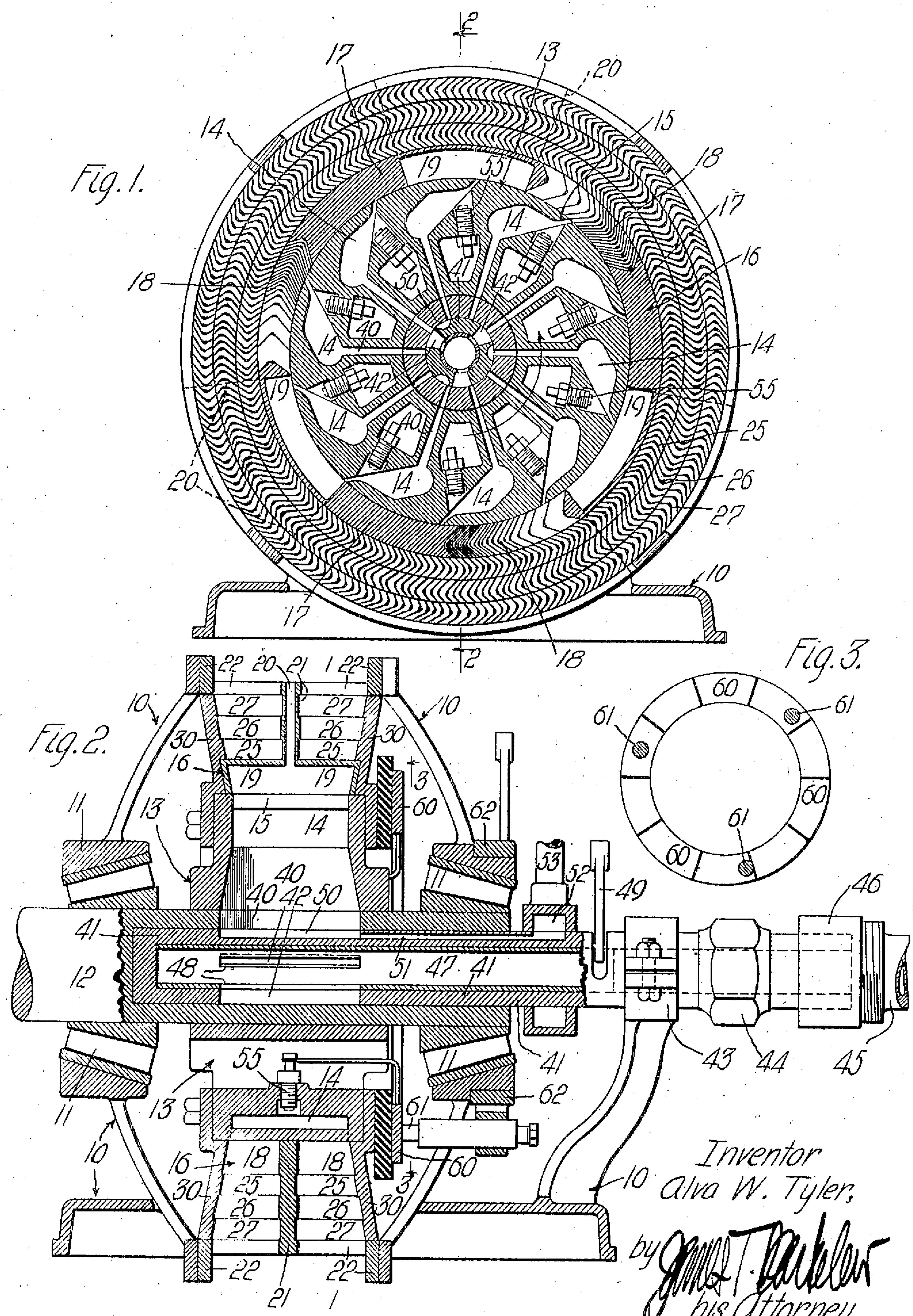
A. W. TYLER.

GAS TURBINE.

APPLICATION FILED MAR. 12, 1918.

1,291,273. Patented Jan. 14, 1919.

2 SHEETS—SHEET 1.



Inventor
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by James T. Barkelew
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2 SHEETS—SHEET 2.

Fig. 4.

