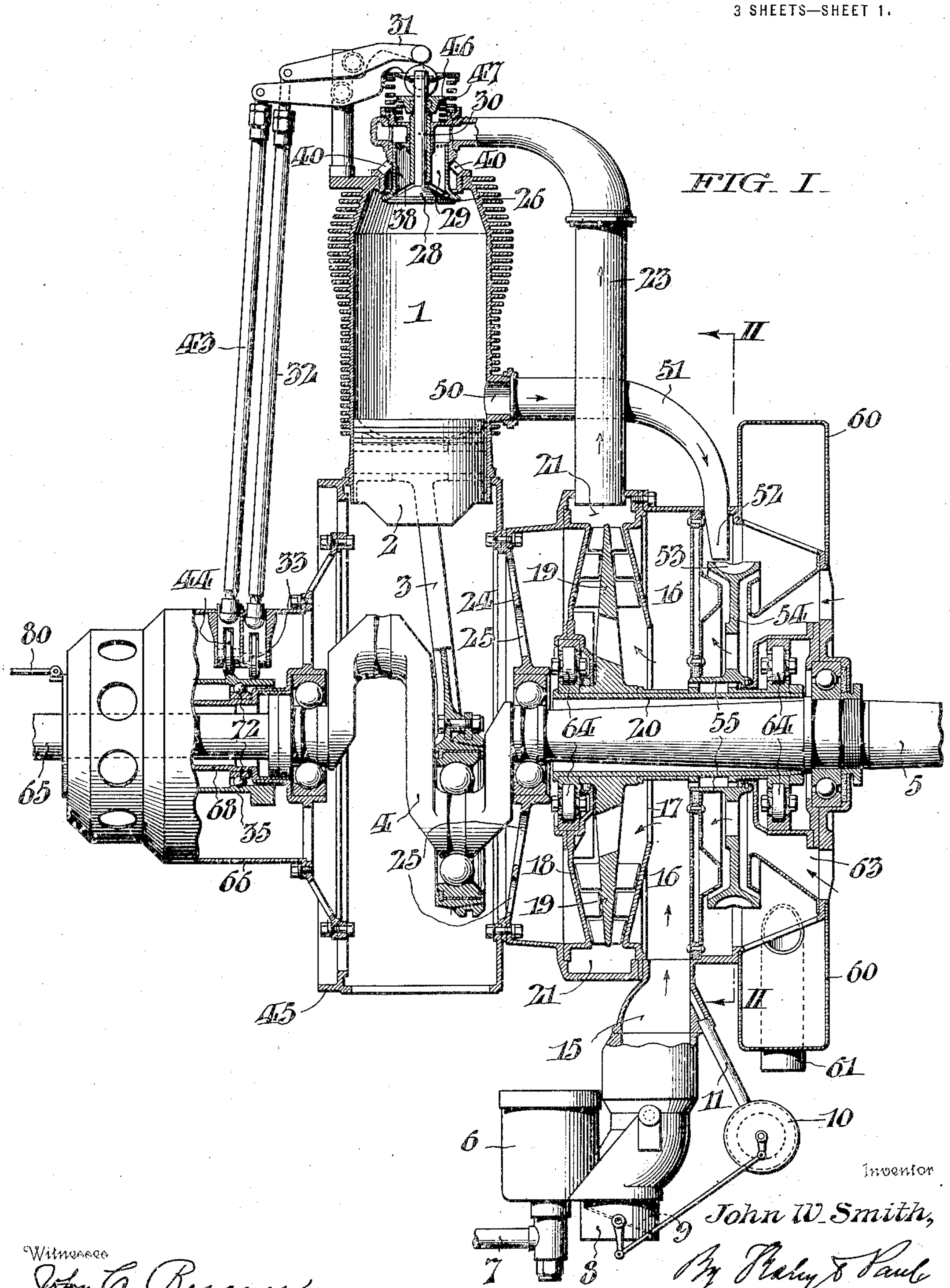
J. W. SMITH.
INTERNAL COMBUSTION ENGINE.
APPLICATION FILED JULY 17, 1918.

1,329,811. Patented Feb. 3, 1920.

3 SHEETS—SHEET 1.

FIG. I.



