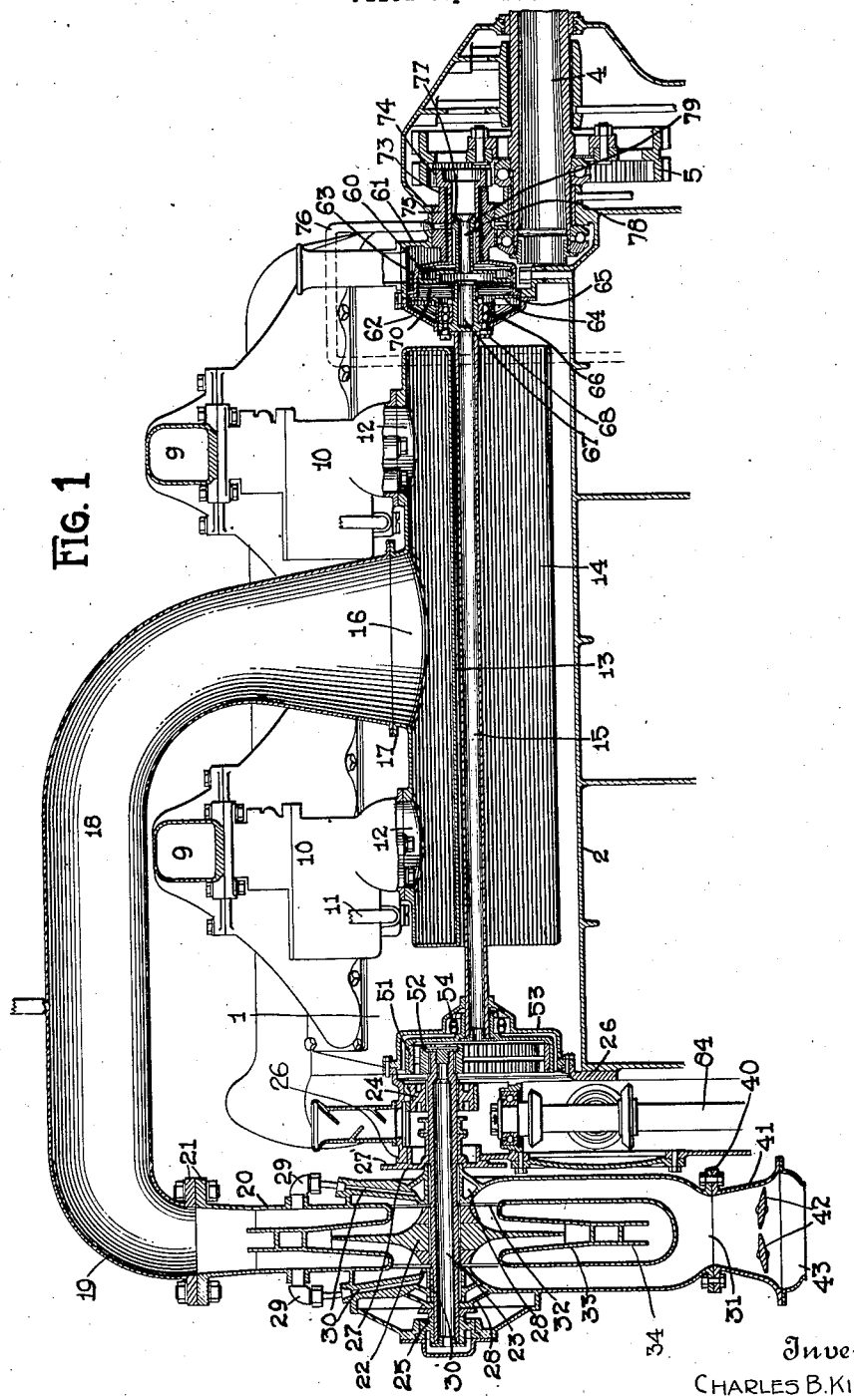
Jan. 8, 1924. 1,479,993

C. B. KIRKHAM

MOTIVE POWER SYSTEM FOR AIRCRAFT

Filed Sept. 16, 1918 3 Sheets-Sheet 1

FIG. 1



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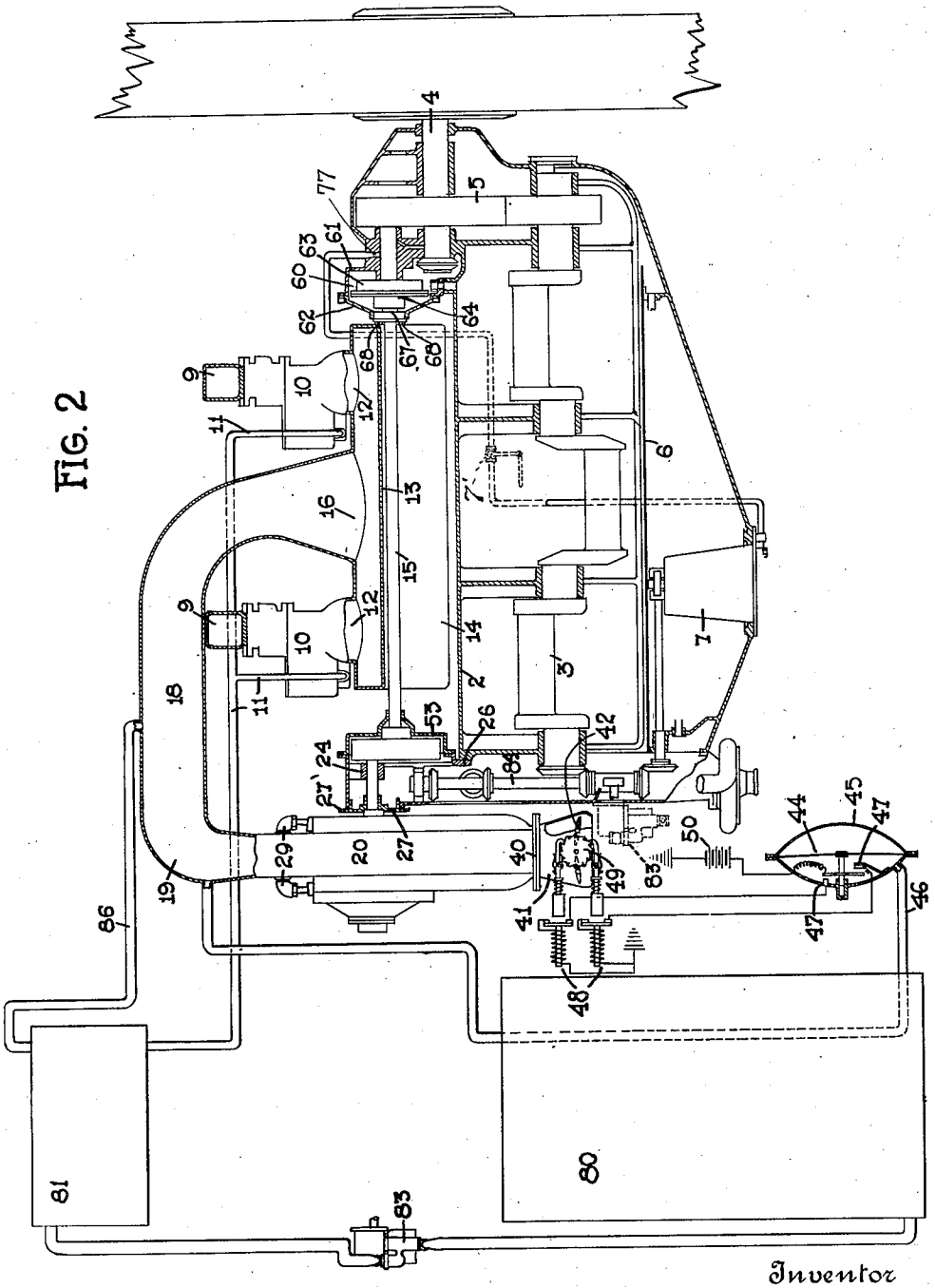
Jan. 8, 1924. 1,479,993

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MOTIVE POWER SYSTEM FOR AIRCRAFT

Filed Sept. 16, 1918 3 Sheets-Sheet 2

FIG. 2



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Jan. 8, 1924. 1,479,993

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MOTIVE POWER SYSTEM FOR AIRCRAFT

