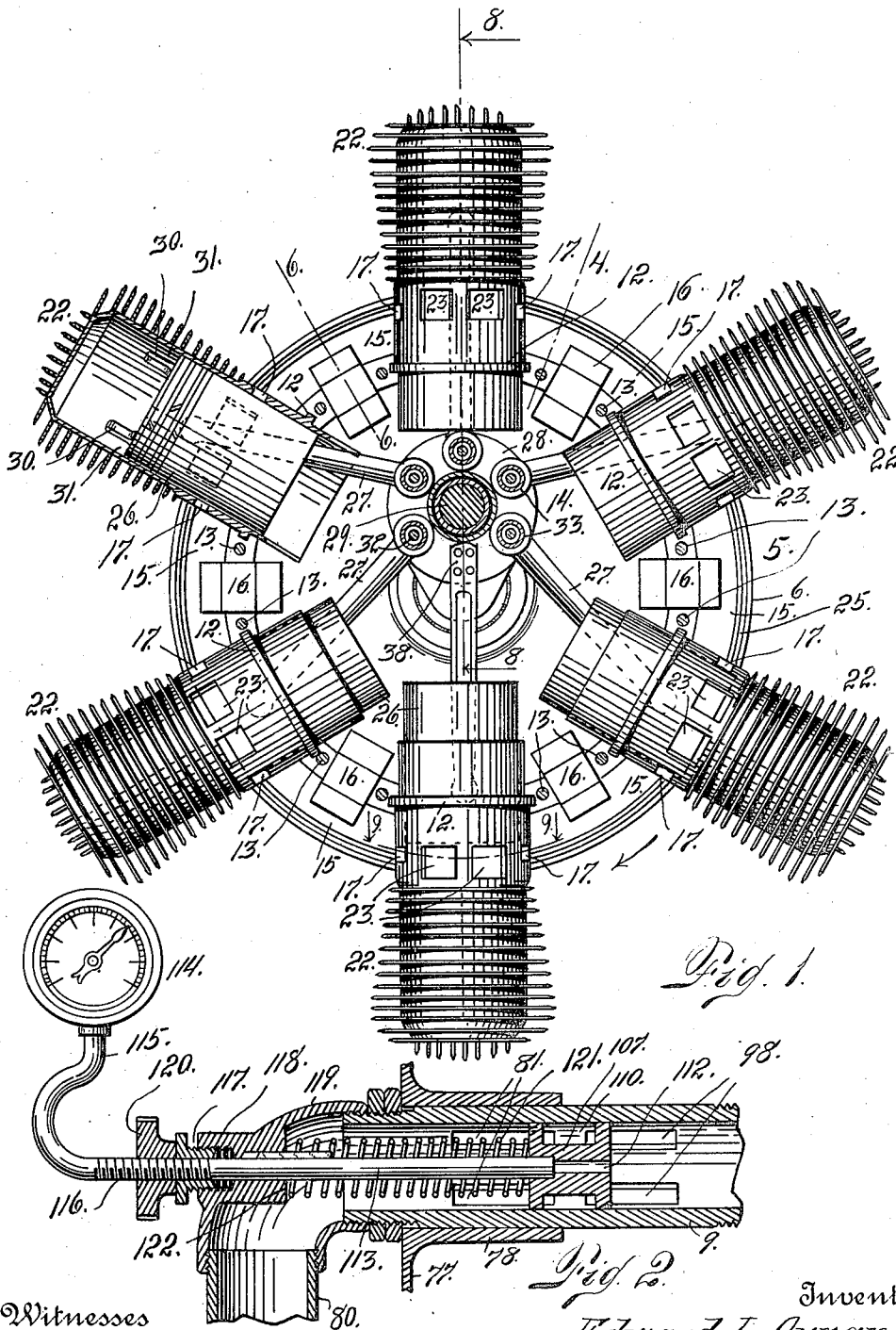


E. L. AURAND.  
 ROTARY EXPLOSIVE ENGINE.  
 APPLICATION FILED FEB. 27, 1913.

1,146,545.

