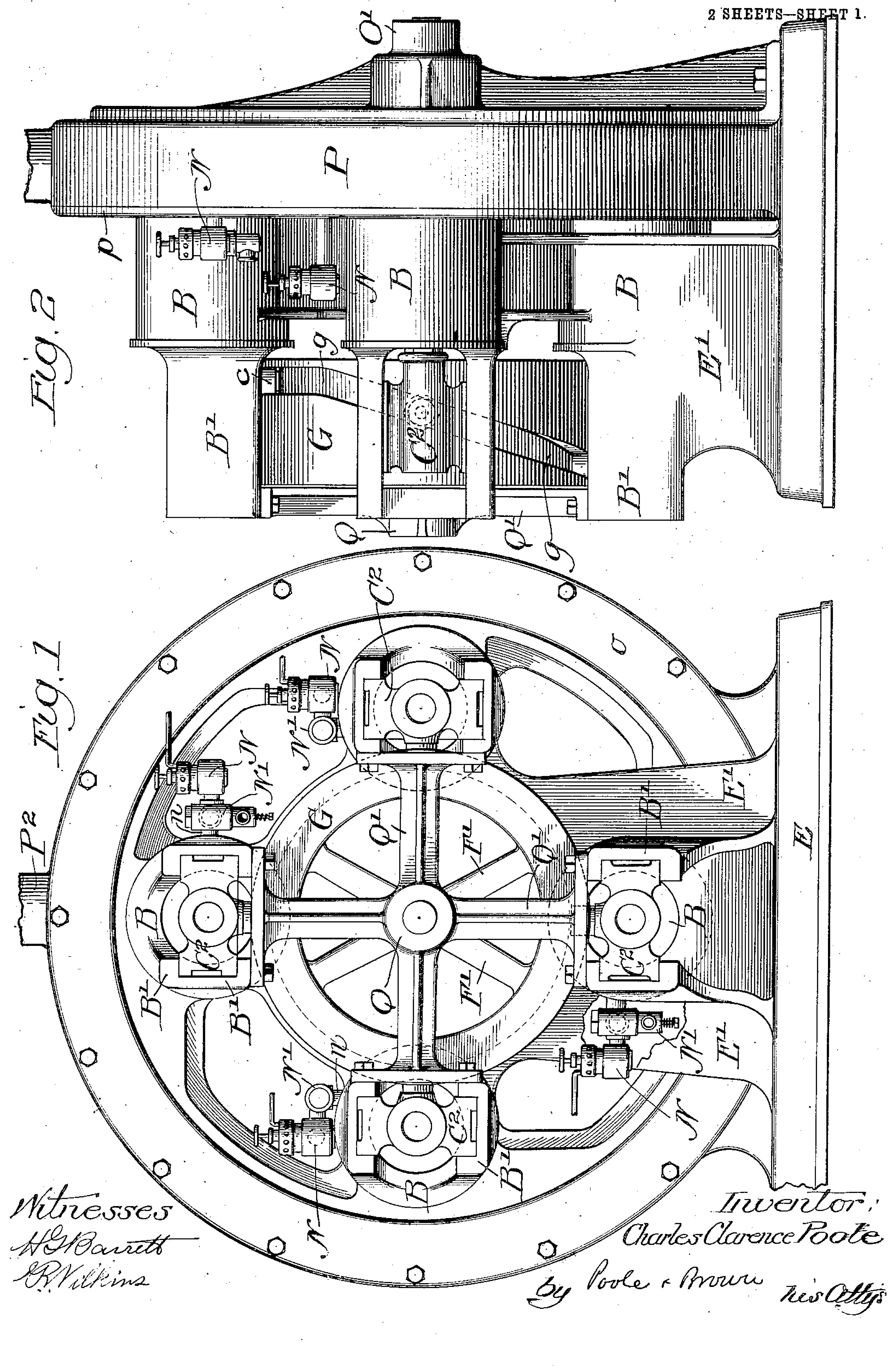
No. 836,945. PATENTED NOV. 27, 1906.

