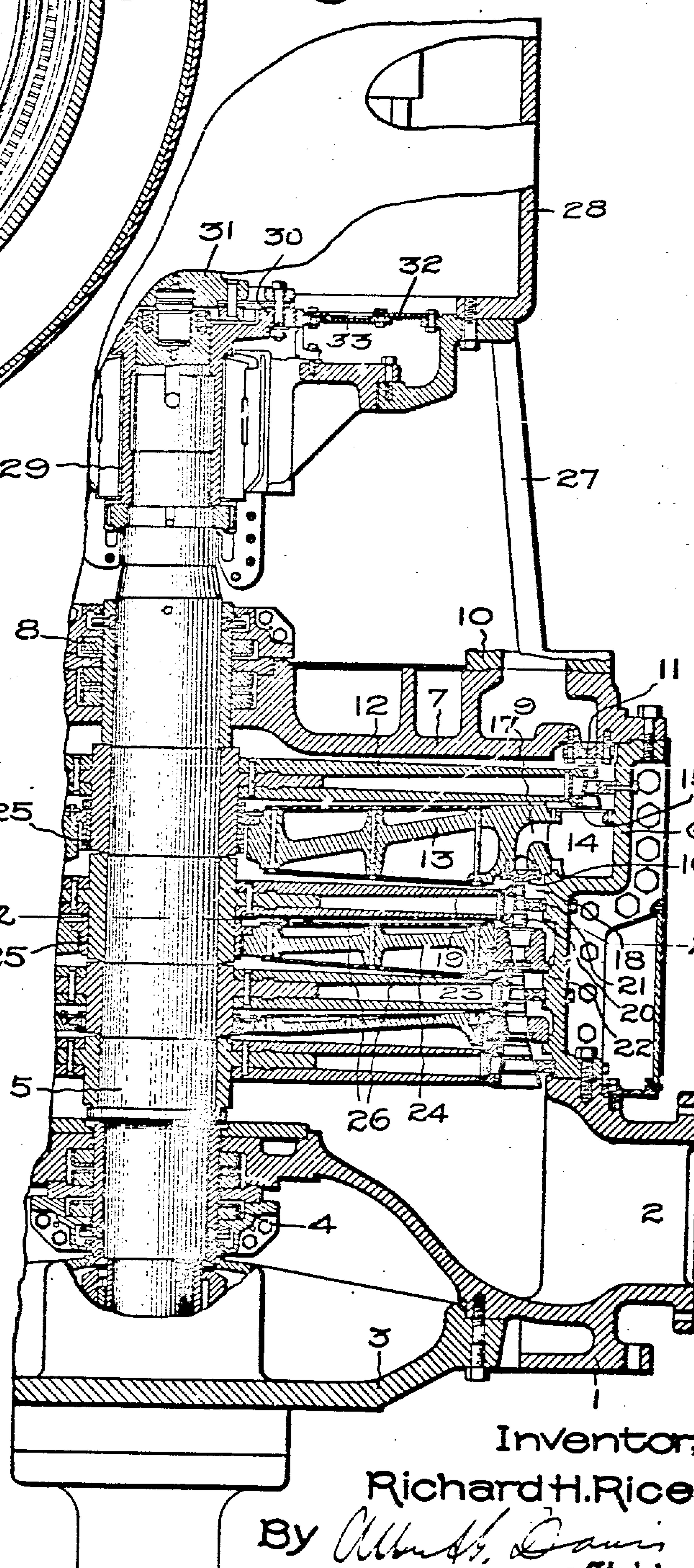
R. H. RICE.
ELASTIC FLUID TURBINE.
APPLICATION FILED FEB. 10, 1908.

963,178. Patented July 5, 1910.

Fig. 1.



