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W. L. POPE.

STEAM TURBINE.

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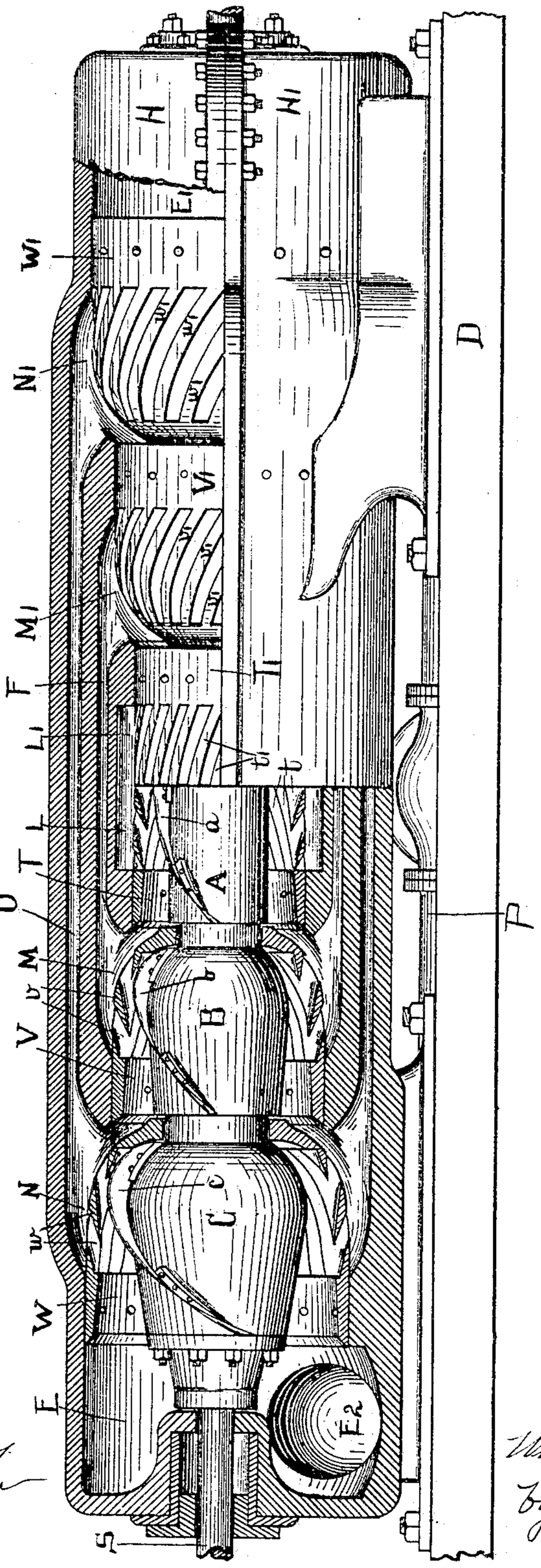

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UNITED STATES PATENT OFFICE.

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STEAM-TURBINE.

SPECIFICATION forming part of Letters Patent No. 782,267, dated February 14, 1905.

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To all whom it may concern:

Be it known that I, WILLIAM L. POPE, a citizen of the United States, residing at Rochester, in the county of Monroe and State of New York, have invented a new and useful Improvement in Steam-Turbines, of which the following is a specification.

My present invention relates to that class of steam-engines in which there are one or more systems of rotating blades in combination with coöperating and corresponding one or more systems of stationary vanes or nozzles arranged to project corresponding series of streams of steam against the rotating blades. In engines of this class I have noticed a serious difficulty, in that the steam as it expands occupies a greater space. Hence there is necessitated an increasing capacity toward the discharging end of a system of rotating blades, and when two or more such systems are arranged tandem, so that each system except the last shall discharge into the next succeeding one, then such an increasing capacity is necessitated toward the discharging end of each system. The initial velocity of the steam as it escapes from the first set of stationary vanes or nozzles is very high, while at or near the discharge end of the system or systems of rotating blades the velocity of the steam is very greatly reduced. In fact, the steam at that point has but little directional tendency compared with what it has at the discharging-points of the first system of the nozzles in the engine. On account of this increased volume which the steam occupies at the discharging end and also on account of the low velocity with which the steam travels and the practical loss, therefore, of directional tendency on the part of the steam there occurs in engines of the usual construction a serious loss by way of backlash. In other words, the revolving blades or vanes near the exit of the steam from the engine are not driven thereby; but oftentimes the rotating blades serve to drive the steam outwardly on account of their screw-like action thereon caused by the angular disposition of the blades and their high rate of rotation relatively to the pressure and rate of travel of the steam. I am aware that any effort exerted by the blades near the exit of the steam from the engine in forcing the steam outwardly is measurably compensated for by the increased "draft," as it may be termed, given to the live steam from the nozzles and operating on the blades nearer the point of entrance of the steam or on the first system of revoluble blades; but when this tendency of the steam to lag and become a load upon the revolving blades becomes too great there results a serious loss in efficiency of the engine.

