No. 777,313. PATENTED DEC. 13, 1904.

J. W. SMITH.

STEAM TURBINE.

APPLICATION FILED JAN. 7, 1904.

NO MODEL. 3 SHEETS—SHEET 1.

Fig: 1.

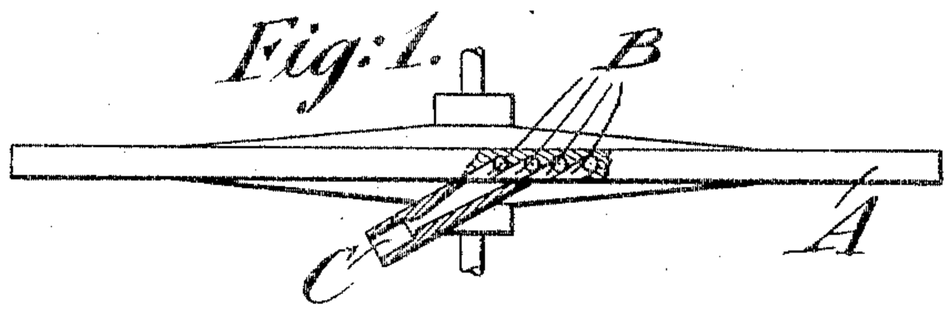


Fig: 2.

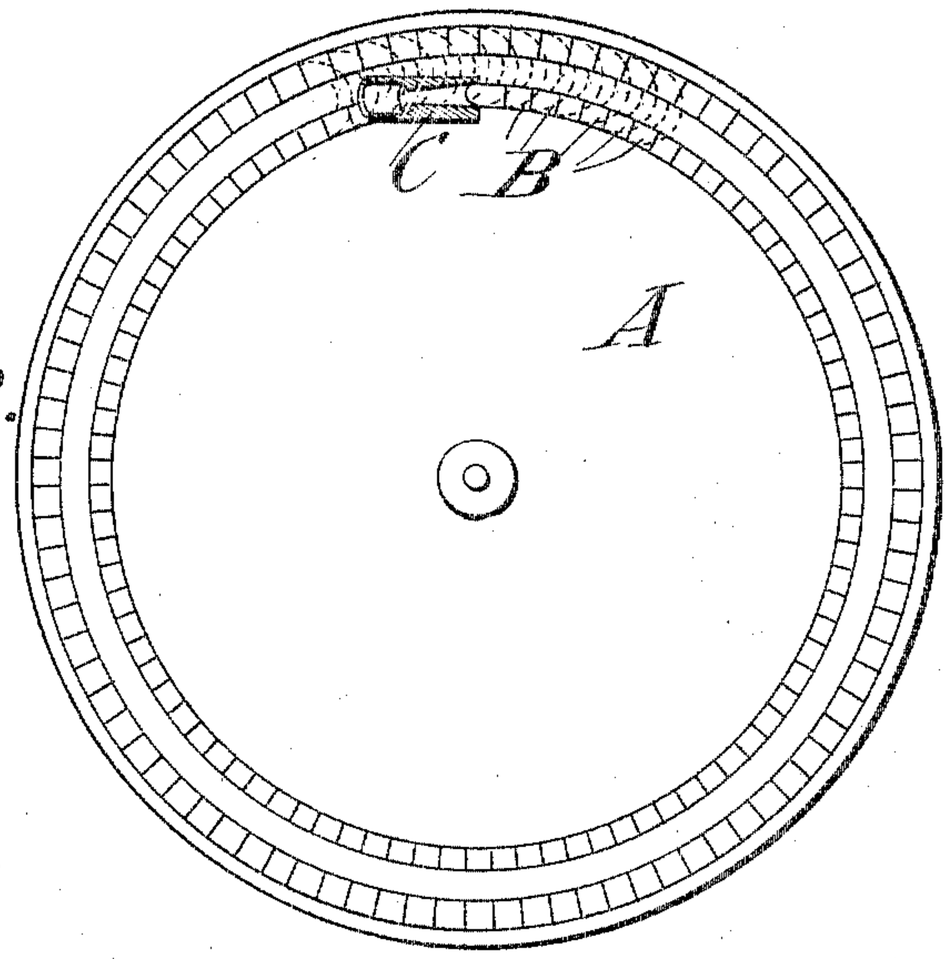


Fig: 3.

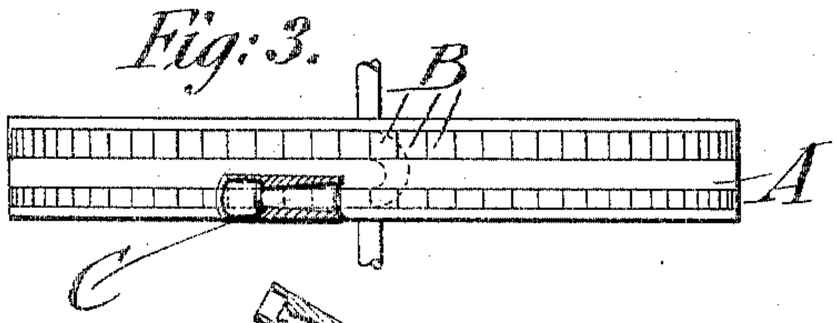


Fig: 4.

