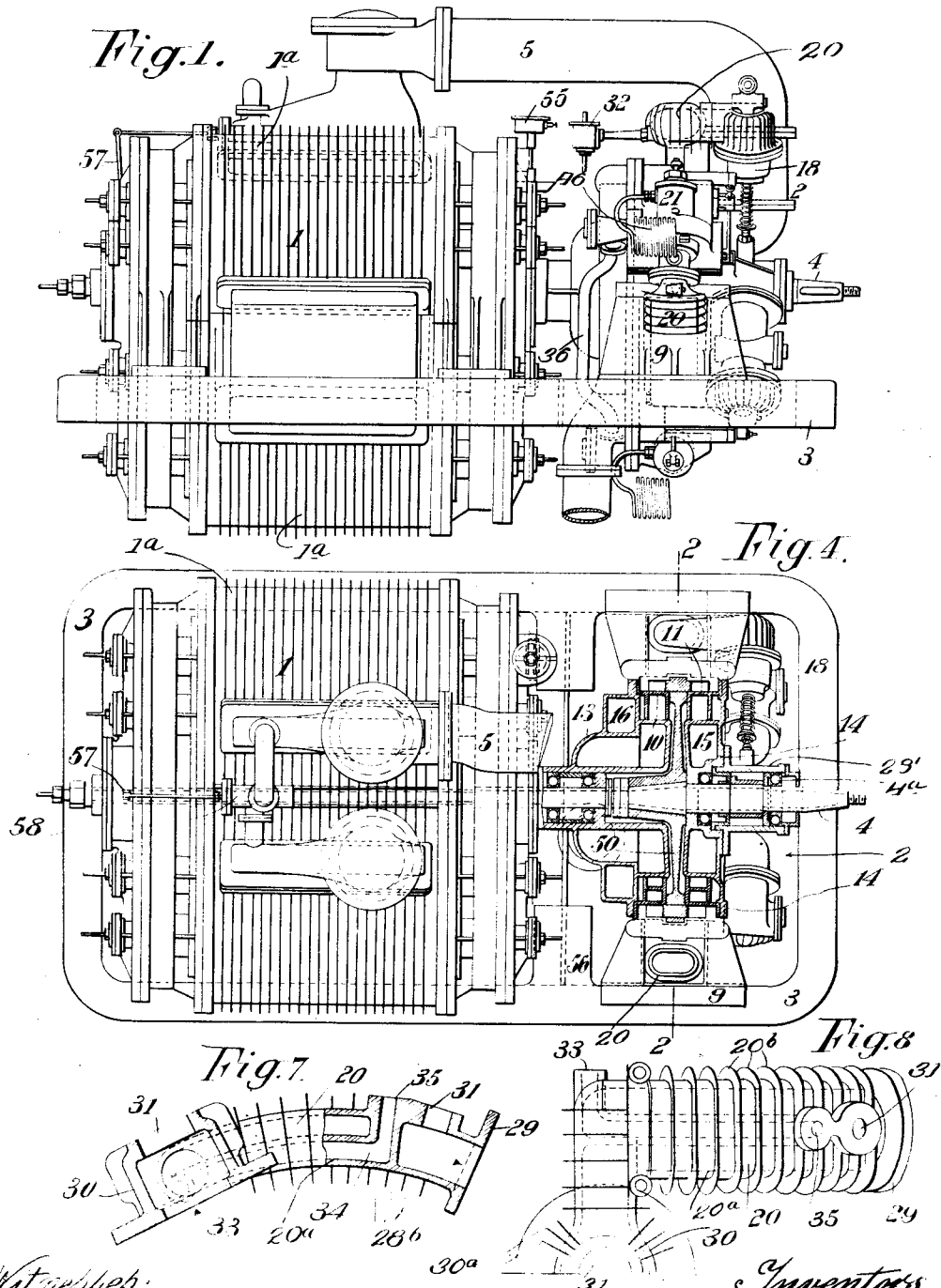


J. RACLOT & C. ENDERLIN.
INTERNAL COMBUSTION TURBINE.
APPLICATION FILED MAY 2, 1910.

1,118,801.

Patented Nov. 24, 1914.

