

E. S. BENNETT.
TURBINE ENGINE.

APPLICATION FILED MAY 31, 1917. RENEWED DEC. 29, 1919.

1,349,487.

Patented Aug. 10, 1920.

4 SHEETS—SHEET 1.

Fig. 1.

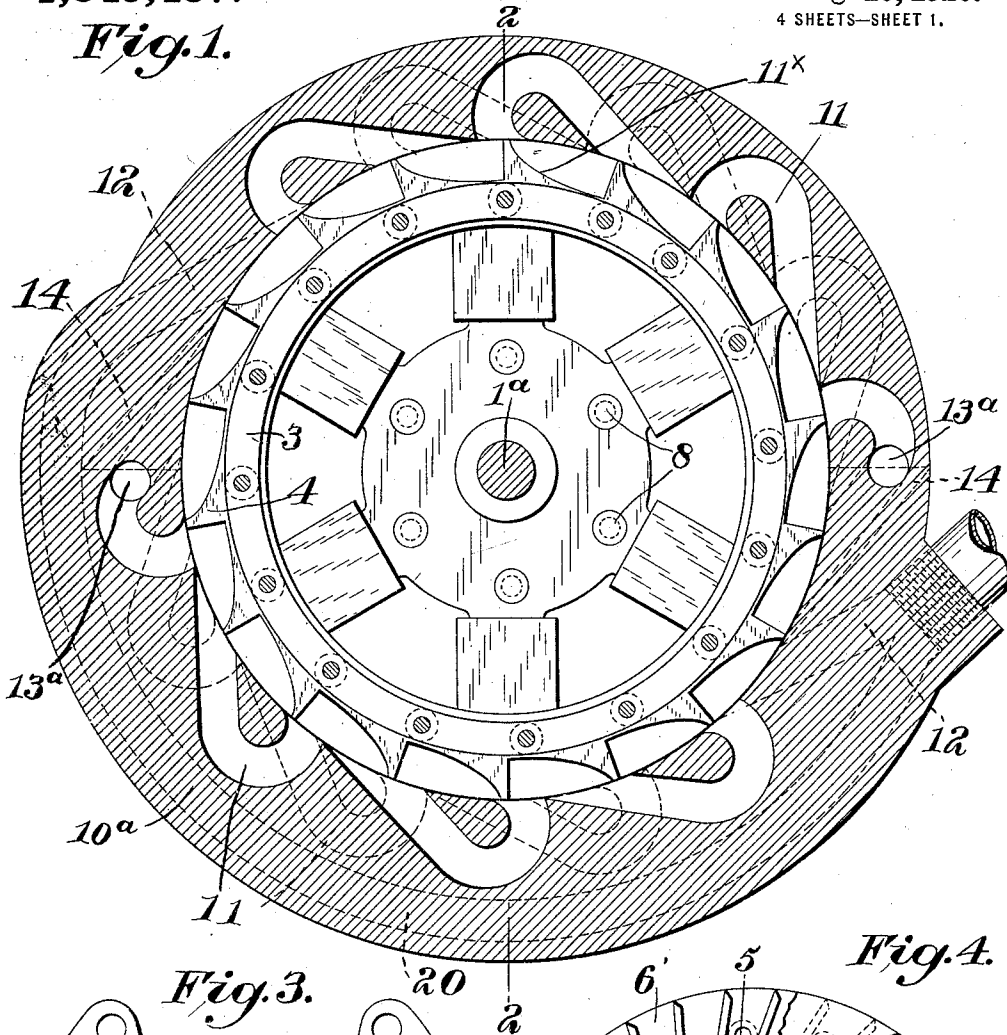


Fig. 3.

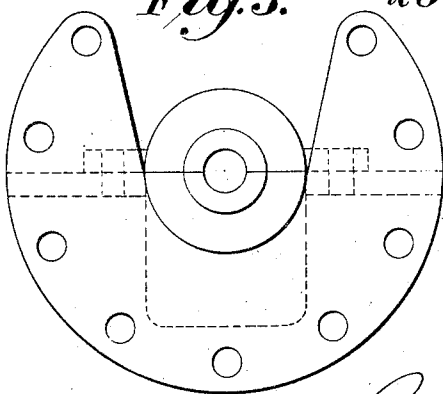


Fig. 4.