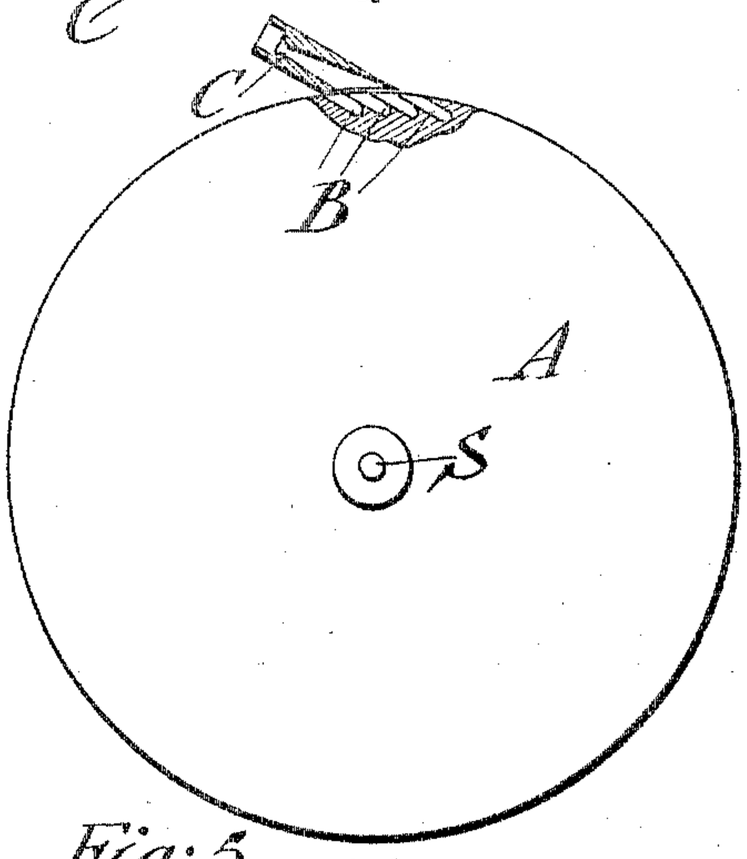
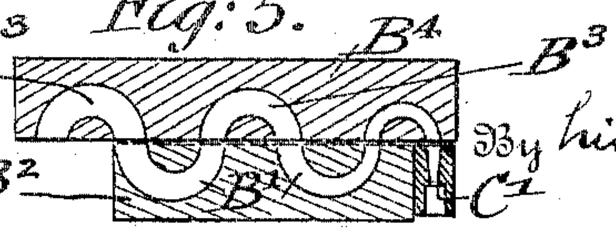


Fig: 5.



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NO MODEL. 3 SHEETS—SHEET 2.

Fig: 6.

