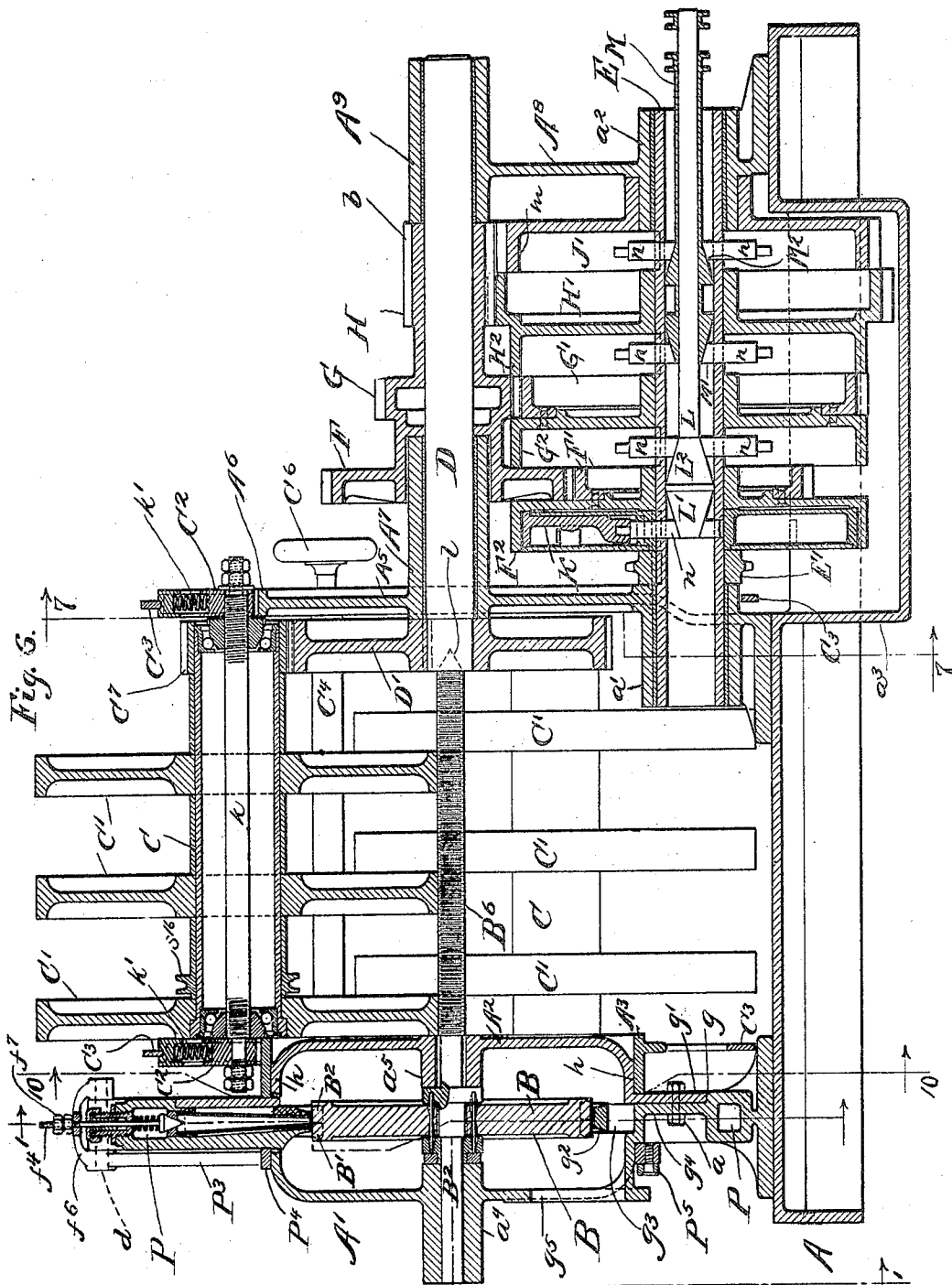




Witnesses:
Walter Winberg.
H^m B. Davies

Inventor:
Jesse W. Sunderland
By *[Signature]* Att'y's.