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3 SHEETS—SHEET 2.

FIG. II.

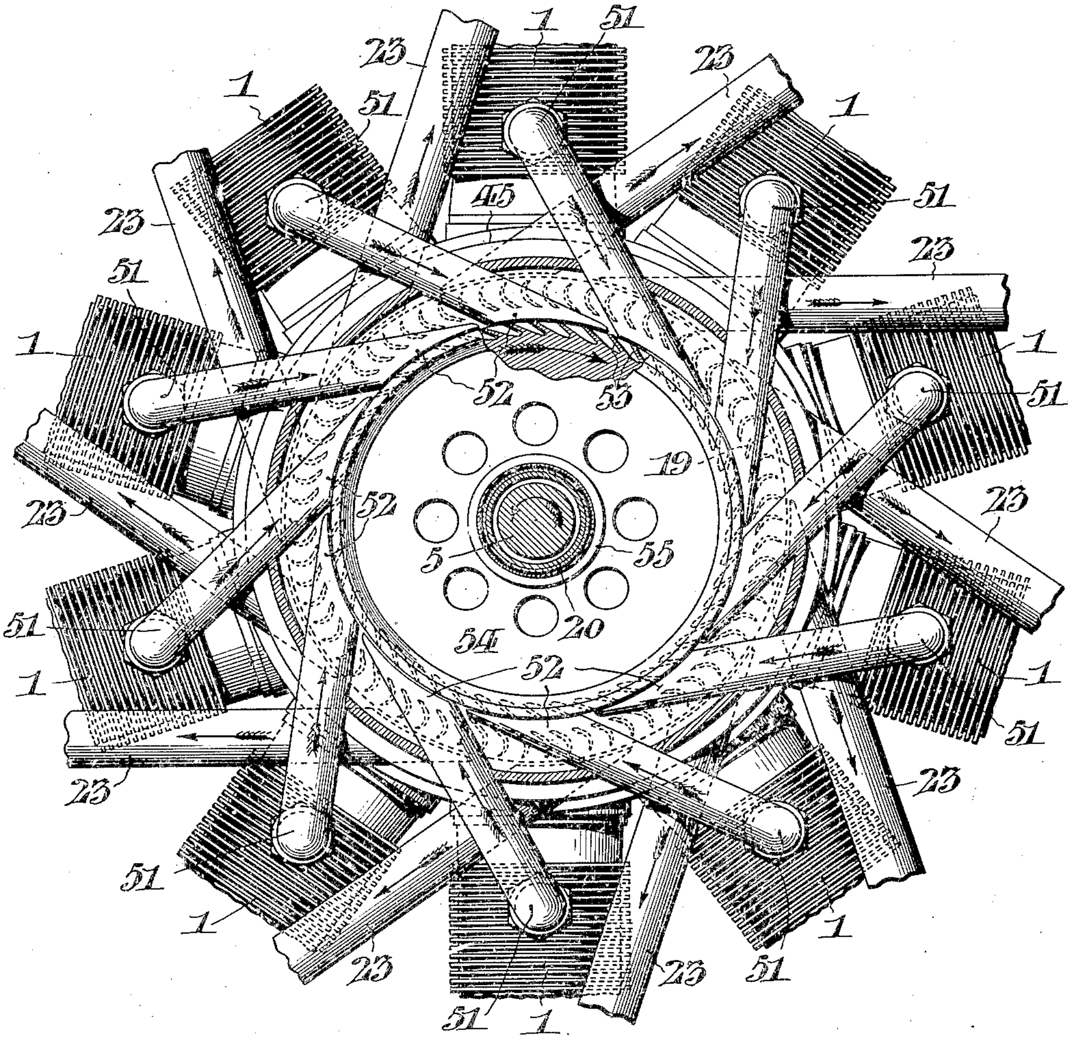
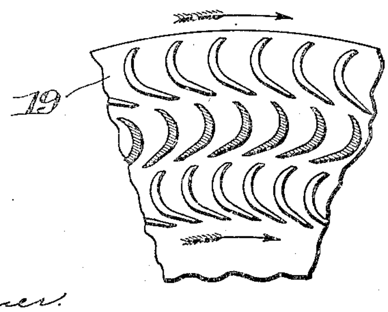


FIG. III.