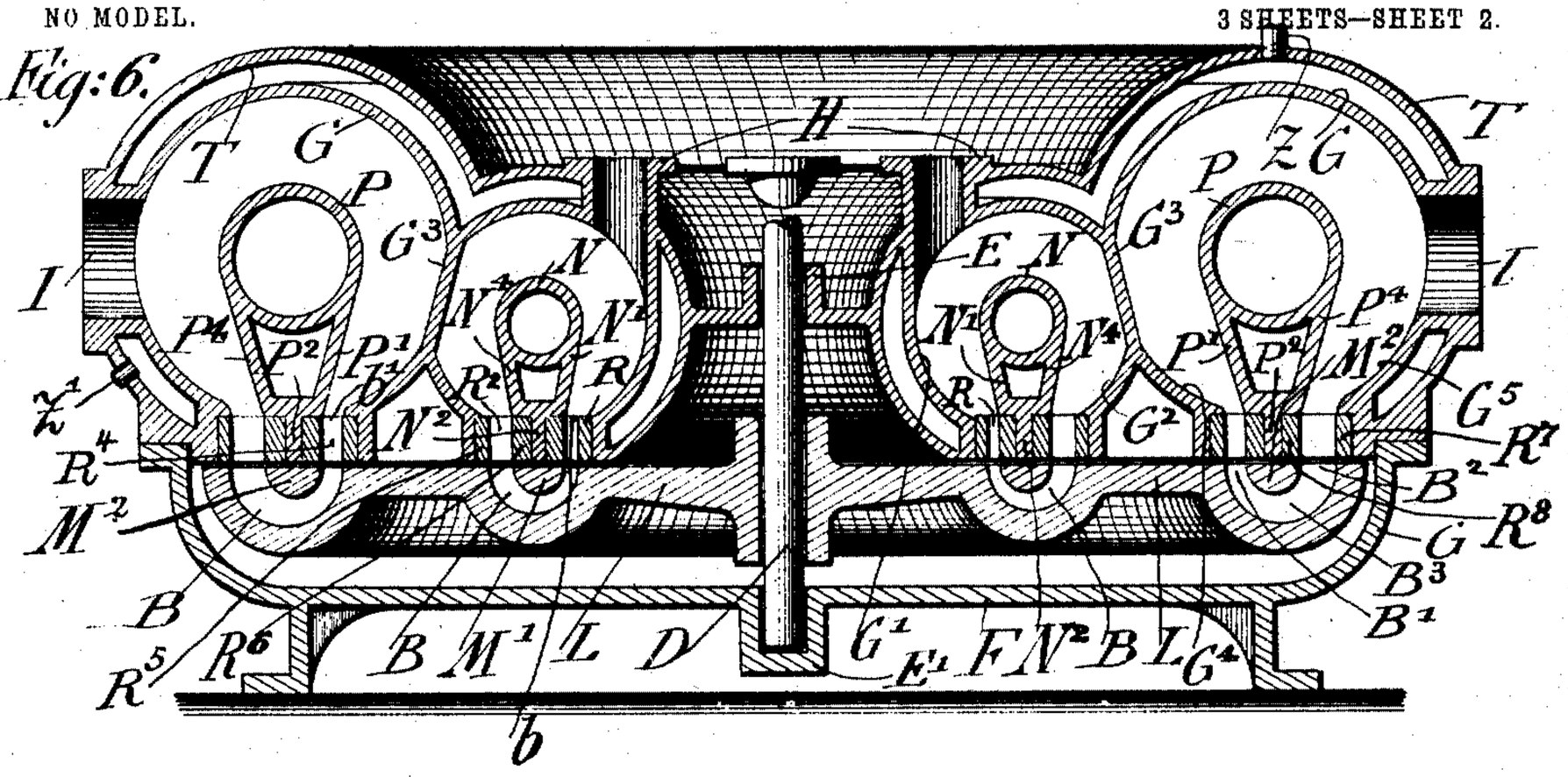
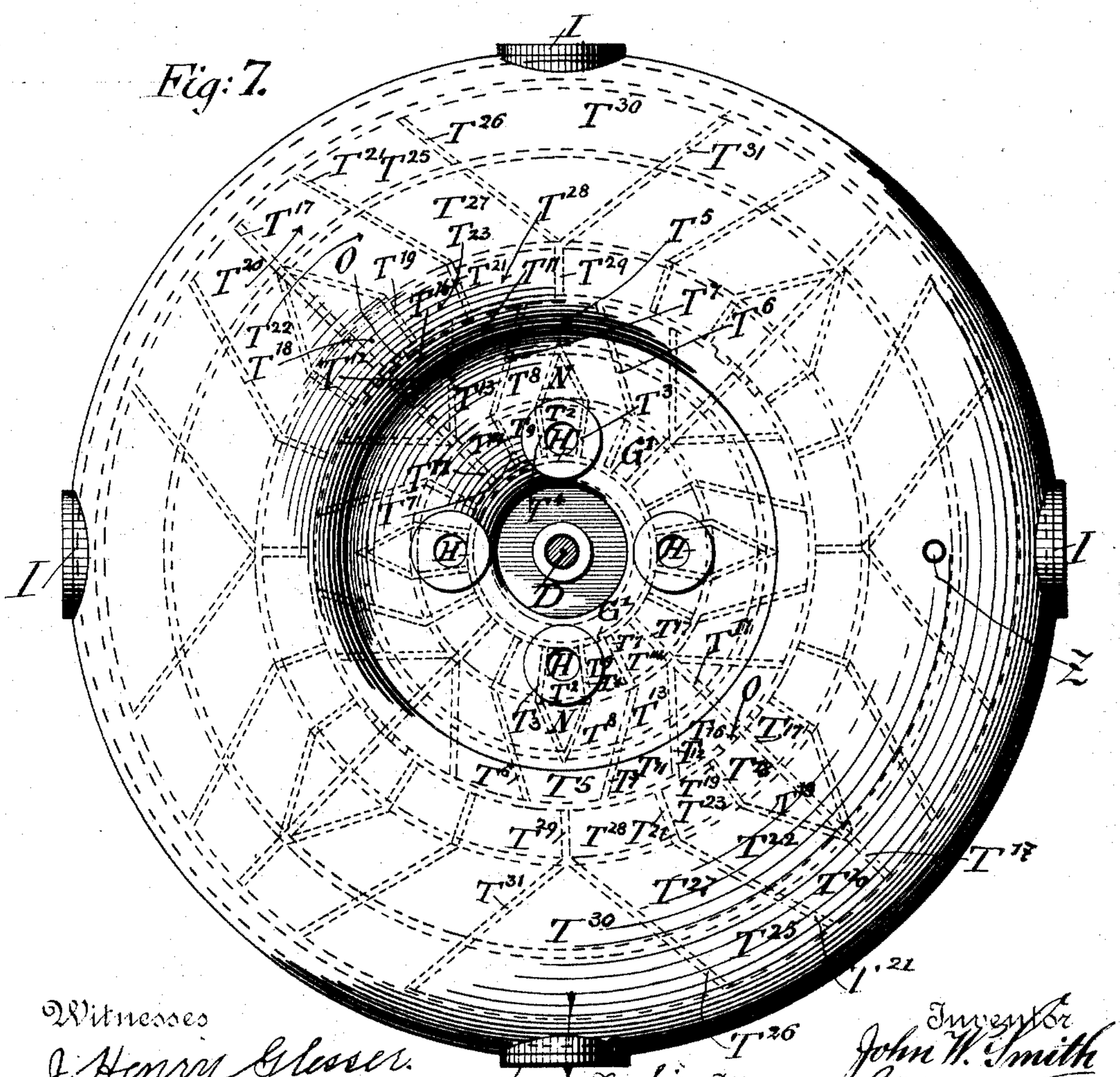


Fig: 7.



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STEAM TURBINE.

APPLICATION FILED JAN. 7, 1904.

NO MODEL. 3 SHEETS—SHEET 3.

Fig: 8.