Fig. 7.

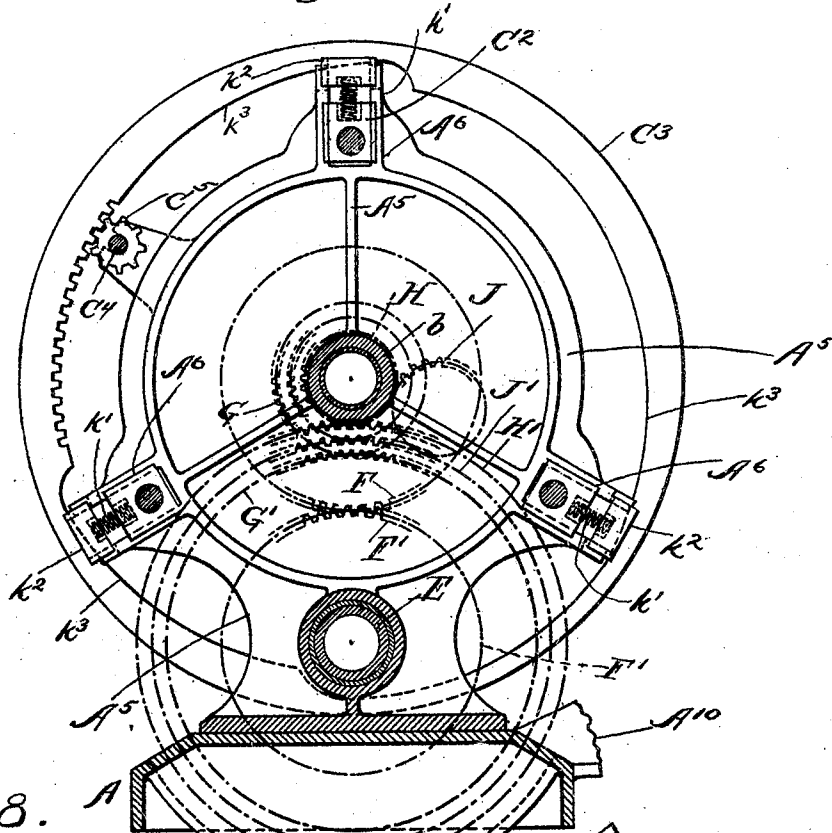


Fig. 8.