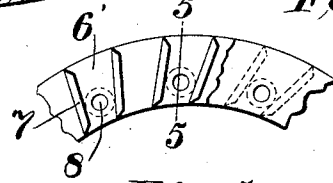
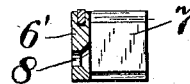


Fig. 5.



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4 SHEETS—SHEET 2.

Fig. 2.

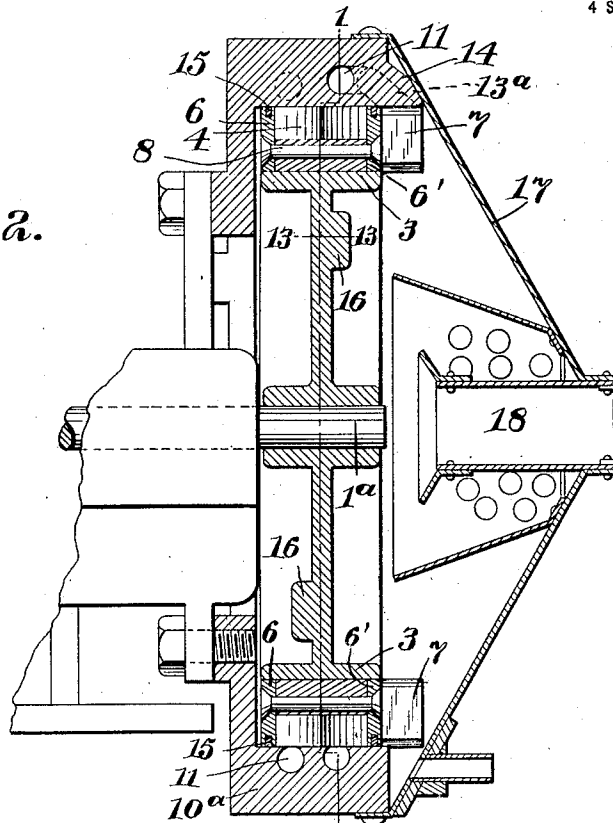


Fig. 6.

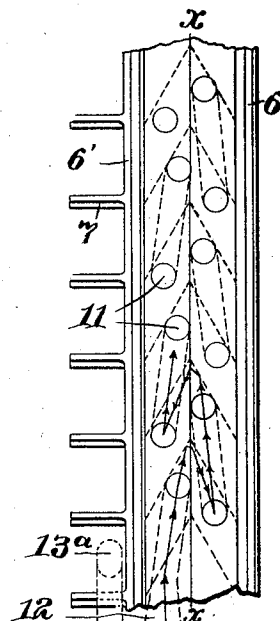


Fig. 7.

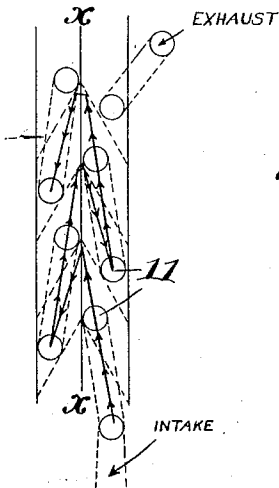


Fig. 8.

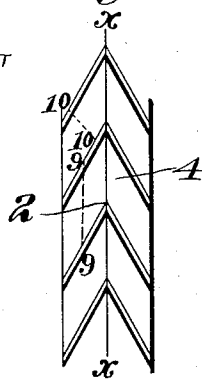


Fig. 9.



Fig. 10.



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4 SHEETS—SHEET 3.