Patented July 13, 1915.

4 SHEETS—SHEET 1.



Witnesses  
 Otto E. Hoddick.  
 Lawrence E. Petersen.

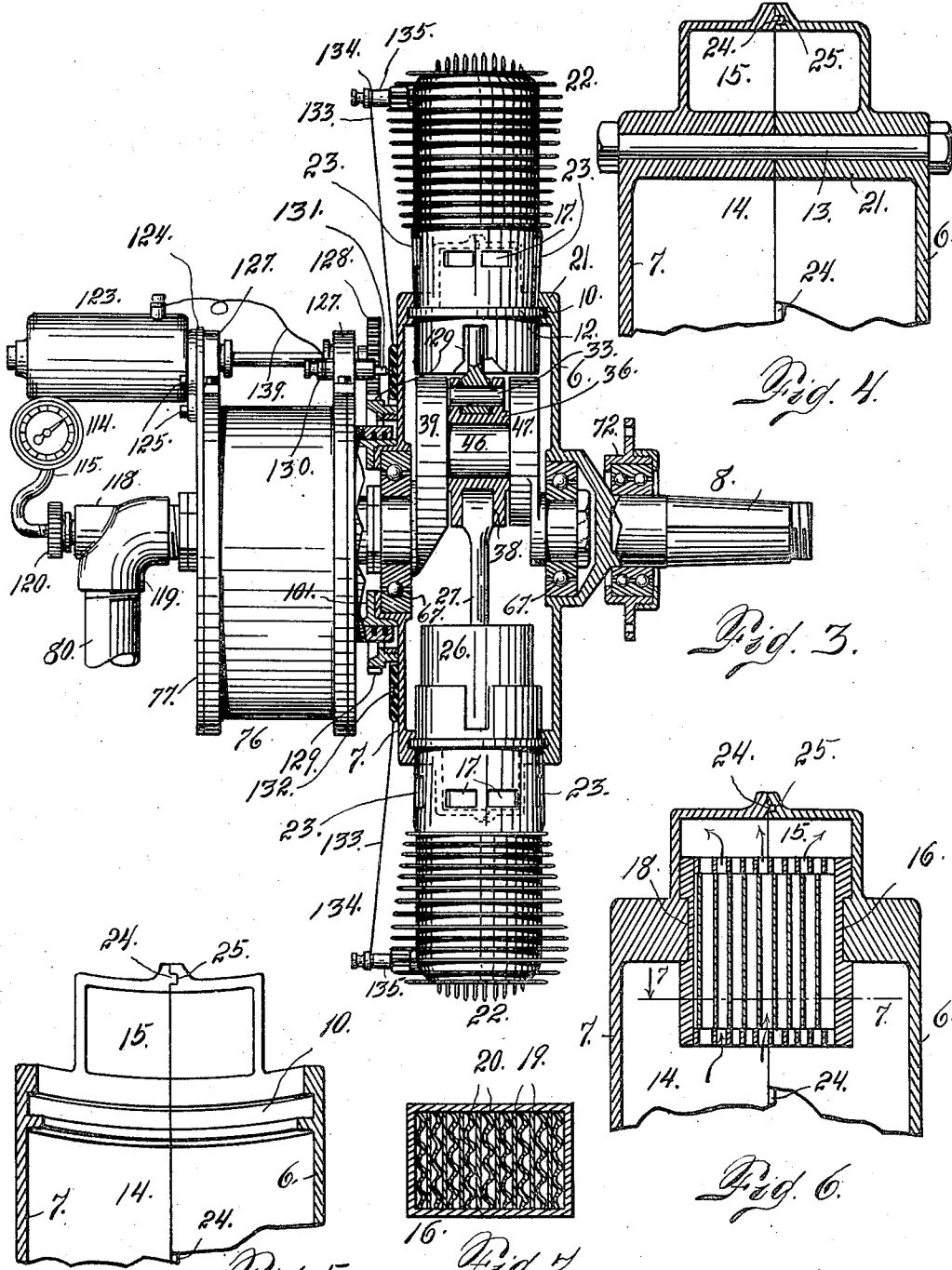
Inventor  
 Edward L. Aurand.  
 By *[Signature]* Attorney

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4 SHEETS—SHEET 2.



