

No. 752,602.

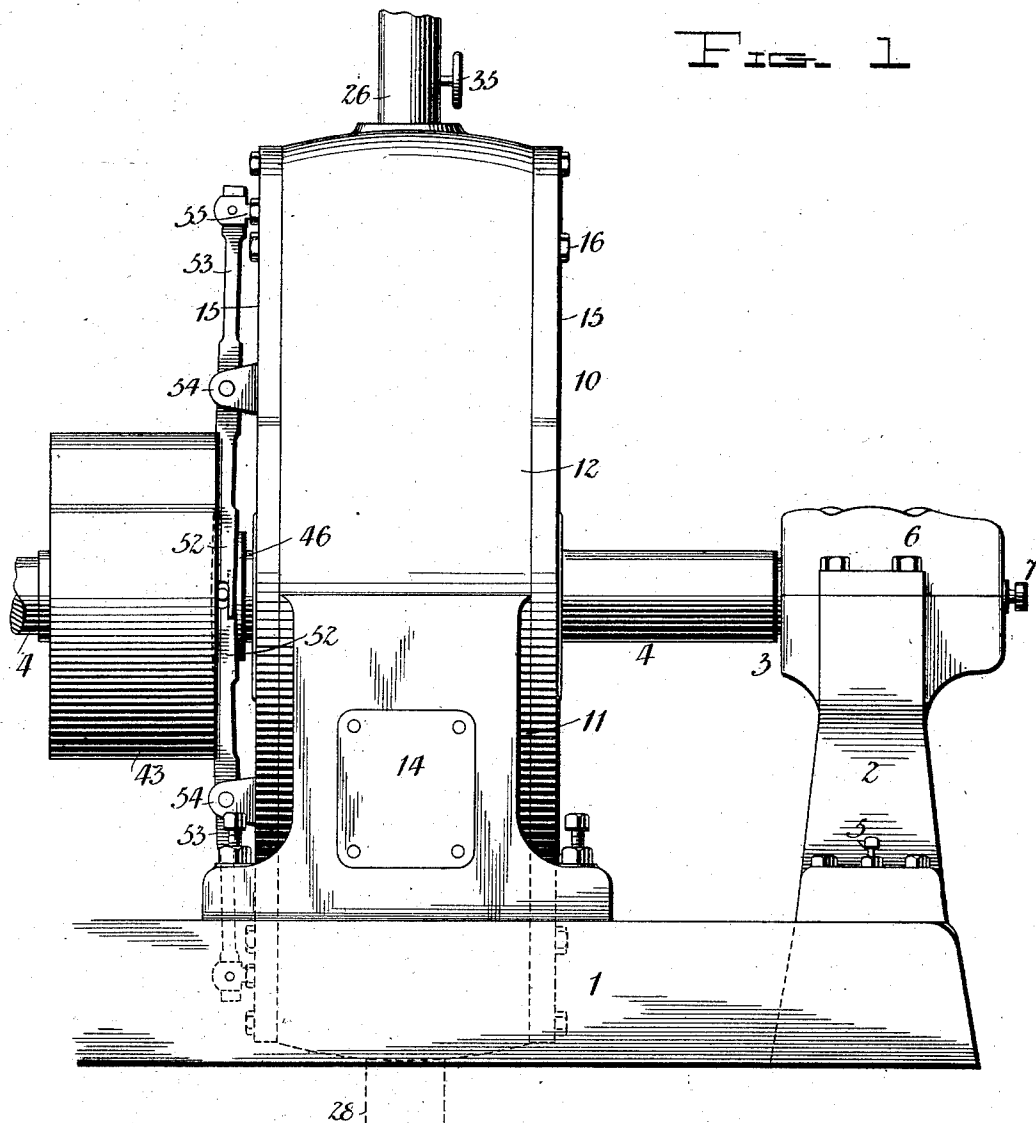
PATENTED FEB. 16, 1904.

E. F. TAYLOR.
ROTARY ENGINE.

APPLICATION FILED AUG. 22, 1902.

NO MODEL.