Filed Sept. 16, 1918 3 Sheets-Sheet 3

FIG. 3

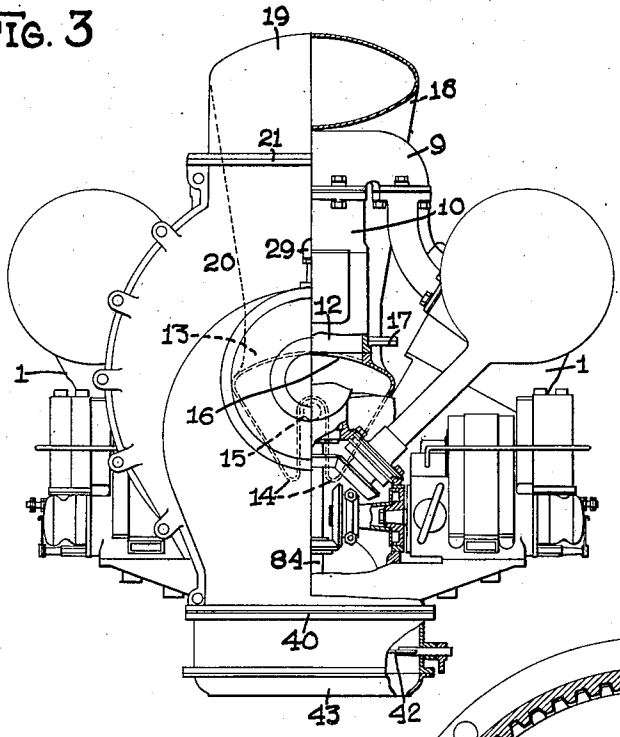


FIG. 5

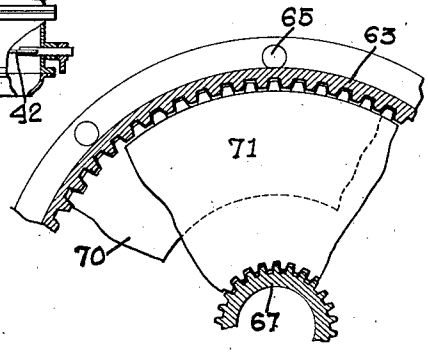
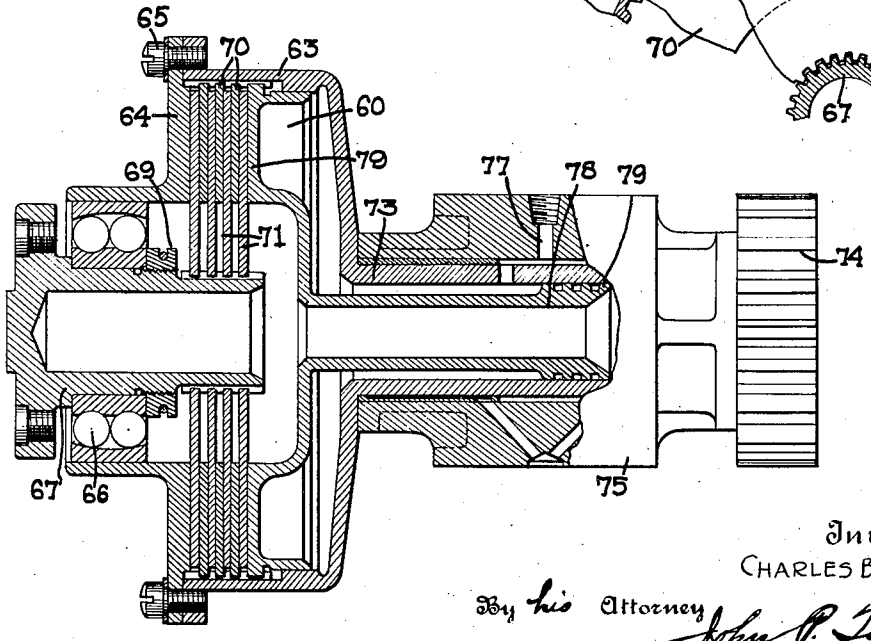


FIG. 4



Inventor
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By his Attorney John P. Barker.

Patented Jan. 8, 1924. 1,479,993

UNITED STATES PATENT OFFICE.

CHARLES B. KIRKHAM, OF GARDEN CITY, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO CURTISS AEROPLANE AND MOTOR COMPANY, INC., A CORPORATION OF NEW YORK.

MOTIVE-POWER SYSTEM FOR AIRCRAFT.

Application filed September 16, 1918. Serial No. 254,283.

To all whom it may concern:

Be it known that I, CHARLES B. KIRKHAM, a citizen of the United States, residing at Garden City, N. Y., in the county of Nassau and State of New York, have invented certain new and useful Improvements in Motive-Power Systems for Aircraft, of which the following is a specification.

My invention relates to aerial machines and particularly to a motive power system therefor including a driving engine of the internal combustion type.

The object of my invention generally stated is to obviate the detrimental effects upon the operation of the driving motor due to changes in altitude.

More specifically stated, the object of my invention is to improve the efficiency and power characteristics of the motor whereby the power thereof is maintained at a maximum regardless of and during changes in the atmospheric conditions, especially changes in atmospheric density and pressure due to different altitudes of the craft.