To overcome these difficulties, I have devised an arrangement of rotating blades and stationary nozzles so located and angularly disposed that there is afforded a passage-way of continually-increasing cross-sectional area through the engine, while at the same time to compensate for the decrease in the velocity of the steam I materially reduce the diameter of the inner circle swept by the rotating blades, and at the same time also I modify the angle of the blades, so that the blades in the last system are arranged at a lesser angle to the plane of rotation than the blades in the first system. By this means the action of the blades tending to force the steam around more rapidly than outwardly is very materially overcome, and thereby less frictional opposition from the steam is secured in its exit from the engine and through the last system, as the steam is not retained in the engine and caused to revolve with the blades. I have also found it desirable to gradually lessen the angle of each rotating blade relatively to its plane of rotation toward the discharging end of such revolving blade.

In the accompanying drawing I have shown my invention as applied to that style of a rotary steam-engine described in a former United States patent of mine, issued June 28, 1904, and numbered 763,425, although I wish it distinctly understood that I do not limit myself in the application of my present invention to any particular style of steam-turbine, as many of the features of my present invention are applicable to rotary steam-engines of the impact type or steam-turbines in general. As the general construction of the engine is clearly brought out in such former patent of mine above mentioned, I shall only

briefly describe such engine herein, making a special reference to the features thereof involving my present invention only.

The accompanying drawing shows to the left a vertical central section through the left-hand half of my engine or turbine with the cylindrical elements carrying the revoluble blades shown in full and with only one blade on each of such revoluble elements in order to bring out more clearly the angular disposition of the blades and the conical contour of the revoluble elements, which constitute essential features of my present invention. To the right of the center vertically in this figure there is shown above the central horizontal line my engine with only the outer casing or shell seen in vertical section, while below the central horizontal line my turbine is shown in full.

Referring to the drawing, H and H′ constitute the upper and lower halves of the inclosing shell of my engine, the lower half of the shell H′ being bolted to a suitable base-piece D. The engine is shown as with the final exhaust-pipe turned from the observer, so as to more clearly bring out the internal construction and arrangement of the parts.

My engine consists within the shell-pieces H and H′ of a shaft S, revolving in suitable bearings in the extreme left and right hand ends of the shell or casing, and on this shaft S there are located corresponding left-hand and right-hand elements A, B, and C, the right-hand elements A′, B′, and C′ being concealed within the casing and the inclosing systems of stationary vanes or nozzles. The elements A and A′ constitute, in effect, a continuous cylinder. Upon the element A are arranged the spirally-disposed revoluble blades *a*, and similarly upon the elements B and C are arranged the spirally-disposed blades *b* and *c*. Only one of each of these blades is seen on each element in order to more clearly bring out the angular relation between such blades themselves and between such blades and the elements upon which they are located. Inclosing the elements A, B, and C, with the spirally-disposed blades *a*, *b*, and *c*, respectively, thereon, are seen the corresponding series or systems of spirally-disposed stationary vanes or nozzles *t*, *v*, and *w*, terminating at their outer ends in cylinders T, V, and W. These systems of stationary vanes or nozzles are located within the chambers L, M, and N, there being corresponding chambers L′, M′, and N′ on the right-hand side of the engine. Connecting ducts or channels O and F, cored out from the casing-sections H and H′, serve to connect, respectively, the chambers N and N′ and chambers M and M′, so as to equalize the pressure in corresponding right and left hand systems of my engine. To the extreme left and right hand end of the engine are seen two exhaust-chambers E and E′, the chamber E having an opening E^2 leading into the final exhaust-pipe P, while a similar arrangement (not seen) is made use of at the right-hand end of the engine.