5 SHEETS—SHEET 1.



Witnesses

John E. Burch

Inventor

E. F. Taylor

By

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his Attorneys

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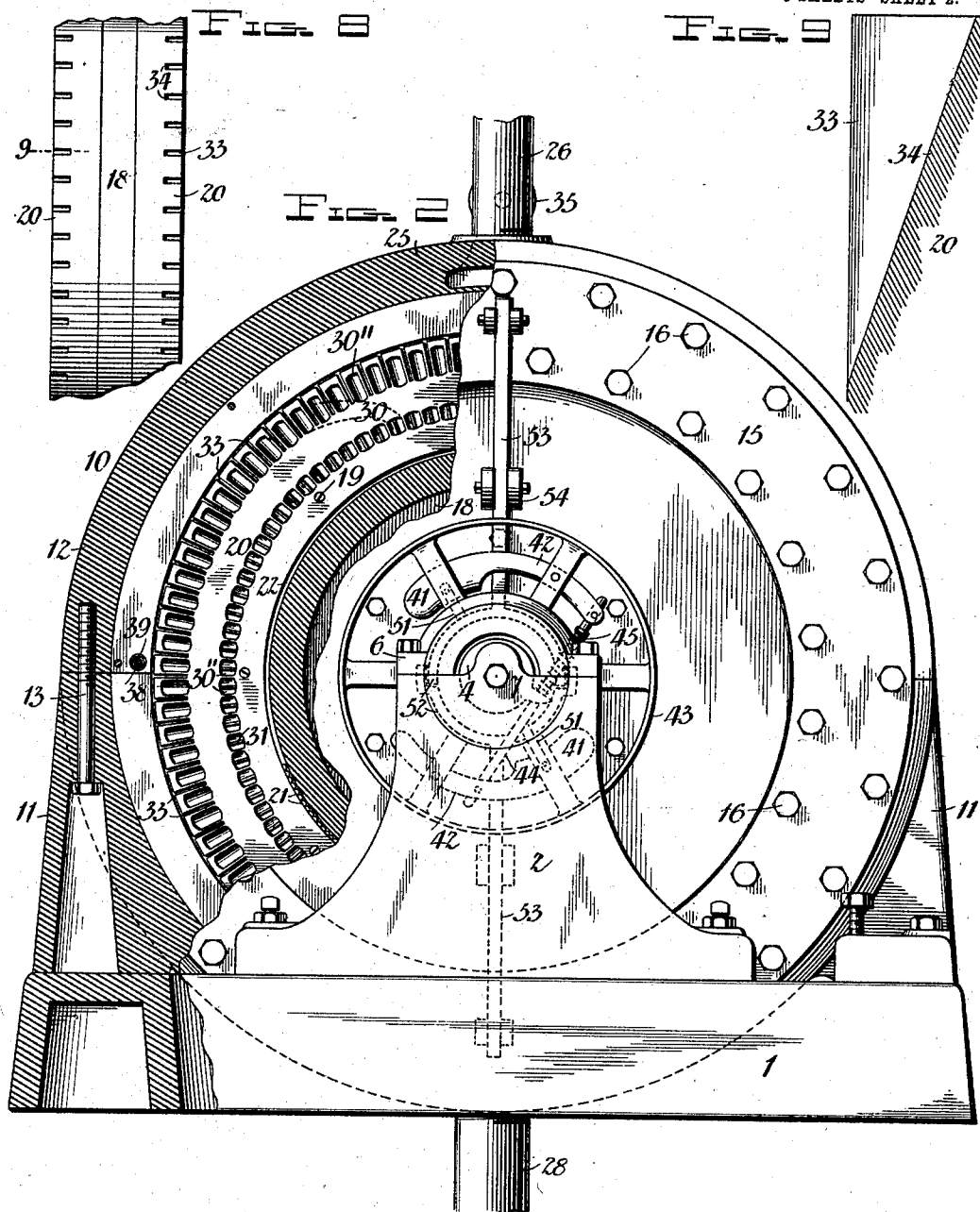
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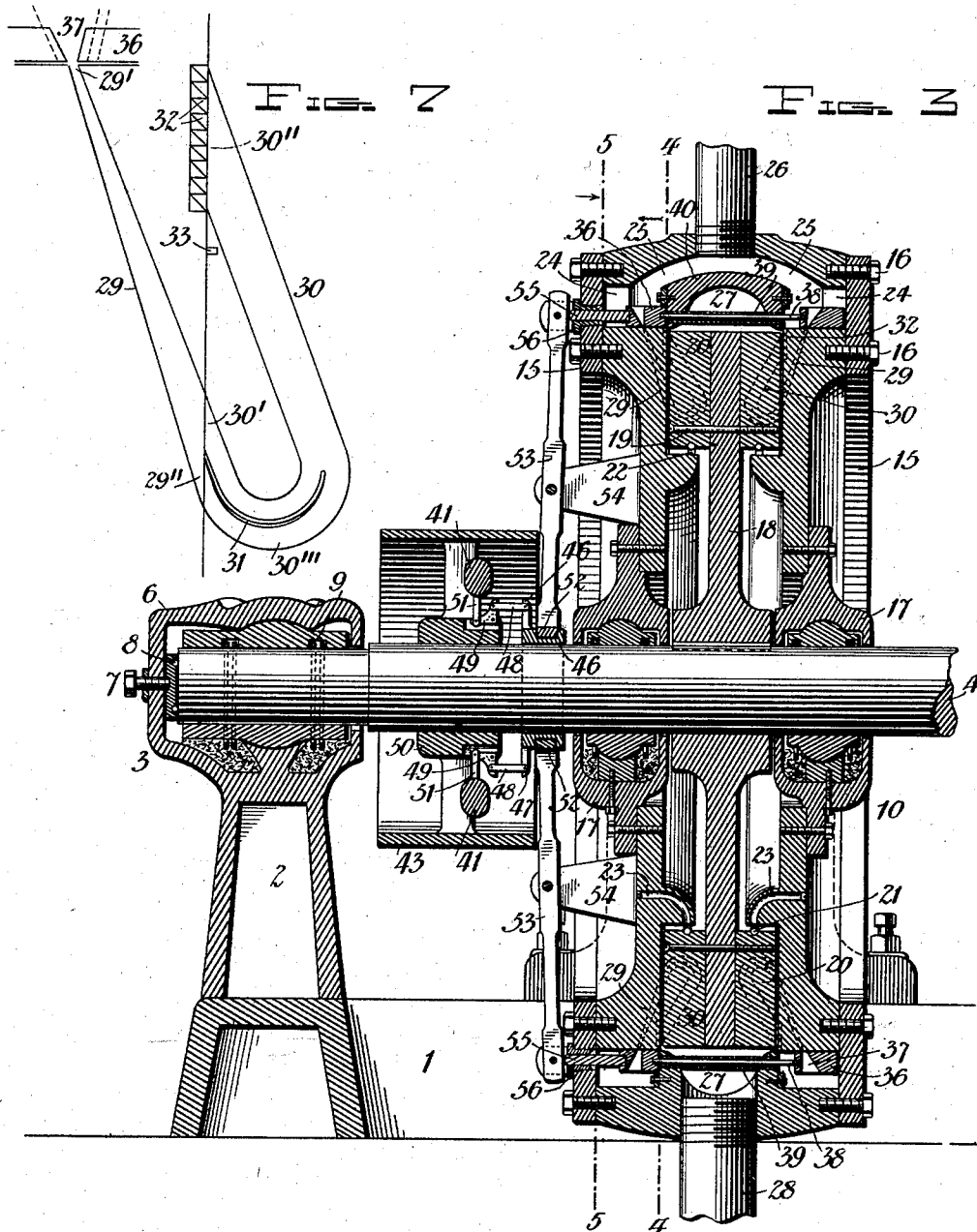
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FIG. 6