As is well known, the power of the driving engine of an airplane or other aircraft, particularly if the engine is of the internal combustion type, varies considerably under different atmospheric conditions, as for instance, with changes in temperature, pressure and density. The temperature, pressure and density vary from the lower to the higher altitudes and this variation is so great that at 23,000 ft. above sea level the density of the air is only substantially half the density at sea level and at 30,000 ft. the density is only approximately .38 of the sea level density. It has been found that the power of the engine decreases rapidly with increase of elevation and that the decrease in horse power of the engine is slightly greater than the decrease in density. Assuming a fixed adjustment of the carbureting apparatus, the torque and horsepower of the engine vary roughly as $\frac{a_1}{a_2}1.1$ where $\frac{a_1}{a_2}$ is the ratio of the density at the flying level to the density at sea level. A partial compensation may be made for this drop in density and loss in power by the adjustment of the carbureting and the air supplying devices, but prior to my invention, so far as I am informed, the devices heretofore tried for maintaining the power of the engine have proven inadequate to obtain any substantial compensation for the decrease in pressure and density of the air supplied to the intakes of the cylinders. A direct result of the loss of power in the driving engine is that the performance of the aerial machine driven thereby is substantially impaired as compared with the performance that could be obtained and would be expected were the power and the efficiency of the driving engine maintained approximately constant or increased in going from the lower to the higher altitudes. For instance, a given airplane would have an enhanced climbing efficiency and ability, its "ceiling" or maximum climbing height would be greatly increased and its load carrying capacity and operating speed would be substantially improved at the higher levels by effecting a substantial compensation for the loss in pressure and density and thereby maintaining the power of the engine substantially constant throughout the changes in elevation. In the rarefied atmospheres the resistance to flight is less than at lower altitudes and assuming the same power per unit weight of power plant for the higher altitudes a higher translational speed may be obtained than at the lower altitudes. In accordance with my improvements I have devised a power plant or engine whose power does not fall off appreciably within wide altitude limits and may even increase within a certain altitude range, thereby providing for a greater power per unit weight at the higher altitudes and as a consequence thereof enabling a better all round performance of the air craft.

More especially, my invention contemplates improvements in a motor of the internal combustion type whereby variations in atmospheric pressure and density are substanially compensated for and the power of the engine thereby increased above normal or maintained substanitally constant through certain altitude ranges, engines of this type being in general use on aircraft and being particularly susceptible, as set forth above, to the detrimental effects of changes in altitude.

According to my invention means is pro-

vided to collect, compress and feed the air for the fuel charge, and preferably air and hydrocarbon, to the carbureter at a pressure above that of the surrounding atmosphere, this means being utilized at sea level if desired as well as at high altitudes. And I further provide means for automatically controlling this feeding means which is responsive to changes in pressure so as to maintain a constant feed pressure, although it is understood that the control may be effected manually.

The compressing apparatus in the present embodiment of my invention comprises a centrifugal blower which is particularly adapted to use in this connection in view of its high efficiency as compared with other types of compressors, a maximum of power and efficiency being attained with a minimum of weight and space occupied, these features being particularly important on airplanes. Constant or super-pressure may thereby be maintained upon the carbureting devices and upon the intake of the cylinders within altitude limits determined by the capacity of the compressor and the regulating devices. The compressor may exhaust directly into the carbureter intakes, but preferably a pressure reservoir is interposed therebetween, and I make the reservoir of such dimensions and capacity with reference to the air capacity of the carbureting apparatus and engine that no undue fluctuations in pressure take place in the air supply. By means of these devices the carbureting apparatus and engine intakes may be supplied with air in the required volumes and at a pressure and density substantially above that of the surrounding atmosphere, thereby substantially compensating for the loss in power due to loss in pressure and density.

The centrifugal blower may be driven in any suitable manner but in the present case I have illustrated it as driven from the engine crank shaft. My invention also contemplates certain novel features in the driving mechanism between the crank shaft and the blower, whereby the blower (which is of a high speed relatively to the engine) may be gradually started from the highly accelerating engine and the inertia of the high speed parts thereby gradually overcome. Undue strains upon the driving means are accordingly avoided. Specifically this means comprises a friction clutch which is operated and controlled by a fluid pressure device operated by the engine.

My invention consists in the novel features, arrangements, combinations and the construction of parts hereinafter described in their preferred embodiment, and the invention is more specifically pointed out in the appended claims.

Further objects and advantages of the invention will more fully appear from the following description taken in connection with the accompanying drawings wherein:

Fig. 1 is a sectional view of a motor (partly broken away) embodying my improvements;

Fig. 2 is a view somewhat similar to Fig. 1 embodying the fuel supply system in addition and other control features;

Fig. 3 is an end view of the motor partly in section;

Fig. 4 is a sectional view through the friction clutch disposed between the compressor and the engine, and

Fig. 5 is a view illustrating the fastening of the clutch discs to the clutch supports.