6 SHEETS—SHEET 1.



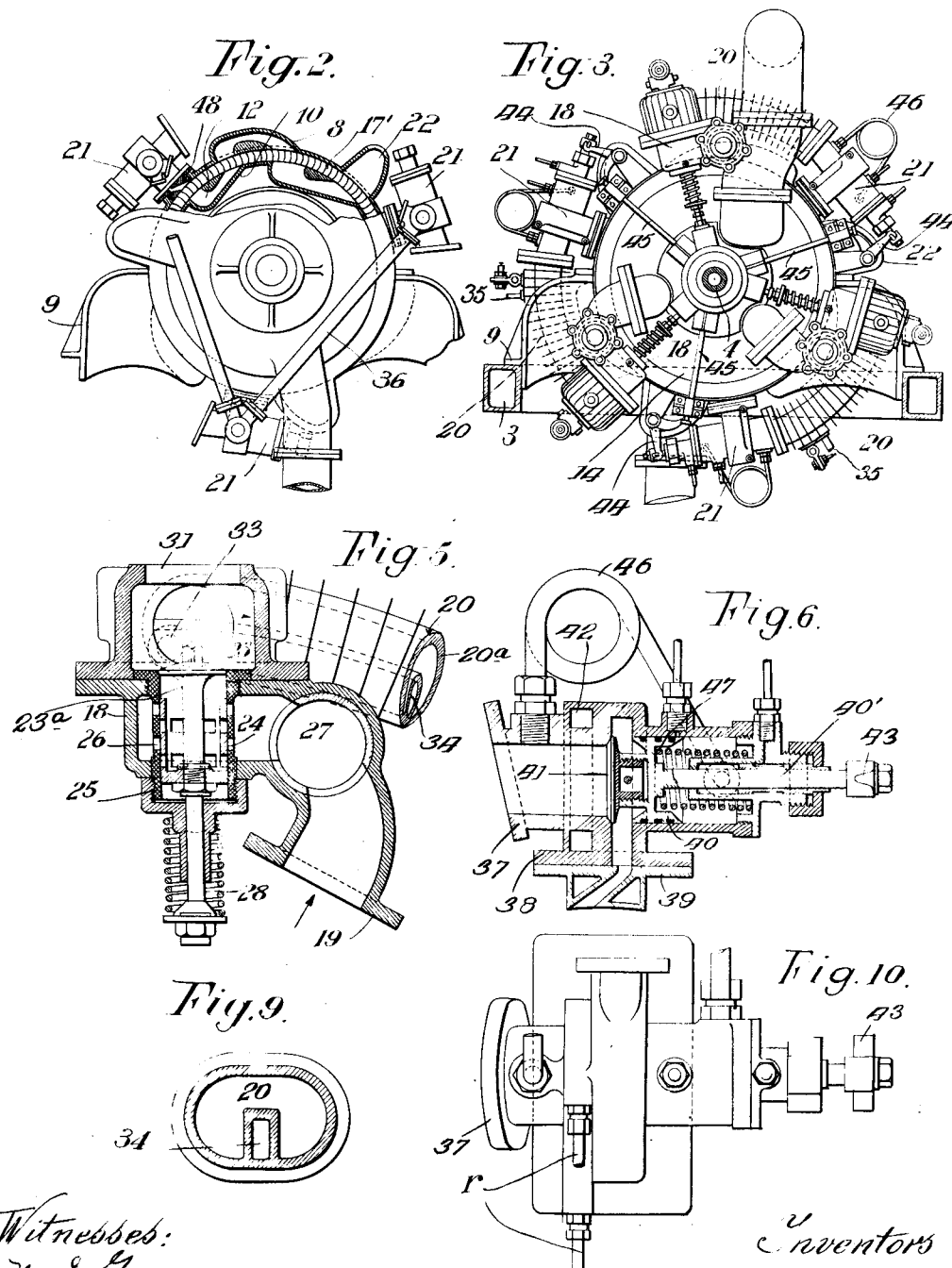
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J. M. Dwyer

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J. M. Dwyer Attorney

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6 SHEETS—SHEET 2.