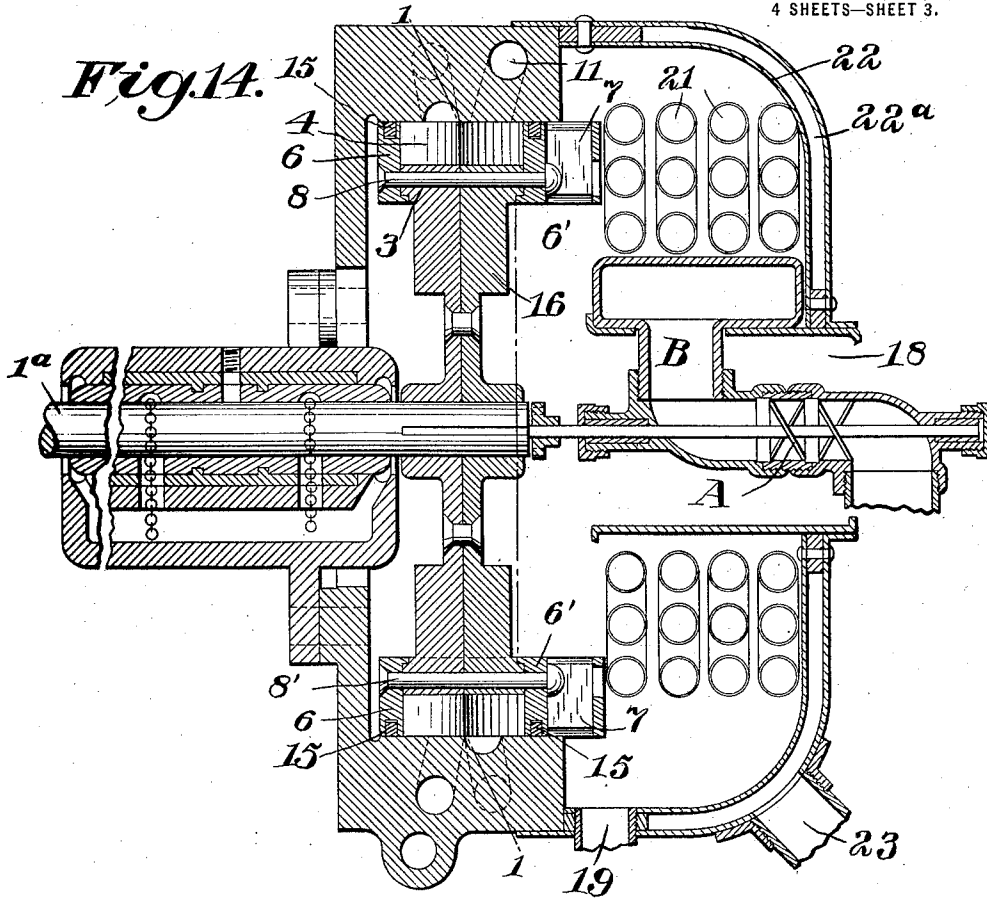


Fig. 12.

Fig. 13.

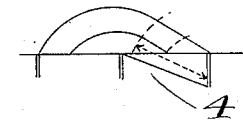
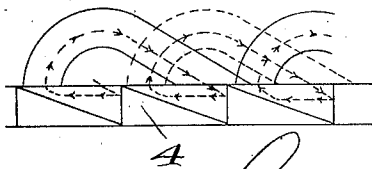
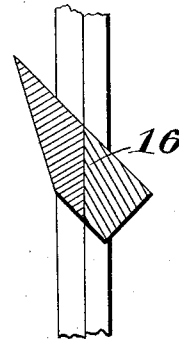


Fig. 11.