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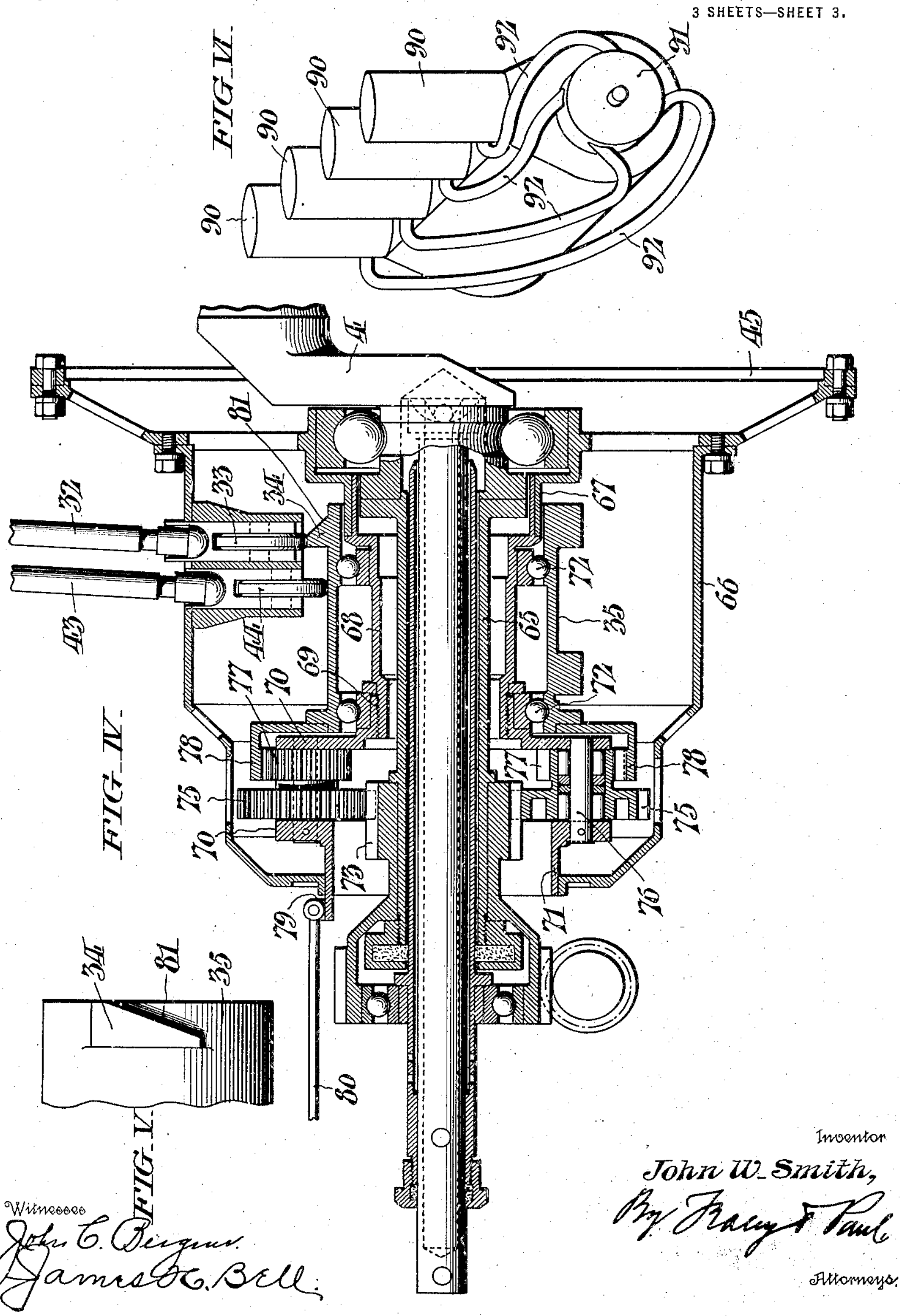
3 SHEETS—SHEET 3.

FIG. VI.

FIG. IV.

FIG. V.



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

1,329,811. Specification of Letters Patent. Patented Feb. 3, 1920.

Application filed July 17, 1918. Serial No. 245,284.