Referring to the drawings where like numerals refer to like parts throughout, I have illustrated my improvements as embodied in an engine of the V type, but it is understood that the improvements are applicable to engines of various and sundry types. The two banks of cylinders are indicated at 1, Fig. 3, and the crank case is designated generally by the numeral 2. The motor comprises the usual crank shaft 3, Fig. 2, which is geared down to a stub propeller shaft 4, suitable reduction gears 5 being provided for this purpose, it being noted that the propeller shaft 4 is slightly above the vertex of the V of the banks of the cylinders and parallelly arranged with reference to the crank shaft. In the bottom of the crank case is disposed a drip pan 6 and beneath the drip pan is disposed the oil sump in which is immersed a lubricating pump 7. In accordance with the well known Curtiss lubricating system the pump 7 scavenges the oil from above the drip pan 6 downwardly in the sump and forces the same from the sump up through connections (not shown) to the crank shaft, piston rods, etc.

The intake manifolds of the cylinders are indicated at 9, and to these intakes are attached the carbureters 10, these carbureters being adapted to receive the liquid fuel through connections 11 and the charge forming and carbureting air through the mouths 12. To these mouths or inlets 12 is attached an elongated pressure reservoir or tank 13, the peculiar shape of this reservoir being illustrated clearly in Fig. 3, comprising, as is shown, an enlarged upper portion and a pair of downwardly extending channels 14. The tank is formed in this manner in order to clear and provide room for the blower drive shaft 15, which passes within the V of the engine and parallel to the crank shaft, as will more particularly appear hereinafter.

This tank 13 is made strong enough to withstand the operating pressure of the air therewithin, and the capacity thereof is such that the suction strokes of the engine produce no substantial pulsations in the pressure of the air therein. It may be secured to the

mouths 12 of the carbureters in any convenient manner. This tank is provided on its upper portion with an enlarged mouth 16, and the walls of this inlet 16 are flanged as indicated at 17 to receive the flanged walls of the flaring outlet of a conduit 18. The conduit 18 extends first upwardly to clear the carbureting devices 10 and then rearwardly to an elbow 19. The elbow 19 is attached to the casing of my air compressor (which is of the centrifugal blower compressor type), the elbow 19 and the outlet of the pump casing having complementary flanges 21 formed thereon for convenience in securing together. The centrifugal compressor 20 overhangs the rear end of the motor and comprises a single propeller element 22 mounted on a shaft 23 for rotation within the pump casing. The shaft 23 with its propeller element is mounted for rotary movement in the inner bearings 24 and the outer bearings 25, the inner bearing being carried by the end plate 26 of the engine frame work and the outer bearings 25 being carried by the pump casing. The end plate 26 or gearing chamber is provided with a transverse opening in alignment with the shaft 23 for the reception of the centering or holding member 27 which together with the bearings 24 and 25 maintain the shaft 23 in its proper alignment. The member 27 is cylindrical in form and has a flange 27′ on its left hand end which bears against the end plate 26 when inserted in position. This member 27 also comprises a sleeve closely surrounding the shaft 23 as indicated. Chambers 28 are provided around the shaft 23 at the points where this shaft passes through the opposed walls of the pump casing 20 and these chambers are maintained in communication with the pump exits by means of the connections 29 which lead downwardly through the passages 30 provided in the casing 20 and upwardly to the pump exits. These chambers 28 are thereby maintained at the pressure of the air in the tank or reservoir during operation of the apparatus. The compressed air enters the annular passages surrounding the shaft through openings 30′ which are provided in the sleeve immediately surrounding the shaft.

The inlet of the compressor is indicated at 31 and is divided into two parallel branches which lead radially toward the shaft 23 and then axially as indicated at 32 into the chamber of the rotating element 22, this chamber being formed by the septums or webs 33 which are in turn formed integrally with the outer part of the pump casing and extend radially outwardly from the shaft. These webs 33 are braced by the transverse webs or walls 34 forming exit chambers for the air under compression, which construction forms a rigid construction. The lower part of the compressor casing is provided with the transverse securing flanges 40 which are adapted to receive complementary flanges formed on the extension 41, the latter containing regulating or controlling valves 42. These valves are illustrated as in the closed position in Fig. 2, thereby closing the inlet of the centrifugal blower. The extension 41 is slightly flared in the downward direction as indicated and receives a mouth or intake 43 which may be secured thereto in any convenient manner. The valves 42 may be actuated in any convenient manner, either by hand or automatically. Preferably they are controlled automatically, as by some such means as a diaphragm 44 (Fig. 2) closed within a chamber 45, the diaphragm being in communication on one side with the air pressure conduit 18 through a connection 46. The other side of the diaphragm 44 may be in communication with the atmosphere or with a source of constant pressure, preferably with a source of constant fluid pressure whereby the changes in atmospheric pressure do not affect the regulation of the device. The diaphragm 44 may control a pair of contacts 47 which are respectively in the circuit of a pair of solenoids 48. These solenoids actuate a pair of pawl and ratchet mechanisms 49 for adjusting the valves 42, a suitable source of current 50 being illustrated for supplying the coils 48. It is understood that this control mechanism is only diagrammatically illustrated and that the mechanical details thereof are omitted for conveniences in illustration, these details being of any conventional design. It is also understood that any other suitable control mechanism may be used, as for instance, a direct acting diaphragm which is adapted to actuate the valves directly, the control mechanism herein shown being merely for illustrative purposes.