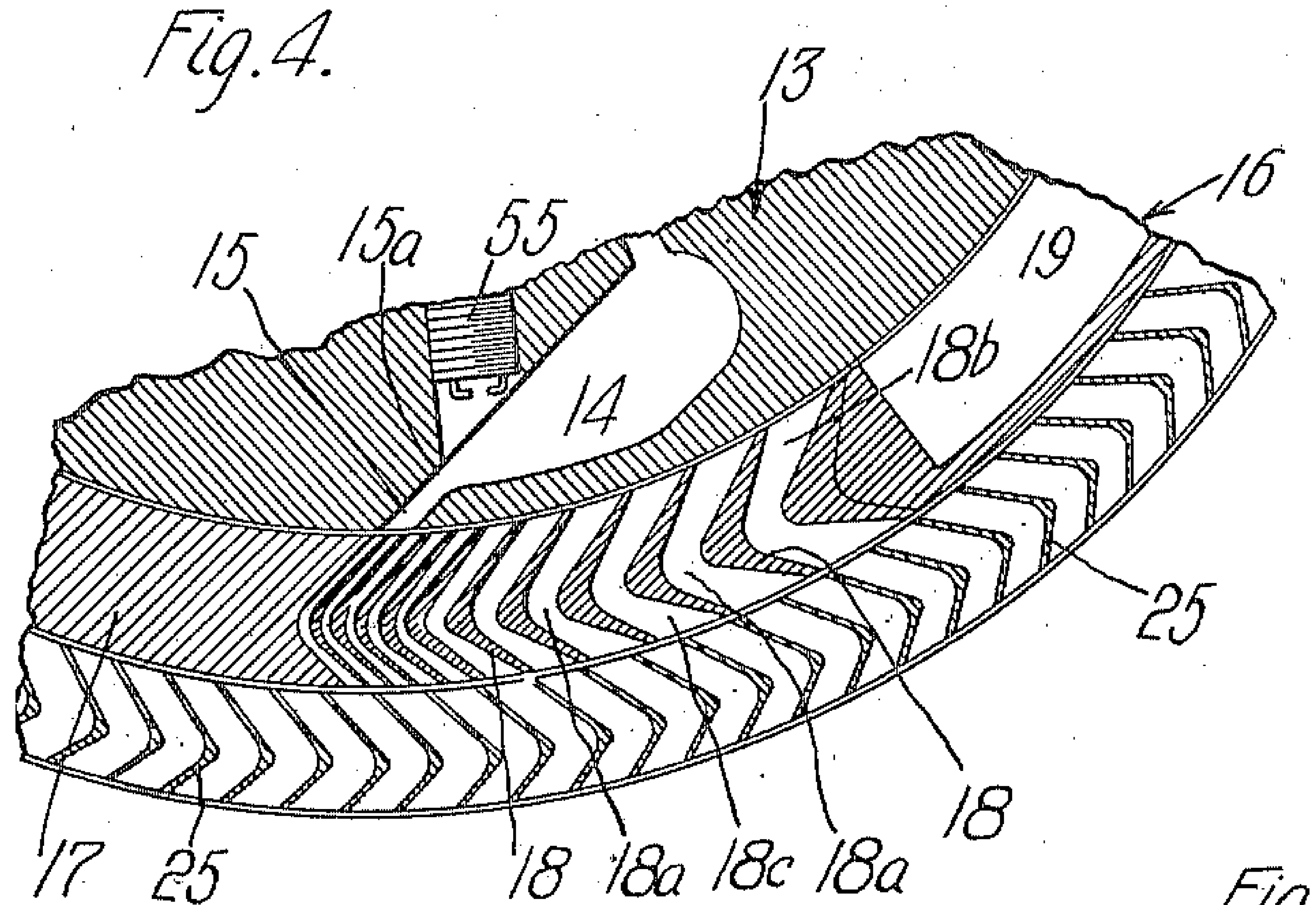


Fig. 5.

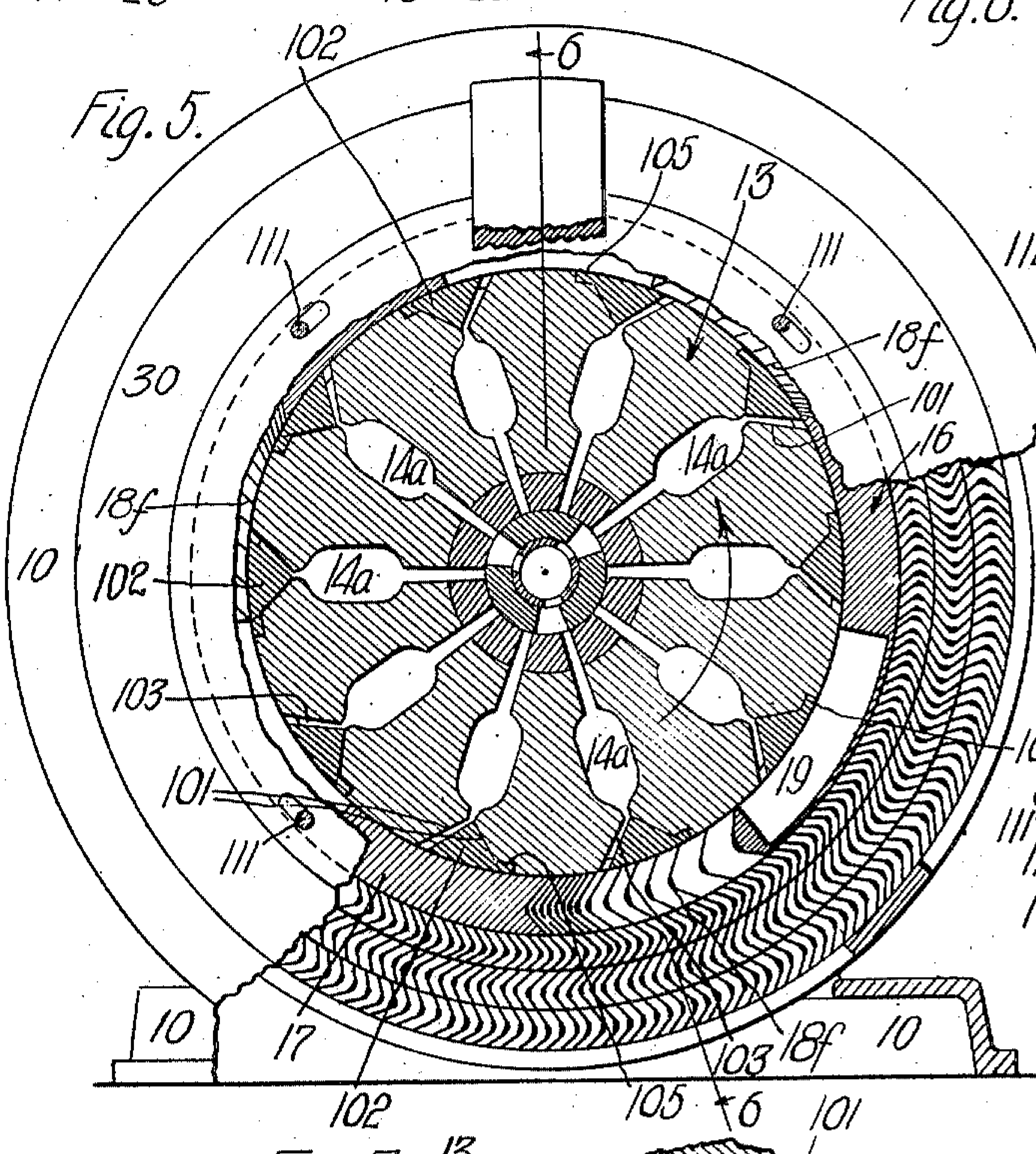


Fig. 6.