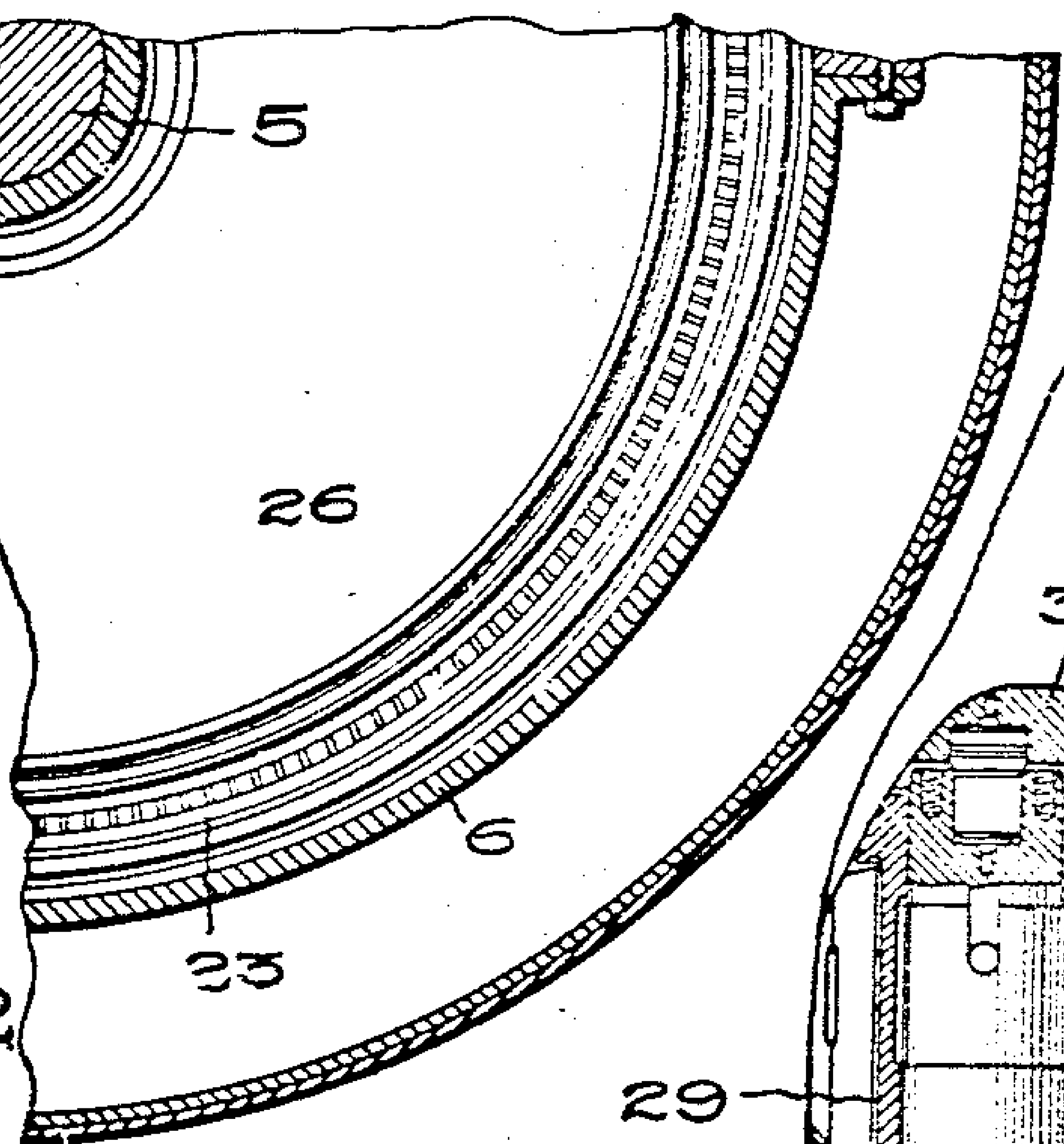
