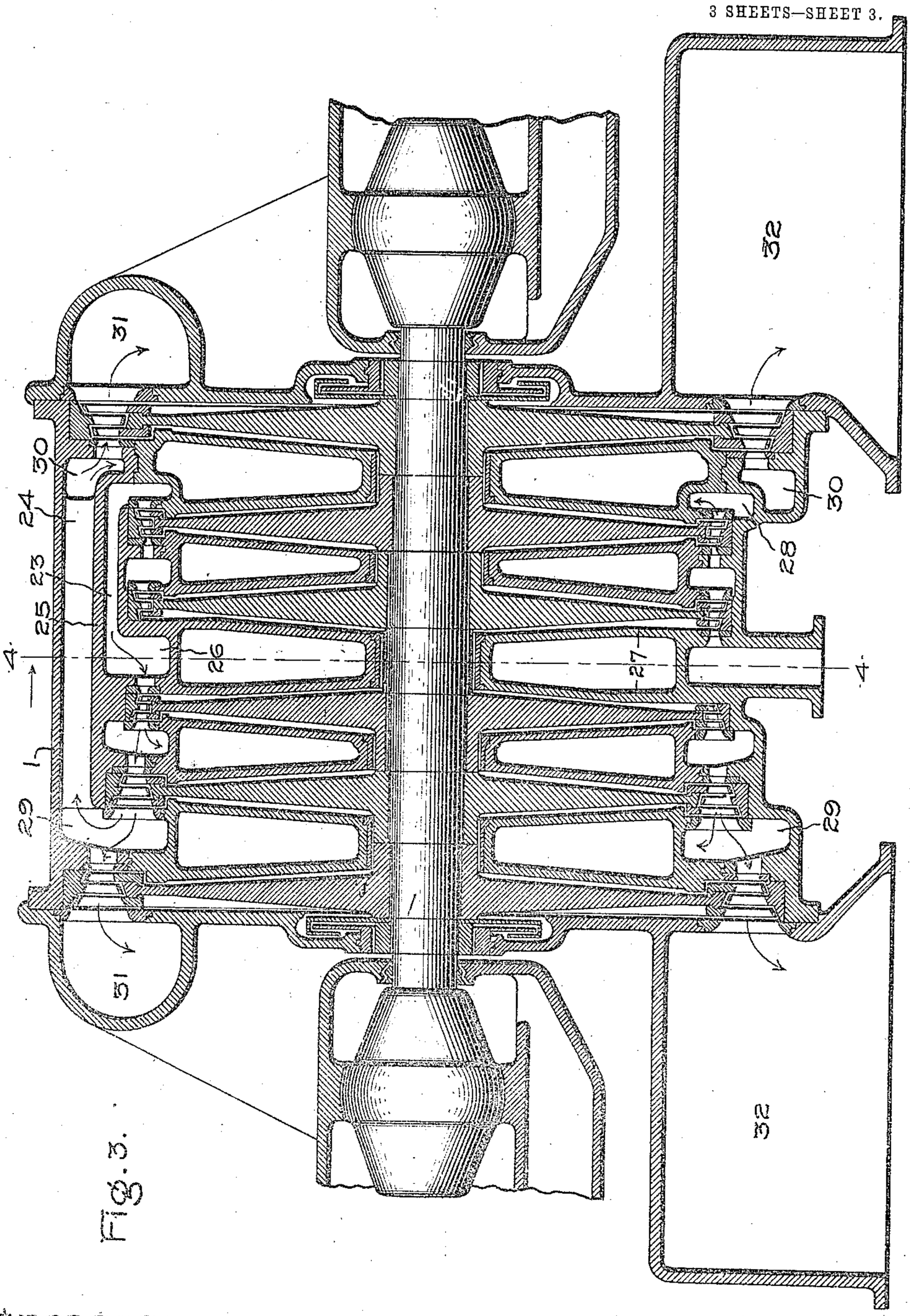

Fig. 3.

Witnesses:

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UNITED STATES PATENT OFFICE.

REGINALD FRANCIS HALLIWELL, OF RUGBY, ENGLAND, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELASTIC-FLUID TURBINE.

963,142. Specification of Letters Patent. Patented July 5, 1910.

Application filed November 25, 1907. Serial No. 403,637.

To all whom it may concern:

Be it known that I, REGINALD FRANCIS HALLIWELL, a subject of the King of Great Britain, residing at 36 Newbold road, Rugby, in the county of Warwick, England, have invented certain new and useful Improvements in Elastic-Fluid Turbines, of which the following is a specification.