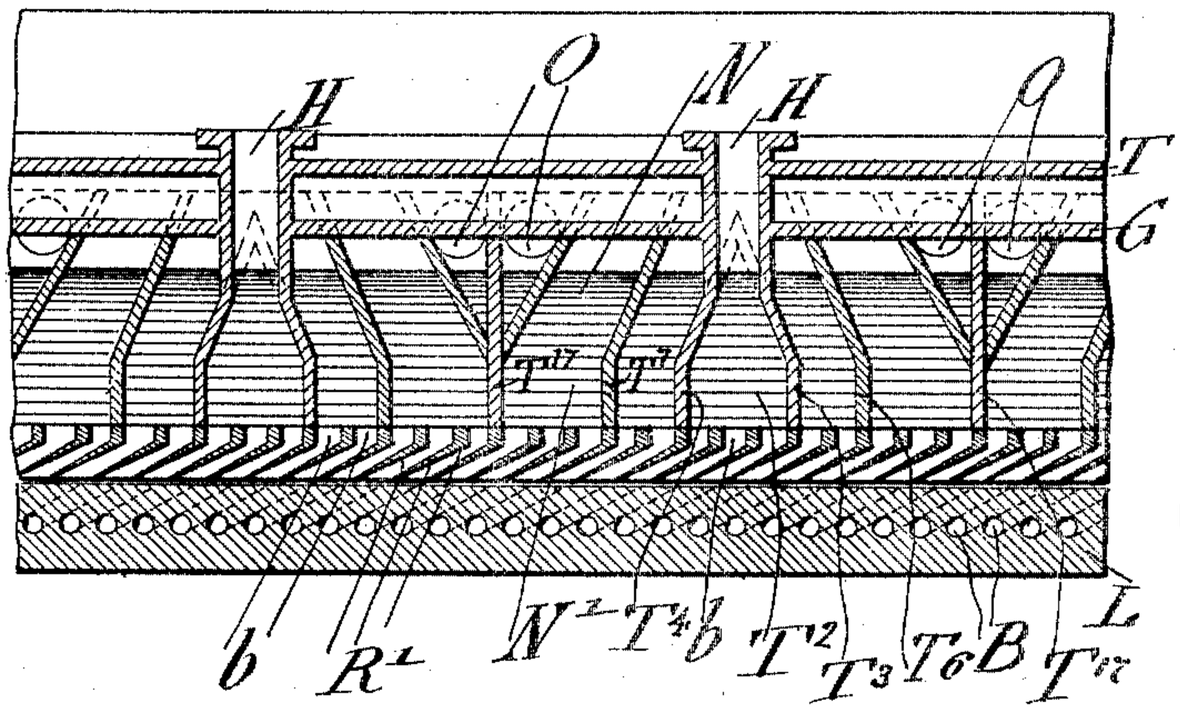


Fig: 9.

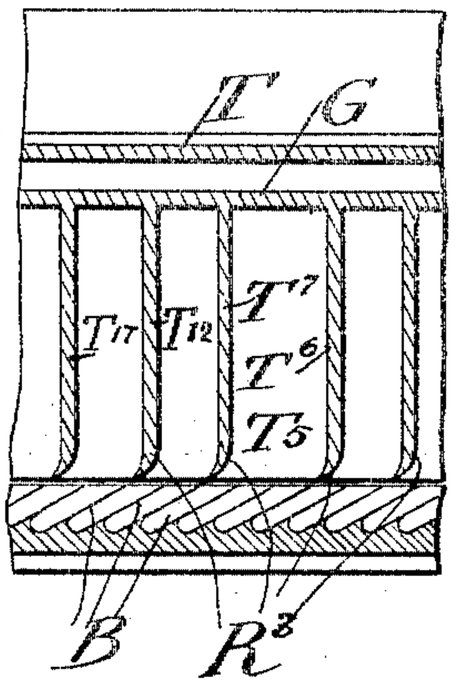
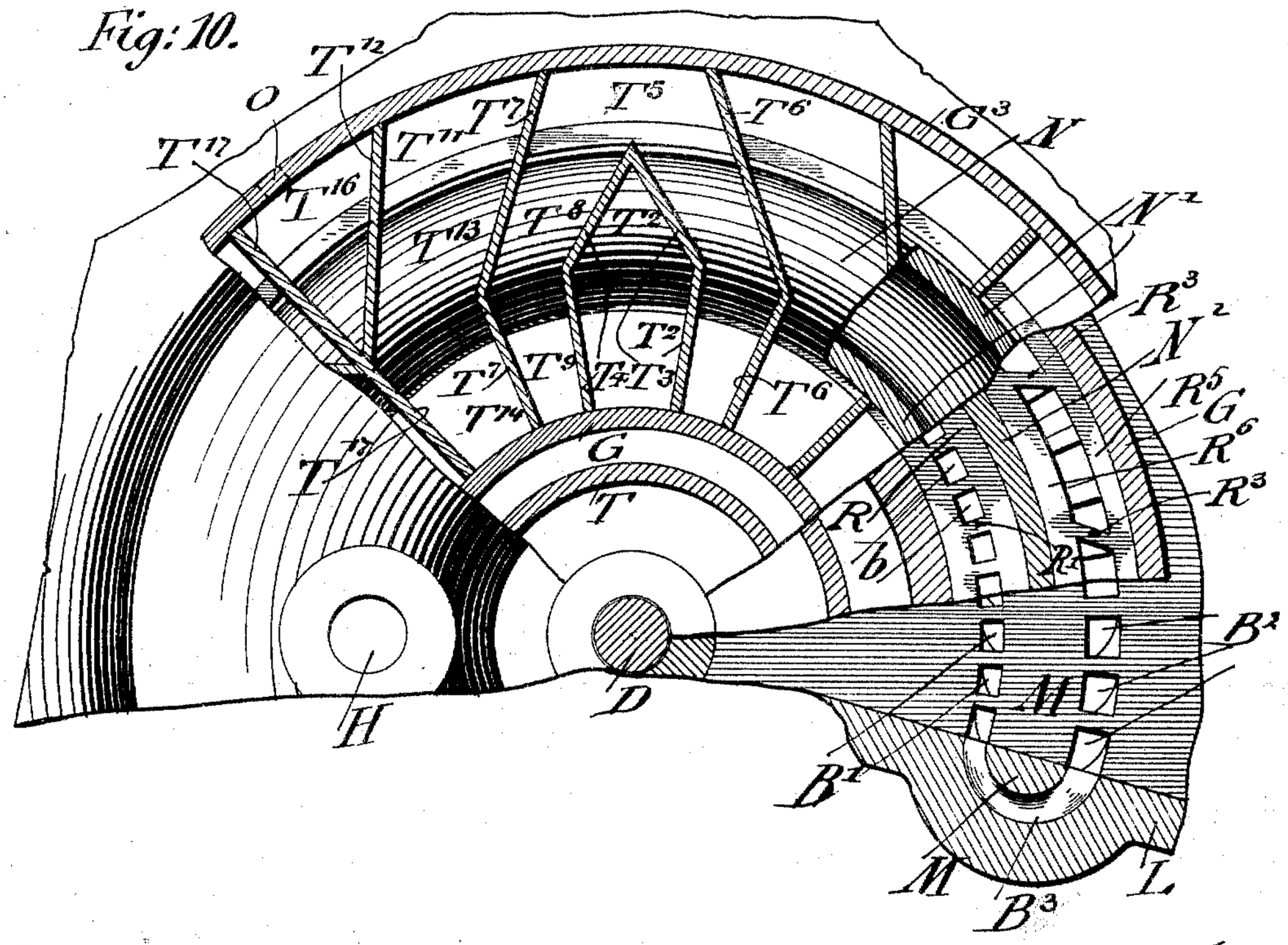