Witnesses:
Mr. E. Gay.
Mr. Meyer

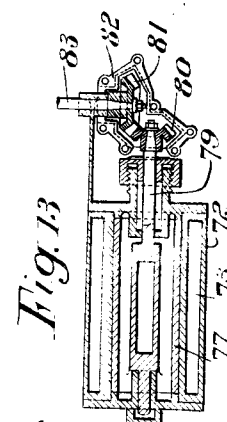
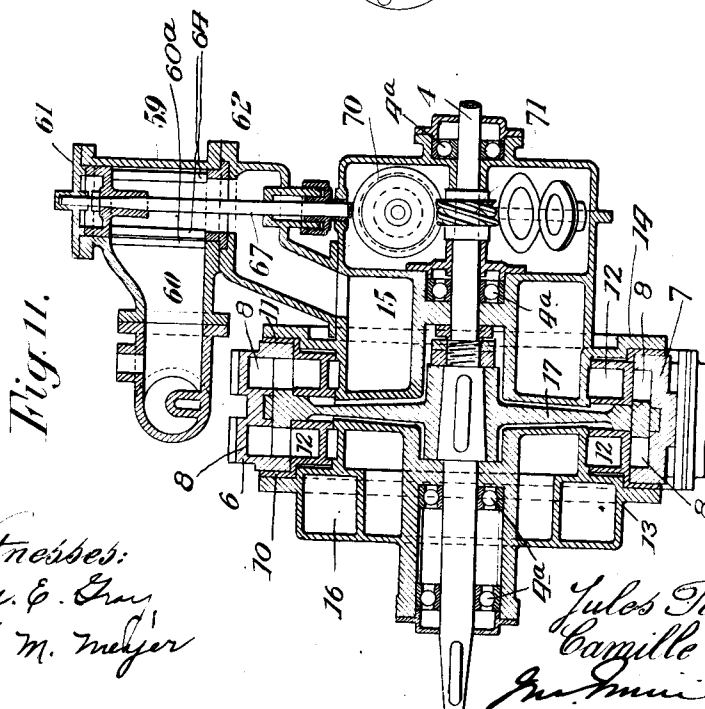
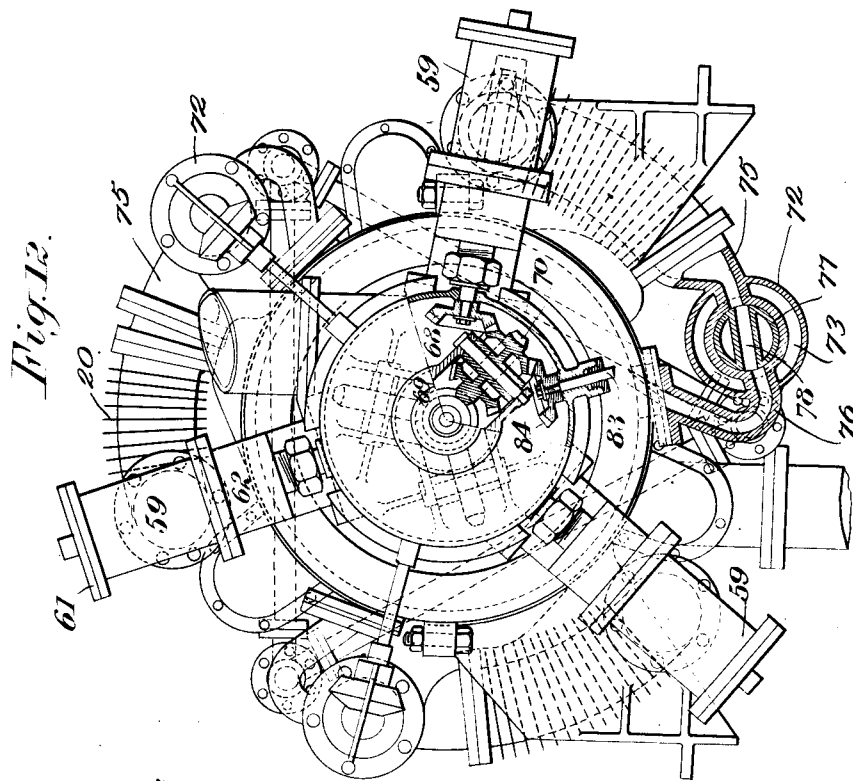
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6 SHEETS-SHEET 2.



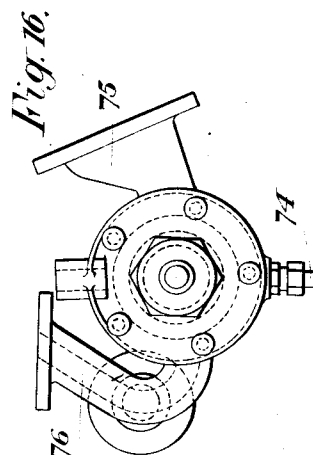
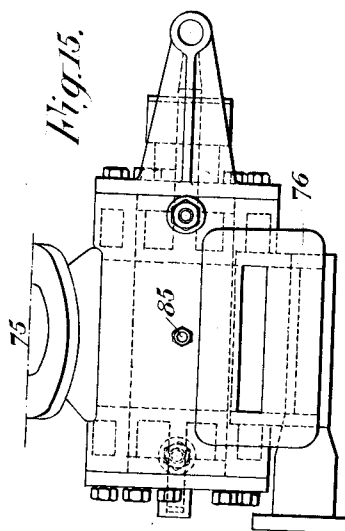
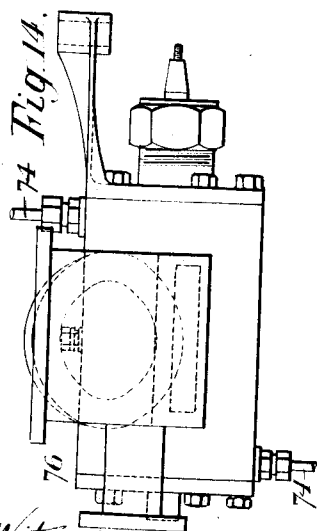
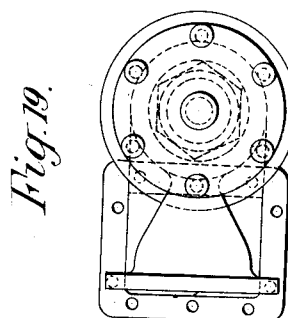
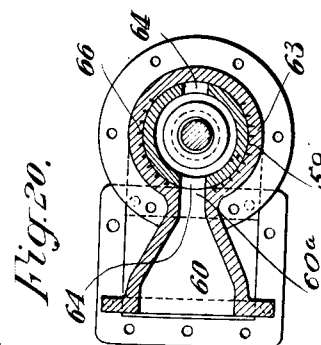
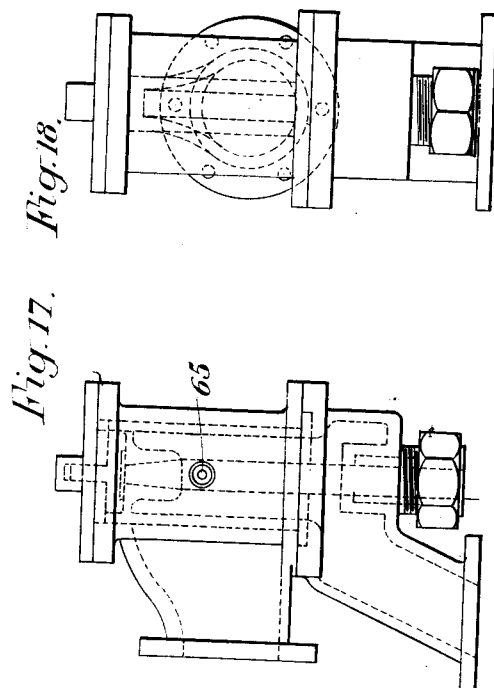
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INTERNAL COMBUSTION TURBINE.
APPLICATION FILED MAY 2, 1910.