The centrifugal blower is driven by means of the shaft 15 which is geared at its left end to the propeller rotating element 23 and at the right hand end to the larger or upper of the reduction gears 5. The shaft 15 is preferably hollow (Fig. 1) and is provided on its left end with an internal gear 51, with which internal gear 51 meshes a smaller gear 52 which is fixed to the shaft or rotating element 23 of the centrifugal blower. The left hand end of the shaft 15 is carried by a bearing and gear housing 53, the latter being secured to the upper part of the main gear housing 26 of the engine frame. Suitable bearings, as for instance, the ball bearings 54 are provided between the shaft 15 and the housing 53. The right hand end of the shaft 15 is not geared directly to the reduction gear 5, but is interrupted near its end to provide for a friction clutch, designated generally by the numeral 60 (Figs. 1 and 4). This clutch 60 is closed within a casing 61 which is carried by the right

hand end of the crank casing, the casing 61 comprising a removable part 62 which may be attached thereto in any convenient manner, as for instance, by the securing bolts illustrated in Fig. 2. The friction clutch comprises a rotatable, cylindrical housing 63 and to this housing 63 there is coupled a retaining member 64 as by means of the bolts 65 passing through the annular, lateral flanges of these members. The member 64 is journaled on the radial ball bearings 66, the latter being disposed around the stub connection 67 which serves to connect the shaft 15, as by means of the attaching bolts 68, to the friction clutch. The stub connection 67 is formed hollow for a portion of its end and on its periphery is provided with a screw threaded connection for the reception of a retaining nut 69, the latter serving to retain the ball bearings 66 in their proper position. The clutch proper comprises two sets of interleaved friction discs, the one set 70 being splined to the interior of the cylindrical rotary member 63 and the other set 71 being splined to the right hand end of the stub connection 67. The discs 70 are in the form of annular rings secured to the interior of the rotary member 63 as indicated. The rotary member 63 is driven from the hollow shaft 73 (being illustrated as formed integrally therewith), which in turn is driven by means of a pinion 74 intermeshing with the internal gear formed on the reduction gear 5. The shaft 73 is journaled in the bearing 75 and a lubricating pipe or connection 76 leads upwardly from the pump 7 and registers with an opening passing radially through the bearing 75 and openings 77 through the hollow shaft 73. The shaft 73 is formed hollow for the reception of the guiding member 78, the latter being formed integrally with a guiding plunger member 79, and the plunger 79 is capable of movement axially of the shafts 15 and 73 thru the spline connection therebetween and the interior of the rotary casing 63. By the adjustment of the axial position of this plunger member 79, the coefficient of friction between the friction discs 70 and 71 and the gripping action of the clutch may be adjusted and regulated in accordance with requirements for controlling the application of power to the blower shaft 15. Preferably the plunger member is actuated by the pressure obtained from the lubricant pump 7 and controlled by a manually or otherwise operated valve 7', the lubricant leading upwardly thru the connection 76 and thru the openings 77 in the shaft 73 into the chamber back of the plunger 79. By means of this arrangement the slippage between the shaft 73 and the shaft 15 may be regulated and adjusted to a nicety. This is a particular advantage in the starting up of the centrifugal blower which is preferably geared up from the propeller shaft to run at a speed higher than that of the motor, in some instances a gear ratio of 10 to 1 being desirable. Upon starting up the engine the friction between the friction discs is small and the slipping of the clutch is accordingly great, but the friction gradually increases and the blower is caused to pick up slowly and gradually with the rise of pressure, of the lubricating oil, thereby avoiding and obviating undue strains upon the driving connections between the blower and the engine. The inertia of the high speed blower is thereby gradually overcome and the difficulties in the starting thereof from the highly accelerating motor avoided.

Any suitable gasoline supply system may be used, but the following system is indicated for illustrative purposes.