Fig: 10.



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No. 777,313. Patented December 13, 1904.

UNITED STATES PATENT OFFICE.

JOHN W. SMITH, OF ERIE, PENNSYLVANIA, ASSIGNOR TO THE BALL ENGINE COMPANY, OF ERIE, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA.

STEAM-TURBINE.

SPECIFICATION forming part of Letters Patent No. 777,313, dated December 13, 1904.

Application filed January 7, 1904. Serial No. 188,018. (No model.)

To all whom it may concern:

Be it known that I, JOHN W. SMITH, a citizen of the United States, residing in Erie, county of Erie, and State of Pennsylvania, have invented certain new and useful Improvements in Steam-Turbines, of which the following is a specification.

This invention relates to steam-turbines provided with curved buckets of that class in which the steam is utilized several times before final exhaust by bringing the same during the various stages of expansion successively in contact with the moving element, so as to utilize all the energy resident in the steam; and the invention has for its object to provide a turbine constructed on principles commensurate with high efficiency and good working.

For this purpose the invention consists of a steam-turbine which will be fully described hereinafter and finally pointed out in the claims.

In the accompanying drawings, Figures 1 to 4 show views embodying the underlying principle of my present invention, in which Fig. 1 is a top view of a radial-flow turbine. Fig. 2 is a side elevation of Fig. 1. Fig. 3 is a top view of an axial-flow turbine, and Fig. 4 is a side elevation of Fig. 3. Fig. 5 shows an arrangement of a series of buckets which may be used either in connection with a radial or with an axial flow turbine. Fig. 6 is a horizontal central section of a vertical turbine embodying my invention. Fig. 7 is a plan view of the turbine shown in Fig. 6, showing the partition-walls forming the admission, guide, and release chambers in dotted lines. Fig. 8 shows a development of a circular portion of the turbine, showing clearly the buckets, admission-blades, and partitions forming the admission-chambers. Fig. 9 shows a development of a circular portion of the turbine, showing clearly the partitions forming the release-chambers; and Fig. 10 is a view showing the construction of the turbine, showing successively the arrangement of parts as superposed on each other from the rotatable element to the top of the casing.

Similar letters of reference indicate corresponding parts.

Referring to the drawings, and more particularly to Figs. 1 to 4, A represents a turbine-wheel provided with buckets B. In Figs. 1 and 2 the buckets are arranged radially to the wheel and receive the steam from a nozzle C, arranged on the side of the wheel and tangential to the same, while in Figs. 3 and 4 the buckets are arranged in a direction parallel to the axis of the turbine-wheel and receive steam from a similar nozzle C, which is arranged in proximity and tangentially to the periphery of the wheel. The buckets are arranged adjacent to each other and are inclined in the radial-flow turbine (shown in Figs. 1 and 2) at an angle of about twenty degrees to the plane of revolution of the wheel A and inclined in the axial-flow turbine (shown in Figs. 3 and 4) at an angle of twenty degrees to a radial line from the shaft S of the wheel. The buckets B are formed of U-shaped channels or of tubes of suitable material, having their inlet ends of rectangular form and their outlet ends somewhat larger than the inlet ends, so as to allow sufficient expansion of the steam to compensate for the loss due to friction of the steam passing through the buckets. Steam directed by the nozzle C into the buckets B impinges against the interior sides of the same and propels the wheel forwardly. The steam having a part of the energy initially resident in the same expended in this work of impulse and reaction emanates from the buckets parallel to and directly opposed to the direction of the stream when it entered the buckets. The line of direction of the incoming steam, the bucket, and the line of direction of the outgoing steam are all in one plane, and the line of the inlet and outlet ends of the buckets is perpendicular to the line of direction of the ingoing steam. In order to avail of the energy still resident in the steam, I direct the steam in a similar manner successively into the adjacent buckets until the entire energy of the steam has been expended, after which it is exhausted into the atmosphere. This principle is clearly shown