Patented Nov. 24, 1914.
6 SHEETS—SHEET 4.



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6 SHEETS—SHEET 5.

1,118,801.

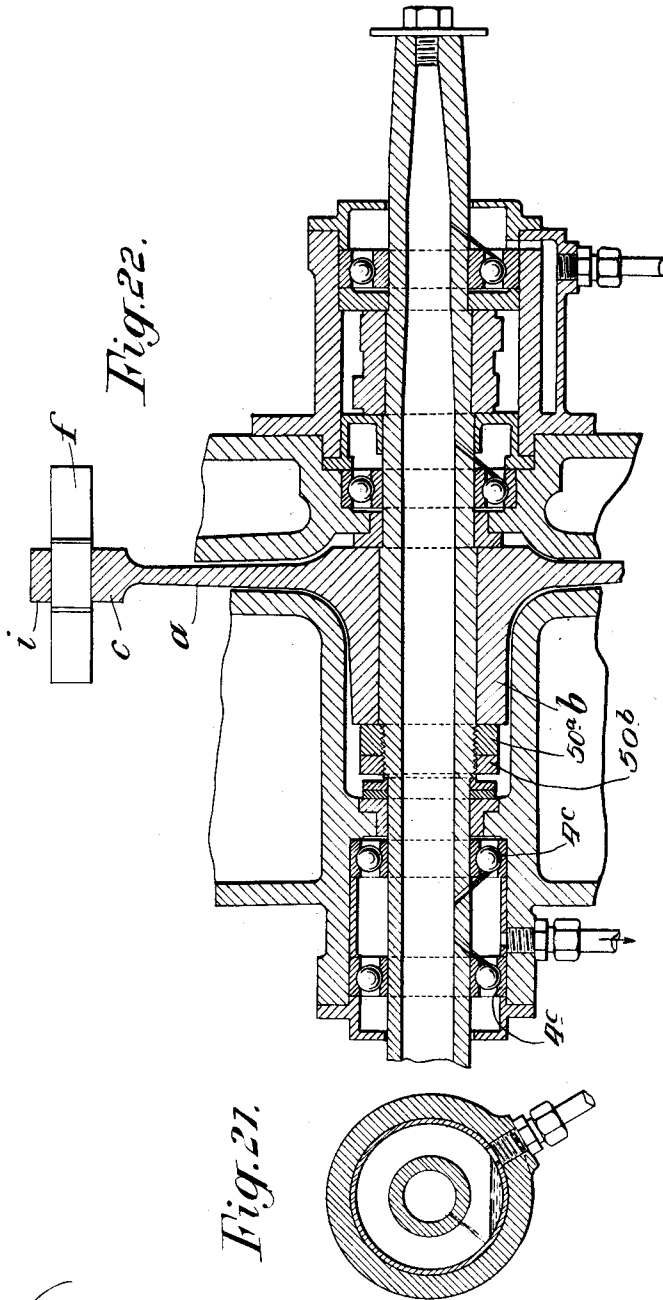
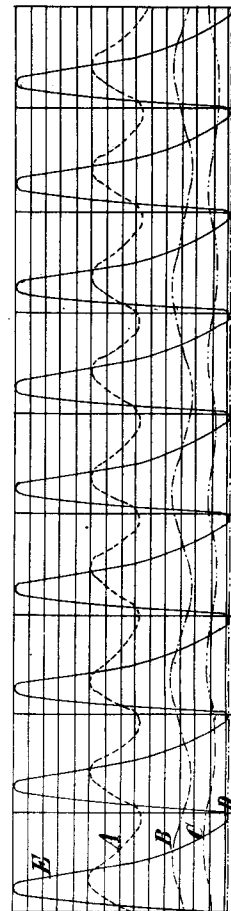


Fig. 28.



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6 SHEETS—SHEET 6.