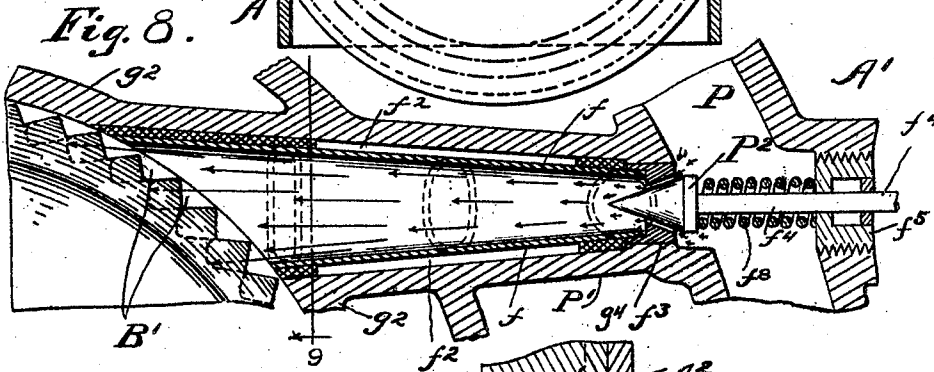
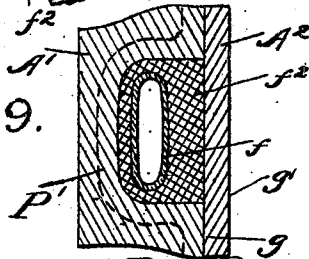
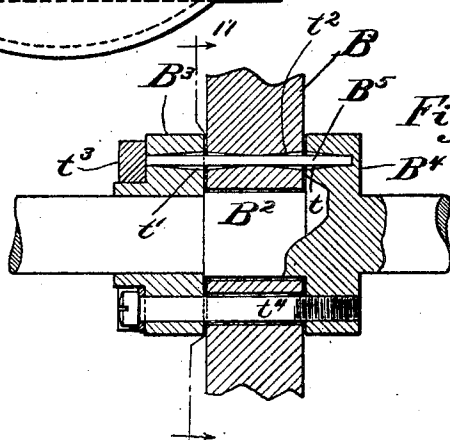
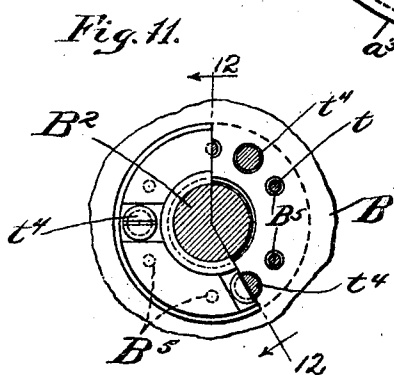
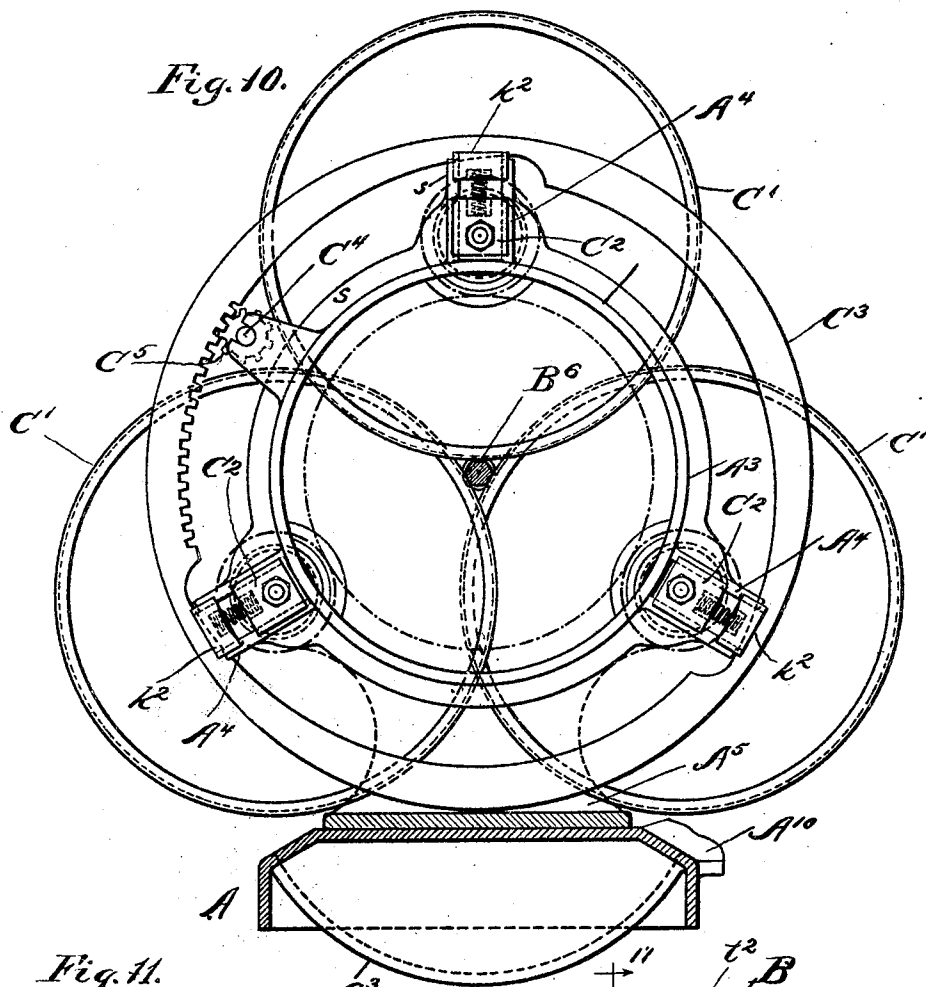


Fig. 9.