To all whom it may concern:

Be it known that I, JOHN W. SMITH, a citizen of the United States, and a resident of Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Internal-Combustion Engines, whereof the following is a specification, reference being had to the accompanying drawings.

My invention relates particularly to the system whereby the thermo-dynamic medium is supplied to the cylinder, and since the embodiment which is now most prominently contemplated by me is in connection with engines for air craft, I have in the accompanying drawings, mainly showed it in connection with a multiple-cylinder engine, adapted to that particular use. It will be understood, however, that the invention is not restricted thereto, and that while its utility is perhaps most notable in connection with the varying atmospheric pressure conditions, incident to air craft service, its general principles can be made available under other circumstances.

One prominent reason for its importance in air craft service lies in the fact that by reason of the great reduction in atmospheric pressure corresponding with high altitudes, some means for supplying the thermo-dynamic medium to the cylinder at a definite pressure, or at any rate at a pressure higher than that afforded by the external atmosphere, are essential to high efficiency.

For this purpose, I employ an air compressor as a part of the fuel-induction system, in order to raise the pressure of the inflowing charge substantially above that of the external atmosphere, and my invention relates broadly to the organization for actuating the compressor and controlling its action, and also to certain adjuncts, whose mode of operation is correlated to the special conditions arising under the employment of the general system. It is generally advantageous and simpler for the air-compressor to act on the air after the admixture of combustible therewith, and I have accordingly shown that arrangement hereinafter. These conditions, and the features of invention which relate to the broad invention, and to the associated objects, will be hereinafter pointed out in detail.

Referring to the drawings, Figure I, is a view, partly in axial section, through the main shaft, and partly in conventional or distorted perspective, indicating the features of the invention as comprised, for instance, in a multiple-cylinder engine, having ten cylinders radially arranged with relation to the crank casing.

Fig. II, is a partial sectional view on the plane indicated by the arrows II—II in Fig. I.

Fig. III, is a fragmentary diagrammatic view showing the relation of the moving and stationary blades of the turbo-compressor, which I prefer to employ.

Fig. IV, is an enlarged sectional view of a portion of the mechanism which is advantageous when throttling of the charge is desired.

Fig. V, is a detail view of the cam sleeve showing one of the profile cams by which the fuel intake valve is actuated.

Fig. VI, is a diagrammatic view, showing how the underlying principle of the invention may be embodied in another type of multiple-cylinder engines, structurally different from the type shown in Figs. I, II, and III.

Referring now to Figs. I, II, and III, the cylinders are indicated at 1, and one of the pistons at 2, the piston-rod 3, being connected to the driving crank 4, of the main shaft 5. The carbureter is conventionally indicated at 6, the fuel supply pipe at 7, and the air inlet at 8. Said air inlet is here represented as controlled by a butterfly valve 9, operatively connected to an aneroid device, conventionally indicated at 10.

The exit pipe 15, from the carbureting system leads into an induction chamber 16, preferably of annular form, and concentric with the driving shaft. The aneroid device 10, communicates through a tube 11, with the chamber 16.

The induction chamber 16, is provided with an annular opening 17, which leads into the casing 18, of a turbo-compressor 19, which, in this instance, is of the radial flow type, and operates in two stages, the relation of the stationary and movable blades being diagrammatically shown in Fig. III. The turbo-compressor is mounted upon a sleeve 20, so that it can be independently rotated by the motor which will be described later on, it being deemed preferable to continue at present with the description of the fuel-supply system.

The turbo-compressor 19, discharges into the annular channel 21, from which, at successive intervals, the induction tubes 23, lead to suitable valve devices at the intake end of the cylinders 1. It will, of course, be obvious by comparing Fig. I, with Fig. II, that the induction tube 23, and adjacent parts are not shown in true perspective, but that the representation is diagrammatic in its character.

On that side of the turbo-compressor casing which is opposite to the induction chamber, I prefer to provide a partition 24, of the casing, having openings 25, for permitting air circulation, said opening also permitting the inflow of lubricating fluid, if desired. At the intake end of the cylinder 1, I have shown a preferred form of the valve system, which comprises the inlet valve 28, controlling the passage 29, into which the induction tube 23, leads, the stem 30, of said valve being controlled by means of a lever 31, and connecting rod 32, which is provided with a cam roller 33, arranged in operative relation to a cam 34, upon a movable cam sleeve 35.