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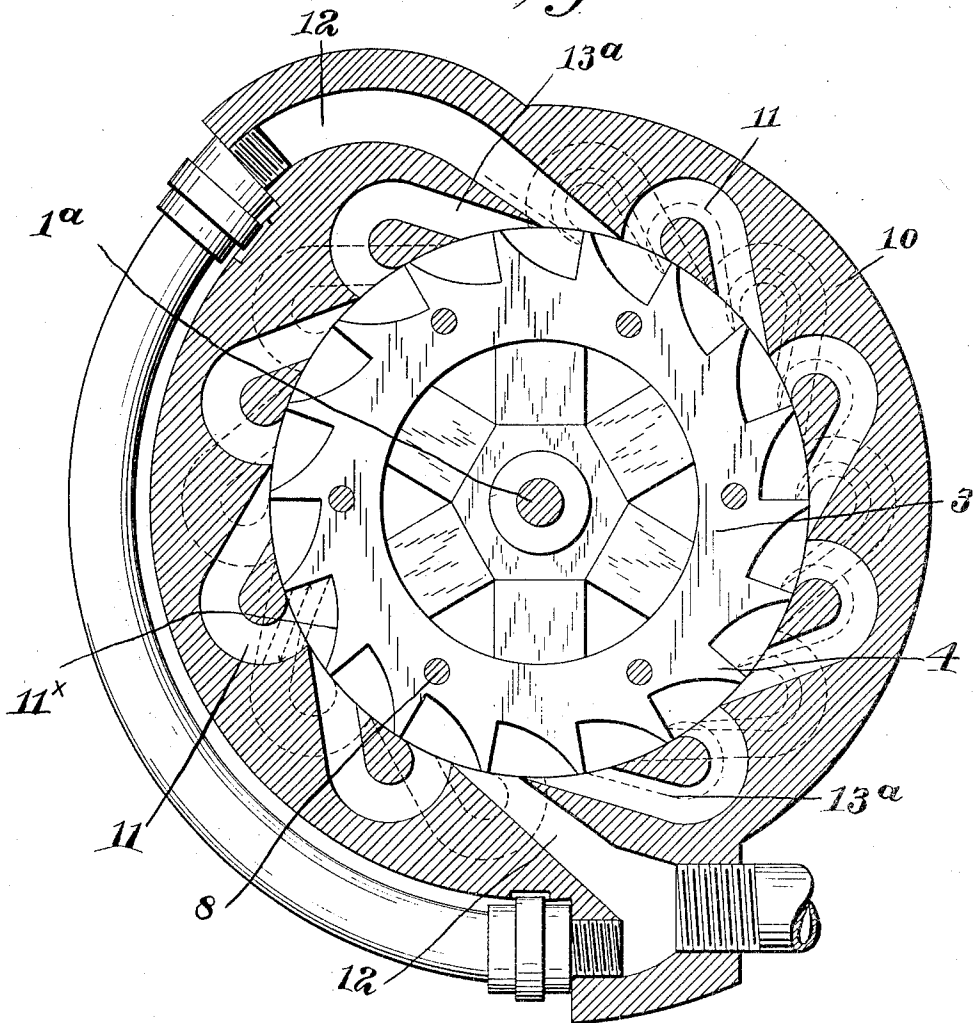
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4 SHEETS—SHEET 4.

Fig. 15.



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UNITED STATES PATENT OFFICE.

ERASTUS S. BENNETT, OF NEW YORK, N. Y.

TURBINE-ENGINE.

1,349,487.

Specification of Letters Patent. Patented Aug. 10, 1920.

Application filed May 31, 1917, Serial No. 172,010. Renewed December 29, 1919. Serial No. 348,037.

To all whom it may concern:

Be it known that I, ERASTUS S. BENNETT, a citizen of the United States, and resident of New York, N. Y., have invented certain new and useful Improvements in Turbine-Engines, of which the following is a specification.

Heretofore in this type of engine the tangentially introduced jet of steam is discharged against a series of blades set at about a 45° angle, this expanded and passed to the exhaust. In some cases this expanded steam is made to pass through one or more similar sets of larger blades fixed on rotors connected to the same shaft with the first rotor, the steam constantly expanding on its way to the exhaust.

It is evident that only a part of the force of impact and practically none of the force due to recoil can be secured in this way; and when it is considered that "action and reaction are equal" some idea of the loss due to the absence of recoil (reaction) may be had, and inasmuch as steam holds its force only when confined, and loses it by expansion, the still further loss by engines wherein the steam is thus rapidly expanded is apparent. The force is taken out of the flow, not by being absorbed in or transmitted to the rotor, but by the loss through expansion.

By my invention these serious losses are eliminated.

The invention consists in the features and combination and arrangement of parts hereinafter described and particularly pointed out in the claims.

In the drawings herewith submitted,

Figure 1 represents a vertical section of the engine substantially on line 1—1 of Fig. 2, and Fig. 14.

Fig. 2 is a vertical transverse section of the same on line 2—2 of Fig. 1.