Witnesses:
Walter Winberg.
Jm D. Davies

Inventor:
Jesse W. Sunderland
By *[Signature]*, *[Signature]* & Lee,
Attys.



Witnesses:
Walter Winberg.
H. B. Davies

Inventor:
Jesse W. Sunderland
By *Ryan, Smith, Ryan, Smith & Lee,*
Att'ys.

UNITED STATES PATENT OFFICE.

JESSE W. SUNDERLAND, OF CHICAGO, ILLINOIS.

ENGINE.

No. 802,122.

Specification of Letters Patent.

Patented Oct. 17, 1905.

Application filed February 5, 1903. Serial No. 141,996.

To all whom it may concern:

Be it known that I, JESSE W. SUNDERLAND, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a new and useful Improvement in Engines, of which the following is a specification.

My invention relates particularly to turbine-engines for use in connection with steam or other elastic fluid; and my primary object is to provide an engine of this character of improved general construction, particular attention being paid to securing economy in steam consumption, simplicity and durability of construction, an advantageous arrangement of reduction-gear, and simple and reliable controlling means for the engine.

The invention is illustrated in one embodiment in the accompanying drawings, in which—

Figure 1 represents a broken left-hand elevational view of my improved engine, one-quarter of the wheel-casing being shown in section; Fig. 2, a broken view showing a portion of the periphery of the turbine-wheel; Fig. 2^a, an enlarged broken section taken as indicated at line 2^a of Fig. 2; Fig. 3, a broken plan sectional view at one of the nozzles; Fig. 4, a broken side elevational view of the wheel; Fig. 5, a broken plan view showing the outer end of one of the nozzle-valves; Fig. 6, a vertical longitudinal section taken as indicated at line 6 of Fig. 1, that portion of the section at the wheel being taken as indicated at the upper left-hand portion of Fig. 1 and rotated into the plane of the vertical section; Fig. 7, a vertical section taken as indicated at line 7 of Fig. 6; Fig. 8, an enlarged broken vertical section showing the nozzle exposed by the section in Fig. 1; Fig. 9, a broken section taken as indicated at line 9 of Fig. 8; Fig. 10, a vertical section taken as indicated at line 10 of Fig. 6, the wheel-casing being removed; Fig. 11, a broken sectional view showing the construction at the central portion of the wheel, the section being taken at line 11 of Fig. 12; and Fig. 12, a section taken as indicated at line 12 of Fig. 11.

In the construction shown I employ a wheel-casing provided with a plurality of admission-nozzles arranged substantially tangentially to the bore of the casing, a wheel having flexible connections with its shaft to provide for unavoidable vibration, a series of valves controlling the admission through said nozzles, a hand-lever through the medium of which

said valves may be opened in succession according to the power required, a governor-controlled main admission-valve governing the common source of supply to said nozzles, a series of sets of friction-wheels bearing peripherally upon opposite sides of an extension of the wheel-shaft, a shaft in alinement with the wheel-shaft and operated through the medium of a gear meshing with pinions on the shafts of said sets of friction-wheels, change and reverse gears operated through said last-named shaft, and friction-clutch mechanism operated through the medium of any suitable single lever (not shown) providing for the use of either of three speeds forward or a reverse corresponding with the slow speed forward.