Witnesses

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Lawrence E. Petersen.

Inventor

Edward L. Aurand.

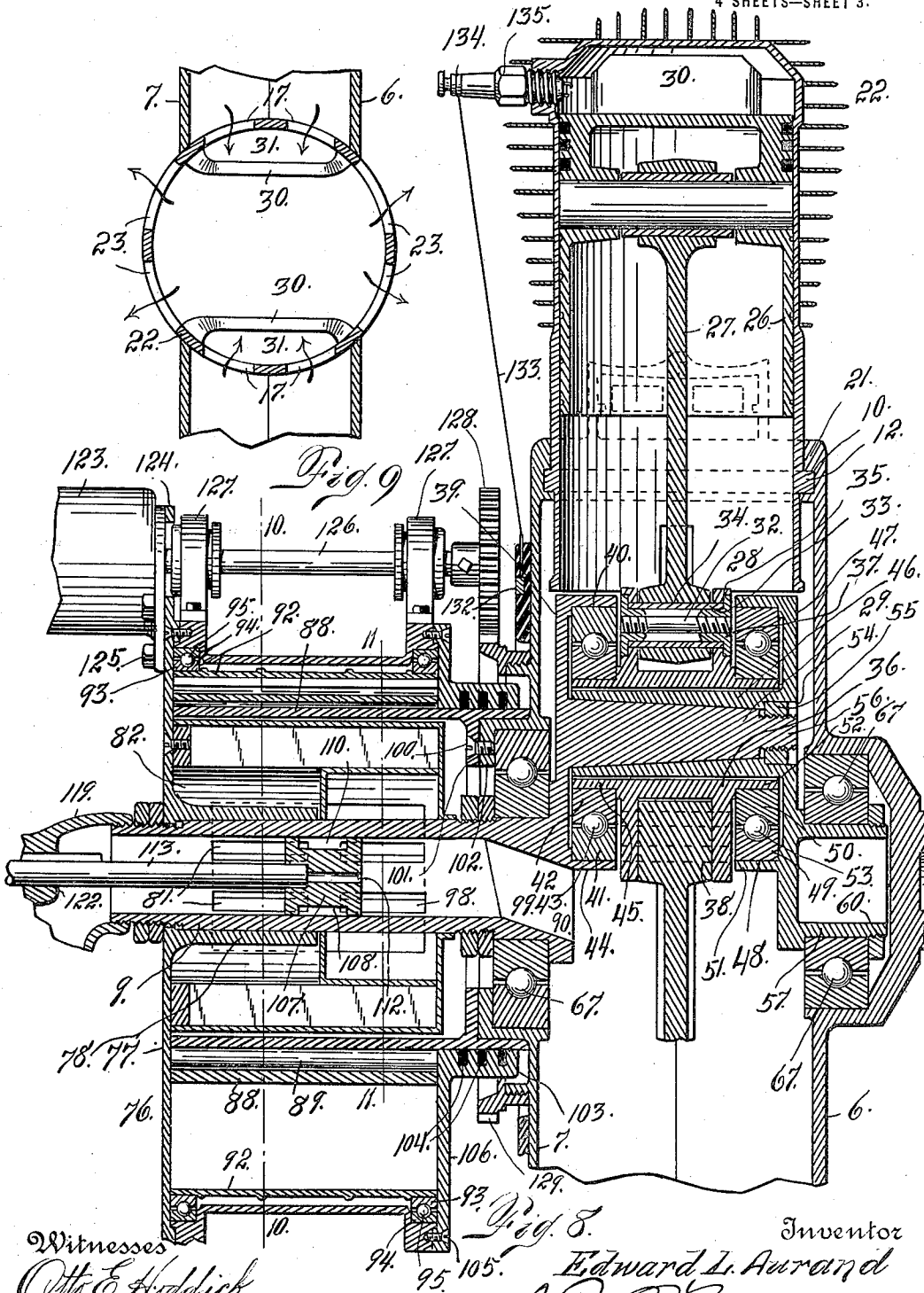
By *A. J. B. Smith* Attorney

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4 SHEETS—SHEET 3.