Thus far the description is practically that of the engine described in my above-mentioned patent. The more essential features of my present invention consist as follows: The blades *a* are disposed upon the element A at a gradually-decreasing angle relatively to the plane of rotation of such blades, and in the same way also, as will at once be seen by reference to the drawing, the blades *b* are disposed upon the element B and the blades *c* upon the element C each at an angle relatively to the plane of rotation of such blades gradually lessening toward the discharging ends of such blades. Attention is also called to the fact that the gradually-increasing cross-sectional area of the steam-passage between the blades on each of the elements B and C is effected by a reduction in the diameter of the circle described by the blades *b* and *c* as they approach the discharging ends of such elements and blades—that is, the element B is tapered downwardly toward its left-hand or discharging end, and the same also with regard to the element C.

From the foregoing description it will at once be seen that there is afforded a gradually-increasing passage for the steam through each system of revoluble blades and that each system of revoluble blades presents a steam-passage of a cross-sectional area greater than that presented at a corresponding point in the next preceding system. Attention is also called to the fact that the lead of the spirally-disposed blades on each system gradually lessens toward the discharging end of each of such systems. On account of these features, for the reasons already hereinbefore set forth, the tendency of the steam to backlash and become a load upon the revoluble blades is greatly lessened.

I would have it understood that by the use of the word "steam" in the foregoing specifications and appended claims I mean any suitable fluid under pressure, whether gaseous or liquid, capable of effecting the same results as the steam under pressure in the usual steam-engine, whether rotary or reciprocating.

What I claim is—

1. In a rotary engine, a revoluble element carrying a series of blades spirally arranged on the periphery of such element and a series of stationary vanes or nozzles also spirally disposed and arranged to project a series of streams of steam against the blades on such revoluble element, a chamber circumferentially inclosing such revoluble blades permitting the escape of steam between such blades in a direction axial or nearly so to the cylinder supporting them and means for maintaining a supply of steam under pressure to between or through such stationary vanes or nozzles, such revoluble blades disposed at an

angle relatively to their axis of rotation gradually increasing toward the discharging ends thereof.

2. In a rotary engine, a revoluble element carrying a series of blades spirally arranged on the periphery of such element and a series of stationary vanes or nozzles also spirally disposed and arranged to project a series of streams of steam against the blades on such revoluble element, a chamber circumferentially inclosing such revoluble blades permitting the escape of steam only between such blades in a direction axial or nearly so to the cylinder supporting them and means for maintaining a supply of steam under pressure to between or through such stationary vanes or nozzles, the space between adjacent ones of such revoluble blades presenting a series of cross-sectional areas gradually increasing toward the discharging end of such system of revoluble blades, such revoluble blades disposed at an angle relatively to their axis of rotation gradually increasing toward the discharging end thereof.

3. In a rotary engine, two or more systems each comprising a revoluble element carrying a series of blades spirally arranged on the periphery of such element and a series of stationary vanes or nozzles also spirally disposed and arranged to project a series of streams of steam against the blades on such revoluble element, a chamber circumferentially inclosing such revoluble blades permitting the escape of steam only between such blades in a direction axial or nearly so to the cylinder supporting them, means for maintaining a supply of steam under pressure to between or through such stationary vanes or nozzles and means for discharging the steam from each one of such systems (except the last) into the next succeeding system whereby such systems are connected up and operate in tandem, such revoluble blades disposed at an angle relatively to their axis of rotation gradually increasing toward the discharging ends thereof.