A description of the preferred construction is as follows: A represents a frame; A', a wheel-casing section fixedly secured thereon at one end thereof; A², a wheel-casing section firmly united to the first-named section by bolts *a*; A³, a ring-form frame member firmly supported upon the casing-section A² and equipped with journal-boxes A⁴ for the bearings of the adjacent ends of three friction-wheel shafts; A⁵, a ring-form frame member provided with journal-boxes A⁶ for the opposite ends of the friction-wheel shafts and having a central bearing A⁷ for an intermediate speed-shaft in alinement with the shaft of the turbine-wheel; A⁸, a frame member having a bearing A⁹ for the opposite end of said last-named shaft; A¹⁰, Fig. 1, a frame member for supporting the speed controlling and reversing lever, (not shown); B, a turbine-wheel mounted within the casing A' A² and provided peripherally with vanes or buckets B'; B², Fig. 12, a shaft provided with collars B³ B⁴, between which the wheel B is somewhat loosely confined; B⁵, a series of flexible steel pins connecting the wheel with said collars and arranged in a circle concentric with the shaft B²; B⁶, an extension of the shaft B², provided with circumferential grooves, Fig. 6; C, a plurality of friction-wheel shafts parallel with the shaft extension B⁶ and equipped with sets of friction-wheels C', having circumferentially-grooved peripheries contacting with the shaft extension B⁶; C², bearings for the friction-wheel shafts supported in the journal boxes or guides A⁴ A⁶; C³, simultaneously-adjustable cam-rings for adjusting the bearings C²; C⁴, a shaft equipped near its ends with pinions C⁵, meshing with cogs, Fig. 7, with which the rings C³ are equipped interi-

orly, and provided at one end with a hand-wheel C⁶, Fig. 6; C⁷, pinions lying in a common vertical plane and secured on the shafts C; D, an intermediate speed-shaft journaled in the bearings A⁷ A⁹ and equipped at its inner end with a spur-gear D', meshing with the pinion C'; E, a hollow shaft parallel with the shaft D and journaled in bearings a' a², with which the frame members A⁵ A⁸ are provided; E', a sprocket-wheel fixed to the shaft E and serving to transmit motion from the engine to the drive shaft of a motor-vehicle, say; F F', G G', and H H', speed-changing gears connecting the shafts D and E in sets; J J', Figs. 6 and 7, reversing-gears, the pinion J meshing with an extension b' of the pinion H; F², G², and H², friction members rigidly connected with the gears F', G', and H', respectively; K, Figs. 6 and 8, friction members connected to rotate with the shaft E and through the medium of which any one of the gears F', G', H', and J' may be connected at will to rotate the shaft E; L, a longitudinally-shiftable shaft provided at its inner end with reverse conical surfaces L' L² and which may be employed to connect either the gear F' or the gear G' to the shaft E at will; M, a longitudinally-shiftable sleeve upon the shaft L and provided with reverse conical surfaces M' M² and which may be employed to connect either the gear H' or the gear J' to the shaft E at will; P, an annular steam-passage with which the casing-section A' is provided near its periphery; P', a plurality of nozzles communicating with the passage P; P², valves controlling the admission to the nozzles; P³, bell-crank levers supported on pivots d on the casing-section A'; P⁴, a cam-ring, through the medium of which the levers P³ may be operated; P⁵, a link connected with the ring P⁴; P⁶, a lever for shifting the cam-ring P⁴ through the medium of the link P⁵; Q, a valve through which steam is admitted to the annular passage P, and R a governor controlling said last-named valve.