Witnesses  
 Otto E. Haddock.  
 Lawrence E. Petersen.

Inventor  
 Edward L. Aurand  
 By *A. J. G. Smith* Attorney

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4 SHEETS—SHEET 4.

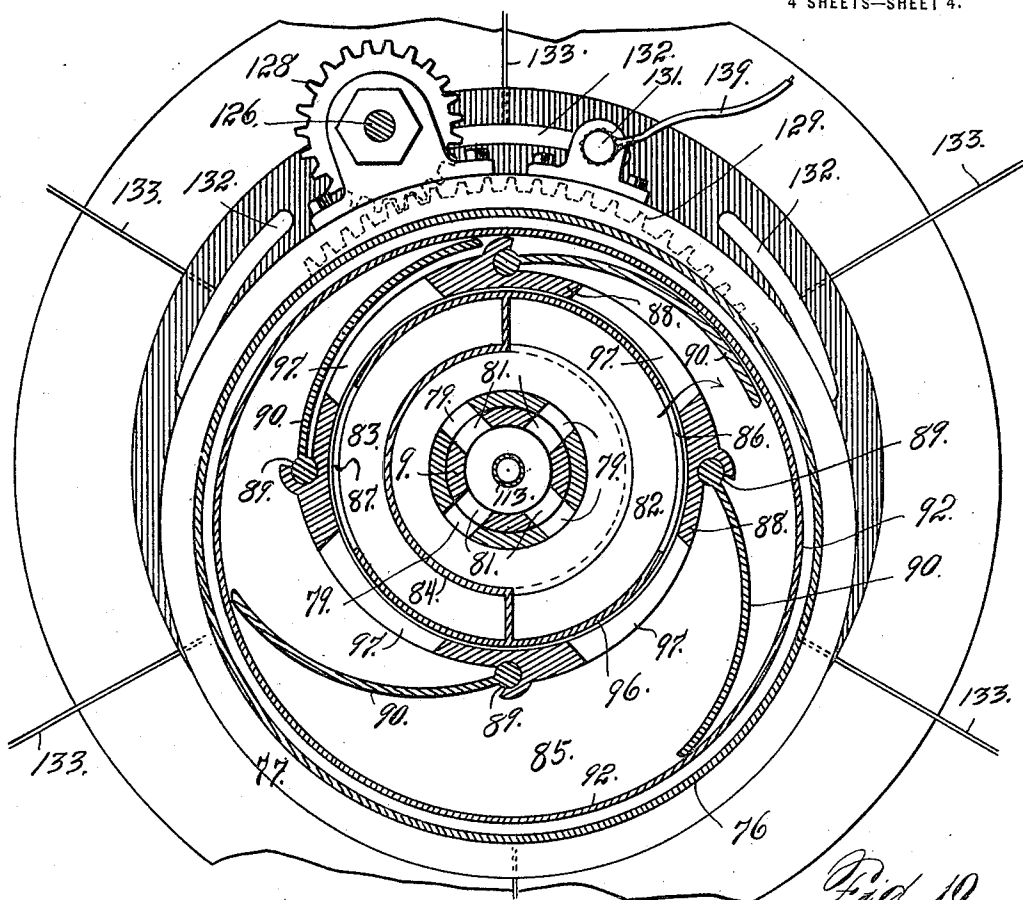


Fig. 10.