A main fuel tank is indicated diagrammatically at 80 (Fig. 2) and a small gravity tank 81 is indicated for supplying liquid fuel by gravity to the carbureting devices through the connections 11. A gasoline pump 83, driven in any suitable manner as for instance, from the vertical shaft 84 (Fig. 3) disposed within the gear housing or end plate of the motor frame work, may be used for raising the liquid fuel from the main tank to the gravity tank, the shaft 84 being suitably geared to the crank shaft as indicated in Figs. 2 and 3. Through the medium of the pump 83, the gravity tank is maintained full of liquid fuel to its required capacity. In order to avoid back pressures in the auxiliary tank, this tank may be connected at its top through the medium of a connection 86 with the pressure conduit 18 and the reservoir or tank which contain the air under pressure, the fuel feeding by gravity from the tank 81 to the carbureters 10.

The operation of my improvements will be understood from the above descriptions thereof. After the engine has operated for a short time and power applied to it the blower 20 succeeds in raising the pressure of the air in the reservoir to the required value, and the pressure may be regulated by hand or automatically, as by means of the diagrammatically illustrated devices shown. The diaphragm 44 through the medium of the contacts 47 and the solenoids 48 controls the position of the flap valves 42 which are located in the intake of the compressor blower. If the pressure in the conduit 18 and the reservoir falls slightly below the normal these valves are automatically actuated to increase the volume of air taken into the blower and on the other hand if the pressure exceeds the required or normal volume these controlling devices act in a contrary sense. Preferably, though not essentially, I choose to raise the charge forming air in the conduit 18 and in the reservoir to a pressure above that of sea level atmos-

phere, say for instance, to a pressure of 18 pounds absolute. This super-charge pressure upon the carbureting devices and the intake of the cylinders effect a substantial increase in the power of the motor at sea level; and within the range of altitudes within which a constant air pressure may be retained therein by the regulating devices, the power of the motor gradually increases due to the lowering of the density and pressure of the air and the exhaust pressure. I propose by my particular compressing devices, including the centrifugal blower illustrated in this application, to maintain a substantially constant pressure up to from ten to twenty thousand feet above sea level, and in accordance with conservative figures and calculations the power for a given engine at such altitudes may be expected to be twice the power that could be obtained without the use of my improvements. Assuming that the power of a given engine is doubled at a particular elevated position, a better and more effective performance of airplanes or other air craft may be expected due to the increase of power without a corresponding increase in weight and mass of the power plant.

It is particularly an advantage to operate the motor at super-pressures or pressures above atmospheric within altitude limits determined by the capacity of the compressing apparatus. For instance, I propose to raise the intake pressure of the engine from the normal atmospheric pressure of slightly over 14 pounds absolute to approximately 18 pounds absolute and to maintain this pressure on the intake of the engine up to altitudes from 10,000 ft. to 20,000 ft. The compressing apparatus, including the centrifugal blower and reservoir together with the correlated carbureters and intake manifolds adapted to cooperate therewith, is particularly adapted to use with motors of the type set forth in my applications Serial No. 181,238 and Serial No. 234,235 filed July 18, 1917, and May 13, 1918, respectively, the motors of these applications embodying improvements in internal combustion engines especially adapted to the aeronautical art. The motor set forth is a high speed motor and adapted to drive a propeller at a reduced speed through a suitable reduction gearing, the motor speeds ranging from a speed of 2,600 or higher downwards. Assuming operation at 2,400 R. P. M. at which speed the particular motor develops over 400 horse power at sea level, the power of this motor would be expected to drop to 200 horsepower at about 16,000 feet and at 30,000 feet the power would be expected to drop below 100 horse power, or less than one-fourth the sea level power. These figures are in accordance with actual tests and calculations made in practice. With my present improvements applied to this motor and assuming the same R. P. M. viz: 2,400, with an initial motor intake or carbureter pressure of 18 pounds absolute (instead of 14 pounds) the powers expected at the same altitudes would be at 16,000 feet over 400 horse power and at 30,000 feet would be over 200 horse power. These results may be expected with a centrifugal blower of a particular design having a 10–1 ratio drive with the engine, the blower being driven at approximately 24,000 R. P. M. These calculations are indicative of the highly advantageous results expected from an areonautical power plant embodying these improvements, the power per unit weight being doubled at the upper altitudes. It is apparent that by means of the present invention the drop in power of a given design of motor is substantially less than the falling off in power of prior power systems and as a direct result of this increase in the available power at the higher altitudes the climbing efficiency of the airplane is substantially better than the climbing efficiency of prior airplanes of the same design and also the load carrying capacity of the plane as well as the speed thereof are also increased at a rate corresponding to the increase in horse power at the different levels.

In accordance with the patent statutes I have set forth in the specific manner required thereby one complete embodiment of my invention, but it is understood that this is only for illustrative purposes and that the invention is capable of assuming other forms than that illustrated, and that the claims hereto annexed are not to be limited to the specific devices illustrated, except as is specifically recited therein.