C. C. POOLE.

INTERNAL COMBUSTION TURBINE MOTOR.

APPLICATION FILED FEB. 17, 1905.

2 SHEETS—SHEET 1.



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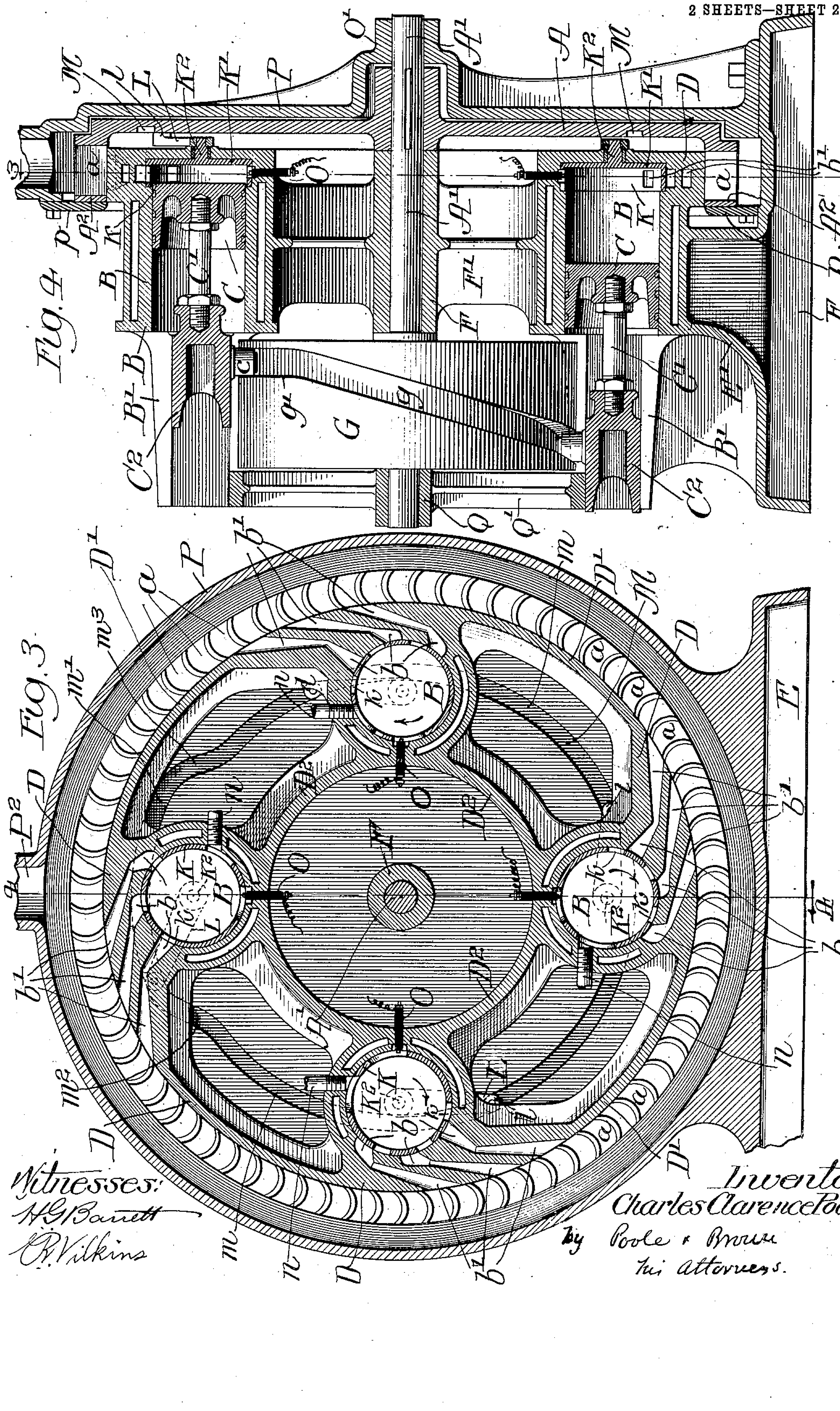

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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION TURBINE-MOTOR.