The enlarged inner extermity 26, of the wall of the inlet passage 29, forms the seat of the inlet valve 28, and said wall also constitutes the exhaust valve, the external periphery of the enlarged end 26, seating upon the inner extremity of the wall 38, of the exhaust passage, which is provided with a plurality of final outlets 40. Said exhaust valve is axially movable with relation to its seat, and is controlled by means of the lever 42, and connecting rod 43, having a cam roller 44, actuated by a suitable cam upon the sleeve 35.

It is obvious that by proper adjustment of the cam surfaces on the sleeve 35, the inlet and exhaust valves 28, and 26, may be opened and closed at any predetermined intervals, or in any desired relative positions, such action being permitted, in this instance, by interposed spring connections, shown at 46, and 47. This positive control of the valves is a feature which should be noted, because, as will be seen hereafter, it has relation to the efficiency of the throttling action of the engine, when such throttling is desirable, and also facilitates timing of certain movements appropriate for the action of the parts now about to be described.

At a point in the cylinder 1, which is preferably immediately adjacent to the inner face of the piston when the latter is at the end of its out-stroke, I provide an outlet duct 50, connected with the pipe 51, which, for purposes of convenient nomenclature I will term the discharge blast pipe.

In one aspect, said pipe 51, constitutes a portion of the exhaust system, but, since its primary function is to supply driving medium to a motor device, its participation as an auxiliary exhaust may be ignored for the purposes of the present description.

The pipe 51, terminates in a nozzle 52, arranged in operative relation to the buckets 53, of a turbine rotor 54, whose hub 55, is secured to the rotatable sleeve 20, which carries the turbo-compressor 19, so that the driving turbine 54, and driven turbine 19, rotate together. The discharge from the turbine 54, is preferably received in the annular chamber 60, which is provided with one or more final discharge pipes 61. I prefer to construct the housing of the chamber 60, with an annular passage 63, admitting air for cooling purposes, to the interior of that portion of the casing. The various moving elements in this part of the organization are provided with roller bearings, as shown at 64, but since these devices constitute no part of my invention, they need not be further described.

It will be understood, of course, that each cylinder is provided with a similar organization of devices to that just described in connection with the cylinder shown in Fig. I.

Referring now to the broad or general features of the invention, and passing, for the present, certain desirable adjunctive details, the action is as follows:

In Fig. I, the piston is represented as having just completed its power out-stroke, the cylinder being, therefore, filled with the products of combustion, under the high pressure characteristic of that moment of the cycle when the exhaust valve is just beginning to open. The discharge outlet 50, having been uncovered by the forward stroke of the piston, and the contents of the cylinder being at the high pressure above referred to, a forcible blast of the products of combustion will rush out through the discharge blast pipe 51, and impinge upon the buckets 53, of the turbine 54, thus driving the latter.

The piston, however, will immediately return and by its passage cover the outlet at 50, so that the discharge of the remaining products of combustion will occur in the normal manner through the exhaust valve. During this period the inlet valve 28, will, of course, remain closed, and when it begins to open in proper relation to the intake stroke of the piston, the thermo-dynamic medium will be supplied under pressure through the induction tube 23, under such pressure as is effected by the action of the turbo-compressor.

Near the close of the intake stroke, the port 50, will have been momentarily uncovered, but owing to the internal pressure conditions, and possibly to what may be called the inertia, of the gaseous contents of the cylinder, and of the residuum in the discharge blast pipe, at that instant, there will be no appreciable sucking in of the contents of the discharge blast pipe, nor, on the other hand, any substantial flow of the new charge out through the opening 50. Furthermore, on the return, or compressing stroke of the piston, the brief instant which corresponds with the period before the piston has covered the opening at 50, will not suffice for the expulsion of any substantial portion of the new charge. In other words, the conditions which might theoretically tend toward re-introduction of spent gas into the cylinder, or of waste of the new charge, are so ephemeral that in view of the pressure conditions existing in the communicating parts, no injurious effect occurs.