in Fig. 5, in which C′ represents the inlet-nozzle, B′ the buckets of the stationary element B^2, and B^3 the buckets of the moving element B^4, which arrangement shows the path of the steam to be undulatory. A practical embodiment of this principle, but having the steam partake of a spiral path, is shown in Figs. 6 to 10, in which D represents a vertical shaft of a horizontal turbine rotatable in neck-bearings E and step-bearings E′ of the bottom F of a casing, which is provided at its top with steam-supply channels H, preferably four in number, and at its sides with corresponding exhaust-channels I, each set corresponding to a separate unit obtained by dividing the turbine into separate parts by means of radial partitions. Secured to the shaft D is a disk or turbine wheel L, provided with a plurality of buckets B, adjacent to each other and inclined at an angle of about twenty degrees to the plane of rotation of the disk or turbine wheel L. The inlet ends B′ of the buckets are somewhat smaller than the outlet ends B^2, and both ends are rectangular in shape. The buckets are approximately circular, being slightly elliptical in shape at their central portion B^3, and are each formed by an annular division-wall, the object of which is to prevent eddy currents from being set up in the buckets. To avail of all the energy resident in the steam, the casing G is divided into a high-pressure chamber and a low-pressure chamber of somewhat larger size, below each of which chambers a series of buckets are arranged. The high-pressure chamber, into which the steam first passes, is provided with a circular ring N, which is supported by converging walls N' N^4 of an annular ring N^2 vertically above the annular division-walls M of the high-pressure buckets B. The ring N, supported by the walls N' N^4, forms a separating-body around which the steam passes in a spiral path. The high-pressure chamber is provided with a plurality of partitions, so as to divide the high-pressure chamber into a series of admission, guide, and release chambers. These separate chambers communicate one with the other in such a manner that the steam passing from one chamber to the other partakes of a spiral path, passing successively into one bucket, out of the same, over the ring N into the succeeding bucket, out of the same, and again over the ring N, expanding during its passage from one bucket to the other. The partitions contact with the ring N and its walls N' N^4 and the inner walls of the high-pressure chamber of the casing G. The low-pressure chamber of the casing, which is of larger size than the high-pressure chamber, owing to the increase of volume of the steam due to expansion, is provided with an annular ring P, similar to the ring N, supported by converging walls P' P^4 of a ring P^2 vertically above the division-wall M^2 of the low-pressure buckets. The low-pressure chamber of the casing is also provided with partitions similar to those of the high-pressure chamber, which also contact with the inner walls of the casing and with the ring P, forming intercommunicating admission, guide, and release chambers which guide the steam in a spiral path around the ring P, during which it successively enters and leaves one bucket after the other. The high and low pressure chambers of the casing G are provided with concentric walls T, forming steam-jackets, which receive their steam from a pipe Z and discharge the steam from a pipe Z′. To insure an efficient entrance velocity to the incoming steam, the partitions of the admission-chambers do not extend clear down to the buckets, but only as far as a ring R, provided with a plurality of admission-blades R′, forming a plurality of nozzles. Similarly the partitions forming the release-chambers extend down as far as the ring R^2, provided with release-blades R^3, which latter are scoop-shaped at their lower ends, as clearly shown in Fig. 9, and which form continuations of the partitions, or the release-partitions may extend clear down to the moving element, allowing, however, sufficient clearance, in which case the lower ends of the partitions which then form the release-blades are surrounded by rings R^5 R^6, the ring R^5 being interposed between the release-blades and the ring N^2 and the ring R^5 being interposed between the release-blades and the lower wall of the casing. Similarly rings R^7 R^8 surround the release-blades of the low-pressure chambers, the ring R^8 being interposed between the release-blades and the ring P^2 and the ring R^7 being interposed between the release-blades and the lower walls of the casing. This arrangement is clearly shown in Figs. 6, 9, and 10. Each of the nozzles formed by the admission-blades R′ corresponds with one bucket, and so guides the steam in a separate jet into one bucket, while the release-blades are so arranged that several buckets discharge their steam between two adjacent release-blades. To form communication between the high and low pressure chambers, the wall G^2, separating the same, is provided with openings O.

The operation of my improved steam-turbine is as follows: Steam enters through the steam-inlet H into the admission-chamber T^2, formed by partitions T^3 T^4, the wall N' of the ring N, and the inner wall G′ of the casing G and enters openings *b* of the ring R, provided with admission-blades R′, forming nozzles directed toward the buckets of the moving element. The steam passes through three buckets which correspond to the admission-chamber T^2 and enters the release-chamber T^5 in the same direction in which it entered the buckets, forming in the release-chamber one main stream. This release-chamber T^5 is formed of partitions T^6 T^7, the wall N^4 of the ring N, and