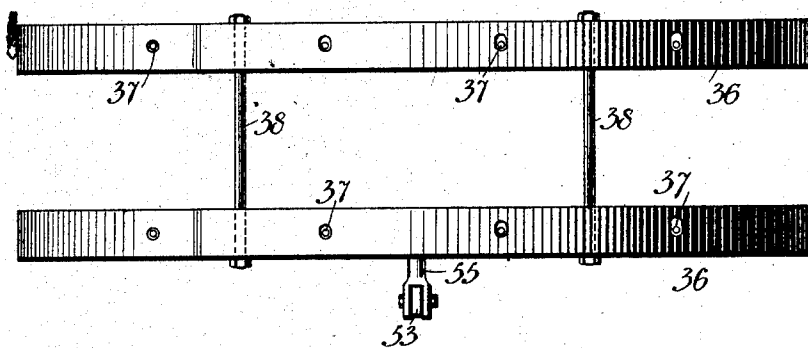
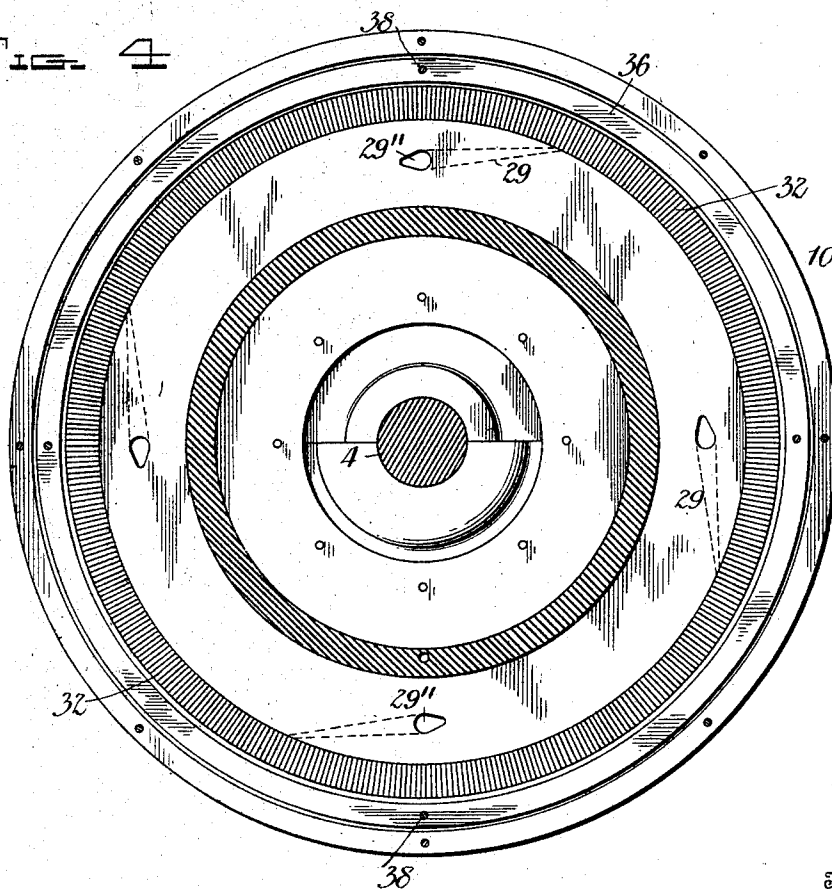