Furthermore, no substantial loss of power will be occasioned, by reason of the fact that the exhaust may be said momentarily to take place under the back-pressure characteristic of the turbine motor system, since, in the main, this discharge occurs while the piston 2, is stationary, or nearly so, and the main exhaust becomes freely open to the atmosphere immediately after the first outgush into and through the discharge blast pipe.

On the other hand, a very substantial increase of efficiency is attained by reason of the fact that even when the external atmospheric pressure is exceedingly low, normal pressure in the fuel-induction system can be maintained by the action of the turbo-compressor.

Furthermore, the internal pressure conditions in the induction system may be maintained practically constant, at any predetermined point, by means of the aneroid device 10, which controls the inlet of air, into the carbureter system, so that, for instance, if the air in the induction chamber is under an outside pressure of ten pounds, it can be raised to normal, or fifteen pounds, in the induction tube, through the action of the compressor.

A further feature of improvement will now be noted. Ordinarily the throttling of an internal combustion engine, is effected at what may be generally described as the carbureter region. The conditions existing in a system embodying the present invention, provided with a discharge blast pipe and a fuel-induction tube under positive pressure from the turbo-compressor, are antagonistic to a throttling control at the region of the carbureter. Hence I provide means for effecting such throttling control at, or adjacent to, the cylinder itself. Thus, by proper arrangement of cam surface 34, upon the sleeve 35, the inlet valve 28, may be kept open until any predetermined position of the piston, after it has passed the port 50, on its compressing stroke, and any desired amount of the initial charge supplied through the induction tube can be returned into the induction system.

In order to effect this throttling action through the actuation of the valves, the cam sleeve 35, has been mounted so as to be axially shiftable, the cam being of such configuration as to afford the necessary movements of the connecting rods 32.

Referring now to Fig. IV, it will be noted that the crank shaft is extended in tubular form, as indicated at 65, so as to accommodate certain elements of a lubricating system which is subordinate to the present invention, and need not, therefore, be further described in this connection. The crank casing 45, is supplemented by an extension 66, which serves as a housing for the cam sleeve, and the parts directly associated therewith. The housing 66, is integrally formed with a central tubular hub 67, within which is received one end of a slidable sleeve 68. The opposite end of the sleeve 68, is threaded, as indicated at 69, to afford a means of attachment for a gear casing 70, having a reduced portion 71, slidably engaged within an opening in the outer end of the housing. The cam sleeve 35, is capable of independent rotation about the sleeve 68, being supported upon suitable interposed ball bearings 72. Rotative motion is transmitted to the cam sleeve through the following instrumentalities:

Fixed to the tubular extension 65, of the crank shaft, near its outer end, (Fig. III), is a gear pinion 73, which meshes with a series of planetary pinions 75, mounted for rotation about studs 76, fixed in the gear casing 70. As shown at the lower side of Fig. III, these pinions are integrally formed with smaller pinions 77, which, in turn mesh with an internal gear 78, secured to the end of the cam sleeve. By the construction thus set forth it will be apparent that the cam sleeve 35, will be bodily moved longitudinally with respect to the crank shaft, in accordance with the movement of the shiftable sleeve 68. This is preferably accomplished manually, and to this end, the reduced portion 71, of the gear casing is formed with an ear 79, to which is pivotally attached an actuating rod 80, extending to a point conveniently accessible to the operator.

The construction of the cam 34, by which the inlet valve 28, is actuated, will be best understood from Fig. V. Here it will be noted that the cam is substantially triangular in outline and that the edges are beveled as indicated at 81, in order to facilitate proper coöperation with the roller during the sliding of the sleeve. From the configuration of the cam, it will be readily understood that as the sleeve 35, is moved transversely across the path of the roller 33, more or less of the peripheral extent of the cam will become effective thereon, with the result that the period of the inlet valve opening will be correspondingly increased or decreased, at the will of the operator, according to the extent of throttling desired. As an illustration, let it be supposed that the cylinder 1, (Fig. I), has been completely filled with a charge; that the piston 2, is upon the return compression stroke; and that the exhaust valve is closed; throttling will be accomplished to substantially any desired extent by the proper shifting of the cam sleeve, whereby the inlet valve 28, will be maintained open during a portion of the return stroke of the piston. As a consequence, of this condition, a corresponding proportion of the charge will be forced back into the induction system, and the succeeding power stroke of the piston will be effected under a reduced charge.