the wall G^2 of the casing G. This main stream in the release-chamber T^5 is divided into two parts, each of which passes over the ring, one substream in one direction and one in the other direction, each in a direction radially inward of the turbine. One of these parts, the action of the other being similar, and hence not to be described in detail, passes through the guide-chamber T^8, formed of partitions T^4 and T^7, into the admission-chamber T^9, formed of partitions T^4 and T^7, the wall N′ of the ring N, and inner wall G′ of the casing G. This substream having in the meantime expanded to some extent enters two openings *b* of the ring R, provided with admission-blades R′, forming nozzles, and as separate jets enters the buckets and propels the turbine-wheel onwardly. These jets emanate from the buckets into the chamber T^{11}, formed of partitions T^7 and T^{12}, the wall N^4, and the ring N and the wall G^2 of the casing G. The separate jets again form one stream which passes through a guide-chamber T^{13}, formed of partitions T^7 and T^{12}, radially inward over the ring N into the admission-chamber T^{14}, formed of partitions T^7 and T^{17}, the wall N′ of the ring N, and the inner wall G′ of the casing G. This stream of steam having again somewhat expanded is subdivided into three jets by entering the openings *b* of the ring R, provided with admission-blades R′, forming nozzles, which blades again direct the steam into buckets of the moving element, so as to propel the same onwardly, from which the steam emanates in the same direction, but with opposite motion to that in which it entered. These separate jets of steam emanating from the buckets form one stream in the release-chamber T^{16}, formed by the partition T^{12}, radial partition T^{17}, wall N^4 of the ring N, and wall G^2 of the casing G. From this release-chamber T^{16} the steam does not pass, as heretofore, radially inward over the ring N, but passes through the opening O of the wall G^3, separating the high-pressure chamber from the low-pressure chamber. The steam having passed through the opening O enters the admission-chamber T^{18}, formed of the radial partition T^{17}, partition T^{19}, wall G^4, and the wall P′ of the ring P. The steam in the admission-chamber T^{18} enters openings *b*′ of the ring R^4, similar to the ring R, provided with admission-blades forming nozzles which guide the steam in separate jets so as to enter the low-pressure buckets below the low-pressure chamber and propel the same onwardly. These separate jets emanate from the buckets and enter the release-chamber T^{20}, formed of the radial partition T^{17}, partition T^{21}, wall P^4 of the ring P, and the wall G^5 of the casing G. In this release-chamber T^{20} the separate jets again form one stream which passes through the guide-chamber T^{22}, formed of partitions T^{19} and T^{21}, radially inward over the ring P into the admission-chamber T^{23}, formed of partitions T^{19} and T^{21}, wall P′ of the ring P, and inner wall G′ of the casing G. From this chamber the steam again enters the buckets and emanates from the same into a release-chamber T^{25}, formed of partitions T^{21} and T^{26}, wall P^4 of the ring P, and wall G^5 of the casing G, from which release-chamber it passes radially inward through the guide-chamber T^{27}, formed of partitions T^{21} and T^{26}, and enters the admission-chamber T^{28}, formed of partitions T^{21} and T^{29}, wall P′ of the ring P, and the wall G^4 of the casing G. From this admission-chamber T^{28} the steam enters the buckets, propels the same onwardly, and again emanates from the same in a release-chamber T^{30}, formed of partitions T^{26} and T^{31}, the wall P^4 of the ring P, and the wall G^5 of the casing G. From this chamber T^{30} the steam exhausts through the channel I into the atmosphere or into a suitable condenser connected with the channel.

From the foregoing it becomes apparent that the steam entering one of the admission-channels H is split into two parts, one of which passes in one direction into one admission-chamber of the high-pressure chamber through several buckets into a release-chamber in the same direction in which it entered the buckets and by a spiral path successively through each intercommunicating guide, admission, and release chamber until it passes radially outward to an admission-chamber of the low-pressure chamber, where it partakes of a similar path, but in opposite direction, passing by a spiral path successively through each intercommunicating guide, admission, and release chamber of the low-pressure chamber until it is finally exhausted through the channels I, having all its energy extracted in having propelled the moving element and simultaneously expanded. The other part of the steam follows a similar spiral path, first in one direction through the high-pressure chamber and then in an opposite direction through the low-pressure chamber, after which it unites with the first split part at the exhaust-channel I. So, similarly, the various streams of steam entering the steam-inlets H are each split into two parts, each of which transgresses a spiral path, first in one direction in the high-pressure chamber and then in the opposite direction in the low-pressure chamber, after which both parts meet and simultaneously exhaust. The streams of steam form, so to say, two belts of fluid above the buckets, inasmuch as the steam passing in its spiral path continually enters one end of the buckets and emanates from the other. In some cases it is preferable to alter the above-described course of the steam and to cause the steam to advance around the periphery of the piston in only one direction during the expansions in the high-pressure buckets and to effect the splitting of the steam and the motion of the same around the piston in both

directions during the expansion of the steam in the low-pressure buckets. When it is desired to reduce the capacity of the turbine, either one or more of the steam-inlets may be cut out, whereupon the turbine can be operated under full load, three-fourths load, one-half load, or one-quarter load with full initial pressure. It will be equally apparent that the steam enters the buckets in a certain direction and emanates from the same in the same direction, but directly opposed in its motion. By this arrangement the reaction work of the steam is the largest obtainable, which reaction work added to that obtained by impulse gives the maximum total work. Turbines constructed according to this principle and allowing for the necessary inherent losses, as mechanical friction, eddy-currents, condensation, and water mechanically entrained, would correspond to the highest efficiency obtainable. Furthermore, my improved turbine may be built in a compound form by using both sides of the turbine-wheel or by building a separate machine, one for high pressure and one for low pressure.

I claim as new and desire to secure by Letters Patent—

1. A turbine-wheel provided with curved buckets, said buckets having their inlet and outlet ends of rectangular shape and their central portion of substantially circular shape, substantially as described.

2. A turbine-wheel provided with curved buckets, said buckets having their inlet and outlet ends of rectangular shape and their central portion of substantially circular shape and adapted to discharge the steam parallel with but in a direction opposite to the direction of the entering steam, substantially as described.

3. In a steam-turbine, the combination with a turbine-wheel provided with curved buckets, said buckets being adapted to discharge the steam parallel with but in a direction opposite to that in which it entered the buckets, with a plurality of nozzles one adjacent the other and in communication with the inlet ends of said buckets and adapted to direct the steam simultaneously into all the inlet ends of the buckets of the turbine-wheel, substantially as described.

4. In a steam-turbine, the combination with a turbine-wheel provided with curved buckets, said buckets being adapted to discharge the steam parallel with but in a direction opposite to the direction of the entering steam, a plurality of nozzles, one adjacent the other and in communication with the inlet ends of said buckets, adapted to direct the steam simultaneously into the inlet ends of all the buckets of the turbine-wheel, and means for guiding the steam discharged from the outlet ends of the buckets back to the nozzles, substantially as described.

5. In a steam-turbine, the combination of a turbine-wheel provided with curved buckets, said buckets being adapted to discharge the steam parallel with but in a direction opposite to the direction of the entering steam, a plurality of nozzles one adjacent the other and in communication with the inlet ends of said buckets, adapted to direct the steam simultaneously into the inlet ends of all the buckets of the turbine-wheel, admission-chambers above the nozzles, and means for guiding the steam discharged from the outlet ends of the buckets back to the admission-chambers, substantially as described.