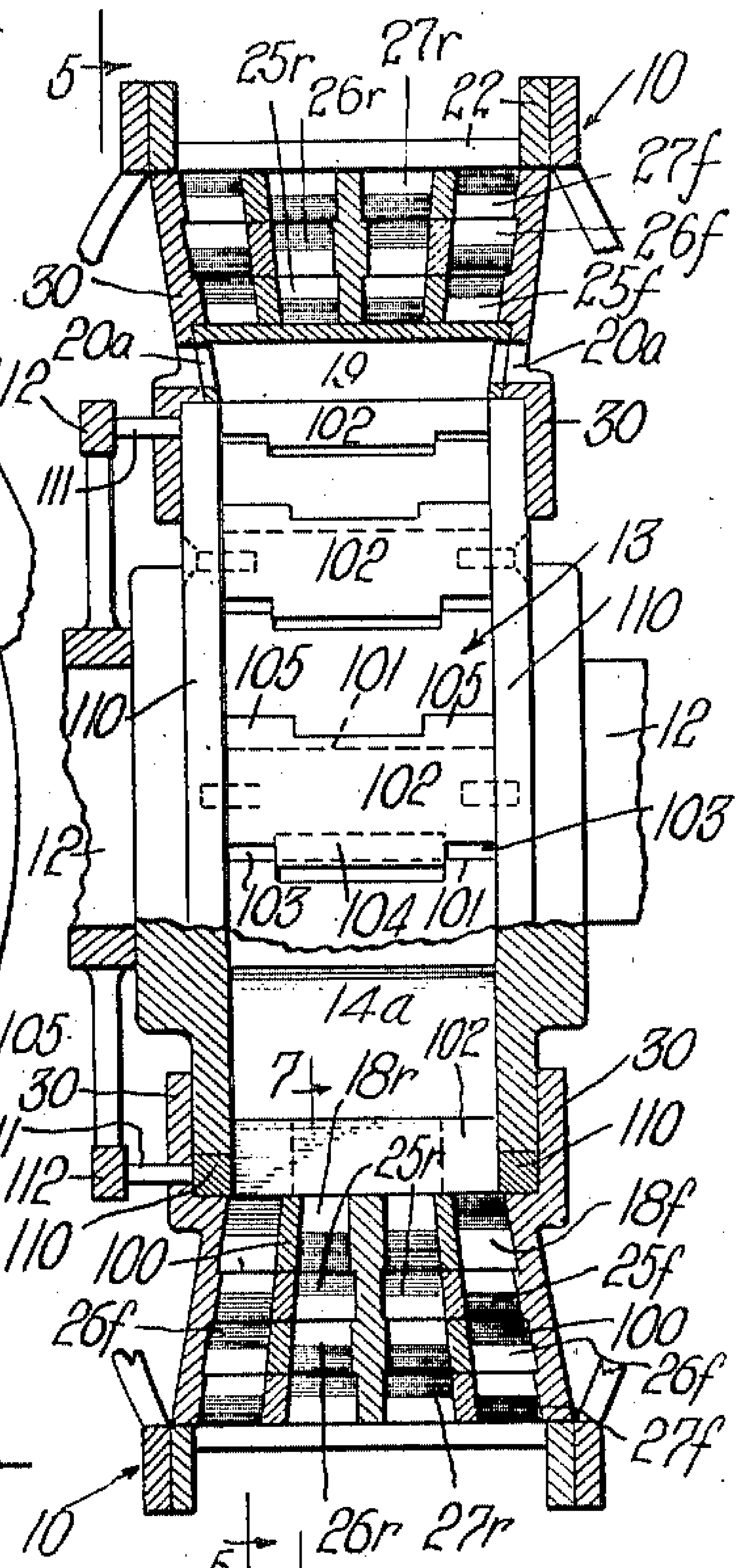
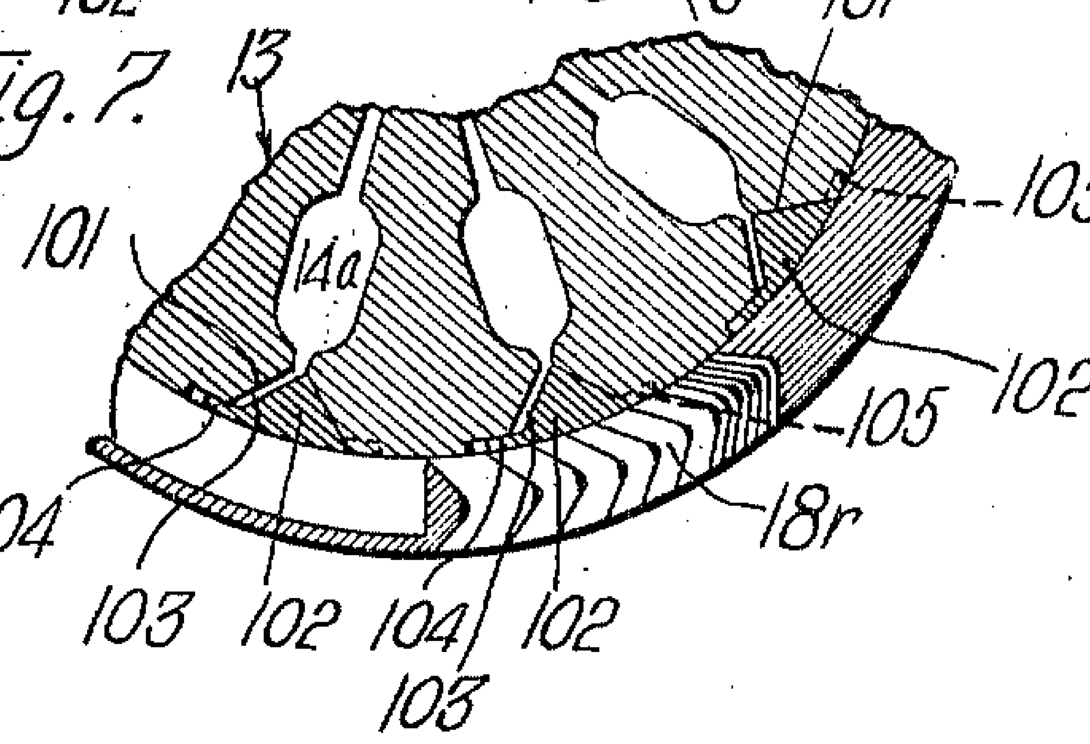