No. 836,945. Specification of Letters Patent. Patented Nov. 27, 1906.

Application filed February 17, 1905. Serial No. 246,092.

To all whom it may concern:

Be it known that I, Charles Clarence Poole, a citizen of the United States, residing at Evanston, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Internal-Combustion Turbine-Motors; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to an internal-combustion turbine motor or engine embracing a rotative member or rotor provided with annularly-arranged blades or buckets and which is given rotative motion through the explosion or combustion within a confined space or inclosure of an admixture of inflammable gas or hydrocarbon vapor and air and the impact against the blades or buckets of jets of the resulting products of combustion, which are directed against said blades or buckets through a discharge-orifice leading from the inclosure in which the gaseous mixture is exploded.

The object of my invention is to employ for giving motion to the rotor of a turbine or impact engine expanding gaseous products of combustion generated by the explosion of an explosive admixture when under compression and acting under substantially the same conditions that prevail in the operation of a reciprocating explosive-engine wherein the expanding gases resulting from the combustion of the explosive admixture act in a cylinder against a moving piston therein. It has been found that the best results and an economical use of the fuel are obtained in the use of reciprocating explosive-engines only when the explosive admixture is ignited or exploded when under a considerable degree of compression. In such engines as heretofore largely and successfully used charges of the explosive mixture are drawn into the power-cylinder by the backward or outward stroke of the piston therein, such charges are compressed within the cylinder in the subsequent inward movement of the piston in the cylinder, and the ignition of the explosive charge takes place at times when the piston is near the inward limit of its movement and the charges are under a high or considerable degree of pressure. In carrying out my invention it is my purpose to ignite or explode a gaseous explosive mixture in an internal-combustion turbine-engine under the same conditions that such admixture is ignited or exploded in such reciprocating explosive-engine—that is to say, when the explosive charge is confined under a high or considerable degree of pressure in an inclosed space or chamber—and to discharge the expanding gases and products of combustion arising from the explosion from said inclosed space or chamber through a discharge opening or nozzle leading directly from said chamber or space against the blades or buckets of the rotative wheel or member of the engine.

To the end stated, an internal-combustion turbine-engine embodying my invention embraces in its general features a rotative wheel or rotor provided with blades or buckets, a compression-cylinder provided with a discharge opening or nozzle through which gaseous products resulting from combustion of the compressed explosive admixture may be discharged directly against the blades or buckets of said rotor, and a reciprocating piston actuated by the rotor for compressing such explosive mixture in the cylinder.

As shown in the drawings, Figure 1 is a view in front elevation of an engine embodying my invention. Fig. 2 is a side view thereof. Fig. 3 is a sectional view taken on line 3 3 of Fig. 4. Fig. 4 is a sectional view taken on line 4 4 of Fig. 3.

As shown in said drawings, A indicates the rotative member or rotor of the engine, which consists of a disk or wheel mounted on a shaft A′ and provided with an annularly-arranged series of blades or buckets *a a*. The said blades or buckets are shown as made of curved form or provided with concave working faces, as common in turbine-motors.