FIG. 4



Witnesses

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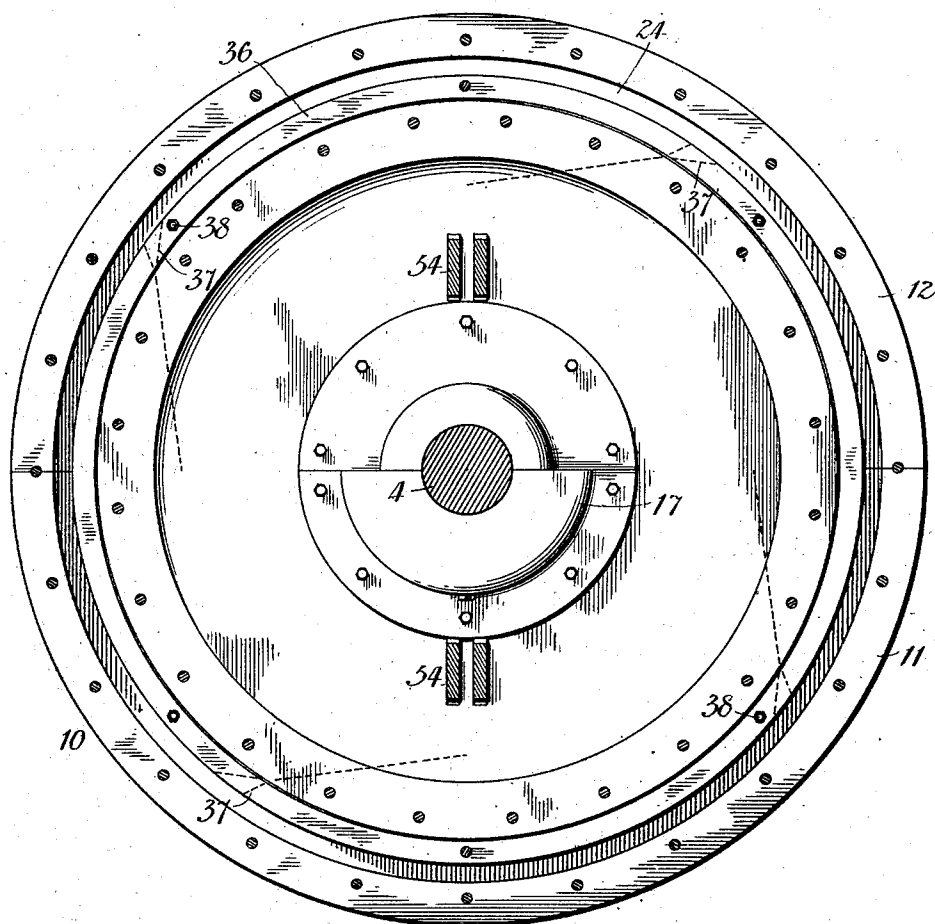
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5 SHEETS—SHEET 5.

FIG. 5



Witnesses

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UNITED STATES PATENT OFFICE.

EDWIN FORREST TAYLOR, OF WESTCHESTER, PENNSYLVANIA.

ROTARY ENGINE.

SPECIFICATION forming part of Letters Patent No. 752,602, dated February 16, 1904.

Application filed August 22, 1902. Serial No. 120,718. (No model.)

To all whom it may concern:

Be it known that I, EDWIN FORREST TAYLOR, a citizen of the United States, residing at Westchester, in the county of Chester and State of Pennsylvania, have invented certain new and useful Improvements in Rotary Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to rotary engines, and is directed more particularly to improvements in the type of rotary engines driven by impact of the motive fluid.

My improved engine belongs, so far as I am aware, to a new and distinctive type, conveniently called by me "multiple-impact," to distinguish from the single-impact class, in which a stationary jet is caused to impinge upon a moving part, and from the reaction type, in which the jet is caused to issue from the moving part, the principle of my invention being the combination of the principles of the said existing types of engines.