Fig. 7.



Inventor
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by James T. [signature]
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UNITED STATES PATENT OFFICE.

ALVA W. TYLER, OF LOS ANGELES, CALIFORNIA.

GAS-TURBINE.

1,291,273. Specification of Letters Patent. Patented Jan. 14, 1919.

Application filed March 12, 1918. Serial No. 222,044.

To all whom it may concern:

Be it known that I, ALVA W. TYLER, citizen of the United States, residing at Los Angeles, in the county of Los Angeles, State of California, have invented new and useful Improvements in Gas-Turbines, of which the following is a specification.

This invention relates to internal combustion motors of the turbine type. It is one of the objects of this invention to provide a simple turbine structure in which there is but virtually one moving part which is the rotating part, in which there are no reciprocating parts and no valves, valve seats or cams, cam shafts or other similar valve operating mechanism; to provide a structure in which the energy of an expanding gas is delivered directly to the rotating parts without the intervention of intermediate members or mechanisms; and to provide a motor having few parts and having relatively high efficiency. And there are several other objects appearing in the following specification.

I provide means for causing the efficient expansion, and the efficient use of the energy of expansion, of the heated gases by providing a novel arrangement and spacing of the vanes or blades into which the expanding gases are initially discharged from the combustion chambers. I also provide means for causing the thorough scavenging of the combustion chambers prior to the introduction of a new charge.

In such a turbine as herein described, my preferred construction includes a combined reaction and impulse arrangement; the vanes or blades being so shaped and spaced as to provide such action. The vanes or blades are also shaped and spaced to provide for uniform and steady flow and expansion of the gases, and consequently uniform and continuous application of power to the rotating parts. I further provide, in a specific form, a reversible turbine.

These features, and others, will be understood from the following description of a preferred embodiment of my invention, reference being had to the illustration of said embodiment in the accompanying drawings in which Figure 1 is a vertical cross section of a preferred form of turbine; Fig. 2 is a longitudinal vertical section taken as indicated by line 2—2 on Fig. 1; Fig. 3 is a reduced diagrammatic view taken as indicated by line 3—3 on Fig. 2; Fig. 4 is an enlarged detail section showing the preferred form of vanes and nozzle outlet for the combustion chambers; Fig. 5 is a partial section, taken on line 5—5 of Fig. 6, showing a reversible form of turbine; Fig. 6 is a section taken on line 6—6 of Fig. 5; and Fig. 7 is a detail section taken on line 7—7 of Fig. 6.

In the drawings I show a construction in which the innermost member—the one containing the explosion chambers—forms a part of the motor; and in which the expansion vanes are arranged for outward radial transmission of the expanding gases. But I do not restrict myself to radial flow; and it will be observed that, in general, these details of construction, as well as other details immaterial to the invention here described, may be changed and varied without exceeding the scope of my invention except as delineated in the appended claims. I illustrate a suitable stationary base and frame 10, carrying bearings 11 in which the shaft 12 is journaled. The inner combustion chamber member 13 is mounted upon the shaft 12 to rotate therewith. This member 13 contains a plurality of combustion chambers 14 arranged in the relative positions illustrated. Each of these chambers has an outlet nozzle 15, which extends across the face of rotating member 13. These nozzles point in direction oblique to a tangent drawn to the circumference of member 13 at the nozzle outlet and the angle of this obliquity may be made such as to suit conditions and such as to cause the most efficient discharge of the expanding gases into the vanes of the immediately surrounding stationary member 16. The combustion chambers are also arranged so that the flow of expanding gases from their rear ends to their discharge nozzles shall be direct and uninterrupted. This is an important feature in connection with the scavenging of the chambers, as hereinafter described.

The stationary member 16 immediately surrounding the rotating member 13 is made up of successive portions which I may term the charging and expanding portions. The charging portions of this member are merely solid or blank parts 17, which close off the nozzles of the combustion chambers as they pass these parts. The expansion parts of this member are provided with vanes 18 into which the expanding gases are directed by the nozzles 15; and the exhaust ports of this member 16 comprise open chambers or passages 19 with which the nozzles of the expansion chambers are in free communication as they pass. Chambers 19 are in free communication with the atmosphere through passages 20. This passage 20 may lead through central web 19 as shown in Figs. 1 and 2, or may lead directly out transversely to atmosphere, as shown at 20[a] in Fig. 6. Central web 21 is, or may be, a part of the outer cylindrical casing 22 of the turbine; and is the means of anchoring the stationary vanes and of anchoring the parts 17 and 19. Generally speaking, the stationary member 16 may be anchored to, or be integral with, the central web 21.