Fig. 3 is an end view of shaft bearing showing the flange, cast on its lower half, which supports the engine.

Fig. 4 shows the segment of the rotor carrying ring, with a series of blades to receive the exhaust to transmit a portion of any remaining force therein to the rotor and deliver the steam to the exhaust chamber for condensation.

Fig. 5 is a cross section of same on line 5—5 of Fig. 4.

Fig. 6 is a diagrammatic plan view of the peripheral face of the rotor showing the outline of the steam passage, its various openings with relation to the teeth of the rotor, the general course the steam takes in its passage and its exhaust.

Fig. 7 is a view similar to Fig. 6 in part showing the rotor teeth in another position with relation to the steam supply openings thereto, the changed angles the course the steam takes with the teeth in this position, and illustrating the fact that the areas of inlet and exhaust in each tooth space are always equal regardless of the relative position of the teeth to the openings in the steam passage.

This figure and the preceding one also shows that the exhaust from each tooth space can occur only after the full force of direction impact and recoil has been imparted to the tooth.

Fig. 8 is a diagrammatic view of a portion of the periphery of the rotor showing that the teeth are in the form of equilateral triangles, the apex of each touching the base line of the next one forward.

Fig. 9 is a cross section of the tooth taken on line 9—9 of Fig. 8.

Fig. 10 is a cross section of the tooth taken on line 10—10 of Fig. 8.

Fig. 11 is a diagrammatic side view showing by dotted lines the course of the flow of steam throughout.

Fig. 12 shows a slight abutment having *per se* but slight effect which, however, is multiplied by the total number of teeth under steam in the engine.

Fig. 13 is a cross sectional view of a part of the rotor taken on line 13—13 of Fig. 2, which acts as a fan when the rotor is in motion.

Fig. 14 is a view like Fig. 2 with modified features.

Fig. 15 is a view like Fig. 1 slightly modified and with rotor in another position.

Throughout the drawings the numeral 1^a represents the shaft of the engine firmly secured to which is the rotor member 3 having peripheral teeth 4. This rotor member is preferably made in halves divided from each other along a plane *x—x* at right angles to the axis of the rotor, that is, it is in the form of two disks. Each half has its own portion of the complete tooth or

bucket. Each section is preferably of cast metal.

This two part formation of the rotor facilitates the manufacture of the rotor, it being possible to readily cut the teeth portions in each half before uniting them. When assembled and secured together the equilateral triangular spaces forming the teeth are provided, the apex of each space at 2 reaching nearly or quite to the imaginary base line of the space next ahead, as will be understood from a consideration of Fig. 8, which shows the outline of the tooth spaces in full lines, or from an inspection of Figs. 7 and 8 in which the angular or A-shape of the pockets is shown in dotted lines.

The side openings of the pockets or teeth are closed by the rings 6 and 6', the latter provided with blades 7. These rings are securely fastened in place by rivets 8, 8', Figs. 1, 2, 4, and 5, so that the pockets at their lateral points are steam tight. The teeth at their periphery and the edges of the rings 6 and 6' are now turned or machined to a given measurement, or so that the tops of the teeth present a true surface in the plane of the periphery of the rotor as in Figs. 8, 9 and 10 and the whole rotor is perfectly balanced.

The rotor thus formed is now ready for the casing 10^a, Fig. 2, which is bored to a close running fit to the teeth and rings 6 and 6'. The casing 10^a with its steam passages 11 may be cast in one piece or in more than one piece and flanged together. There are two intakes 12 or more than two may be used and the steam passage leading from each of these intakes may be said to be made up of the connecting conduits 11 between the pockets, these conduits and pockets providing a way for the passage of the steam from each intake to the exhaust 13^a belonging thereto. In other words each steam passage extends from the intake 12 to the exhaust 13^a and is made continuous between these points by the tooth spaces of the rotor, the whole passage being of uniform cross sectional area.

A suitable lug shown at 14 in dotted lines Fig. 1 and in Fig. 2 is cast on the casing to carry the exhaust end 13^a of the passage to a proper alinement with the blades 7, Fig. 2.