6. In a steam-turbine, the combination of a turbine-wheel provided with curved buckets, said buckets being adapted to discharge the steam parallel with but in a direction opposite to the direction of the entering steam, a plurality of nozzles one adjacent the other and in communication with the inlet ends of said buckets, adapted to direct the steam simultaneously into the inlet ends of all the buckets of the turbine-wheel, admission-chambers above the nozzles, guide-chambers in communication with the admission-chambers, and means for guiding the steam discharged from the outlet ends of the buckets back to the guide-chambers, substantially as described.

7. In a steam-turbine, the combination of a turbine-wheel provided with curved buckets, said buckets being adapted to discharge the steam parallel with but in a direction opposite to the direction of the entering steam, a plurality of nozzles one adjacent the other and in communication with the inlet ends of said buckets, adapted to direct the steam simultaneously into the inlet ends of all the buckets of the turbine-wheel, admission-chambers above the nozzles, guide-chambers in communication with the admission-chambers, and release-chambers in communication with the guide-chambers, said release-chambers being adapted to receive the steam discharged from the buckets, substantially as described.

8. In a steam-turbine, the combination of a turbine-wheel provided with curved buckets, said buckets being adapted to discharge the steam parallel with but in a direction opposite to the direction of the entering steam, a plurality of nozzles one adjacent the other and in communication with the inlet ends of said buckets, adapted to direct the steam simultaneously into the inlet ends of all the buckets of the turbine-wheel, admission-chambers above the nozzles, guide-chambers in communication with the admission-chambers, release-chambers in communication with the guide-chambers, and scoop-shaped release-blades in the release-chambers, said blades and chambers adapted to receive the steam discharged from the outlet ends of the buckets, substantially as described.

9. In a steam-turbine, the combination of a turbine-wheel provided with curved buckets, of a casing for the same having inlet and ex-

haust ports, and provided with a plurality of intercommunicating admission, guide and release chambers, the steam being conducted from the inlet-ports in a spiral path from the admission-chambers through the buckets into the release-chambers and through the guide-chambers again into adjacent admission-chambers, and finally to the exhaust-ports, the steam discharged from the buckets being parallel with but in a direction opposite to the direction of the steam entering the buckets, substantially as described.

10. In a steam-turbine, the combination with a wheel provided with curved buckets, of a casing for the same having inlet and exhaust ports, and provided with a plurality of intercommunicating gradually-increasing admission, guide and release chambers, the steam being conducted from the inlet-ports in a spiral path from the admission-chambers through the buckets into the release-chambers and through the guide-chambers again into the adjacent admission-chambers and adjacent buckets, and finally to the exhaust-ports, the steam discharged from the buckets being parallel with but in a direction opposite to the direction of the steam entering the buckets, substantially as described.

11. In a steam-turbine, the combination with a turbine-wheel provided with curved buckets, of a casing provided with a plurality of intercommunicating admission, guide and release chambers, a plurality of nozzles below the admission-chambers, an increasing number of nozzles corresponding to each admission-chamber depending on the expansion of the steam, said nozzles being in communication with the admission-chambers and adapted to guide the steam to the buckets, said steam passing from the buckets into the release-chambers and through the guide-chambers into the adjacent admission chambers and nozzles, and into the adjacent buckets, substantially as described.

12. In a steam-turbine, the combination of a casing provided with steam inlet and exhaust ports, a turbine-wheel therein provided with curved buckets, a ring-shaped tube supported by walls in said casing, partitions in said casing contacting with the ring tube and supporting-walls, and inner walls of the casing, and dividing the casing into admission, guide and release chambers, the lower ends of the partitions in the release-chambers forming release-blades in proximity to the outlet ends of the buckets, and a plurality of admission-blades immediately below the admission-chambers for guiding the steam into the inlet ends of the buckets, substantially as described.

13. In a steam-turbine, the combination of a casing provided with a plurality of steam inlet and exhaust ports, radial partitions in said casing dividing the same into separate units, corresponding in number to the inlet-ports, a turbine-wheel, a plurality of curved buckets on said turbine-wheel, and a plurality of partitions in said casing dividing the same into admission, guide and release chambers, said chambers being adapted to guide the steam in a spiral path successively from one admission-chamber and through a guide-chamber into the next admission-chamber until the steam reaches the exhaust-ports, said separate units being adapted to be used individually or jointly, substantially as described.

14. In a steam-turbine, the combination, of a casing having inlet and exhaust ports, a turbine-wheel provided with a plurality of curved buckets, and a plurality of partitions in said casing dividing the same into admission, guide and release chambers adapted to split the steam into two parts during either the high or low pressure expansions and to guide each part in a spiral path successively from one chamber through the buckets into a release-chamber and then through a guide-chamber into the next admission-chamber and bucket, and finally to the exhaust-port, substantially as described.

15. In a steam-turbine, the combination of a casing divided into a high-pressure and a low-pressure chamber, steam-inlet channels for the high-pressure chamber, steam-outlet channels for the low-pressure chamber, a turbine-wheel provided with a plurality of curved buckets, and a plurality of partitions in said casing dividing the same into admission, guide and release chambers, adapted to first split the steam into two parts and to guide each part in a spiral path in the high-pressure chamber successively from one admission-chamber through the buckets into a release-chamber and then through a guide-chamber into the next admission-chamber, and similarly each part in a spiral path in the low-pressure chamber until both parts meet and are simultaneously exhausted, substantially as described.

In testimony that I claim the foregoing as my invention I have signed my name in presence of two subscribing witnesses.

JOHN W. SMITH.

Witnesses:

LILLIE F. FELTON,

O. Y. FELTON.