The central rotating member 13 rotates in the direction indicated by the arrow; and means are provided, as hereinafter explained, for igniting the mixture in each combustion chamber in proper time to have the expanding gases expand outwardly through the vanes 18. Now it will be noted that the vanes 18 are progressively spaced farther and farther from each other in the direction of rotation. This means that when the pressure in the combustion chamber is high, at the beginning of the expansion period, the space between the vanes is correspondingly small to pass a given quantity or mass of gases under high pressure; while, when the pressure is low, at the end of the expanding period, the space between the vanes is correspondingly wide to pass the same given quantity or mass of gases under low pressure. This has the effect of keeping the velocity of the gases in each compartment between vanes maximum during the expansion period until a pressure at or near atmospheric pressure has been reached; and since the discharge area of the low pressure vanes is relatively larger they embrace a correspondingly larger number of rotating vanes, thus giving a uniform reaction for each compartment.

The gases which pass through the vanes 18 then pass progressively through surrounding sets of vanes 25, 26 and 27, and then finally exhaust at atmosphere through the open cylindrical casing 22. The vanes 25 rotate; vanes 26 are stationary and vanes 27 again rotate. Of course it will be understood that I may have any number of alternately stationary and moving sets of vanes. The number here shown is merely typical. Vanes 25 and 27 are mounted upon side flanges 30, which in turn are mounted upon, and rotate with, the rotating member 13. The stationary vanes 18 and 26 are mounted upon the central web 21. As hereinbefore stated, I have shown these sets of vanes arranged concentrically, one around the other, and arranged and designed for radial passage of the expanding gases. Although this is not an essential element of my invention, yet it has certain advantages. With the parts arranged as shown, they may be efficiently air cooled by the rotation of flanges 30 and member 13 in the atmosphere. The frame 10 is open so as to allow free access of the atmosphere to the rotating parts; and to allow artificial cooling, if desired, by artificial air currents, etc.

I provide mechanism, now about to be described, for causing the charging, the firing and the scavenging of the combustion chambers in the proper sequence and at the proper times to carry on the sequence of operations herein described. Each of the combustion chambers has an intake passage 40 extending radially out to the combustion chamber from the interior of hollow shaft 12. These intake passages communicate with the respective combustion chambers at their rear ends; that is, at their ends farthermost from the expansion outlet nozzles 15. Within the hollow shaft 12 I place a stationary sleeve 41; and this stationary sleeve is provided with ports 42 of the same number as the number of intake portions 17 in the member 16. In the turbine herein described, there are three of these portions, and therefore three ports 42; and each of the ten combustion chambers 14 goes through three complete cycles of operation during each revolution; making thirty explosions in this turbine for each revolution. The outer end of sleeve 41 is anchored in a suitable anchor bearing 43, being adjustable in position so as to adjust the position of ports 42. The member shown at 44 is engageable by a wrench to adjust the position of the sleeve; or any other suitable means of adjustment may be used.

The previously prepared explosive mixture is fed to the turbine under pressure through a pipe 45 having a connection at 46 with sleeve 41, allowing the sleeve to be rotatably adjusted. Within sleeve 41 I provide an interior throttle sleeve 47 with ports 46 adapted to be more or less fully registered with the sleeve ports 42. This throttle sleeve 47 may be rotated through the medium of arm 49, for the purpose of controlling the charge delivery to the combustion chambers.

Immediately before the inlet passages 40 register with ports 42 they register with small ports 50. These ports 50 are connected by ducts 51 with a compressed air inlet 52 to which compressed air may be supplied through a pipe 53. When the turbine is in operation, the following cycle of operations takes place for each time that one of the passages 40 passes a port 42. When a passage 40 comes into register with a port 42 then the outlet nozzle of the corresponding chamber 14 is just passing onto one of the intake portions 17 of member 16, the nozzle outlet being thus closed. Explosive mixture under pressure is forced into the combustion chamber 14 during the period of passage across the charging portion 17. Immediately the nozzle reaches the end of this portion, it then passes into communication with vanes 18 and at or before this time the compressed charge in the chamber is ignited by means of spark plug 55. The subsequent burning and expansion of the gases causes their flow through the various vanes and causes the continued rotation of the rotating parts. The position of the spark plugs 55 close to the nozzle insures the first ignition and expansion of the gaseous charge close to the nozzle, the combustion then proceeding back to the rear or inner end of the chamber. This precludes the possibility of any unburnt or fresh gases being forced out of the nozzle, and insures that the combustion shall take place in the combustion chamber and not in the vanes. By the time the nozzle has passed the vanes 18, the pressure in the chamber 14 has been reduced to or near atmospheric pressure. The major exhaust of the burnt gases takes place outwardly to atmosphere through the sets of vanes. The nozzle then passes into communication with the exhaust chamber 19 through which the remaining gases escape to atmospheric pressure (or below atmospheric pressure, due to the centrifugal throwing out of the gases from chamber 14). During the latter part of the exhaust period, the intake passage 40 comes into register with one of the compressed air ports 50; and compressed air is allowed to flow into the chamber 14 at its inner end, forcing out any remaining burnt gases. It will now be noted that the connection of passage 40 with chamber 14 is at the end farthest from the discharge nozzle and that, consequently, forcing in of compressed air at this point will completely scavenge the chamber of burnt gases and will leave the chamber filled with a charge of clean, fresh air under approximately atmospheric pressure. The pressure necessary to introduce the fresh air may, in some circumstances, be very little more, if any more, than atmospheric; as the centrifugal forces have a tendency to throw the burnt gases out of the chamber and thus create a partial vacuum therein. This final scavenging of the chamber and introduction of fresh air thereto takes place just before the outlet nozzle passes again onto a charging portion 17, and when the nozzle passes onto this charging portion the intake passage 40 then passes into the register with the next port 42, causing the chamber to be again charged. This complete cycle of operations is repeated, in this particular instance, three times in each revolution. The ratio of the number of chambers to the number of ports 42 being incommensurate, no two explosions occur simultaneously; and there being thirty explosions per revolution, each followed by a period of reaction through the vanes, it will be seen that the application of power to the rotating element of the turbine is uniform and constant.