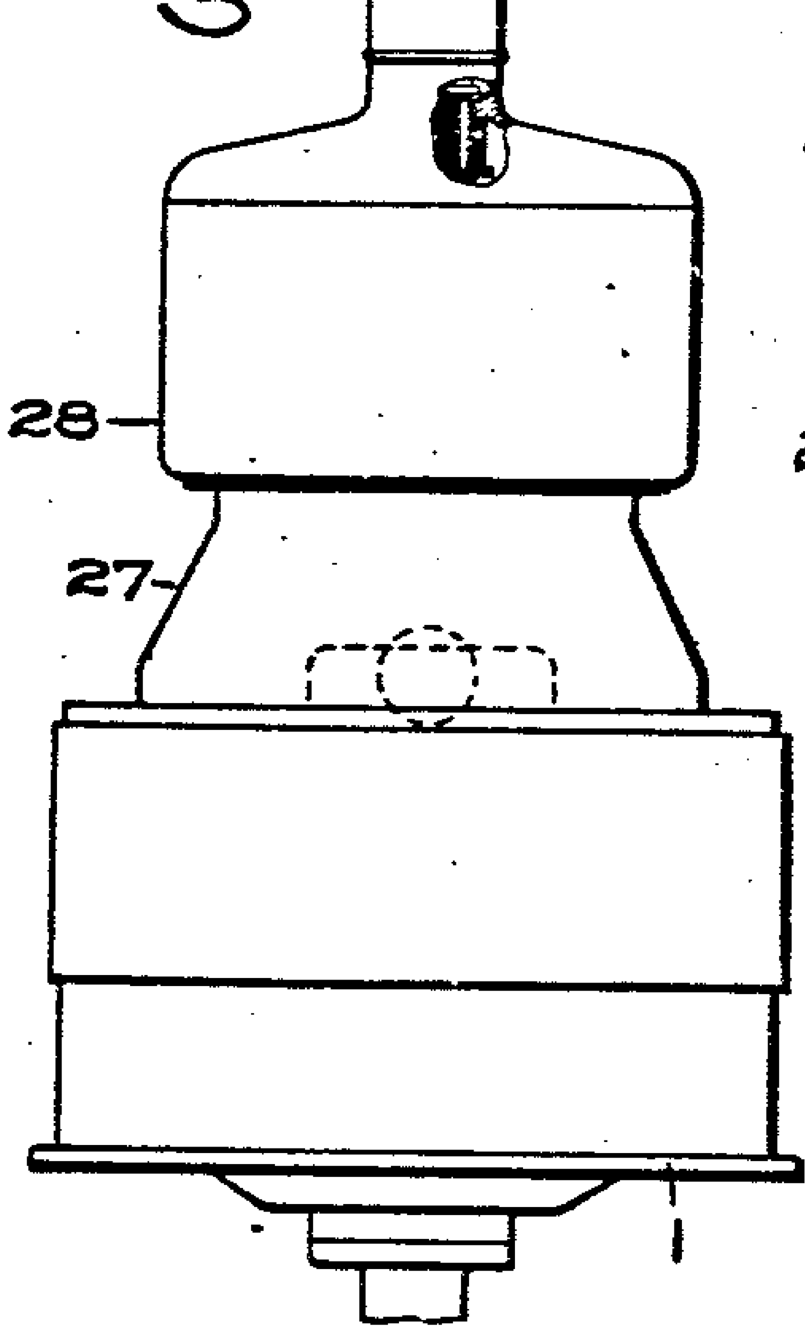