The non-rotative part or stator of the engine embraces a plurality of cylinders B, each provided with a reciprocating piston C and in which charges of mixed air and gas or vapor are compressed and ignited, as in the power-cylinder of an explosive reciprocating engine. The inner ends of said cylinders, in which the charges are compressed, are located adjacent to the blades *a a* of the rotor and are provided with valved outlet ports or passages *b b* for the exit from the inner ends of the cylinders of the expanding gases and products of combustion resulting from the ignition of the compressed charges. Said outlet-ports communicate with discharge passages or nozzles *b′ b′*, in which the products of combustion expand, the initial pressure is converted into *vis viva*, and by which the products of combustion moving at a high velocity are directed upon or against the said blades *a a* of the rotor. Provision is made for supplying charges of explosive mixture to the cylinders, which charges are drawn into the cylinders in the retractive movement of the pistons therein, together with means for igniting the compressed charges after the pistons have been advanced to compress the same, and the parts are so arranged that a charge enters the cylinder at each retractive stroke of a piston, the charge is compressed in the subsequent advance stroke of the piston, the charge is ignited while the piston is in its advanced position, and the expanding gases and products of combustion pass from the inner end of the cylinder through the valved exit-ports and discharge-nozzles, the valve controlling the said exit-ports being closed in the retractive and advance strokes of the piston while the charge is being introduced and compressed and opened at the time of ignition to permit the discharge of the expanding gases generated by the explosion or combustion of the compressed admixture.

In the arrangement of the parts illustrated in the accompanying drawings the buckets *a a* extend laterally from one side of the peripheral portion of the disk A and are attached to a ring A^2, arranged parallel with the disk. In connection with the buckets thus disposed four cylinders B B are employed, which are arranged parallel with the shaft A′, with their closed ends within and adjacent to the path of the blades *a a*. In this arrangement of the cylinders the exit-passages *b b* and nozzles *b′ b′* open laterally from the closed ends of the cylinders at the sides thereof adjacent to said blades and are arranged in a plane parallel with the disk A. Said nozzles *b′ b′* are formed in nozzle-blocks D D, provided with outer faces curved concentrically with the line of the inner margins of the blades *a a* and through which the nozzles open. Said nozzle-blocks are preferably made integral with the side walls of the cylinders. The cylinders are rigidly held in proper position with relation to each other and to the blades of the rotor by segmental connecting members D′, extending between and joining nozzle-blocks D, and like connecting-plates D^2, which extend between and join the inner parts of the side walls of the cylinders, which latter and the connecting members D′ and D^2 together constitute, in effect, the non-rotative member or stator of the engine. The stator as a whole is attached to a horizontal base E, being joined thereto by a supporting-standard E′.

A central bearing-sleeve F for the rotor-shaft A′ is conveniently supported within the space between the cylinders by radial arms F′ F′, extending from the said bearing-sleeve to the ring formed by the cylinders and the frame members D^2.

For giving reciprocating motion to the pistons C C a construction is shown in the drawings, as follows: To said pistons are attached piston-rods C′ C′, to the outer ends of which are secured cross-heads C^2 C^2, which slide in guides B′ B′, attached to and projecting from the cylinders. Each cross-head carries a bearing pin or stud *c*, which extends inwardly or toward the central axis of the machine. On the rotor-shaft A′ is mounted a rotative cam-cylinder G, provided in its cylindric outer surface with a cam-groove *g*, which is engaged by the several studs *c c* on the cross-heads C^2 C^2. The cam-groove *g* has oblique or inclined parts adapted to move the cross-heads backwardly and forwardly a distance equal to the stroke of the pistons at each complete revolution of said cam-cylinder. The said cam-groove has a part *g′*, which is straight or in a plane perpendicular to the central axis of the cam-cylinder and which serves to hold the pistons for a somewhat prolonged period of time at the forward limit of their compressing stroke. In the rotation of the cam-cylinder the cam-groove serves to advance and retract the pistons successively in the several cylinders, each piston being advanced to compress the explosive charge and retained in its advanced position by the straight part *g′* of the cam-groove until the gases resulting from the ignition of the compressed charges have exhausted from the cylinder through the discharge-nozzles.