The spark plugs 35 are supplied with current through the medium of a commutator of ten segments 60. Three brushes 61 bear on this commutator, the brushes being mounted upon a brush carrying ring 62, rotatable upon the frame 10. By rotating the brushes, the position of spark may be adjusted and regulated.

The foregoing description applies generally to all the forms of structure shown in the various drawings. In Fig. 4 I show the details of a preferred form of blades or vanes, and also of the nozzle outlet of the combustion chamber. In this structure I show the vanes 18 spaced in the manner hereinbefore described; and I show them of such configuration, that, at the point 18^a, each space between the vanes, there is a comparative constriction. That is, the spaces between the vanes at 18^b narrow down toward the point 18^a and then expand at 18^c. This narrowing of the spaces gives more or less of a nozzle effect and prevents the expanding gases escaping too quickly from the chambers 14. The preferred form of nozzle outlet 15, from chamber 14, is also shown in this view, the nozzle having a constriction at 15^a and then expanding somewhat toward its end so as to allow a maximum velocity of the gases at the outlet. Each one of the spaces 18^b takes the expanding gases from the chamber 14, and these expanding gases are then held for an appreciable period while they escape through the constriction 18^a into the widening spaces 18^c. By making the construction in this manner, I obtain a certain amount of reaction against the inner revolving member 13, and I also retard the outward passage of the expanding gases through and from the vanes 18, so as to more evenly distribute the power application and make a more continuous application of power to the rotating element of the turbine.

In Figs. 5, 6 and 7 I illustrate a form of turbine which is, in essentials, the same as the form shown in the other views, excepting that it is equipped with a reversing mechanism.

In this form of turbine I divide each of the sets of vanes 18, 25, 26 and 27 by central partitions 100 into separated sets 18^f 25^f, 27^f and 18^r, 25^r, 26^r and 27^r. Those vanes denoted by the numerals with suffixed "f" are arranged to cause rotation in one direction; while those with suffixes "r" cause rotation in the opposite direction. For the purposes of this reversing form, I arrange the combustion chambers 14^a radially in the member 13, and at the outlet end of each combustion chamber, I make a V-shaped opening 101 extending across the face of member 13. In each of these openings I place a reversing block 102 adapted to be shifted circumferentially a short distance. The blocks and openings are of such relative sizes that a nozzle outlet space 103 is left on one side or other of the block. In the drawings the parts are shown in position to cause rotation in the direction indicated. The nozzle outlet space 103 shown open in the drawings is restricted to the opposite sides of the member 13 by a central flange 104 of the block which covers up the central part of this nozzle opening 103, restricting the escape of the expanding gases to the uncovered parts of the opening 103, in the positions shown distinctly in Fig. 6. The other side of each block has flanges 105 at each side. When the blocks are shifted circumferentially to form the nozzle opening 103 on the other side of the blocks, then the gases escape centrally at that side of the block, being prevented from escaping at the ends of the block by the flanges 105. When the gases escape through this central opening at the other side of the block, they escape in such a direction as to properly impinge upon the vanes 18^r; and the turbine is thus caused to rotate in the direction opposite that indicated by the arrow.

The blocks 102 are secured to and between side rings 110. Studs 111 may be mounted in these side rings and extend through the side members 30 of the revolving member 13 and are secured to a ring 112. This ring 112 may be rotatably adjustable upon the shaft 12 in any desired manner. Suitable means may be employed for holding the blocks 102 in their positions when once set; or there may be sufficient friction present to hold them without any special arrangements to that effect.

I provide a turbine in which there is a direct application of the energy of expanding gases to the rotating parts, and in which there are no operating parts intermediate. The valve mechanism is relatively simple; and the turbine includes essentially but one moving part and that the rotating part. There is an absence of internal friction surface and, therefore, no need for internal lubrication of hot rubbing parts. In fact, there is no friction in my engine except that of the main bearings, and the friction of the small surfaces of the internal sleeve valve. This friction is small, and the valve surface is easily lubricated and, moreover, is cooled by the incoming charge of fresh gas. Excepting these valve surfaces and the bearings, there are no wearing parts. And, in spite of this simplicity, there is high efficiency of gas expansion and of application of energy to the rotating element. These are outstanding features of my invention and various forms of structure may be designed and built to include one or all of them. I therefore do not limit myself to the specific embodiment herein shown, except as stated in the following claims.

What I claim is:

1. In a gas turbine, the combination of a pair of relatively rotatable elements; one of said elements having combustion chambers therein and the other of said elements carrying vanes adapted to receive the expanding gases from the combustion chambers, said vanes being progressively spaced wider apart in the direction of the rotation of the first mentioned element relative to the second mentioned element.

2. In a gas turbine, the combination of an inner rotating element and an outer stationary element; said inner rotating element having combustion chambers with outlets at its periphery, and said outer stationary element having successively around its periphery, parts provided with vanes to receive and react against the expanding gases from the combustion chamber outlets and parts having exhaust openings leading to atmosphere; the number of said combustion chambers and the number of said parts in the outer element being incommensurate.

3. In a gas turbine, the combination of two relatively rotatable elements, one of said elements having combustion chambers therein, and the other of said elements having arranged in succession therearound parts having vanes adapted to receive and react against expanding gases from the combustion chambers and parts having exhaust openings leading to atmosphere; the number of said combustion chambers in one element and the number of said parts in the other element being incommensurate.

4. In a gas turbine, the combination of two relatively rotatable elements, one of said elements having combustion chambers therein, and the other of said elements having arranged in succession therearound parts having vanes adapted to receive and react against expanding gases from the combustion chambers and parts having exhaust openings leading to atmosphere, the said vanes in said second mentioned element being spaced successively wider and wider apart in the direction of rotation of the first mentioned element relative to the second mentioned element.