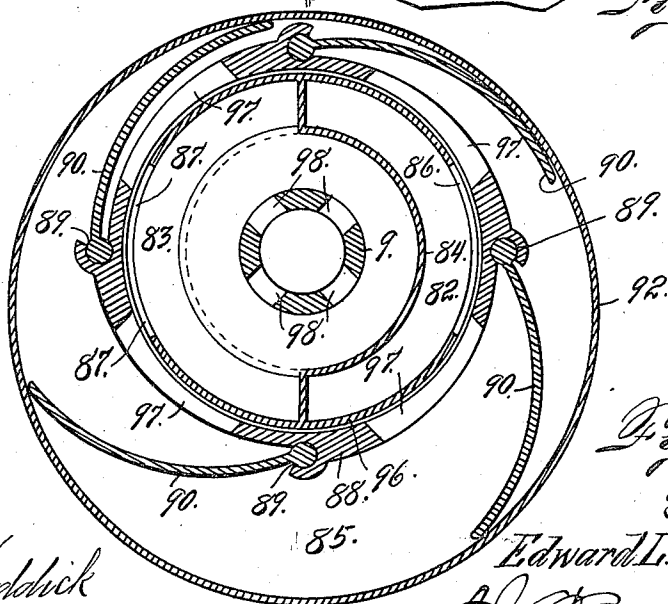


Fig. 11.

Witnesses

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Attorney

# UNITED STATES PATENT OFFICE.

EDWARD L. AURAND, OF DENVER, COLORADO, ASSIGNOR TO HENRY O. JACKSON, OF DENVER, COLORADO.

## ROTARY EXPLOSIVE-ENGINE.

1,146,545.

Specification of Letters Patent.

Patented July 13, 1915.

Application filed February 27, 1913. Serial No. 751,055.

*To all whom it may concern:*

Be it known that I, EDWARD L. AURAND, a citizen of the United States, residing in the city and county of Denver and State of Colorado, have invented certain new and useful Improvements in Rotary Explosive-Engines; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon, which form a part of this specification.

My invention relates to improvements in rotary explosive engines being more especially intended for use as motors for driving the propellers of flying machines or airships, and to this end my improved construction embodies a small amount of material, comparatively speaking, whereby its weight is reduced to a minimum, while at the same time it is exceedingly efficient as a motor of the class described.

While my improved engine is particularly designed for use on flying machines of the heavier-than-air class, it is evident that it may be employed in connection with dirigible airships and also as a rotary motor of general application or use.

In my improved construction, the crank case proper is in the form of a drum. Upon the periphery of the latter is mounted a hollow annular member interrupted at regular intervals by the cylinders of the motor. Induction ports are located in those portions of the cylinders which are inclosed by the said annular member of the case, while the exhaust ports open directly to the atmosphere.

Another feature of novelty consists in the special construction for the introduction of the explosive mixture to the inner compartment or chamber of the crank case through one member or extremity of the crank shaft, in which is located a longitudinally adjustable valve so constructed as to cooperate with ports in the crank shaft, whereby the explosive mixture is first passed into a chamber of a blower or pump and thence returned to the crank shaft through similar ports on the opposite side of the longitudinally adjustable valve or on the crank case side of the valve whence the explosive mixture passes directly to the inner compartment of

the crank case. This special construction makes it practicable to so adjust the valve in the hollow portion of the crank shaft as to automatically regulate the pressure in the crank case in order to guard against the excessive pressure within the said case. A pressure gage attachment is connected with the valve located in the hollow portion of the crank shaft whereby the pressure within the crank case may be conspicuously indicated at all times.

Having briefly outlined my improved construction, I will proceed to describe the same in detail, reference being made to the accompanying drawing in which is illustrated an embodiment thereof.