The nature of the improvements, together with the mode of operation and resultant advantages, are set forth in the following detailed description, in connection with which attention is called to the accompanying drawings, illustrating the invention in its preferred form, it being understood that various changes and modifications may be made therein without departing from the spirit of the invention as defined by the claims.

In the drawings, Figure 1 is a side elevation of a rotary multiple-impact engine embodying my invention, one end of the shaft and its journal-bearing being broken away. Fig. 2 is an elevation, partly in section, of the left-hand end of the engine. Fig. 3 is a vertical longitudinal central sectional view of the same, one end of the shaft and its journal-bearing being broken away. Fig. 4 is a vertical transverse sectional view on line 4 4 of Fig. 3. Fig. 5 is a vertical transverse sectional view on line 5 5 of Fig. 3. Fig. 6 is a top plan view of the governor-valves and their connections. Fig. 7 is an enlarged detail view showing end of the nozzles and valve. Fig. 8 is a view of a portion of the periphery of the wheel.

Fig. 9 is an enlarged sectional view on line 9 of Fig. 8.

Referring to the drawings by numerals, 1 denotes the base of the engine, on which are bolted pedestals 2 2, having boxes 3 3, affording bearings for the shaft 4.

5 5 are adjusting-bolts and jam-nuts for alining the boxes and shaft. The boxes include the usual caps 6 6, provided with oiling-openings, and 7 7 are thrust-bearing bolts for the shaft ends, balls or rollers 8 8 being interposed to minimize friction. The bolts 7 are provided with jam-nuts to maintain the adjustment of the thrust-bearings and shaft, and the balls or rollers 8 are carried by disks, with which the bolts 7 engage. The journal-boxes are preferably of the self-lubricating type, being provided with rings 9 9, rotated by engagement with the shaft to convey the oil from an oil-chamber beneath.

10 designates the engine-casing, adjustably secured by bolts and jam-nuts to the base 1 between the pedestals. The casing is formed of a lower section 11 and an upper section 12, secured together by bolts 13, accessible at openings in the casing closed by bolted covers 14, and also of heads 15 15, secured by bolts 16 16 to the casing ends. At the openings in the casing ends for the shaft are provided journal-boxes 17 17, bolted to the casing and equipped with means for rendering them self-lubricating. Keyed to the shaft and arranged within the casing is a wheel 18, of disk form, having secured to the faces thereof by bolts 19 19 rings 20, the peripheries of which coincide with the periphery of the wheel. The wheel is driven by both the impact and the reaction of the steam at a high rate of speed, and to obtain the proper balance of the wheel I provide a plurality of ball-weights 21 21, which occupy annular grooves or raceways 22 22 in the inner surface of the rings, the balls being introduced through openings 23 23 in the casing-wall, provided with suitable closures. As will presently appear, an object of my invention is to obtain a peripheral speed of the wheel approximating four hundred and fifty feet a second, and to accomplish this with safety, secure perfect running, and permit the use of the common type of bearing, I provide

the described ball-weights, which, being free to move in the grooves or raceways, are acted upon by gravity or by centrifugal force, dependent upon which force prevails. The velocity obtained is much above what is known as the "critical" speed, (three hundred feet a second,) which when reached changes the rotation of the revolving body from the mechanical or geometrical axis to its axis of gravity. Below the critical speed, should there be any difference of weight in the make-up of the body or wheel, there is a tendency of the heavier part to move from the shaft; but when the critical speed is reached the heavier part has a tendency to move inwardly toward the axis and the lighter part leaves the mechanical axis to revolve about the axis of gravity. By the use of the automatically-shifting weights, which in the revolution of the wheel find their proper positions to compensate for variations in the weight of the different parts of the wheel, the axis of gravity is after the critical speed is reached brought into coincidence with the mechanical or geometrical axis, and thus is maintained an even and uniform balance of the wheel, permitting the employment of the ordinary type of bearings without the necessity of providing the usual cushioning means or other expedient to overcome the danger and imperfect operation attending the revolution of a wheel at a velocity above the critical point. The casing is provided at opposite sides of the wheel with annular steam-chambers 24 24, connected by passages 25 25 with the steam-inlet pipe 26.

27 is an exhaust-steam chamber around the wheel at its periphery and having its outlet at 28. The steam leaving the chambers 24 24 in the form of jets operates by impact against the wheel to rotate it, after which the steam is caused to react from the moving wheel against fixed abutments and finally to exhaust at the point 28.