The base of the engine-frame has a depressed portion a³ to accommodate the reduction-gears, Fig. 6. The wheel-casing serves as a frame-standard and is secured to the base in any suitable manner. Likewise the standards A⁵ and A⁸ are secured to the base in any suitable manner. (Not shown.) One end of the turbine-wheel shaft B² is journaled in a bearing a⁴, with which the casing-section A' is provided, and the other end of the shaft passes loosely through a bearing a⁵, with which the casing-section A² is provided, this end of the shaft being practically supported by the friction-wheels C'. The casing-section A' bears at its periphery the annular steam-passage P, and extending at suitable angles are the nozzles P', communicating therewith and leading to the periphery of the wheel. Preferably the nozzles are formed of independent tube-sections f, Figs. 8 and 9, of varying

form of cross-section, as indicated by the dotted lines on Fig. 21, said tube-sections being received by cavities f' left in the casting of the casing-section A' and open at one side, as shown in Fig. 9. The nozzles are properly centered and held in place by Babbitt metal f². The exposed lateral surface of the Babbitt metal is turned down with the corresponding surface of the casing-section A' to receive the casing-section A². The outer end of each tube-section f is of circular cross-section and has secured thereto a tapered valve-seat f³. Each valve P² is of conical form and has a stem f⁴ extending through a stuffing-box f⁵, the outer extremity of which passes through a perforation in the short arm f⁶ of the corresponding lever P³. The extremity of the stem is threaded and equipped with nuts f⁷, and a spring f⁸, confined between the stuffing-box and the base of the valve, tends to hold the valve in its closed position. The long arm of each lever P³ is provided with a cam-shaped end f⁹, which bears upon the periphery of the ring P⁴. As indicated in Fig. 1, the ring P⁴ is provided with a series of cams f¹⁰, which correspond in general position with the position of the levers P³, but are so arranged that, commencing with the lower right-hand valve shown in Fig. 1, the valves will be opened in succession as the hand-lever P⁶ is moved to the left.

As indicated in Figs. 6 and 9, the casing-section A' has an annular depression g, the surface of which is turned to receive a flange g', with which the casing-section A² is provided. In the operation of turning said surface the corresponding surfaces of the Babbitt metal are turned flush with the surface, as appears from Fig. 22. The casing-section A' is provided with annular ring-sections g², which fit somewhat closely about the periphery of the wheel and join the inner ends of the nozzles. This provides spaces g³, which permit the steam to pass readily from one side of the wheel to the other within the casing. It should be remarked that the section shown in Fig. 1 is so taken that a portion g⁴ of the exterior surface of the casing-section A² is shown at the section. The casing is provided with an exhaust-passage g⁵, which should be of ample size to conduct the exhaust-steam and avoid back pressure.

The annular-form frame member A³, Figs. 6 and 10, fits snugly on the portion h of the casing-section A². It should be remarked that the casing is shown broken at its upper portion in Fig. 6 to indicate that the section at the upper portion of the figure has been rotated out of its proper plane. The shafts C are preferably three in number, and each shaft bears three friction-wheels provided with circumferential grooves engaging the corresponding circumferential ribs on the shaft extension B⁶. Each shaft C is of tubu-

lar form and is antifrictionally journaled upon an inner shaft k , having its ends supported by the bearing-blocks C^2 . The bearing-blocks C^2 have grooved connection with the journal boxes or guides A^6 , Fig. 7, and are yieldingly confined by springs k' , whose outer ends fit in blocks k^2 , grooved to receive the cam-ring C^3 . It will now be understood that when the ring C^3 is moved about its axis the cam-surfaces k^3 press the blocks k^2 inwardly and compress the springs k' . Inasmuch as both of the rings C^3 are simultaneously moved through the medium of the shaft C^4 and the pinions C^5 , all of the bearings of all of the three shafts C are simultaneously adjusted. It will be understood the shafts are, in effect, bound together by the spring-held bearing-blocks C^2 , and consequently the shaft extension B^6 is pressed upon from all sides equally.