4. In a rotary engine, two or more systems each comprising a revoluble element carrying a series of blades spirally arranged on the periphery of such element and a series of stationary vanes or nozzles also spirally disposed and arranged to project a series of streams of steam against the blades on such revoluble element, a chamber circumferentially inclosing such revoluble blades permitting the escape of steam between such blades in a direction axial or nearly so to the cylinder supporting them, means for maintaining a supply of steam under pressure to between or through such stationary vanes or nozzles, the spaces between adjacent ones of such revoluble blades presenting a series of cross-sectional areas gradually increasing toward the discharging ends of such systems of revoluble blades and means for discharging the steam from each one of such systems (except the last) into the next succeeding system whereby such systems are connected up and operate in tandem, such revoluble blades disposed at an angle relatively to their axis of rotation gradually increasing toward the discharging ends thereof.

5. In a rotary engine, two or more systems each comprising a revoluble element carrying a series of blades spirally arranged on the periphery of such element and a series of stationary vanes or nozzles also spirally disposed and arranged to project a series of streams of steam against the blades on such revoluble element, a chamber circumferentially inclosing such revoluble blades permitting the escape of steam only between such blades in a direction axial or nearly so to the cylinder supporting them, means for maintaining a supply of steam under pressure to between or through such stationary vanes or nozzles and means for discharging the steam from each one of such systems (except the last) into the next succeeding system whereby such systems are connected up and operate in tandem, each one of such systems after the first presenting steam-spaces of greater cross-sectional area than those presented at approximately similar points in the preceding system, such revoluble blades disposed at an angle relatively to their axis of rotation gradually increasing toward the discharging ends thereof.

6. In a rotary engine, two or more systems each comprising a revoluble element carrying a series of blades spirally arranged on the periphery of such element and a series of stationary vanes or nozzles also spirally disposed and arranged to project a series of streams of steam against the blades on such revoluble element, a chamber circumferentially inclosing such revoluble blades permitting the escape of steam between such blades in a direction axial or nearly so to the cylinder supporting them, means for maintaining a supply of steam under pressure to between or through such stationary vanes or nozzles, the space between adjacent ones of such revoluble blades presenting a series of cross-sectional areas gradually increasing toward the discharging end of such system of revoluble blades and means for discharging the steam from each one of such systems (except the last) into the next succeeding system whereby such systems are connected up and operate in tandem, each one of such systems after the first presenting steam-spaces of greater cross-sectional area than those presented at approximately similar points in the preceding system, such revoluble blades disposed at an angle relatively to their axis of rotation gradually increasing toward the discharging ends thereof.

7. In a rotary engine a revoluble element carrying a series of blades spirally arranged on the periphery of such element and a series

of stationary vanes or nozzles also spirally disposed and arranged to project a series of streams of steam against the blades on such revoluble element, a chamber circumferentially inclosing such revoluble blades permitting the escape of steam only between such blades in a direction axial or nearly so to the cylinder supporting them and means for maintaining a supply of steam under pressure to, between or through such stationary vanes or nozzles, the space between adjacent ones of such revoluble blades presenting a series of cross-sectional areas gradually increasing by a reduction of the diameter of the circle described by the inner edges of such revoluble blades toward the discharging end of such system of revoluble blades.

8. In a rotary engine two or more systems each comprising a revoluble element carrying a series of blades spirally arranged on the periphery of such element and a series of stationary vanes or nozzles also spirally disposed and arranged to project a series of streams of steam against the blades on such revoluble element, a chamber circumferentially inclosing such revoluble blades permitting the escape of steam between such blades in a direction axial or nearly so to the cylinder supporting them, means for maintaining a supply of steam under pressure to, between or through such stationary vanes or nozzles, the spaces between adjacent ones of such revoluble blades presenting a series of cross-sectional areas gradually increasing by a reduction of the diameter of the circle described by the inner edges of such revoluble blades toward the discharging end of such system of revoluble blades and means for discharging the steam from each one of such systems (except the last) into the next succeeding system whereby such systems are connected up and operate in tandem.

9. In a rotary engine two or more systems each comprising a revoluble element carrying a series of blades spirally arranged on the periphery of such element and a series of stationary vanes or nozzles also spirally disposed and arranged to project a series of streams of steam against the blades on such revoluble element, a chamber circumferentially inclosing such revoluble blades permitting the escape of steam between such blades in a direction axial or nearly so to the cylinder supporting them, means for maintaining a supply of steam under pressure to, between or through such stationary vanes or nozzles, the space between adjacent ones of such revoluble blades presenting a series of cross-sectional areas gradually increasing by a reduction of the diameter of the circle described by the inner edges of such revoluble blades toward the discharging end of such system of revoluble blades and means for discharging the steam from each one of such systems (except the last) into the next succeeding system whereby such systems are connected up and operate in tandem, each one of such systems after the first presenting steam-spaces of greater cross-sectional area than those presented at approximately similar points in the preceding system.