In explanation of the theory of my improved engine a complete transfer of the energy of the steam to the engine means that when abandoned by the latter the steam must be at rest or, in other words, must be deprived of all energy and motion. This is most easily accomplished by the impact type of engine. If the blades of the usual type of impact-wheel were stationary, the jet of steam directed thereagainst would be reflected at the same velocity it had in arriving minus the friction, and no energy would be absorbed. If the velocity of moving blades is the same as the velocity of the jet, there is no impact or absorption of energy. If, however, the blades are caused to move at a rate of speed which is approximately one-half the velocity of the jet, the steam will impact upon and be reflected from the blades at practically one-half its velocity relative to a fixed object, and as the blade is going forward with the same relative velocity with which it reflects back the jet the

resultant steam velocity becomes at rest. The theoretical velocity for an impact-wheel is therefore for the abstract case one-half the velocity of the steam. An engine constructed on the general lines above stated would have a peripheral velocity far beyond the limit of strength of material and an unmanageable speed. In the present engine the ratio of expansion of the steam is kept down to 1.25. Starting with, for example, one hundred and twenty-five pounds pressure absolute and with an expansion to one hundred pounds, the velocity will be about nine hundred feet a second. To comply with the conditions above set forth, the peripheral velocity of the wheel must be approximately one-half of the velocity of the steam to obtain maximum efficiency, or approximately four hundred and fifty feet a second. This velocity allows a fair factor of safety. A further feature of the present engine is the gradual expansion of the steam, or, in other words, the largest ratio of expansion necessary to the greatest economy is effected by successive steps in order that the velocity may be kept within practical limits.

The jets of steam are formed by what are conveniently termed "nozzles," which are adiabatic line or curve fluid-ports and are each designated by the numeral 29. By referring to Fig. 4 it will be noted that by preference four nozzles are employed at each side of the wheel, although a greater or less number may be provided. The nozzles which are formed in the casing-walls have their inlets at the steam-chambers and their outlets at the inner sides of the casing-walls and in the path of a plurality of steam-channels 30, provided in the rings 20. The nozzles are arranged at an angle of approximately twenty degrees to the plane of rotation, and the outlets thereof are at opposite points, whereby the force is exercised equally and at the same instant on opposite sides of the wheel. The inlets 30' of the channels 30 have their plane of rotation at the nozzle-outlets, the channels thus forming continuations of the nozzles, and each channel has its outlet 30'' at the face of the ring 20 and adjacent to the periphery of the latter. The channels, as illustrated by dotted lines in Fig. 2, are arranged at an angle of approximately thirty-five degrees to the plane of rotation, and, as shown more particularly in Fig. 7, each channel adjacent to its inlet 30' has a return-bend 30'', forming a surface against which the steam from the nozzle impacts. Each nozzle 29 (see particularly Fig. 7) is of diverging form, the diameter increasing gradually from the inlet end 29' to the outlet end 29''. Starting with a maximum pressure of one hundred and twenty-five absolute, the steam passing through the diverging nozzle has an adiabatic partial expansion until at the point 29'' or 30' it has reached a velocity of nine hundred feet a second and enters the channel 30 at a reduced pressure of one hundred pounds. The steam

exercises a kinetic force at the point 30'' in the channels 30 and moves the wheel forward with a peripheral velocity of four hundred and fifty feet a second. As the channel 30 is a continuation of a nozzle 29, the increased area of the nozzle at its outlet 29'' enables the insertion of a web 31 in the return-bend 30'' to provide an additional impact-surface for the steam. With a maximum pressure of one hundred and twenty-five pounds absolute at the start it is found that due to the expansion stated the desired steam velocity of nine hundred feet a second is reached and that there is a resultant pressure of one hundred pounds. If, for example, the steam is to exhaust at three pounds absolute, forty-one of such expansions are necessary on the theory of the division of 125 by 3. The first expansion takes place, as stated, in the diverging nozzles, and it is necessary therefore to continue the expansion by steps of 1.25 of the remaining pressures until exhaust is reached. The steam after impacting against the described surfaces 30'' and 31 moves rearwardly through the channel 30, continuing its same ratio of expansion toward the outlet 30'' step by step aided by the centrifugal force and expends its energy at said outlet into an annular series of radially-disposed pockets 32 32, provided in the inner casing-wall at the path of rotation of the outlets 30''. Thus the steam in lieu of exhausting directly to the atmosphere impacts in its passage successively in the pockets 32 as they consecutively pass the outlet 30'', resulting in a reacting energy on the revolving wheel. The pockets are consecutively passed by a series of openings 33 33, formed in the rings 20, through which the steam escapes to the exhaust-chamber 27, and finally exhausts at the point 28, as previously stated. The openings 33, which have each an inclined rear wall 34, are shown more clearly in Figs. 7, 8, and 9. The openings are so placed that they register with a pocket after the passage of an opening 30'', whereby direct discharge of steam is avoided. Thus after each pocket receives its impact and reacts upon the wheel it exhausts itself through an opening 33, the steam finally discharging, with its energy given up in kinetic force and the whole wheel becoming a mass of energy.