Fig. 2.

Fig. 3.



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UNITED STATES PATENT OFFICE.

RICHARD H. RICE, OF LYNN, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELASTIC-FLUID TURBINE.

963,178. Specification of Letters Patent. Patented July 5, 1910.

Application filed February 10, 1908. Serial No. 415,024.

To all whom it may concern:

Be it known that I, RICHARD H. RICE, a citizen of the United States, residing at Lynn, county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Elastic-Fluid Turbines, of which the following is a specification.

The present invention relates to elastic fluid turbines, and more especially to those of the impact type, and has for its objects to improve their efficiency and also their construction.

In the accompanying drawing which illustrates one of the embodiments of my invention, Figure 1 is a partial axial section of a vertical shaft turbine; Fig. 2 is a detail sectional view taken on line 2—2 of Fig. 1; and Fig. 3 is a view in side elevation of a turbo-generator.

1 indicates the base of the turbine having an outlet 2 through which the exhaust steam normally passes to a condenser or it may pass to atmosphere. Bolted to the base is a spider 3 that supports the step- and lower guide-bearings. Above the guide-bearing and carried by the base is a packing 4 to prevent the escape of steam from the chambered base; or the entrance of air.

5 indicate the main shaft upon which are secured the bucket wheels, a single wheel with two rows of buckets being provided for each stage.

Mounted on the base is a wheel casing 6 made up in segmental sections of suitable size, the upper or high pressure end of the casing being larger in diameter than the bottom or low pressure end. The upper end of the casing is provided with a head 7 having a central bore through which the shaft passes and a packing 8 to prevent the escape of steam or other elastic-motive fluid. In the head are passages 9 communicating with the valve chest 10 and with the sections or passages of the divergent nozzle 11 bolted or otherwise secured to the under side of the head. These admission nozzles cover a relatively small wheel arc and have a greater ratio of expansion than the stage nozzles so as to reduce the pressure within the first stage or wheel compartment to such a low value under all conditions of operation as to keep the strains on the casing within a safe margin.

The idea of a multistage impact type of turbine operating with a greater pressure drop in the first than in any one of the subsequent stages is not of itself broadly new but I provide for a materially greater pressure drop than has been contemplated heretofore, and by reason of this and other features am enabled to obtain superior results. Turbines of the character referred to are provided with stage nozzles which are normally in service and other stage nozzles which are put into service automatically or otherwise as the load increases and the steam pressure in the first stage tends to build up or when additional steam is needed. When the stage valves operate automatically they are arranged, in so far as possible, to maintain a constant stage pressure under varying conditions of load. By reducing the pressure in the first stage to an extremely low value as I do, it is lower at light loads than is necessary to safeguard the wheel casing, hence when the load increases to maximum the pressure will only rise by a certain predetermined amount, the total value of which does not exceed the safe working limits of the casing and its parts. From this it will be understood that I am able to dispense with stage valves, and hence all of the stage nozzles will constantly be in service when the turbine is in use. As has been pointed out the velocity of the fluid issuing from the admission nozzles is greater than that from the stage nozzles, hence in order to extract an amount of velocity from the steam in the first stage comparable with that extracted in the subsequent stages the bucket speed should be higher. This is attained by making the first stage wheel larger in diameter than the wheels of the subsequent stages. Owing to the fact that the pressure in the first stage is abnormally low as contrasted with pressures previously employed, I am able to utilize a wheel of large diameter and this without high rotation losses because of the low density of the steam. By "rotation losses" I mean the losses due to friction between the wheel and the surrounding medium and the fan-like action of the wheel buckets. Decreasing the first stage pressure as described renders it easier to pack the wheel shaft where it passes through the casing head. Other things being equal it also reduces the weight of the casing, head, diaphragm, etc. Dispensing with stage valves reduces mechanical complication and initial cost. Further it decreases the number of parts which have to be looked after by the engineer in charge of the machine.