For controlling the exit-ports *b b* of each cylinder in such manner that said ports will be closed in the backward or charging stroke and forward or compressing stroke of the piston and will be opened to effect the discharge of the expanding gaseous products of combustion while the piston is held in its advanced position I have shown in the drawings a valve and valve-actuating device, as follows:

K is a valve-ring, which is seated and adapted to turn or oscillate in an annular seat or groove formed in the inner end of the cylinder adjacent to the cylinder-head. Said valve-ring is provided with ports *k k*, corresponding in location with the ports *b b* and adapted to register with the same. The valve-ring is secured to a disk K′, which rests against and turns upon the inner face of the cylinder-head. The said disk is provided with a rigidly-attached central shaft K^2, which extends outwardly through a central bearing-aperture in the cylinder-head. Attached to the said shaft K^2 outside of the cylinder-head is a crank-arm L, having at its outer end a pin *l*, which engages a cam-groove M, formed in the inner face of the disk A of the rotor. Said cam-groove is provided with concentric parts m and m', located at different radial distances from the center of the rotor and which are joined by oblique or outwardly-deflected parts m^2 m^3, Fig. 3. The circumferential part m' extends through an arc corresponding generally with the length of the straight port g' of the cam-groove g. When the pin l of the crank-arm L is engaged with the part m of the cam-groove M, the valve-ring is held in position to close the ports b b, the imperforate parts of said valve-ring then covering or closing said ports, and when the said pin is engaged with the part m' of said cam-groove the valve-ring is held in position with the parts m m thereof in register with the ports b b, and the latter are open. The deflected parts m^2 and m^3 of the cam-groove M are so located that the valve will be moved or shifted to its open position at such time with relation to the termination of the compressing stroke of the piston and the time of ignition of the compressed charge that the ignition of the explosive mixture will take place while the valve is still closed and the charge is held under maximum compression, while the gaseous products of combustion will be allowed to escape from the cylinder as expansion takes place as the result of the explosion or combustion of the admixture. In other words, the valve will be opened in such manner as to secure conditions approximating those which obtain in the explosion of the charge in a reciprocating-piston gas-engine wherein ignition of the explosive mixture takes place about the time of maximum compression or when the piston is fully advanced and the crank is on its dead-center, and any considerable expansion of the burning gases does not take place until the crank has moved past the dead-center so far that the piston has acquired considerable rapidity of movement in its outward stroke, while the expanding gases continue to act on the piston through the greater part of its outward stroke. In such explosive reciprocating engines the ignition of the charge when fully compressed and confined between the cylinder and head and piston, associated with a retarded expansion of the gaseous products resulting from combustion, due to the gradual enlargement of the space in which the burning gases are confined as the piston moves outwardly under the pressure of the expanding gases, has been found to produce economical results in operation, and like conditions of ignition under maximum compression and retarded expansion may be obtained in the engine described by so turning or moving the valve which controls the outlet-ports b b as to produce correspondingly favorable results. Moreover, it is manifest that the oblique parts m^2 and m^3 of the cam-groove may be so located and shaped and the movements of the valve thereby so timed or varied in speed that the escape of the expanding gases will be accelerated or retarded according to the rapidity of the expansion thereof and in such manner as to equalize so far as is possible or practicable the pressure of the gases during their exit through the outlet-ports, with the result of obtaining substantially or practically uniform initial pressure at the outlet-port and consequent substantially constant velocity in the jets from the discharge-nozzles during the time the gases are being discharged against the blades of the rotor.

For supplying a suitable admixture of air and gas or hydrocarbon vapor to the engine-cylinders any suitable or well-known means may be employed. The drawing shows carbureters N N of common construction as applied to each cylinder, with check-valves N′ N′ interposed between the carbureters and the cylinders, the check-valve casings being connected with the cylinders by inlet-pipes n n. Said inlet-pipes are shown as inserted through the side walls of the cylinders near the heads thereof, the valve-rings K K being cut away opposite the same to permit free ingress of the carbureted air in all positions of the valve-rings. The said carbureters operate in the same manner as those generally used in explosive-engines, the air being drawn through the same into the cylinders in the outward stroke of the pistons and being charged with carbon-vapor in its passage through the carbureters.