In the operation of my improved rotary engine there is at all times a maximum steam-pressure at the inlet end of the nozzles 29. The common method of controlling rotary engines of the general type to which the present engine belongs is by the use of a throttle or reducing valve. By this means the steam has a partial expansion between the throttling device and the steam chamber or chest into which it opens, increasing as the load on the engine varies from the maximum to the minimum; whereas the maximum efficiency of a rotary engine can only be reached by exercising the entire energy of the steam on the

rotating part. Thus in the old type of engine the energy from expansion not being exercised on a moving part is lost and there is the consequent reduced efficiency in the engine and especially in an engine of the impact type. In starting the present engine the throttle-valve 35 is opened to admit the maximum pressure of steam—say one hundred and twenty-five pounds—to the steam-chambers 24 24, and the engine is controlled by valves operated through the medium of a governor. Two valves 36 36 are provided, one for each series of nozzles, said valves being of ring form and provided with diverging openings 37 37, arranged to be brought by lateral movement of the valves into and out of register with the inlet ends of the nozzles. The valves are connected together to move in unison by rods 38 38, slidable in tubular casings 39 39, extending through the exhaust-chamber and having their ends secured to be fluid-tight in the inner casing 40, which separates the exhaust and steam chambers.

Any suitable type of governor may be employed to move the valves and control the engine, though I prefer the type shown, which consists of weights 41 41, carried by arms 42 42, pivoted to the spokes of a pulley 43 and connected together by a rod 44, and of a spring 45, operating to retract the arms and weights. The weights are moved from the axis of the revolving pulley by centrifugal action against the action of the spring, and such movement is transmitted to the valves by the following means: Loose on the shaft is a collar 46, projecting from which are ears 47 47, each connected by a link 48, with one arm of a bell-crank lever 49, pivoted on the pulley-hub 50. The other arms of the bell-crank levers are connected by links 51 51 with the weights 41 41. The collar 46 is provided with an annular groove in its periphery, which receives the forked inner ends 52 52 of levers 53 53, pivoted to ears 54 54, projecting from the casing ends. The other or outer ends of the levers 53 are connected by rods 55 55 with the adjacent valve 36, the rods passing through openings in the casing-heads 15, at which are stuffing-boxes 56 56. Referring more particularly to Fig. 3, it will be understood that movement of the valves to the left to close the nozzles is coincident with the outward movement of the governor-weights but by reference more particularly to Figs. 6 and 7 it will be observed that the series of valve-openings 37 are of gradually-increasing size, whereby the nozzles are successively closed to cut off the steam-supply. The first opening 37 is approximately the size of a valve-opening, and the sizes of the other valve-openings increase in such proportion as to effect the successive opening or closing of the nozzles by the movement of the valves, whereby the maximum pressure of steam which, as before stated, is present in

the steam-chamber always exists at the inlets of the uncovered nozzles regardless of their number. The engine is therefore self-governing, and this advantage is obtained without in any way affecting a loss of energy from the steam and a consequent impaired efficiency in the engine. With a maximum steam-pressure in the steam-chamber and the governing means acting directly at the inlets of the nozzles a constant speed is maintained regardless of the load within its rated capacity, and all of the energy of the steam is directed on the moving part. It will be understood that the governing device acts in conjunction with the valves to open or close the nozzles accordingly as the load varies and that no expansion of the steam takes place until it enters the nozzles, whereupon the steam is expanded adiabatically, as above explained.

I claim as my invention—

1. In a rotary engine, a stationary part and an impact and reaction wheel having a diverging passage formed of sections circular in cross-section for adiabatically expanding radially in all directions from its axial flow a motive fluid, and means for absorbing at the intervals of impact and reaction predetermined amounts of the caloric energy of the motive fluid.

2. In a rotary engine, an impact and reaction wheel, a stationary part having a section of a diverging passage circular in cross-section for maintaining a continuous adiabatic expansion of a motive fluid up to a predetermined point, means for utilizing the expanded fluid at the said point to effect the impact against said wheel, a second section of a diverging passage in said wheel circular in cross-section for further continuously expanding the fluid adiabatically after such impact, and means for utilizing the further expanded fluid at the point of reaction, said expansions of the fluid being radial in all directions from its axial flow.

3. In a rotary engine, a wheel driven by the kinetic force of a motive fluid acting upon both sides of the wheel, a stationary part having a section of a diverging passage circular in cross-section for creating and maintaining a continuous adiabatic expansion of the motive fluid to the point of impact, a second section of a diverging passage in said wheel circular in cross-section for further continuously expanding the fluid adiabatically after the impact, and means for utilizing the further expanded fluid at the point of reaction, said expansions of the fluid being radial in all directions from its axial flow.

4. In a rotary engine, a stationary part having a section of a diverging passage circular in cross-section, a wheel driven by the kinetic impact force of a motive fluid issuing from said passage-section and having an adiabatic partial expansion radial in all directions from its axial flow, and driven by the kinetic reac-

tive force of the further adiabatically-expanded fluid issuing from another similar passage-section in said wheel.