What is claimed is:

1. In combination with a multi-cylinder internal combustion engine including a crank shaft and a gear down propeller shaft, a blower compressor attachment, a driving connection between the blower attachment and the propeller shaft, a pressure reservoir, a connection between the pressure reservoir and the blower, and a carburetor for the engine arranged to receive its supply of air from said reservoir.

2. In combination with a multi-cylinder internal combustion engine having its cylinders arranged in banks, a blower compressor attachment mounted at one end of the engine, a pressure reservoir, a connection between the blower attachment and the reservoir, gearing at the opposite end of the engine from the blower attachment, a driving connection between the gearing and the blower attachment extended between the banks of cylinders, and a carburetor for the engine arranged to receive its supply of air from said reservoir.

3. In combination with a multi-cylinder

internal combustion engine including a crank shaft and a geared down propeller shaft at one end of the engine, a blower compressor attachment at the opposite end of the engine, a driving connection between the propeller shaft and the blower attachment, a pressure reservoir, a connection between the pressure reservoir and the blower attachment, and a carburetor for the engine arranged to receive its supply of air from said reservoir.

4. In combination with a multi-cylinder internal combustion engine having its cylinders in banks, a blower compressor attachment for the engine mounted at one end thereof, a driving connection for the blower attachment extended between the banks of cylinders, a pressure reservoir of a construction adapting it to fit between the bank of cylinders and to straddle the driving connection for the blower attachment, a connection between the pressure reservoir and the blower attachment, and a carburetor for the engine arranged to receive its supply of air from said reservoir.

5. In combination with an internal combustion engine including an oil circulating system thru which oil is circulated under pressure to the various parts of the motor requiring lubrication, a blower compressor attachment, a driving connection between the blower attachment and the engine, a pressure reservoir, a connection between the blower attachment and the pressure reservoir, a carburetor for the engine arranged receive its supply of air from said reservoir, clutch mechanism interpolated in the driving connection between the engine and the blower attachment for regulating the speed of the blower attachment, and mechanism operable according to the pressure in the lubrication system to automatically regulate the clutch.

6. The combination with a multi-cylinder internal combustion engine, a blower attachment therefor, a driving connection between the blower attachment and the engine, a pressure reservoir, a connection between the blower attachment and the pressure reservoir, said connection being provided with a flaring mouth which open directly into the reservoir, and separate carburetors for the engine arranged to receive their supply of air from said reservoir, the connections between the separate carburetors and the reservoir being disposed respectively on opposite sides of the flaring mouth.

7. In a motive power system for aircraft, the combination of an internal combustion engine, a charge forming and inducting means including a casing having a propeller element rotatable therein, a driving connection between the propeller element and the engine, said connection comprising gearing for rotating the propeller element at a speed exceeding the speed of operation of the engine, a friction clutch interpolated in the driving connection between the motor and the propeller element, a fluid pressure pump driven by the engine, and a fluid pressure device associated with the friction clutch, said fluid pressure device being responsive to the fluid pressure pump driven by the engine.

8. In a motive power system for aircraft, the combination of an internal combustion engine, a fluid pressure pump driven by the engine, a centrifugal blower compressor for supplying super-charges to the engine cylinders, said compressor being driven from the engine crank shaft and geared thereto for operation at higher speed than said engine, a friction clutch interposed between said compressor and said engine comprising a pressure reservoir and a fluid pressure device which is responsive to the fluid pressure pump driven by the engine.

9. In a motive power system for aircraft, the combination of an internal combustion engine, a device responsive to engine speed a centrifugal blower compressor geared down to said engine and operated therefrom, and a friction clutch interposed between said centrifugal compressor and said engine, said clutch being controlled by means of the device responsive to the speed of the engine.

10. In a motive power system for aircraft, the combination of an internal combustion engine, a centrifugal blower compressor supplying compressed air to the charge forming devices, said compressor being driven by and geared down to the engine crank shaft, a lubricating pump for supplying said engine with forced lubricant under pressure and a friction clutch interposed between said centrifugal blower and said engine, said clutch comprising a plunger and chamber in communication with the outlet of said lubricating pump.

11. In a motive power system for aircraft, the combination of an internal combustion engine of the V type, carbureting devices disposed within the V of the engine, a pressure reservoir also disposed within said V and within communication with said carbureting devices, a centrifugal blower compressor adapted to take air from the atmosphere and compress the same into said pressure reservoir, said compressor being disposed at one end of the engine, a driving connection between the crank shaft of the said engine and said compressor comprising a shaft extending parallel to the crank shaft and disposed between the cylinder banks, said driving connection also including a number of reduction gears and a friction clutch for the purpose set forth.

In testimony whereof I hereunto affix my my signature.

CHARLES B. KIRKHAM.