The shaft D preferably has its inner end recessed to receive the pointed extremity of the shaft extension B^6 , as indicated by the dotted lines l in Fig. 6. The gears F , G , H , and b are preferably formed integrally, as shown. The friction member F^2 and gear F' are oppositely turned and rigidly secured together in any suitable manner, and this is true of the friction member G^2 and gear G' and of the friction member H^2 and gear H' . The gear J' is so positioned that its flange m serves as a friction member. One of the inner friction members K is shown in section in Fig. 6, and another of said members is shown in elevation in Fig. 8. Each comprises a hub portion m' , fixed to the shaft E and having radial arms m^2 , bearing circumferential portions m^3 and radially-movable segments m^4 , moving between guide-surfaces m^5 at the extremities of the sectors m^3 . The members m^4 are equipped with lugs m^6 , against which bear springs m^7 , having their extremities secured at the extremities of the sectors m^3 . Thus the sectors m^4 are normally held out of engagement with the inner circumferential surface of the outer friction member. The hollow shaft E is provided with radial perforations through which extend members n , having beveled inner ends contacting with the cones with which the longitudinally-shiftable shafts L and M are provided. All but the left-hand one of the inner friction members have been omitted from Fig. 6. It will be understood from the preceding description, however, that any one of said friction members may be thrown into operative engagement with the corresponding outer friction member by shifting either the shaft L or the shaft M , as required.

The means by which either one of the shafts L and M may be shifted in either direction by the single lever are not shown, but any suitable means may be employed.

The admission to the annular steam-passage P is through the valve Q , which may be of any suitable construction. The valve prefer-

ably is controlled by the governor R , which is not shown in detail, but which has its operative parts actuated by a pulley s^{14} , belt s^{15} , and pulley s^{16} , Figs. 1 and 6.

As shown in Figs. 11 and 12, the collar B^4 of the shaft B^2 is provided with a series of sockets t , arranged concentrically with the shaft, and these sockets taper, as shown. The collar B^4 is formed integrally with the shaft. The collar B^3 is provided with a series of perforations t' , which taper in a direction opposite the taper of the sockets t . The wheel B is provided with a series of perforations t^2 , which are cylindrical at their central portions and flare toward their ends, as shown in Fig. 12. The pins B^3 extend through the perforations in the collar B^3 and the perforations in the wall and into the sockets t . They are confined against removal by a ring t^3 , secured by bolts t^4 , which pass loosely through the wheel and bind the collar B^3 to the collar B^4 . From this description it will be observed that the wheel has yielding connection with its shaft owing to the flexibility of the members B^5 , which support it. This permits the wheel to adjust itself under the centrifugal force developed in its rotation, it being understood that it is impossible to so construct and balance a wheel as to overcome all lateral strain under the high velocity at which the wheel is rotated.

The construction at the periphery of the wheel is illustrated in Figs. 2, 2^a, 3, and 4. As there shown the vanes of the wheel are constructed by providing two series of peripheral pockets $v v'$, arranged side by side and separated by a sharp dividing-wall v^2 . These buckets are provided by milling the wheel, so that the bores produced intersect at the meeting edge v^2 between two buckets. The milling-tool may be located in the plane of the wheel and of such form that it will cut in under and leave an overhanging shoulder v^3 . The wheel is located so that the dividing-walls v^2 lie in a central vertical plane through the inner extremities of the nozzles. In plan section the buckets are concave, so that the steam will enter along both sides of the dividing-wall v^2 and be directed to the right and left, somewhat as indicated in Fig. 3. The nozzles have a cross-section of varying shape, as indicated in Fig. 8, the shape changing from a circle at the outer extremity to an elongated oval shape at the inner extremity, the long axis of the oval lying in a vertical plane. In setting the valves P^2 properly by means of the adjusting-nuts f^7 the engine is tested for economy till the proper opening for a given wheel velocity and given pressure is secured. The inner-ends of the nozzles are large enough to permit the nozzle-valves to be adjusted so that the steam will expand to a proper degree to acquire a velocity which will bear the correct theoretical ratio to the velocity of the wheel to insure

the transfer of the greatest possible amount of energy from the steam to the wheel. In other words, the kinetic energy of the steam moving as a mass is transferred to the wheel and only sufficient residual velocity remains in the steam to insure against back pressure. The change in velocity of the steam in passing from the orifice at the nozzle-valve to the buckets is roughly illustrated graphically in Figs. 3 and 8 by the relative lengths of the arrows. It follows that as the velocity decreases the area of the steam-passage should increase to permit the steam to pass freely from the engine, and this is provided for in my construction.