5. In a gas turbine, the combination of an inner rotating element having therein near its periphery a plurality of combustion chambers with outlets leading diagonally to the periphery of the element, a hollow shaft carrying said element, there being an inlet passage for each combustion chamber leading from the inner end of the combustion chamber opposite the outlet to the interior

of the hollow shaft, a stationary ported valve sleeve within the hollow shaft, means for feeding combustible mixture into the valve sleeve; a stationary element around the rotatable element, said stationary element having arranged successively around its periphery in the direction of rotation of the rotatable element parts which present a solid blank to close the combustion chamber outlets when opposite them, parts having vanes adapted to receive expanding gases from the combustion chambers, and parts having exhaust openings leading to atmosphere, said vanes being successively spaced wider and wider apart in the direction of rotation of the rotatable element.

6. In a gas turbine, the combination of an inner rotating element having therein near its periphery a plurality of combustion chambers with outlets leading diagonally to the periphery of the element, a hollow shaft carrying said element, there being an inlet passage for each combustion chamber leading from the inner end of the combustion chamber opposite the outlet to the interior of the hollow shaft, a stationary ported valve sleeve within the hollow shaft, said sleeve valve being rotatably adjustable, a rotatably adjustable throttle sleeve within the sleeve valve having ports adapted to be registered with the sleeve valve ports, means for feeding combustible mixture into the throttle sleeve; a stationary element around the rotatable element, said stationary element having arranged successively around its periphery, parts which present a solid blank to close the combustion chamber outlets when opposite them, parts having vanes adapted to receive expanding gases from the combustion chambers, and parts having exhaust openings leading to atmosphere.

7. In a gas turbine, the combination of an inner rotating element having therein near its periphery a plurality of combustion chambers with outlets leading diagonally to the periphery of the element, a hollow shaft carrying said element, there being an inlet passage for each combustion chamber leading from the inner end of the combustion chamber opposite the outlet to the interior of the hollow shaft, a stationary ported valve sleeve within the hollow shaft, said sleeve valve being rotatably adjustable, a rotatably adjustable throttle sleeve within the sleeve valve having ports adapted to be registered with the sleeve valve ports, means for feeding combustible mixture into the throttle sleeve; a stationary element around the rotatable element, said stationary element having arranged successively around it periphery parts which present a solid blank to close the combustion chamber outlets when opposite them, parts having vanes adapted to receive a react against expanding gases from the combustion chambers, and parts having exhaust openings leading to atmosphere, said vanes being successively spaced wider and wider apart in the direction of rotation of the rotatable element.

8. In a gas turbine, the combination of an inner rotating element having therein near its periphery a plurality of combustion chambers with outlets leading diagonally to the periphery of the element, a hollow shaft carrying said element, there being an inlet passage for each combustion chamber leading from the inner end of the combustion chamber opposite the outlet to the interior of the hollow shaft, a stationary ported valve sleeve within the hollow shaft, means for feeding combustible mixture into the valve sleeve; a stationary element around the rotatable element, said stationary element having arranged successively around its periphery, in the direction of rotation of the rotating element parts which present a solid blank to close the combustion chamber outlets when opposite them, parts having vanes adapted to receive expanding gases from the combustion chamber, and parts having exhaust openings leading to atmosphere, the arrangement being such that the inlet passages come into register with the sleeve valve ports when the corresponding combustion chamber outlets are closed by said blank portion of the stationary element; and means in conjunction with said valve sleeve to introduce fresh air to the chambers through their inlet passages during the registry of the combustion chamber outlets with the exhaust openings in the stationary element.

9. In a gas turbine, the combination of an inner rotating element having therein near its periphery a plurality of combustion chambers with outlets leading diagonally to the periphery of the element, a hollow shaft carrying said element, there being an inlet passage for each combustion chamber leading from the inner end of the combustion chamber opposite the outlet to the interior of the hollow shaft, a stationary ported valve sleeve within the hollow shaft, means for feeding combustible mixture into the valve sleeve; a stationary element around the rotatable element, said stationary element having arranged successively around its periphery in the direction of rotation of the rotating element parts which present a solid blank to close the combustion chamber outlets when opposite them, parts having vanes adapted to receive expanding gases from the combustion chambers, and parts having exhaust openings leading to atmosphere, said vanes being successively spaced wider and wider apart in the direction of rotation of the rotatable element.

10. In a gas turbine, the combination of an inner rotating element having therein near its periphery a plurality of combustion chambers with outlets leading diagonally to

the periphery of the element, a hollow shaft carrying said element, there being an inlet passage for each combustion chamber leading from the inner end of the combustion chamber opposite the outlet to the interior of the hollow shaft, a stationary ported valve sleeve within the hollow shaft, means for feeding combustible mixture into the valve sleeve, a stationary element around the rotatable element, said stationary element having arranged successively around its periphery in the direction of rotation of the rotating element parts which present a solid blank to close the combustion chamber outlets when opposite them, parts having vanes adapted to receive expanding gases from the combustion chambers, and parts having exhaust openings leading to atmosphere, said vanes being successively spaced wider and wider apart in the direction of rotation of the rotatable element; and alternate rotatable and stationary elements with vanes surrounding said first mentioned stationary element to receive the expanding gases passing outwardly from the vanes in the first mentioned stationary element.

11. In a gas turbine, the combination of a pair of relatively rotatable elements; one of said elements having combustion chambers therein and the other of said elements carrying vanes adapted to receive and react against the expanding gases from the combustion chambers, said vanes being progressively spaced wider apart in the direction of the rotation of the first mentioned element relative to the second mentioned element, and the spaces between said vanes being constricted in the direction of flow of the expanding gases.