A groove is cut in the periphery of the rings 6 and 6', Figs. 2 and 14, for the reception of the split rings 15, which are of slightly greater diameter than the rings 6 and 6'. They fit loosely in their grooves and are compressed when the rotor is in the casing. The rotor turns on them with practically no contact and while they hug the base of the casing they will move readily to any side pressure, should there be any end motion to the rotor shaft.

Their object is to reduce leakage to a min-

imum by forming a tight joint with the casing and a labyrinthine passage otherwise.

The discharge side of the casing 10^a is covered by the sheet metal hood 17 forming an exhaust chamber having its outlet at 18 as shown in Fig. 2 or otherwise. The blast of cold air from the outside propelled by the blades 16 forcing the air against the hood and its partitions and very thoroughly mixing it with the steam, will condense a large percentage thereof, and the addition of water jacket 22 to and water pipes 21 in the hood as in Fig. 14 can be made to cause quite a perfect condensation to be fed back to the boiler as hot water, via outlet 19.

It is evident that two or more such rotors on the same shaft may be connected by suitable steam passages in the casing 10^a carrying the confined steam from one to the other, thus multiplying the power to be obtained from a given diameter or size of rotor.

It is also evident that to make this engine reversible two rotors set to run in opposite directions may be mounted on the shaft.

In order that the rotor shall be steam balanced it is essential that at least two columns of steam must be introduced as shown in drawings, at opposite sides, one at each of the intakes 12, since the pressure constantly diminishes from inlet to exhaust and a single column of steam extending entirely around the rotor would therefore place the rotor out of balance.

It is obvious that, owing to the shape of the teeth, and the direction of the force, the steam tends to hold the rotor to a fixed point to the entire elimination of thrust or end motion.

An inspection of the diagrams in Figs. 6 and 7 and especially 11 will show that, in this construction involving the pockets or teeth 4 of the rotor and the series of conduits 11 in the casing connecting the pockets, the three forces due to velocity of flow of steam under pressure, viz: that due to direction, impact and recoil are utilized repeatedly on a single rotor, or set of blades without expansion between inlet and exhaust, and that whatever force is left in the exhaust is made to do useful work on the blades 7 of the rotor before any expansion can take place.

The action of the steam may be followed out from the arrows in these Figs. 6, 7 and 11 from which it will be noted that the steam passes from one pocket to the other and by its direction and impact acts on the front walls of these pockets in the direction of their apices and the flow on its recoil passes out through the inlet end of the conduit 11 and is carried to the next pocket in advance and so on throughout the whole series until the exhaust 13^a is reached.

It will be seen from Figs. 6 and 7 that the conduits 11 are in staggered relation to each other and as soon as one conduit, due to the forward motion of the rotor, begins to be uncovered to discharge into a pocket the companion conduit begins to open to receive the recoil steam pressure and direct it to the next pocket in advance.

The percentage of force absorbed from the steam in its transit from port to exhaust correspondingly decreases the pressure and velocity through the passages and consequently the velocity of the rotor.

In the engine shown the rotor is not only balanced in steam but its weight is counter-balanced by introducing the steam first on the lower side thence through the passage 20 to the upper side. The slight difference caused by the longer travel will usually compensate for the weight of the rotor so that, so to speak, the rotor will be floated by steam pressure.

Referring to Fig. 14, I may employ a small screw pump A located in the large exhaust passage 18. The discharge head B from this pump has four outlets which connect with four spiral tubes 21 in the exhaust chamber which discharge at the top into the water space 22^a, the latter discharging at 23.

The following features of detail may be noted:

The steam passages 11 are cast in the casing 10^a. The cross section of passage 11 from inlet to exhaust is of uniform cross sectional dimension and practically steam tight so that there can be no expansion of steam until the exhaust is passed.

The steam passage is made complete and continuous from inlet to outlet by the steam tight tooth spaces of the rotor, said spaces being of practically the same cross sectional area as the main passage in the casing 10^a.

Each tooth space is provided with its separate inlet and outlet, so arranged that the inlet and outlet from any tooth space shall always be of equal capacity, *i. e.*, when the inlet to a tooth space is partly open to that space the outlet from that space shall be equally open.