In Fig. VI, the general principle of the application of blast discharge conduits for turbine operation has been diagrammatically illustrated in an engine of ordinary type with cylinders alined in adjacent relation. In this figure, the cylinders are represented at 90, and the motor turbine at 91. As in the previous embodiment, the discharged blast conduits 92, lead from the described regions of the cylinders and terminate in suitable nozzles by which the turbine is operated. In this alternative organization, it is, of course, to be understood that the described instrumentalities for fuel induction and valve operation can be identically incorporated for the performance of analogous functions as in the first described instance.

Returning now to the type shown in Figs. I, II, and III, it will be observed that the structural organization is peculiarly adapted for use in connection with air craft engines, where not only symmetrical distribution of weight, but balanced operation of moving parts is of great importance. Hence not only is the use of a turbine motor, and of a turbine compressor directly related to the desired conditions, but I also prefer to provide the additional feature that the direction of movement of the turbomotor and its compressor shall be opposite to the direction of movement of the main shaft, as indicated by the respective arrows in Fig. II. While this mode of operation is facilitated by the structural details above described and shown, it is to be understood that I do not limit myself in that respect to the specific structural organization shown.

In order to avoid misunderstanding as to the nature of my invention, it is proper to point out that the characteristic principle thereof does not involve broadly the idea of utilizing a portion of the energy of the thermo-dynamic charge as a means of driving an auxiliary motor device, but depends upon peculiar conditions which arise in a specific mode of operation of a certain class of internal combustion engines.

Thus, an important factor is the great rapidity with which certain critical periods of traverse of the pistons re-cur, particularly in multiple-cylinder engines of usual types, whereby advantage may be taken of contemporaneous internal conditions of the gaseous contents of the cylinder and adjacent parts of the system.

This time element, in conjunction with what may be called the inertia of the body of products of combustion on the one hand, and probably the direction of momentum of the induction current of thermo-dynamic medium, on the other hand, permits a momentary utilization of the energy developed during each power stroke and the application of that energy for the purposes of enhancing the induction pressure, in the manner above stated, without substantial interference with the normal behavior of the exhaust or induction systems.

While I do not limit my claims to the employment of any specific number of cylinders, or to the employment of the characteristic devices in connection with each and every cylinder of a relatively large number, I believe it to be essential that there should be a plurality of such devices, in order to obtain a sufficiently rapid succession of impulses for practically continuous actuation of the auxiliary motor element, and hence I employ the expression "multiple-cylinder" as indicating such plurality, but without other restriction.

In my claims I use the expression "thermo-dynamic medium," as comprehending broadly any mixture of gas or vapor and atmospheric air.

I do not claim that it is broadly new to effect throttling of the charge at the cylinder inlet, nor do I claim, *per se*, the specific mechanism which I have described and shown for that purpose. On the other hand, I wish it to be understood that my claims for the combinations which include that element, are not limited to the employment of the particular means described and shown, since these are merely typical of means adapted for use in the new combination.

I claim:

1. In a multiple-cylinder internal combustion engine having an induction system common to the cylinders for supply of thermo-dynamic medium thereto, said cylinders being provided with inlet and exhaust valves; the combination, with the cylinder and its piston, of a blast discharge conduit leading from the cylinder at a limited region traversed by the piston near the extremity of its out-stroke; an auxiliary motor device, operatively related to the blast discharge conduit; and an air-com-

pressor, actuated by said motor device, and having a discharge conduit which communicates with the induction system, substantially as set forth; said blast discharge conduit serving to supply the motor with expanded products of combustion at about the end of the out-stroke, and said exhaust valve thereafter serving for discharge of the remaining products of combustion in the normal manner, so as to relieve back pressure on the piston and prevent contamination of the succeeding charge of thermo-dynamic medium.