12. In a gas turbine, the combination of two relatively rotatable elements, one of said elements having combustion chambers therein, and the other of said elements having arranged in succession therearound parts having vanes adapted to receive and react against the expanding gases from the combustion chambers and parts having exhaust openings leading to atmosphere, the said vanes in said second mentioned element being spaced successively wider and wider apart in the direction of rotation of the first mentioned element relative to the second mentioned element, and the spaces between said vanes being constricted in the direction of flow of the expanding gases.

13. In a gas turbine, the combination of an inner rotating element having therein near its periphery a plurality of combustion chambers with outlets leading diagonally to the periphery of the element, a hollow shaft carrying said element, there being an inlet passage for each combustion chamber leading from the inner end of the combustion chamber approximately opposite the outlet to the interior of the hollow shaft, a stationary ported valve sleeve within the hollow shaft, means for feeding combustible mixture into the valve sleeve; a stationary element around the rotatable element, said stationary element having arranged successively around its periphery parts which present a solid blank to close the combustion chamber outlets when opposite them, parts having vanes adapted to receive expanding gases from the combustion chambers, and parts having exhaust openings leading to atmosphere, said vanes being successively spaced wider and wider apart in the direction of rotation of the rotatable element, and the spaces between said vanes being constricted in the direction of flow of the expanding gases.

14. In a gas turbine, the combination of an inner rotating element having therein near its periphery a plurality of combustion chambers with outlets leading diagonally to the periphery of the element, a hollow shaft carrying said element, there being an inlet passage for each combustion chamber leading from the inner end of the combustion chamber opposite the outlet to the interior of the hollow shaft, a ported sleeve valve within the hollow shaft, said sleeve valve being rotatably adjustable, a rotatably adjustable throttle sleeve within the sleeve valve having ports adapted to be registered with the sleeve valve ports, means for feeding combustible mixture into the throttle sleeve; a stationary element around the rotatable element, said stationary element having arranged successively around its periphery parts which present a solid blank to close the combustion chamber outlets when opposite them, parts having vanes adapted to receive and react against expanding gases from the combustion chambers, and parts having exhaust openings leading to atmosphere, said vanes being successively spaced wider and wider apart in the direction of rotation of the rotatable element, and the spaces between said vanes being constricted in the direction of flow of the expanding gases.

15. In a turbine of the character described, the combination of a pair of relatively rotatable elements, one of said elements having means for directing the flow of an expanding fluid, and the other of said elements having vanes adapted to receive the expanding fluid, the space between said vanes being progressively larger and larger in the direction of rotation of the first mentioned element.

16. In a turbine of the character described, the combination of a pair of relatively rotatable elements, one of said elements having means for directing the flow of an expanding fluid, and the other of said elements having vanes adapted to receive the expanding fluid, the space between said

vanes being progressively larger and larger in the direction of rotation of the first mentioned element, and the spaces between said vanes being constricted in the direction of flow of the expanding fluid so as to hold and retard the flow of expanding fluid between said vanes.

17. In a gas turbine, the combination of an inner rotating element having therein near its periphery a plurality of combustion chambers with outlets leading diagonally to the periphery of the element, a hollow shaft carrying said element, there being an inlet passage for each combustion chamber leading from the inner end of the combustion chamber approximately opposite the outlet to the interior of the hollow shaft, a stationary ported valve sleeve within the hollow shaft, means for feeding combustible mixture into the valve sleeve; a stationary element around the rotatable element, said stationary element having arranged successively around its periphery, parts which present a solid blank to close the combustion chamber outlets when opposite them, parts having vanes adapted to receive expanding gases from the combustion chambers, and parts having exhaust openings leading to atmosphere, said vanes being successively spaced wider and wider apart in the direction of rotation of the rotatable element, and the spaces between said vanes being constricted in the direction of flow of the expanding gases.

18. In a gas turbine, the combination of a pair of relatively rotatable elements, one of said elements having radially arranged combustion chambers therein, and the other of said elements having vanes adapted to receive and react against the expanding gases from the combustion chambers, said vanes being divided into two parts, one part formed for causing rotation in one direction and the other for causing rotation in the opposite direction, and means on the first mentioned element for directing the expanding gases from the combustion chambers in either of two tangentially opposite directions into either of said parts of the vanes.

19. In a gas turbine, the combination of two relatively rotating elements, one of said elements having therein a combustion chamber with an outlet at the surface of the element adjacent the other element; the other element having thereon, in arrangement to be successively traveled over by the combustion outlet, a part presenting a blank wall to the combustion outlet, then a part provided with vanes adapted to receive the expanding gases from the outlet, and then part open to exhaust; means to feed combustible mixture under pressure into the combustion chamber during passage of the blank wall, means to cause combustion in the chamber during passage of the vanes, and means to feed in fresh air under pressure during passage of the exhaust part.

20. In a gas turbine, the combination of two relatively rotating elements, one of said elements having therein a combustion chamber with an outlet at the surface of the element adjacent the other element; the other element having thereon, in arrangement to be successively traveled over by the combustion outlet, a part which presents a blank wall to the combustion outlet, then a part provided with means for causing rotation by action of the expanding gases from the combustion outlet and leading to atmosphere; means to feed combustible mixture under pressure to the chamber during passage of the first mentioned part, means to cause combustion in the combustion chamber during passage of the first portion of the second mentioned part, and means to feed in fresh air under pressure during passage of the remainder of the second mentioned part.

21. In a gas turbine the combination of a pair of relatively rotatable elements, one of said elements having two sets of vanes arranged for causing rotation in opposite directions; the other element having combustion chambers leading to the periphery of the element, and movable deflecting members mounted in the peripheral part of said element to deflect the expanding gases from the combustion chamber in either one or the other of the two opposite tangential directions.

In witness that I claim the foregoing I have hereunto subscribed my name this 26 day of February, 1918.

ALVA W. TYLER.

Witness:

V. I. BERINGER.