5. In a rotary engine, a wheel and a stationary part having a diverging passage formed of sections circular in cross-section, said wheel being driven by the kinetic impact and reactive forces of a proportionate adiabatic expansion radial in all directions from its axial flow and a corresponding change in entropy of a motive fluid issuing from said passage-sections.

6. In a rotary engine, a stationary part having a section of a diverging passage circular in cross-section and forming an adiabatic line or curved fluid-port, a wheel arranged to receive the kinetic impact force from the change in entropy of the fluid expanded in said port radially in all directions from its axial flow, a diverging passage circular in cross-section and forming a second section of an adiabatic line or curved fluid-port in said wheel, and a stationary surface receiving the kinetic force from the change in entropy of the fluid further expanded in said port radial in all directions from its axial flow and discharging from the wheel.

7. In a rotary engine, a wheel provided with a plurality of impact-surfaces, and a stationary part provided with sections of diverging passages each circular in cross-section forming an adiabatic line or curve fluid-port arranged to direct adiabatic partially-expanded fluid with a change in entropy corresponding to the degree of expansion against said surfaces, said fluid being expanded equally in all directions from its axial flow.

8. In a rotary engine, a wheel provided with sections of an adiabatic line or curve fluid-port each having a plurality of impact-surfaces, a rotary part having a section of an adiabatic line or curve fluid-port arranged to direct adiabatic partially-expanded fluid with a change in entropy corresponding to the degree of expansion of said fluid against said surfaces, and a plurality of stationary reactive surfaces reflecting the impact from the change in entropy from the further adiabatically-expanded fluid discharging from the fluid-ports carried by the wheel, said fluid being expanded radially in all directions from its axial flow in each section.

9. In a rotary engine, stationary and movable parts having a series of sections of a diverging passage circular throughout in cross-section providing a complete adiabatic line or curve fluid-port, each section adapted to adiabatically partially expand in all directions from its radial flow a motive fluid, and means at the outlet of each section for effecting a change in entropy of the fluid corresponding to the degree of expansion of the latter.

10. In a rotary engine of the character described, a wheel provided with a plurality of fluid-channels arranged at an angle to the plane

of rotation of the wheel and each having an inlet and an outlet and a return-bend adjacent to the inlet providing an impact-surface, a web in the return-bend providing an additional impact-surface, a diverging nozzle arranged to direct expanded fluid against the impact-surfaces, a plurality of stationary pockets receiving the impact of the fluid from the channel-outlets, and exhaust-outlets for the fluid between the channel-outlets.

11. In a rotary engine of the character described, a wheel having at each side a ring provided with a plurality of fluid-channels in which is an impact-surface, a nozzle at each side of the wheel arranged to direct fluid into opposite channels and against the impact-surfaces, and a plurality of stationary pockets at each side of the wheel arranged to receive the impact of the fluid discharging from opposite channel-outlets.

12. In a high-speed rotary engine, a wheel driven by the impact of the motive fluid and carrying a concentric channel and means permitting the introduction of a weighting medium during the rotation of the wheel.

13. In a rotary engine of the character described, a rotary wheel carrying impact-surfaces, a series of diverging nozzles arranged to direct expanded motive fluid against said surfaces, a steam-chamber common to said nozzles, a ring-valve at the nozzle-inlets said valve having a series of openings of gradually-increasing size and a governor operatively connected with the valve to move it and consecutively open or close said nozzles.

14. In a rotary engine, a rotary wheel provided at each side with a plurality of impact-

surfaces, a plurality of diverging nozzles at each side of said wheel arranged to direct expanded motive fluid against said surfaces, a motive-fluid chamber common to both series of nozzles, a ring-valve at the inlets of each series of nozzles, said ring-valves each having a series of openings, a connection between said ring-valves to effect their simultaneous movement, and a governor connected with said valves to operate them in the manner substantially as set forth.

15. In a rotary engine, stationary and movable parts having a series of sections of a diverging nozzle circular in cross-section said series providing a complete adiabatic line or curve fluid-port, each nozzle-section adapted to partially expand adiabatically a motive fluid, and means at each nozzle-outlet for effecting a change in entropy of the fluid corresponding to its degree of expansion.

16. In a rotary engine, stationary and movable parts having a series of sections of a motive-fluid passage the walls of each section diverging at an angle coinciding relatively to the axial line in all directions, said sections each effecting an adiabatic partial expansion of the fluid, and means at the outlet of each section for absorbing from the fluid caloric energy corresponding to the degree of expansion of said fluid.

In testimony whereof I affix my signature in presence of two witnesses.

EDWIN FORREST TAYLOR.

Witnesses:

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S. G. BERNARD.