2. In a multiple-cylinder internal combustion engine having an induction system common to the cylinders for supply of thermo-dynamic medium thereto, said cylinders being provided with inlet and exhaust valves; the combination, with the cylinder and its piston, of a blast discharge conduit leading from the cylinder at a limited region traversed by the piston near the extremity of its out-stroke; a turbine motor operatively related to the blast discharge conduit; and an air compressor driven by said motor, and having a discharge conduit communicating with said induction system; said blast discharge conduit serving to supply the motor with expanded products of combustion at about the end of the out-stroke, and said exhaust valve thereafter serving for discharge of the remaining products of combustion in the normal manner, so as to relieve back pressure on the piston and prevent contamination of the succeeding charge of thermo-dynamic medium.

3. In a multiple-cylinder internal combustion engine having an induction system common to the cylinders for supply of thermo-dynamic medium thereto, said cylinders being provided with inlet and exhaust valves; the combination, with the cylinder and its piston, of a blast discharge conduit leading from the cylinder at a limited region traversed by the piston near the extremity of its out-stroke; a turbine motor operatively related to the blast discharge conduit; and a turbo-compressor driven by said motor, and having a discharge conduit communicating with said induction system; said blast discharge conduit serving to supply the motor with expanded products of combustion at about the end of the out-stroke, and said exhaust valve thereafter serving for discharge of the remaining products of combustion in the normal manner, so as to relieve back pressure on the piston and prevent contamination of the succeeding charge of thermo-dynamic medium.

4. In a multiple-cylinder internal combustion engine having an induction system common to the cylinders for supply of thermo-dynamic medium thereto, said cylinders being provided with inlet and exhaust valves; the combination, with the cylinder and its piston, of a blast discharge conduit leading from the cylinder at a limited region traversed by the piston near the extremity of its out-stroke; an auxiliary motor device, operatively related to the blast discharge conduit; an air-compressor, actuated by said motor device, and having a discharge conduit which communicates with the induction system; a valve controlling the air inlet to the induction system; and an aneroid device provided with means for actuating said inlet valve.

5. In a multiple-cylinder internal combustion engine, having an induction system common to the cylinders for supply of thermo-dynamic medium thereto, said cylinders being provided with inlet and exhaust valves; the combination, with the cylinder and its piston, of a blast discharge conduit leading from the cylinder at a limited region traversed by the piston near the extremity of its out-stroke; an auxiliary motor device, operatively related to the blast discharge conduit; an air-compressor, actuated by said motor device, and having a discharge conduit which communicates with the induction system; a throttling device operatively located at a point in the induction system which is between the compressed air conduit and the cylinder; and means whereby the timing of movement of the inlet valve of the cylinder may be varied, to control throttling after the introduction of the compressed air; said blast discharge conduit serving to supply the motor with expanded products of combustion at about the end of the out-stroke, and said exhaust valve thereafter serving for discharge of the remaining products of combustion in the normal manner, so as to relieve back pressure on the piston and prevent contamination of the succeeding charge of thermo-dynamic medium.

6. In an internal combustion engine having multiple-cylinders radially arranged with relation to a main shaft, said cylinders being provided with inlet and exhaust valves, and having also an annular induction chamber axially symmetrical to said shaft; the combination, with a plurality of symmetrically located cylinders and with their respective pistons, of blast discharge conduits leading from the cylinders at a limited region traversed by the piston near the extremity of its out-stroke; a turbine motor mounted co-axially with, but independent of, said shaft and operatively related to the blast discharge conduits; and a turbo-compressor mounted co-axially with said motor and operatively connected therewith; the discharge of said compressor communicating with the induction chamber.

7. In an internal combustion engine hav-

ing multiple-cylinders radially arranged with relation to a main shaft, said cylinders being provided with inlet and exhaust valves, and having also an annular induction chamber axially symmetrical to said shaft; the combination with a plurality of symmetrically located cylinders and with their respective pistons, of blast discharge conduits leading from the cylinders at a limited region traversed by the piston near the extremity of its out-stroke; a turbine motor mounted co-axially with, but independent of, said shaft; nozzles upon said conduits arranged to drive the turbine in a direction opposite to the direction of rotation of the main shaft; and a turbo-compressor mounted co-axially with said motor and operatively connected therewith; the discharge of said compressor communicating with the induction chamber.

In testimony whereof I have hereunto signed my name, at Philadelphia, Pennsylvania, this 12th day of July, 1918.

JOHN W. SMITH.

Witnesses:
JAMES H. BELL,
E. L. FULLERTON.