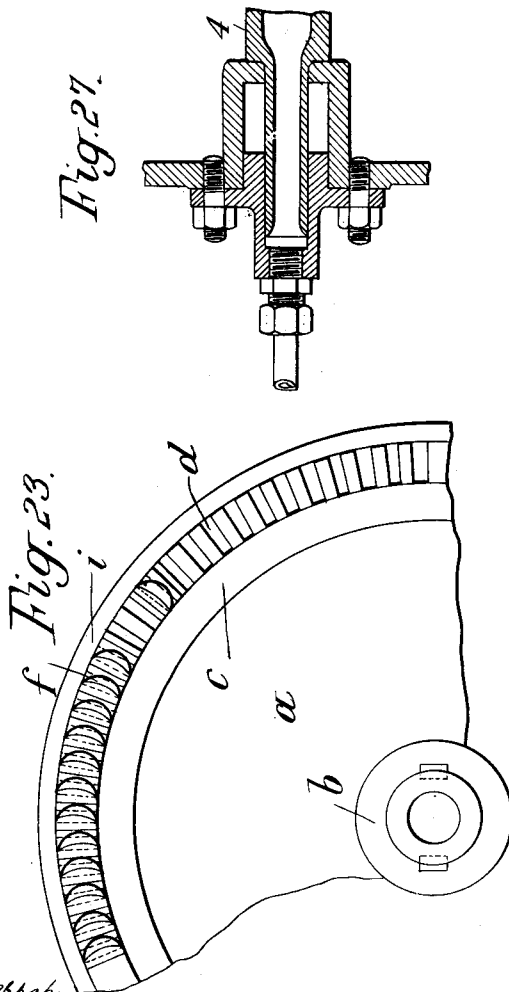


Fig. 27.

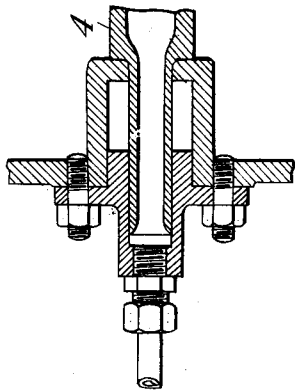


Fig. 25.

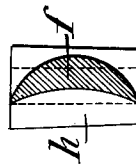


Fig. 24.

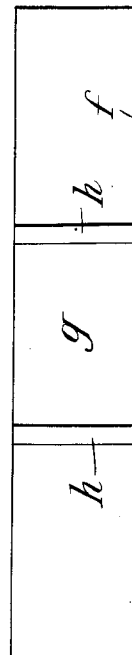
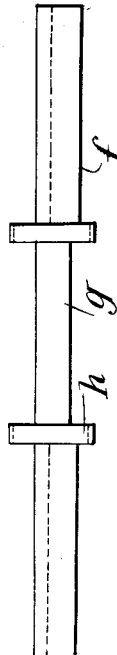


Fig. 26.



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UNITED STATES PATENT OFFICE.

JULES RACLOT AND CAMILLE ENDERLIN, OF ST.-MAUR DES FOSSÉS, FRANCE.

INTERNAL-COMBUSTION TURBINE.

1,118,801.

Specification of Letters Patent.

Patented Nov. 24, 1914.

Application filed May 2, 1910. Serial No. 558,754.

To all whom it may concern:

Be it known that we, JULES RACLOT and CAMILLE ENDERLIN, both citizens of the French Republic, and residents of St.-Maur des Fossés, Seine, France, have invented certain new and useful Improvements in and Relating to Internal-Combustion Turbines, of which the following is a specification.

This invention relates to an internal combustion or explosion turbine adapted to use a combustible gas or liquid hydrocarbon and more especially intended to form a part of a power group comprising the turbine proper and a compressor which may or not be keyed on the same shaft and it has for its object to compress the explosive gas mixture before its admission into the turbine. When a fluid hydrocarbon such as ordinary lamp petroleum is employed the turbine is provided with a device which permits the utilization of the heat disengaged by the explosions for converting the said petroleum into vapors which are thereafter conveyed to the compressor wherein they are compressed before their utilization in the turbine.

The internal combustion turbine which forms the subject matter of this invention has the following characteristic features of operation; the fresh compressed explosive gases are first conveyed into combustion pockets wherein the combustion or explosion takes place under a constant volume; thereafter the gases thus produced are admitted under a high pressure, simultaneously to several points on the paths of the blades of the turbine which they are obliged to cross several times thus moving alternately toward and from the shaft of the turbine and expanding progressively before arriving at the escape ducts. The arrival of the fresh explosive gases in the combustion pockets and the admission of the burnt gases to the blades may be controlled by means of an ordinary valve gear or of a rotary cylindrical valve gear. The rotor of the turbine is provided with two sets of blades; and an auxiliary turbine, which receives the gases from the combustion pockets, may be employed for actuating various accessory apparatuses of the turbine such as magneto, dynamo, circulating pumps and so on.