10. In a steam-turbine, two or more systems each comprising a series of revoluble blades and stationary vanes or nozzles and means for supplying steam under pressure to between or through such stationary vanes or nozzles, each system (except the last) arranged to discharge into the next succeeding system, the revoluble blades of each system (except the first) arranged at a greater angle relatively to their axis of rotation than those of the next preceding system.

11. In a steam-turbine, two series of systems of relatively right and left hand angularly-disposed revoluble blades and stationary vanes or nozzles and means for supplying steam under pressure to between or through each system of stationary vanes or nozzles, the revoluble blades in each system disposed relatively to their axis of rotation at an angle gradually increasing toward their discharging ends.

12. In a steam-turbine, two or more systems each comprising a series of revoluble blades and stationary vanes or nozzles and means for supplying steam under pressure to between or through such vanes or nozzles, each system (except the last) arranged to discharge into the next succeeding system, such revoluble blades disposed relatively to their axis of rotation at an angle gradually increasing toward their discharging ends, the revoluble blades of each system (except the first) arranged at a greater angle relatively to their axis of rotation than those of the next preceding system.

13. In a steam-turbine, two series of systems of relatively right and left hand angularly-disposed revoluble blades and stationary vanes or nozzles and means for supplying steam under pressure to between or through each system of stationary vanes or nozzles, the revoluble blades in each system disposed relatively to their axis of rotation at an angle gradually increasing toward their discharging ends, the revoluble blades of each system (except the first) arranged at a greater angle relatively to their axis of rotation than those of the next preceding system.

14. In a steam-turbine, a series of revoluble blades and stationary vanes or nozzles and means for supplying steam under pressure to between or through such stationary vanes or nozzles, such stationary vanes or nozzles disposed relatively to the axis of rotation of such revoluble blades at an angle gradually increasing toward their discharging ends.

15. In a steam-turbine, two or more systems each comprising a series of revoluble blades and stationary vanes or nozzles and means for supplying steam under pressure to between

or through such stationary vanes or nozzles, each system (except the last) arranged to discharge into the next succeeding system, the stationary vanes of each system (except the first) arranged at a greater angle relatively to the axis of rotation of its revoluble blades than those of the next preceding system.

16. In a steam-turbine, two series of systems of relatively right and left hand angularly-disposed revoluble blades and stationary vanes or nozzles and means for supplying steam under pressure to between or through each system of stationary vanes or nozzles, the stationary vanes in each system disposed relatively to the axis of rotation of its revoluble blades at an angle gradually increasing toward their discharging ends.

17. In a steam-turbine, two or more systems each comprising a series of revoluble blades and stationary vanes or nozzles and means for supplying steam under pressure to between or through such vanes or nozzles, each system (except the last) arranged to discharge into the next succeeding system, such stationary vanes or nozzles disposed relatively to the axis of rotation of corresponding revoluble blades at an angle gradually increasing toward their discharging ends, the stationary vanes of each system (except the first) arranged at a greater angle relatively to the axis of rotation of its revoluble blades than those of the next preceding system.

18. In a steam-turbine, two series of systems of relatively right and left hand angularly-disposed revoluble blades and stationary vanes or nozzles and means for supplying steam under pressure to between or through each system of stationary vanes or nozzles in each system disposed relatively to the axis of rotation of its revoluble blades at an angle gradually increasing toward the discharging ends of such revoluble blades, the stationary vanes or nozzles of each system (except the first) arranged at a greater angle relatively to the axis of rotation of its revoluble blades than those of the next preceding system.

19. In a steam-turbine, two series of corresponding right and left hand angularly-disposed revoluble blades disposed at an angle relatively to their axis of rotation gradually increasing toward their discharging ends and means for supplying and projecting a series of streams of steam to and against such revoluble blades in each of such systems thereof.

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Witnesses:
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