In this drawing, Figure 1, is a sectional view of my improved engine taken circumferentially through the crank case and cutting the crank pin of the pitmen transversely. In this view one-half of the crank case is removed and one of the cylinders is shown in longitudinal section. Fig. 2, is a sectional detail view of the hollow intake portion of the crank shaft illustrating the special valve construction and means for indicating the pressure of the explosive mixture within the crank case. Fig. 3, is a sectional view showing the crank case cut at right angles to Fig. 1, two of the cylinders being shown in elevation. Fig. 4, is a fragmentary sectional view of the outer portion of the crank case being a section taken on the line 4-4, Fig. 1, but on a larger scale. Fig. 5, is a fragmentary view of the crank case viewed from the inside and illustrating the groove for receiving the collar on the cylinder. Fig. 6, is a section taken on the line 6-6, Fig. 1, cutting one of the filtering devices, the parts being shown on a larger scale. Fig. 7, is a transverse section taken through a filtering device on the line 7-7, Fig. 6. Fig. 8, is a section taken on the line 8-8, Fig. 1, and showing the blower or rotary pump in section all of the parts being shown on a larger scale. Fig. 9, is a cross section taken through one of the cylinders on the line 9-9, Fig. 1, shown on a larger scale. Fig. 10, is a section taken through the pump or blower on the line 10-10, Fig. 8. Fig. 11, is a view taken on the line 11-11, Fig. 8.

The same reference characters indicate the same parts in all the views.

Let the numeral 5, designate the crank

case which is composed of two members, 6 and 7, which are supported by a rotating stub shaft 8 and a hollow fixed crank shaft 9. The two members of this crank case are  
 5 grooved as shown at 10, to receive ribs or collars 12, formed on the cylinders whereby the latter are securely locked within the crank case when the two members of the  
 10 latter are connected by bolts 13, which are passed through registering openings formed in the webs between the cylinders and constituting a partition separating the crank  
 15 case into inner and outer compartments designated by the numerals 14 and 15, respectively. This partition forms a perfect separation between the compartments 14 and 15,  
 except that the partition is provided with slots or openings in which are inserted filtering members 16, through which the ex-  
 20 plosive mixture passes from the inner compartment of the crank case to the outer compartment 15, thereof, just prior to the passage of the explosive mixture to the cyl-  
 25 inders through the intake ports 17, which are in communication with the crank chamber compartment 15, as heretofore explained. An important object of these filtering  
 members is to increase the surface area exposed to contact with the explosive  
 30 mixture, to such an extent as to prevent so called back firing. Still another function is the breaking up of the explosive mixture, or finely dividing the same, whereby its vol-  
 atile character is enhanced and its activity  
 35 facilitated. These filtering members may be of any suitable construction that may be adapted to properly perform the aforesaid function. However, as illustrated in the  
 drawing, each filter member consists of a  
 40 box-like structure grooved on opposite sides to receive lugs or relatively short inwardly projecting parts 18, formed on the respec-  
 tive members of the crank case whereby the filtering members are locked securely in  
 45 place. Within the shell or four outer walls of this box-like device is located a number of separated plates 19, between which are interposed corrugated members 20, forming  
 a relatively extensive surface area which is  
 50 exposed to contact with the explosive mixture whereby back firing is prevented. These parts 19 and 20, arranged in the relation stated form a sort of mesh or intricate  
 structure so interwoven and connected as to  
 55 finely divide the explosive mixture, or semi-gaseous substance, as it leaves the inner compartment of the crank case on its way to the outer compartment thereof, and  
 whence it passes directly to the cylinders  
 60 for explosive purposes. Beyond the reinforced parts 21, of the crank case, in which are formed the grooves 10, for receiving the  
 ribs or collars 12, of the cylinders, the crank case is reduced in thickness, whereby the  
 65 portions of the cylinders 22, which extend