In the accompanying drawings: Figure 1 is a longitudinal elevation of the general arrangement of a power group, comprising a compressor and an internal combustion turbine constructed according to the present invention in one form of embodiment given by way of example. Fig. 2 is a side elevation view of the turbine, a part of which is shown in section on line 2—2 of Fig. 4. Fig. 3 is an end view. Fig. 4 is a top plan view of a turbine and its compressor. Fig. 5 is a vertical axial section of one of the feed valves. Fig. 6 is a vertical axial section of one of the inlet valves. Fig. 7 is a vertical section with parts being shown in elevation of one of the combustion pockets together with the upper part of the corresponding feed valve body. Fig. 8 is a top plan view of same. Fig. 9 is a cross section on the line 9—9, of Fig. 5. Fig. 10 shows a top plan view of one of the inlet valves corresponding to Fig. 6. Fig. 11 is an axial section of a second form of the turbine showing a modified type of valve arrangement. Fig. 12 is an end elevation of the modified turbine. Fig. 13 is a longitudinal section of the modified inlet valve. Figs. 14 and 15 are elevations of the modified inlet valve taken at right angles to each other. Fig. 16 is an end view of the modified inlet valve. Figs. 17 and 18 are front and side views respectively of the modified feed valve. Figs. 19 and 20 are respectively an end view and a cross section of the modified feed valve. Fig. 21 is a cross sectional view of the turbine shaft. Fig. 22 is a longitudinal section showing the mounting of the blade wheel and of the lubricating devices. Fig. 23 is a partial side elevation view of this rotor. Fig. 24 is a front elevation view of a double blade drawn at a somewhat larger scale. Fig. 25 is a cross sectional view of said blade. Fig. 26 shows a top plan view of said blade. Fig. 27 is a section showing the connection between the oil feed pipe and the shaft. Fig. 28 is a diagram of the pressure cycles of the turbine.

The turbine which forms the subject matter of this invention has been shown in particular by Figs. 1 and 4 as forming a part of a power group comprising a rotary compressor 1 which feeds the compressed explosive

gas mixture into the turbine proper 2. The group or plant is supported on a base 3. In the form shown the compressor 1 is formed by rotary pumps 1^a, mounted in series round the motor shaft 4 arranged at angles of 120°. Each of these pumps is preferably of the type described in our copending application for "Rotary Pump" Serial No. 593552 filed November 21, 1910. The explosive mixture compressed by the compressor is conveyed into the turbine by the pipe 5. The compressor is directly keyed on the shaft of the turbine or it is indirectly driven by the latter.

The turbine proper comprises a casing formed in two parts 6, 7 (Figs. 4 and 11) connected together along a horizontal diameter and cast integral with the ducts 8 (Fig. 2). The lower half 7 is provided with supporting brackets 9 (Fig. 3). Arranged on both sides of these halves 6, 7 are two symmetrical rings 10, 11 which are provided with ducts 12 (Fig. 2) and are secured to the inner faces of the plates or heads 13, 14 of the casing. The head 14 is connected with the duct 5 and is formed with a receiver 15 for the compressed explosive mixture. The other head 13 on the contrary receives the gas escaping from the turbine in the space 16. The shaft 4 of the turbine extends through the heads 13 and 14 and is supported in ball bearings 4^a. Upon this shaft is mounted the rotor 17 carrying the blades or buckets 17'.

The turbine is divided as a whole, into three identical parts occupying each an angle of 120° and comprising each a feed valve 18 (Fig. 5) connected by means of the flange 19 with the head 14; a combustion pocket 20 is arranged around the periphery of the turbine and serves to allow the lighting and the combustion of the explosive mixture to take place, there being an admission valve 21 which establishes at a given moment communication between the combustion pocket and the blades 17 of the turbine. The burnt explosive mixture admitted by this valve 21 to the blades 17 passes through the spaces between the latter a first time (Fig. 2) and is afterward guided by one of the passages 12 so as to pass a second time through the spaces between the blades. It is then again taken up by one of the ducts 8 which causes it to cross the blades a third time and finally by a second duct 12 which causes it to pass between the blades a fourth time. The burnt gases which have thus been expanded pass then through the duct 22 and flow into the receiver 16 intended to receive the exhaust gases. This cycle starts simultaneously in each of the three parts of the turbine. The various parts of the latter are constructed and mounted in the following manner: Each feed valve 18 (Fig. 5) comprises a

valve body of the usual type. On the stem 23^a of the valve is carried cylindrical slide valve 24. The valve body works with relation to a seat made integral with a jacket 25 secured into the box of the valve and provided with ports 26 adapted to afford passage to the fresh compressed gas arriving from the receiver 15 through the flanged connection 19 bolted to this receiver. A cock 27 interposed between the receiver and the valve box allows of the latter being cut off for examination. A spring 28 assures the rapid closure of the valve and its adherence to its seat and the stem of each valve is actuated by a suitable cam. The combination of the valve 23 with the slide valve 24 has for its object to prevent any return of the products of explosion into the receiver 15 in case the valve 23 also carried on the stem 23^a were not tightly applied to its seat. As a matter of fact the openings of the slide valve are arranged so that the latter closes the openings 26 before the valve body 23^b is applied to its seat. Furthermore the valve is thus nearly entirely balanced, whereby the necessity of too strong return springs 28 is avoided.

Each of three feed valves 18 of the turbine brings the compressed explosive mixture to one of the three combustion pockets 20. Each of these pockets is formed by a tube 20^a provided with radiator fins (Figs. 7, 8, 9) 20^b and having a circular or flattened section provided with a flange 29 at one of its ends and at its opposite end with an extension 30 provided with radiator fins 30^a and serving as a cap for the corresponding feed valve 18. Tapped holes 31 are provided in the pocket and in the cap 30 to receive igniting plugs.