As above stated, in my improved turbine the velocity of the steam in the first stage is higher than in any of the remainder and the said stage does considerably more work, in the turbine illustrated about one-third of the total, the remainder being divided about equally between the last three stages. By initially providing for a large drop in pressure in the first stage, and one greater than is required to merely protect the parts of the wheel casing from excessive pressure, it follows that the pressure may be quite largely augmented in the first stage as the load increases without, however, endangering the casing, and since the pressure distribution in the stages changes somewhat under these conditions the lower pressure stages will automatically do more work as the pressure increases. As the load falls off the pressures in the several stages gradually change until the initial condition is resumed. As an example of the pressure relations: that of the supply may be 200 pounds absolute, the pressure in the first stage 30 pounds absolute, and that of the exhaust 1 pound absolute. The great drop in pressure due to the nozzle 11 having divergent walls results in a high spouting velocity of the steam. In order to effectually utilize this velocity I provide a bucket wheel 12 in the first stage of considerably larger diameter than those of the succeeding stages, and owing to this large diameter the bucket speed closely approaches the theoretical for the conditions mentioned. For example, the bucket speed may be 500 feet per second with a normal spouting velocity at the nozzle end of 2200 feet per second. The diameter of the upper end of the casing is greater than that of the lower end to accommodate the large bucket wheel. At the point of change in diameters a shoulder is provided upon which rests the largest diaphragm 13 in the machine. It is not only larger in diameter but it is also thicker. Surrounding the diaphragm is an annular chamber 14, the annular outer and bottom walls being formed by the casing, the inner wall by the periphery of the diaphragm and the upper wall by a relatively thin metal ring 15 riveted or otherwise attached to an internal projection on the wheel casing and to the peripheral edge of the diaphragm. This ring is cut away at a point directly under the admission nozzles to form a segmental opening of suitable shape and area to permit the steam exhausting from the wheel to freely enter it. It is to be noted that the annular chamber 14 surrounds the diaphragm 13 instead of being confined in a small arc directly between the exhaust side of the first wheel and the nozzles of the next stage. This arrangement permits of a chamber of large cross-section without increasing the axial length of the turbine by any appreciable amount. Owing to the great drop in pressure in the admission nozzles the volume of the steam increases enormously by the time it enters the chamber and to utilize this to its best advantage all of the stage nozzles leading into the second stage as well as those leading into the succeeding stages are active. Bolted to the largest diaphragm is a stage nozzle 16 that imparts velocity to the steam and completely surrounds the second stage wheel so that all or practically all of the buckets will be active. This nozzle or the sections thereof are fed with steam from the annular chamber 14 by passages 17 cored in the peripheral portion of the diaphragm. Owing to the fact that the chamber 14 is annular and communicates with all of the second stage nozzles the latter are all supplied with steam at the same pressure.

The stage nozzles may be divergent or non-divergent in character, in any event the velocity of the motive fluid discharged thereby will be considerably less than that discharged from the admission nozzles. For example, the spouting velocity of the steam at the ends of these nozzles may be 1600 feet per second when that of the admission nozzle is 2200 feet per second. Under these conditions the bucket speed of the low pressure stages can with advantage be about 425 feet per second.

In the second stage compartment 18 is a bucket wheel 19 of considerably smaller diameter than the one in the first stage. This wheel as well as the others in the turbine are each provided with two rows of buckets 20 and intermediate buckets 21 between the rows. In the first stage these intermediates cover only a comparatively small wheel arc, substantially the same as covered by the admission nozzles, while in the second and in the succeeding stages they cover the entire wheel circumference.

The diaphragms between the stages of the lower pressure differ in construction from the large high pressure diaphragm. Since the construction of these diaphragms and their supports are the same a description of one of them will be sufficient.

Formed on the inner wall of the wheel casing is a shoulder 22 and seated thereon is a ring 23 comprising an inner and an outer cast metal portion and sheet metal partitions dividing the space between them into passages all of which extend in the same direction and discharge steam at the same angle to the wheel buckets. In making these rings the sheet metal partitions are put into the core and the core is then placed in the mold in the usual manner. The part of the mold forming the inner portion of the ring is poured first. After the metal has had a chance to cool somewhat the outer portion of the ring is poured. In cooling the outer portion will contract somewhat and instead of the partitions being under tension, as would be the case if the parts were poured simultaneously, they are under compression which I regard as being an important advantage. In so far as the broader features of my invention are concerned they are not to be construed as limited to the particular construction of these rings and diaphragms. The outer portion of the ring rests on the internal shoulder of the casing while its inner portion is provided with a shoulder to receive the diaphragm proper. This diaphragm 24 is provided with a shaft opening and supports a packing sleeve 25 of suitable character around the shaft. It is provided with concentric ribs to strengthen it, and also with sheet metal disks 26 on opposite sides each of which present a smooth surface to the steam in the compartment so as not to oppose its movement, and also to decrease the size of the wheel compartment so as to limit the amount of steam contained therein.