beyond the portions 21, of the case, are ex-  
 posed on two opposite sides as best illus-  
 trated in Fig. 9, of the drawing. These  
 exposed portions of the cylinders contain  
 70 ports 23, which serve for the exhaust of the burnt gases or products of combustion as  
 the pistons approach their inward limit of  
 movement following the explosions in the  
 outer extremities of the cylinders. It will  
 75 thus be apparent that while the exhaust ports 23, are at all times open to the atmos-  
 phere, the intake ports 17, are at all times protected by the crank case and in direct  
 communication with the compartment 15,  
 80 thereof, the last named compartment being in communication with the inner compart-  
 ment 14, by way of the filtering members 16, as heretofore explained. In order that  
 the crank case members may be properly  
 85 joined or made gas tight, one of these members is provided at the periphery of the case  
 and between the cylinders with tongues 24, entering grooves 25, formed in the adja-  
 cent member. Within each of these cylin-  
 90 ders 22, is located a piston 26, which is connected by means of a pitman 27, with a  
 bearing 28, of the crank pin 29. The outer  
 extremity of each of these pistons is pro-  
 vided with two projections 30, which extend  
 95 toward the outer extremity of the cylinder and are located inwardly beyond the wall of  
 the cylinder, whereby spaces 31, are left between the wall of the cylinder and the said  
 projections, the latter being arranged adja-  
 cent the opposite sides of the cylinder where  
 100 the intake ports 17, are located, whereby as the outer extremity of the piston passes  
 inwardly far enough to uncover the intake  
 ports 17, the explosive mixture will enter  
 the cylinder through said ports and, coming  
 105 in contact with the projections 30, the latter will constitute deflectors whereby, the said  
 mixture will be deflected or guided out-  
 wardly toward the outer extremity of the  
 cylinder, thus protecting the fresh explosive  
 110 mixture from contact or intermingling with the burnt gases or products of combustion  
 as the latter are being removed through the  
 exhaust ports during the scavenging of the  
 cylinders as heretofore explained. 115

The inner extremity of each pitman 27,  
 is connected with the bearing 28, of the  
 crank pin 29, by means of an auxiliary pin  
 32, the said pins for all the pitmen being  
 120 annularly arranged around the crank pin 29, and connected with the bearing 28, in such  
 a manner that as the crank case rotates in  
 response to the action of the explosions in  
 the various cylinders, the stems 32, will  
 125 travel in an orbit around the crank pin 29, and permit the pitmen to be reciprocated  
 within the cylinders during the regular per-  
 formance of their function. The stems 32,  
 are passed centrally through sleeves 33,  
 which pass through openings 34, in the inner 130

extremities of the pitmen 27. The extremities of these sleeves extend beyond the opposite sides of the pitmen extremities and enter openings 35, formed in a sort of spool 36, annularly arranged around the crank pin. The stems 32, are secured in place centrally within the sleeves 34, by means of nuts 37, secured upon the threaded extremities of the stems and fitting closely within the adjacent extremities of the sleeves 33. The outer extremities of the nuts 37, are flanged to overlap the extremities of the sleeves, and these flanges also occupy recesses or counterbores, formed in the spool 36. All of the pitmen 27, are connected with the spool in the manner just explained, except one which is rigidly secured to the spool as shown at 38, thus giving a positive rotary action in a given direction to the spool. The body of the crank pin 29, is provided with a sort of disk 39, at one extremity which is formed integral therewith, the said disk extending annularly beyond the body of the crank pin and being recessed, as shown at 40, to receive bearing rings 41, and 42, between which are interposed bearing balls 43, the two rings having cooperating grooves forming raceways for the balls. The ring 42, is fast on the spool 36, and the two rings 41 and 42, are interposed between an outer annular flange 44, formed on the disk 39, and an inner annular flange 45, formed on the spool 36. However, as the ring 42, is secured to the spool by brazing or otherwise, it is substantially a part thereof.