Any suitable form of igniting device may be used. That shown in the drawings consists of sparking plugs O, inserted through the side walls of each cylinder near the head thereof, the valve-ring K being cut away opposite the inner ends of the plugs. Any common form of switch device operated by the rotor may be employed to effect the sparking or ignition at the proper time. Such devices are well known, and it is not thought necessary to illustrate the same.

An exhaust-chamber to receive the exhaust from the blades of the rotor is provided by means of a housing P, which surrounds the outer face and periphery of the rotor A, the same being attached to the base E and provided at the margin of its outer cylindric part, which surrounds the buckets a, with an inwardly-extending ring p, arranged adjacent to the ring A^2 and overlapping the same. The housing P is shown as provided with a central bearing-hub O′, forming an outer end bearing for the shaft A′, and with an exhaust delivery-pipe P^2. A bearing is provided for the end of the shaft A′ exterior to the cam G, consisting of a bearing hub or sleeve Q, which is supported by radial arms Q′ from the outer ends of the cross-head guides B′ on the cylinder B.

An important advantage arising from the employment of the general features of the construction described is that the expanding products of combustion produced by the ignition of the explosive admixture within the cylinders pass directly from the spaces in which they are compressed and ignited to the discharge passages or nozzles, by which they are directed against the blades or buckets of the rotor, with the result that there occurs substantially no cooling of the expanding gases, and consequently no contraction or diminution in volume of such gases, which are therefore discharged against the blades or buckets with a velocity due to the full pressure in the cylinder resulting from the expansion of the gases in the combustion thereof.

While I have shown the engine as provided with four compression-cylinders, yet one cylinder or any greater number of cylinders may be employed, according to the size of the rotative member or rotor, and other conditions which may exist in any particular engine. Generally it is desirable that as many compression-cylinders shall be used as is necessary to secure continuous action of the jets from the discharge-nozzle upon the blades or buckets of the rotor. For example, if the circumference of the ring of blades or buckets in proportion to the size of a cylinder (or quantity of explosive admixture compressed therein at any one stroke of the piston) is such that the expanding gases produced in one explosion will act upon the blades or buckets during one-fourth of a rotation of the said rotor, then it is desirable that four equally-spaced cylinders should be employed, so that as soon as the expanding gases are fully exhausted from one cylinder explosion will take place in the next succeeding cylinder, and a continuous action of the jets on the rotor will thus take place.

It is, moreover, to be understood that means different from the devices shown may be employed for communicating motion from the rotor to the pistons for controlling the exit-ports of the cylinders, for supplying the explosive admixture to the cylinders, and for igniting the explosive charges, the several devices for these purposes being illustrated in the accompanying drawings merely for the purpose of disclosing one form in which my invention may be carried out in practice. Moreover, the general organization of the machine may be variously modified in practice with respect to the location of the cylinders relatively to the rotor, in other features of construction and arrangement, the construction illustrated being only one convenient way in which the operative parts of the engine may be arranged or designed in practice. Certain of the details of construction illustrated and described, however, in themselves embrace features of novelty and are herein claimed as part of my invention.

In the motor shown in the accompanying drawings the smallest or most restricted parts of each discharge-passage constitute the discharge-aperture for the escape from said chamber or cylinder of the expanding products of combustion and are made of the area required for the delivery of the expanding gases from the cylinder in such volume as required for efficient action of the motor. The receiving ends of the said passages between said restricted ports and the delivery-apertures are made as short as practicable and are gradually contracted from the cylinder to the said apertures, so as to lessen so far as possible frictional resistance in the escape of the expanding gases from the cylinder through said discharge-apertures. The flaring portions of said passages exterior to the restricted ports or discharge-apertures serve to confine the expanding jets in their passage from the discharge-orifices to the blades or buckets of the rotor. Such flaring portions of the discharge passages or nozzles are not essential to the operation of the motor, but are desirably employed to increase the speed of the jets passing therethrough and concentrate said jets upon the blades or buckets according to the well-known theory of operation of the correspondingly-flaring nozzles of the De Laval and other turbines.