As shown by the drawings, the combustion pockets 20 are each provided with a device which allows, where vapors of ordinary petrol are used as explosive mixture, the utilization of the heat of these pockets for vaporizing this petrol. In this case, the mixture delivered by the carbureter 32 (Fig. 1) arrives at 33 (Figs. 7 and 8) and passes through a duct 34 cast integral with each pocket. Each duct 34 is connected at 35 with a pipe leading to the suction port of the compressor which sucks in the petrol vapors produced and compresses them with a view of their utilization in the pocket 20 as stated above for an explosive mixture.

The products of explosion are admitted to the blades 17' of the turbine through the medium of inlet valves 21 (Figs. 6 and 10) which are connected with each other by pipes 36 (Fig. 2). Each of these valves is connected with the adjacent combustion pocket by means of the flange 37 bolted to the flange 29 of the pocket and with the casing of the turbine by means of a flange 38

bolted to a nozzle plate 39. The body of each of these valves is cylindrical and contains a piston 40 on which a valve head 41 is screwed and secured in place by a cotter pin. The seat of this valve lies adjacent a passage 42 for cooling water, this passage communicating with the pipes *r*, shown. The valve stem 40' passes through a stuffing box and carries a T head 43 adapted to be acted upon by the forked end of a bell crank lever 44 (Fig. 3) actuated through the medium of a rod 45 operated by a suitable cam on the shaft of the turbine. A coiled pipe 46 establishes communication between the inlet pipe of the valve connected with the corresponding combustion pocket, and the opposite surfaces of the piston valve 40 and valve head 41 so as to balance the latter in such a manner that a relatively weak spring 47 will be sufficient for normally returning the valve 41 to its seat. When the valve stem is pulled outward by the rod 45 the valve 41 is opened and engages the cylinder so as to permit the passage of the exploded gases. The latter pass then through the nozzle of plate 39 and reach the rotor, passing through the casing of the turbine. The latter is provided to this end with three rectangular openings 48 positioned at 120° with reference to each other and receiving the plates 39 which are removable. As the valve casings 49 of the valves 21 are connected together by the pipes 36, the admission of the burnt gases on the blades of the turbine takes place simultaneously at three points of the system of blades, these points being situated at 120°. Figs. 21 to 27 show in detail certain structural features of the turbine which do not admit of adequate illustration in Figs. 1 to 10.

The rotor (Figs. 22 and 23) is formed by a wrought iron disk 50 provided with a central hub and with a rim in which mortises 51 are provided, the latter being adapted to receive the middle part of the blades 17 which extend laterally on both sides of the disk. A shrunk ring 52 prevents the blades from escaping from their housings under the action of the centrifugal force. Lugs 53 provided on the blades 17 prevent any longitudinal shifting of the blades. The hub is provided with a conical bore and is secured to the shaft by means of keys and a nut 50^a and lock nut 50^b. The turbine shaft 4 is hollow and provided with ball bearings housed in sleeves 4' provided to this end in the heads 13 and 14 of the casing. The lubrication of these ball bearings is performed by injecting oil into the shaft. This oil is projected by the centrifugal force on the balls themselves through holes 54 provided in the shaft at the required places.

As it has been stated above, the burnt gases after having crossed a first time

through the system of blades of the turbine 65 from the outside to the inside, transmitting an impulsion to the wheel (Fig. 2) pass through the channels 12 which bring them back to the blades from the inside to the outside, then through the channels 8 which bring them back to the blades from the outside to the inside. This operation is repeated. Then after having done their work and passed between the blades four times the expanded burnt gases pass as already stated through the ducts 22 to the receiver 16 of the head 13.

The turbine which has an electrical timer 55 (Fig. 1) which at the exact desired moment sends the current into the igniting plugs of the three combustion pockets. This switch is actuated by a suitable train of gear wheels actuated from the shaft 4. The function of this turbine is based on the two stroke cycle of the piston explosion motors. The control of the valves is so arranged, that for each combustion pocket the cycle of working (if one admits one explosion on each pocket for each revolution of the shaft) may be described in the following manner: Applying the duration of each phase of the movement to an amplitude of 360° the feeding will take place during a rotation of 125°; the fresh gases which are introduced during this phase into the combustion pocket will be heated while cooling the walls of the combustion pocket during a period of rotation of 75°; the combustion will take place in this pocket under a constant volume during a rotation of 45° and the escape of the burnt gases during a rotation of 120° *i. e.* a total rotation of 365° which shows that the feed valve will open the combustion pocket, in order to admit fresh gas thereto, 5° before the closure of the valve admitting the burnt gases to the blades of the wheel for the purpose of expelling entirely the burnt gases from the combustion pocket. As there are three combustion pockets in which the explosion takes place at equal intervals (120°) and as the inlet valves 21 communicate together so that the burnt gases under pressure are admitted at each explosion at three equidistant points of the blades, it follows that for one complete revolution each of the blades of the wheel receives a very powerful continuous jet of burnt gases, the pressure of which pass through three points of maximum pressure and as many points of minimum pressure, the diagram being indicated rather exactly by Fig. 30 where revolutions of the wheel have been indicated as abscissæ having a value of 120° and the pressure in kilograms as ordinates. The curve A shows the pressure in the first expanding duct, the curve B the pressure in the second expanding duct and the curve C the pressure in the third duct. The curve D

designates the pressure at the escape port and the curve E the variations of the pressure on each nozzle plate 39. Owing to the high speeds of rotation produced, the said alternations or variations of the pressure have no effect on the working of the machine as after the first passage on the blades they are nearly imperceptible.