Located above the casing is a stool 27 that supports the casing 28 of an electric generator. The upper end of the turbine shaft is provided with a guide bearing 29 supported by the stool. On the end of the shaft is a coupling 30 for uniting it with the generator shaft 31 above it. The guide bearing is supported at suitable points by the stool and between the points of support are spaces to permit of access to the bearing. From this it follows that the heated air from around the turbine would pass directly into and through the generator thereby increasing its temperature and endangering its life. To prevent this a ring shaped plate 32 is provided that is bolted to the stool or other support. It is provided with one or more openings through which access may be had to the parts above, and these openings are covered by doors 33 that are held in place by bolts or other means.

By reason of my improved construction I am able to produce a turbine which has a relatively low shaft speed and at the same time one having high economy of operation. The parts are simple and rugged in construction and the machine can be erected or taken down with a minimum expenditure of time and labor. By using a larger first stage wheel and a casing having two diameters, ample provision can be made for the annular chamber receiving steam therefrom and this without unduly increasing the axial length of the machine. Since I avoid the use of stage valves and separate nozzles controlled thereby the first cost of the machine is materially reduced as is also the number of parts. The cost of attendance and maintenance is also reduced.

I have shown the wheels all located in the same casing since this is a desirable construction but the invention is not to be construed as so limited unless specified in the claims.

I obtain the high bucket speed of the first stage by using a larger wheel than in the later stages and mounting all of the wheels on the same shaft, but in those cases where a divided shaft arrangement can be utilized the same advantage may be obtained by rotating one shaft faster than the other with wheels of suitable diameter.

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. A turbine that is divided into stages of expansion, divergent admission nozzle which discharges the motive fluid into the first stage at a pressure that is only a small percentage of the initial pressure with a correspondingly high velocity so that a larger percentage of the work will be performed in the first stage than in any one of the later stages and the casing strains under varying load conditions and the leakage losses will be reduced to a relatively low value, a wheel for said stage that has a bucket speed great enough to effectively convert the high velocity of the fluid into mechanical work, stage nozzles each of which converts a lesser percentage of the pressure into velocity than the said admission nozzle, a wheel for each of the low-pressure stages located adjacent its nozzle which acts on the impact plan to fractionally extract the velocity, each wheel having a bucket speed which is less than that of the initial stage, shaft means for carrying the wheels, inclosing means for the wheels, and exhaust-receiving means.

2. In combination, a turbine divided into stages, admission and stage nozzles, the former having a greater ratio of expansion and imparting a greater velocity to the motive fluid than the latter, bucket wheels for the stages all of which act on the impulse plan to extract the velocity produced by the nozzles in successive operations, one of the high pressure stage wheels operating at a higher bucket speed and performing a greater amount of work than a low pressure stage bucket wheel, and an exhaust conduit.

3. In a multi-stage turbine, the combination of a casing, means dividing the turbine into separate wheel compartments or stages, a supply chest, admission and stage nozzles, the former shaped to cause a greater drop in pressure and a higher spouting velocity

of the motive fluid than the latter, bucket wheels in the stages, the bucket wheel in the first stage having a greater diameter than the remaining wheels and performing more work than said wheels, and an exhaust conduit.