The present invention relates to improvements in multi-stage elastic fluid turbines of the type in which the motive fluid flows through parts of the turbine in opposite directions for the purpose of balancing the end thrust.

The object of my invention is to provide an improved elastic fluid turbine having a casing provided with ports and passages for conducting the motive fluid in the required directions for the purpose of balancing the end thrust, and also permitting of the convenient splitting up of the low pressure stage into sections so as to obviate the use of abnormally long buckets in turbines of large power.

A further object of the invention is to permit of the high temperature steam being kept as far as possible from the bearings and also to do away with the necessity for high pressure shaft packings.

In carrying out my invention, the motive fluid is preferably admitted to the turbine nozzles at the center of the machine and from below, whence it passes through the first two stages in one direction into what I term an annular collection chamber within the casing, then by means of conduits parallel to the shaft into what I term an intermediate annular chamber, and thence through the third or intermediate pressure stage and the fourth or low pressure stage in the opposite direction to the flow through the first two stages. In the case of a five stage turbine after leaving the fourth, or what is then the intermediate pressure stage, the fluid enters what I term an annular collection chamber communicating with a similar chamber at the other end of the turbine by means of longitudinal conduits, and from these two chambers the fluid passes through the two wheels of the low pressure stage in multiple with respect to the source of supply, which wheels are arranged one at each end of the turbine. By disposing the low pressure stage in two portions the buckets are kept at a reasonable length even in turbines of very large power.

In the accompanying drawings which are illustrative of the invention, Figure 1 is a longitudinal section of a four stage horizontal turbine taken on line 1—1 of Fig. 2; Fig. 2 is a cross-section on line 2—2 of Fig. 1; Fig. 3 is a longitudinal section of a five stage turbine taken on line 3—3 of Fig. 4; and Fig. 4 is a cross section taken on line 4—4 of Fig. 3.

Referring to Figs. 1 and 2 of the drawings the outer shell or casing 1 comprises two approximately semi-cylindrical portions 2 and 3 which when assembled constitute the turbine body. This casing is provided at its center with nozzle passages 4 forming a steam inlet and a central double walled diaphragm 5 which is adapted to carry a packing 6 for the turbine shaft, and on each side of the central diaphragm flutings 7 are provided on the internal face of the casing for securing the stationary bucket segments 8 and also double walled or hollow diaphragms 9 arranged between the first and second and second and third stage bucket wheels respectively. Within the central double walled diaphragm 5 an intermediate steam chamber 10 is formed, which, when the two halves of the casing are assembled, extends as far around the turbine body as the steam inlet will allow as shown in Fig. 2. This chamber is not in direct communication with the steam inlet, but by means of longitudinal passages or conduits 11 formed in both halves of the casing it communicates with the annular collection chamber 12 formed in the right hand end cover 13 of the turbine. This end cover comprises a casting formed with the annular steam chamber 12 therein and also with dished parts 14 to accommodate shaft packings 15 surrounding the turbine shaft.

The diaphragm 9 between the first and second stages is double walled and in cross section increases in width toward its periphery. The flutings in the periphery of this diaphragm together with flutings in the internal face of the main casing, form an equalizing steam chamber 16 into which the steam from the first stage passes where it is equalized and distributed for doing work in the second stage.

The third and fourth stages are located on

the opposite side of the middle or main diaphragm and are separated by a double-walled diaphragm 9 similar to that between the first and second stages and likewise forming, together with the main casing, an annular equalizing steam chamber 17 through which the steam passes on its way to the fourth stage. An end cover 18 is also provided for this end of the turbine having a steam passage 19 communicating with the exhaust conduit 20 leading to a condenser or to the atmosphere. The two outer diaphragms surround the hubs of the bucket wheels with suitable packing 21 interposed.

The steam from the second stage of the turbine passes into the annular collection chamber 12 and from thence flows in the reverse direction through longitudinal passages 11, of which four are shown, into the annular intermediate steam chamber 10 and then through the nozzles supplying the third stage. From the third stage the steam passes into annular equalizing chamber 17 and through the fourth stage to the condenser or other exhaust 20.

In order to guide and direct the steam leaving the wheels and also to form parts of the chambers, rings 33 are provided which have properly shaped vanes or blades 34 separated by passages through which the steam passes. These vanes also prevent the steam from reacting on the wheels.

The two halves of the casing may be bolted or otherwise secured together and for that purpose the castings are provided with longitudinal and semi-circular flanges; the latter for securing the end covers. In this construction the turbine shaft is journaled in suitable bearings 22 located outside the turbine body.