In a device embodying my invention, therefore, the delivery or exit orifice, through which the products of combustion are discharged from the compression chamber or cylinder, is located in the wall of the said chamber or cylinder and adjacent to the valve by which said delivery or exit orifice is controlled. It follows that said delivery or exit orifice affords substantially an immediate or direct discharge of the gaseous products of combustion from the compression-chamber in which the charge is compressed and ignited, with the result that the gaseous products of combustion make their exit from said chamber to the space of less pressure exterior to the chamber substantially under the initial pressure due to the combustion or explosion and without any substantial reduction in temperature, and that the initial pressure is converted into *vis viva* at the said exit-orifice without any substantial loss of energy through frictional retardation or diminution of volume by cooling.

I claim as my invention—

1. An internal-combustion impact-motor embracing a rotor and means operated by the rotor for compressing and exploding charges of a gaseous explosive mixture embracing a chamber in which the charges are compressed by decreasing the internal capacity of said chamber, said chamber being provided with a discharge-passage having a restricted portion located substantially at the receiving end of said passage and through which the products of combustion pass directly from the chamber to convert the initial pressure resulting from the explosion into *vis viva*, a

valve for controlling said discharge-passage, which valve is closed during the compression of the charge and opened to permit the passage of the products of combustion from said orifice, and means for igniting the charge while under compression.

2. An internal-combustion impact-motor embracing a rotor, and means operated by the rotor for compressing and exploding charges of a gaseous explosive mixture, embracing a chamber in which the charges are compressed by decreasing the internal capacity of the chamber, said chamber being provided with a discharge-passage extending therefrom to the blades or buckets of the rotor, having a restricted portion adjacent to its receiving end, and a flaring portion in which the gaseous products of combustion expand after their passage through said restricted portion to convert the initial pressure resulting from the explosion into *vis viva* at the delivery end of said passage, and a valve at the receiving end of said passage, which valve is closed during the compression of the charge and opened to permit the discharge of the products of combustion.

3. An internal-combustion impact-motor embracing a rotor, a compression-cylinder, a reciprocating piston in said cylinder actuated by the rotor, said cylinder being provided in its wall with a discharge-passage having at its receiving end a restricted portion through which the products of combustion pass directly from the cylinder to convert the initial pressure resulting from the explosion into *vis viva*, a valve for controlling said discharge-passage, which valve is closed in the compression of the charge and opened to permit the discharge of the gaseous products of combustion from the cylinder, means for supplying charges of the explosive gaseous admixture to the cylinder during the backward stroke of the piston therein, and means for igniting the charges when compressed.

4. An internal-combustion impact-motor embracing a rotor, a compression and explosion cylinder provided with a reciprocating piston, the backward stroke of which effects the charging of the cylinder and the advance stroke of which effects the compression of the explosive charge and means actuated by the rotor for giving reciprocating motion to the piston adapted to retain the piston in its advance position during the discharge of the products of combustion from the cylinder, said cylinder being provided with a discharge-passage having at its receiving end a restricted portion through which the products of combustion pass directly from the cylinder to convert the initial pressure resulting from the explosion into *vis viva*, and a valve for controlling said discharge-passage which is closed during the backward and forward strokes of the piston and is opened to permit the discharge of the products of combustion after the compression of the explosive charge.

In testimony that I claim the foregoing as my invention I affix my signature, in presence of two witnesses, this 15th day of February, A. D. 1905.

CHARLES CLARENCE POOLE.

Witnesses:

TAYLOR E. BROWN,

GERTRUDE BRYCE.