The inlet and outlet of the conduits 11 to each tooth space are so placed that the full force of direction, impact and recoil must be delivered to the face 4 of the tooth by the current before the exhaust for that space can be reached.

The unexpanded steam, after imparting a major portion of its pressure and velocity to the series of teeth, is discharged on the blades 7 and made to impart a part of its remaining force to the rotor.

A single jet or column of steam under pressure is caused to impart to each of a number of teeth in a rotor (or rotors) of a

turbine, a portion of the force of its velocity flow, without expansion.

Throughout the steam is confined to small areas rendering the use of superheated steam at high pressure perfectly safe.

Since all the parts subject to heat are kept at about an equal temperature in this construction and will expand together, the difficulties resulting from unequal expansion of parts are avoided.

With practically no actual contact of moving parts the necessity for lubrication other than the steam is obviated.

The rotor, the only moving part, being practically frictionless enables it to devote all the force absorbed by it to useful work and therefore adds to its efficiency.

As before stated the cross sectional area of the passages 11 in the casing and the cross sectional area of the tooth spaces is approximately equal so that there will be no expansion of the steam until the exhaust is reached, and in order that this cross sectional area may be preserved I preferably form the teeth on a curve at their bottoms, as shown at 11^a, so that this effect can be secured without making a comparatively small number of teeth to the wheel or deepening the face of the blade.

Attention is also called to the curve of the passages 11 in Figs. 1 and 15, as compared with that in Figs. 11 and 12 by which I secure an increase in the area of the abutment surface indicated in Fig. 15 between the dotted lines *t*, *u*, and the direction of the pressure effect being indicated by the dotted arrow *v*.

Fig. 15 also illustrates the fact that the supply passage to the inlets may consist of a pipe arranged external to the casing instead of a passage formed in the casing.

What I claim is:—

1. A rotary engine comprising a rotor having peripheral pockets, having their front walls converging from the sides toward the center line of the periphery, a casing having inlet and exhaust ports for the steam to and from said pockets and having conduits connecting each pocket with that in advance for the passage of the steam from pocket to pocket throughout the series, said conduits being arranged in two sets, the conduits of both sets communicating simultaneously with the pockets, substantially as described.

2. A rotary engine comprising a rotor having peripheral pockets with their front walls converging from the sides forwardly to the central line of the periphery and with their bottoms substantially in the plane of chords of arcs of said periphery, a casing surrounding the rotor having inlet and exhaust ports and having also two sets of conduits communicating with the pockets, said conduits having their inlet ports located nearer the

side planes of the rotor than their discharge ports and the conduits of one set being arranged in staggered relation to those of the other set, substantially as described.

- 5 3. In combination a rotor having peripheral pockets, a casing having intake and exhaust ports communicating with said pockets in succession, conduits in the casing connecting the pockets and vanes on the lateral face of the rotor to receive the steam pressure from the exhaust, substantially as described.

- 10 4. In combination a rotor having peripheral pockets, a casing in which the rotor moves having intake and exhaust ports, said casing having an extension water-jacketed, condenser pipes in the casing extension connected with said water jacket, a pump on the rotor shaft for circulating water through said pipes and blades or vanes on the rotor for inducing circulation of air among said condensing pipes, substantially as described.

- 20 5. In combination in a rotary engine, a rotor having buckets to receive the steam current, a casing surrounding the rotor and

having inlet and exhaust passages for the motive fluid, said casing having also conduits therein provided with inlet and discharge orifices so disposed relatively to each other that when the inlet orifice of a conduit is in communication with one bucket to receive the recoil motive fluid current therefrom the discharge orifice of said conduit is in communication with a preceding bucket to deliver the motive fluid current thereto, the motive fluid being held against expansion in the buckets and conduits until the buckets are passing the exhaust, substantially as described.

- 40 6. A rotary engine comprising a rotor having peripheral pockets, a casing having a plurality of diametrically opposite inlet and exhaust ports, and conduits connecting each pocket with that in advance for the passage of the steam from pocket to pocket throughout the series, said conduits being arranged in two sets with those of one set staggered in relation to those of the other set.

In testimony whereof I affix my signature.
ERASTUS S. BENNETT.