In a modified construction Figs. 3 and 4 such as may be used for a five stage turbine the main body casing 1 is provided with four or more sets of two steam passages 23 and 24 respectively separated by a wall 25 these passages being parallel with each other and the turbine shaft. The shorter passage 23 of the groups communicates with the intermediate steam chamber 26 partially surrounding the main diaphragm 27 and with an annular collection chamber 28 formed by flutings in the body casing and diaphragm separating the second and the one portion of the fifth stage. The steam from the fourth stage passes into the collection chamber 29 then divides, one portion passing directly through the adjacent wheel of the fifth stage while the other portion of the fluid flows through the longer longitudinal passages 24 to the other end of the turbine into an annular chamber 30 formed in the main casing from which it passes through the other wheel of the fifth stage. The fluid from both sections of the final stage passes into passages or ducts 31 formed in the end covers leading to the condenser or other exhausts 32. Both end covers in this modification are constructed with passages leading the steam from the respective halves of the low pressure stage to the condenser or other exhaust and also with means as already described with reference to Figs. 1 and 2, for accommodating shaft packing about the turbine shaft.

Obviously the number of stages employed may be varied without departing from the spirit of the invention. For an increase in the number of stages there will be a modification of the main body portion to allow a corresponding increase in the number of annular chambers formed in conjunction with the diaphragm.

The initial and stage nozzles convert the pressure of the motive fluid into velocity and discharge the same at the proper angle against the wheel buckets. These nozzles can be arranged to have the same or different pressure drops and the stages may perform equal or unequal amounts of work.

From the foregoing it will be seen that the turbine can be balanced as to end thrust whatever its cause. There are no steam or exhaust connections to be broken when it becomes desirable or necessary to take down the turbine, and this is an important feature because it saves much time and labor. By admitting steam to the turbine from the under side, the use of overhead piping is obviated, and the appearance of the machine improved. Since the high pressure stage is in the middle of the turbine it follows that the leakage therefrom cannot escape to atmosphere but must pass to the other stages where it will do useful work. The packings at the ends of the shaft where it passes through the casing pack against low pressure differences and hence are more easily maintained in effective condition.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. In an elastic-fluid turbine, the combination of a casing, a plurality of diaphragms dividing the casing into compartments, bucket wheels in the compartments some of which receive motive fluid from one direction and the remainder from the opposite direction, nozzles converting the pressure of the motive fluid into velocity and located midway of the casing and initially admitting it to the turbine, and a conduit that receives the exhaust from certain of the

wheels and conveys it past said devices and in a direction contra to the flow therefrom and discharges it to the remaining stages, the said stages serially receiving motive fluid.

2. In an elastic-fluid turbine, the combination of a casing, wheel buckets therein arranged to abstract the velocity of the motive fluid by successive stages, the motive fluid passing through the stages in series, devices arranged midway of the ends of the casing which initially admit fluid at high velocity to the machine, other fluid-discharging devices between the stages which convert pressure into velocity, an annular collection chamber that receives fluid from certain of the wheels, diaphragms between the stages, and a passage arranged outside of the wheels that conveys fluid from the chamber past the wheels it has acted upon and discharges it to a stage of lower pressure located adjacent the admission devices.

3. In an elastic fluid turbine, the combination of a casing, a main diaphragm located intermediate the ends of the casing and containing a substantially annular intermediate chamber adjacent its periphery that is cut off from the high-pressure supply and a passage for said high-pressure supply, wheel buckets, diaphragms between the stages, means arranged in the diaphragms adjacent their peripheries for directing the flow of fluid from one stage to the next, a collection chamber receiving the exhaust from certain of the buckets, passages conveying the fluid from the collection chamber past the buckets on which it has acted to the intermediate chamber, and devices receiving fluid from the intermediate chamber and discharging it against the wheels on one side of the main diaphragm.

4. In an elastic fluid turbine, the combination of a casing, fluid-discharging devices, a centrally located diaphragm, bucket wheels arranged in sets on opposite sides thereof, other diaphragms between the wheels, equalizing chambers formed between the periphery of each of said diaphragms and the casing through which fluid flows from one stage to the next, and a conduit that receives the fluid exhausting from the set of wheels on one side of the main diaphragm and conveys it past the wheels it has acted on and also the interposed diaphragms and discharges it against the set of wheel buckets on the other side of the main diaphragm.