An engine constructed in substantial accord with the drawings and description here given is well adapted for use in connection with motor-vehicles. Thus the engine is designed to work economically regardless of the number of nozzles which may be in use, and the power of the engine may be varied over a range of many horse-powers. The lever P⁶ is set to throw one or more nozzles into use, as desired. When the engine attains a given speed, the governor acts to close the admission to the annular steam-passage P, thereby cutting off the supply to all the nozzles. When the supply is so cut off, the engine continues to operate under its own inertia. Thus it will be seen that the steam is not throttled at any of the nozzles, and that hence a given ratio of steam velocity and wheel velocity are maintained, that ratio being the ratio at which the greatest amount of energy can be transferred from the steam to the wheel.

It readily will be understood that changes in details of construction within the spirit of my invention may be made. Hence no undue limitation should be understood from the foregoing detailed description, which has been given for clearness of understanding only.

What I regard as new, and desire to secure by Letters Patent, is—

1. In an engine of the character described, the combination with a suitable wheel, of circumferentially-arranged nozzles, a plurality of valves for said nozzles, levers connected with said valves, and a shiftable cam-ring for moving said levers.

2. In an engine of the character described, the combination with a suitable wheel, of circumferentially-arranged nozzles, a plurality of valves for said nozzles, bell-crank levers supported on stationary pivots and having their outer ends connected with the stems of said valves and their inner ends provided with cam-surfaces, and a shiftable cam-ring provided with a plurality of cam-surfaces arranged to engage said levers in succession, for the purpose set forth.

3. In an engine of the character described,

the combination with a suitable wheel, of a nozzle, a valve therefor, a valve-operating lever provided with a cam-arm, a shiftable cam-ring, and a hand-lever connected with said ring and serving to shift the same, for the purpose set forth.

4. In an engine of the character described, the combination with a suitable wheel, of a casing therefor comprising two sections, one of said sections having a cavity with a lateral opening, and an independently-formed nozzle within said cavity and secured therein by Babbitt metal, or the like, and the other section bearing against the exposed surface of the Babbitt metal.

5. In an engine of the character described, the combination with a suitable wheel, of a casing provided with an external annular shoulder, a cam-ring journaled on said shoulder, valve-operating levers controlled by said cam-ring, valves connected with said levers, and nozzles controlled by said valves.

6. In a machine of the character described, the combination of a shaft having a collar fixed thereon, a wheel loosely mounted on said shaft adjacent to said collar and provided with a series of bolt-receiving perforations and a series of pin-receiving perforations, a second collar adjacent to the opposite side of said wheel, a plurality of flexible pins passing through the wheel and into the collars, and a plurality of bolts passing loosely through the proper perforations of the wheel and connecting said second-named collar to the first-named collar, for the purpose set forth.

7. In a machine of the character described, the combination with a shaft provided with collars, of a wheel confined between said collars and provided at its hub with a series of perforations, and a plurality of flexible members passing through said perforations and into said collars, whereby the wheel is supported and motion transmitted to the shaft through the medium of said members.

8. The combination of a shaft provided with an annular recess for receiving the hub of a wheel and having a plurality of taper openings, of a wheel provided with a plurality of double taper openings and flexible pins, for the purpose set forth.

9. The combination of a shaft provided with a collar having a plurality of lateral sockets, a second collar provided with a plurality of perforations in alinement with said sockets, a wheel provided with a plurality of perforations, pins extending through said perforations and into said sockets, and a collar confining said pins.

JESSE W. SUNDERLAND.

In presence of—

L. HEISLAR,

WALTER WINBERG.