4. In combination, a turbine divided into stages, admission nozzles which cover a limited wheel arc and cause a greater drop in pressure between the source of supply and the first stage than do all of the stage nozzles combined, stage nozzles, a bucket wheel for the first stage acting on the impulse plan, the buckets of which have a greater velocity than those of the subsequent stages, bucket wheels for the remaining stages also acting on the impulse plan to extract the velocity of the motive fluid in successive operations, and an exhaust conduit.

5. In combination, a turbine divided by diaphragms into stages, an admission nozzle which imparts a greater velocity to the motive fluid than do the stage nozzles, a bucket wheel coöperating therewith whose diameter is greater than that of the wheel of the stage of lowest pressure and which performs more work, an annular chamber which receives the fluid exhausting from the first stage and supplies it to the next, stage nozzles converting the pressure of the fluid into velocity, certain of said nozzles receiving motive fluid from said chamber, rotating buckets for the remaining stages all of which act on the impulse plan, and an exhaust conduit.

6. In a turbine, the combination of a shouldered casing, a supply conduit, a removable diaphragm resting on one of said shoulders and which divides the casing into compartments, an annular chamber which is located between the periphery of the diaphragm and the inner wall of the casing, wheel buckets exhausting into the chamber, stage nozzles receiving motive fluid from the chamber, the conduits in the peripheral face of the diaphragm supplying motive fluid to said stage nozzles, additional diaphragms resting on shoulders in the casing for dividing the latter into other compartments, stage nozzles and rotating buckets for the last mentioned compartments, and an exhaust conduit.

7. In a turbine, the combination of a casing having portions of different diameter with a shoulder between the one of larger diameter being located at the high pressure end, a diaphragm for dividing the casing which rests on the shoulder, smaller diaphragms also for dividing the casing which are supported by the portion thereof having the smaller diameter, an annular chamber bounded by the first mentioned diaphragm, the shoulder and the inner wall of the casing, rotating buckets for the compartments separated by the diaphragms, admission and stage devices discharging fluid to the buckets, and an exhaust carrying means.

8. In a turbine, the combination of a casing having a high pressure portion of greater diameter than the low pressure portion with a shoulder between, a diaphragm which rests on the shoulder, divides the casing into compartments and is provided with passages communicating with the fluid discharging devices of the adjacent stage, an annular chamber which surrounds the diaphragm and supplies fluid to the passages, means dividing the casing into additional compartments, admission and stage devices for discharging motive fluid, buckets for the compartments for extracting energy from the motive fluid, and an exhaust conveying means.

9. In an elastic fluid turbine, the combination of a casing, means dividing it into stages or compartments, rotating buckets for the stages which abstract velocity from the motive fluid due to the nozzles, those in the first stage performing a greater amount of work than those in any other stage, a support for the buckets, the portion for the high pressure stage buckets being greater in diameter than the remainder to give a higher bucket speed, admission nozzles which impart to the fluid a greater velocity accompanied by a greater pressure drop than do the stage nozzles, the said admission nozzles supplying fluid to only a limited number of buckets, stage nozzles which impart velocity to the fluid and discharge it to all of the buckets in the remaining stages, and an exhaust conveying means.

10. In an elastic fluid turbine, the combination of a shouldered casing, a diaphragm which rests on the shoulder and divides the casing into compartments, an annular nozzle on the low pressure side of the diaphragm, and passages in the diaphragm which open on the peripheral face thereof and convey fluid to the nozzle on the side thereof.

11. In a turbine, the combination of a casing, wheel buckets therein, a vertical shaft carrying the buckets, a device driven by the shaft, bearings for said shaft, a means for preventing fluid at high temperature from around the turbine passing upward into the said device, a door in said means through which access may be had to the parts of said device, and means for conveying motive fluid to and from the turbine.

In witness whereof, I have hereunto set my hand this fifth day of February, 1908.

RICHARD H. RICE.

Witnesses:
JOHN A. McMANUS, Jr.,
HENRY O. WESTENDARP.