5. In an elastic-fluid turbine, the combination of a casing divided auxiliary into two principal parts, a centrally located diaphragm that is cast integral with the casing and is provided with passages, other diaphragms on opposite sides thereof which are independent of the casing, bucket wheels, nozzles receiving high-pressure fluid from the passages in the main diaphragm, a collection chamber that receives the exhaust from the bucket wheels on one side of the main diaphragm, and a conduit that receives fluid from the chamber, conveys it past the wheels and detachable diaphragm on one side of the main diaphragm and discharges it against the wheels on the opposite side of the main diaphragm.

6. In an elastic-fluid turbine, the combination of a high-pressure stage, an intermediate pressure stage, a divided low-pressure stage, one portion of which is located on one side of the high-pressure stage and the other on the opposite, and means for conveying motive fluid in multiple to the portions of the low-pressure stage after it has passed through the intermediate pressure stage.

7. In an elastic-fluid turbine, the combination of a casing, a high-pressure stage located midway between the ends thereof, an intermediate pressure stage located on one side thereof, a second intermediate stage of lower pressure than the first and receiving fluid therefrom and located on the opposite side of the high pressure stage, and a divided low-pressure stage, the wheels of which receive motive fluid in multiple.

8. In an elastic-fluid turbine, the combination of a casing, a high-pressure stage located centrally of the casing, intermediate pressure stages located on opposite sides thereof, diaphragms between the stages, and a divided low-pressure stage, one part of which is located at one end of the machine and the other at the opposite, and means for supplying motive fluid to the parts of the low-pressure stage in multiple.

9. In an elastic-fluid turbine, the combination of a casing, a high-pressure stage located midway between the ends, stages of lower pressure located on opposite sides of the high-pressure stage and receiving motive fluid therefrom in series, the fluid acting first on one side and then on the other of said stage, and a divided low-pressure stage one part of which is located at one end of the casing and the other at the opposite, the said parts receiving motive fluid in multiple.

10. In an elastic fluid turbine, the combination of a casing, a high-pressure stage located mid-way the ends thereof, a diaphragm separating the high-pressure stage from the next stage, an equalizing chamber formed between the rim of the diaphragm and the casing that receives the exhaust from the high-pressure stage, a stage located at one side of the high-pressure stage and receiving fluid from said chamber, a collection chamber, an intermediate chamber receiving fluid therefrom, a stage located on the opposite side of the high-pressure stage and receiving fluid from the intermediate chamber, a diaphragm between said stage and the next, an equalizing chamber formed between the rim of said diaphragm and the

casing, a stage receiving fluid therefrom, and an exhaust conduit.

11. In an elastic-fluid turbine, the combination of a casing, a main diaphragm that divides the casing and is provided with an intermediate chamber which substantially surrounds it and also with inlet passages leading to the high-pressure nozzles, the said chamber containing motive fluid at an intermediate pressure, other diaphragms which coöperate with the casing to form equalizing chambers, an end head for the casing having a collection chamber, bucket wheels for the compartments, admission and stage nozzles for supplying motive fluid to the buckets, and a conduit which connects the collection and intermediate chambers.

12. In an elastic-fluid turbine, the combination of stages wherein the fluid flows axially in one direction, a collection chamber receiving the fluid, an intermediate chamber communicating therewith, stages receiving fluid from the intermediate chamber and through which the fluid flows in the opposite direction to that in the first-mentioned stages, a pair of collection chambers which receive motive fluid in multiple from the last-mentioned stages, and a divided low-pressure stage through the parts of which the fluid flows in opposite directions from the said pair of chambers.

13. In a steam turbine, the combination of a casing, a centrally located main diaphragm in said casing which is provided with live steam inlet passages in its lower portion leading to high pressure nozzles at one side of the diaphragm, and is also provided with a steam chamber in the other portion thereof that supplies steam to intermediate nozzles at the opposite side of the diaphragm, a high pressure stage on one side of the main diaphragm receiving steam through said high pressure nozzles, an intermediate stage beyond the high pressure stage on the same side of said diaphragm and through which the steam flows in the same direction, other intermediate or lower pressure stages arranged on the opposite side of the main diaphragm through which steam from said intermediate nozzles flows in a direction opposite to that of the flow through said high and intermediate stages, and means conveying steam discharged from the first mentioned intermediate stage to said chamber.

In witness whereof, I have hereunto set my hand this seventh day of November, 1907.

REGINALD FRANCIS HALLIWELL.

Witnesses:
CHARLES H. FULLER,
J. A. FOSTER.