The speed of the turbine is controlled by a centrifugal governor 57 (the details of which are not deemed necessary to be shown) housed in the carrier of the gear wheel of the compressor and actuated from the shaft of the motor. This governor actuates a cylindrical piston valve 58 (Fig. 4) which is connected on the one side with the inlet port of the compressor and on the other side with the delivery pipe. When the speed of the turbine increases, the governor opens the communication between the delivery duct and the inlet duct and consequently reduces the pressure of the explosive gases. The caloric charge of the combustion chambers is reduced as their volume remaining constant, the pressure of the gases which must fill them is reduced. The work and consequently the speed of the turbine are reduced in a corresponding proportion.

In the types of turbines running at very high speeds, exceeding 3500 revolutions per minute, the valve gear is adjusted in such a manner that only one explosion takes place in each pocket every two, three or four revolutions of the turbine shaft. The gear members are then controlled so as to perform a working cycle which will be proportionately similar to that described above. It is preferable in this case to replace the feed and inlet valves just described by rotary cylindrical valves doing away with any reciprocating movement. This arrangement has been shown by Figs. 11 to 20. In this case, each feed valve is replaced by a rotary cylindrical valve positioned between the reservoir for the explosive gases 15 provided in the head 14 of the machine and each combustion pocket 20. This cylindrical valve comprises a cylindrical casing 59 (Figs. 11, 12, 17-20) provided with a flared tubular extension 60 connected with combustion pocket 20. The said tubular extension 60 registers with a longitudinal opening 60^a provided in the cylinder 59, one of the ends of which is closed by a cover 61 while the other end is bolted to a connecting member 62 in communication with the reservoir 15 for the explosive gases. Inside this cylinder 59 is a cage 63 provided with two ports 64 which are diametrically opposed (Fig. 20) and the dimensions of which are equal to those of the slot of the cylinder. The lubrication oil arrives at 65 (Fig. 17) and grooves 66 have been provided along the

generating lines in the inner wall of the cylinder so as to increase the tightness of the cage which rotates under the action of a shaft 67 which is actuated through the medium of two bevel gear wheels 68, 69 (Fig. 12) a helicoidal wheel 70 and a worm 71 keyed on shaft 4 of the turbine. The valve 63 is thus suitably actuated in such a manner that the combustion pockets 20 receive fresh compressed gas from the receiver 15.

Each of the rotary inlet valves replacing the ordinary valves comprises, as shown by Figs. 12-16, a cylinder 72 provided with a jacket 73 for the cooling water circulating through the pipes 74 and two tubular extensions; one 75 connected with the combustion pocket and the other 76 connected with the nozzle plate (Fig. 12). The cylinder 72 contains a rotary valve 77 provided with a longitudinal slot 78 (Fig. 12) which is adapted to establish the communication between the extensions 75 and 76. This rotary valve 77 is actuated by the shaft 79 and the beveled gear wheels 80, 81 inclosed in the housing 82 containing oil. The wheel 81 is keyed on a shaft 83 driven by a beveled gear wheel 84 (Fig. 12) in mesh with the helicoidal wheel 70 which is driven as already stated by the turbine shaft. The lubricating agent is admitted at 85 (Fig. 15). Each inlet member 77 thus receives a rotary motion which is suitable for admitting burnt gases under pressure to the blades 17 of the turbine.

Having now fully described our said invention, what we claim and desire to secure by Letters Patent is:

1. In an internal combustion turbine, the combination of a rotor, a casing, combustion chambers arranged on the periphery of said casing, igniting devices in said chambers, a feed valve connected with each of said chambers, a receiver for compressed explosive gas connected with said feed valve, an inlet valve connected with each of said chambers, means for connecting said inlet valves for communication with each other, removable nozzle plates connected with said inlet valves and positioned in spaced relation around the periphery of the rotor, means adapted to actuate the feed valves, the inlet valves and the igniting devices in such a manner that the compressed gases enter the combustion chambers through the feed valves, then are ignited in the various combustion chambers and burn therein and thereafter are admitted after each explosion by the inlet valve communicating with the chamber where the explosion takes place and communicating simultaneously with the other inlet valve at several points of the blades of the turbine, one explosion taking place in each chamber of combustion at a

predetermined number of revolutions of the rotor.

2. In an internal combustion turbine, a plurality of combustion chambers, each having an internal channel connected with a source of liquid fuel supply and a compressor connected also to the channels, and operable to draw liquid fuel therethrough and to deliver it to the combustion chambers, the heat developed in the latter serving to

vaporize the liquid fuel passing through the channels.

In testimony whereof we have hereunto set our hand in presence of two witnesses.

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CAMILLE ENDERLIN.

Witnesses:

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