A hollow crank pin member 46, is applied to the body of the crank pin at the opposite end from the disk 39, this hollow member 46, having a cone shaped opening, to receive the body of the crank pin which is of counterpart shape. The member 46, is so constructed that when applied to the body of the crank pin, the latter, when the member 46 is considered a part thereof, is exteriorly cylindrical in shape. This member 46, is also provided with an integral disk 47, which extends outwardly beyond the body of the member 46, the outwardly extending portion being recessed as shown at 48, to receive bearing rings 49 and 50, which are substantially identical with the rings 41 and 42, and perform the same function in the mechanism. The two rings, 49 and 50, are interposed between an annular flange 51, with which the disk 47, is provided, and an annular flange 52, with which the spool 36 is provided. The flange 52, is identical in construction with the part 45, at the opposite end of the spool. The ring 50, is secured to the spool and forms a part thereof in the same manner as the ring 42 is connected with the spool, and bearing balls 53 are interposed between the two rings 49 and 50. It will be understood that the rings 41 and 49, are fastened in the disks 39 and 47, re-

spectively. The hollow crank pin member 46, is counterbored as shown at 54, to receive a nut 55, which is threaded upon the reduced extremity 56, of the body of the crank pin, whereby the said body of the pin 70 and the hollow member 46, are connected in operative relation and locked together to form a substantially integral device.

The body of the crank pin and the disk 39, as illustrated in the drawing are formed integral with the hollow member 9, of the crank shaft, while the disk 47, is formed integral with a hub 57.

The crank case is rotatably mounted at each side upon the stationary crank shaft, ball bearings 67 being employed. The stub shaft 8 of the crank case whose axis coincides with the axis of the case is rotatably mounted upon a frame piece 72 which may be secured to any stationary structure (not shown). A ball bearing is interposed between the shaft 8 and the frame piece 72.

From the previous description it should be understood that when the engine is in use the crank case will rotate on the ball bearings 67, while the crank shaft member 9, remains stationary. During the rotary action of the crank case the inner extremities of the pitmen travel around the crank pin whose axis is sufficiently offset from the axis of the crank case to give the pistons the necessary reciprocating movement within their respective cylinders. The spool 36, which is carried around the crank pin with the inner extremities of the pitmen, fits loosely around the outer member 46, of the crank pin, and does not touch the latter. Hence, the bearing of the spool and its rings 50 and 42, is upon the bearing balls 43 and 53, and consequently the thrust due to the explosion within a cylinder located directly above the crank pin is upon the lowest parts of the bearing rings 41 and 49, which are so low as to be almost in line with the axis of the crank case, thus largely relieving the machine from the tendency of the thrust which, were the bearing pin higher up, would make it much more difficult to properly secure the engine upon a stationary frame work of a flying machine or other structure upon which it is used.

Attention is called to the fact that my improved rotary engine is of the two-cycle type and consequently there is an explosion in each cylinder during each reciprocation or back and forth movement of its piston and whereby it results that the volume or mass of the pistons within the crank case is always the same, and consequently there is no compression of the explosive mixture within the crank case due to the action of the pistons. However, in order to produce the necessary pressure upon the explosive mixture within the crank case in order to force said mixture into the cylinders when

the induction ports are open, other means must be resorted to. I have therefore, attached to the engine structure as heretofore described, a blower which is designated in its entirety by the numeral 76. This blower consists of a stationary blower casing 77, eccentrically mounted upon and secured to the member 9, of the crank shaft. As illustrated in the drawing this stationary casing 77, is provided with a sleeve 78, in direct engagement with the crank shaft member 9, the said sleeve being provided with slots or elongated openings 81, registering with slots 79, formed in the crank shaft member, whereby the explosive mixture as it enters the crank shaft member from the carburetor (not shown) through a pipe 80, is caused to pass into a compartment 82, formed in a stationary structure 96, and in which is formed a partition 84, separating the compartment 82 from a compartment 83, the outer shell of the structure 96, being annularly arranged around the crank shaft member 9. The compartment 82, communicates with a chamber 85, eccentrically arranged around the crank shaft member 9, by an opening 86, while the compartment 83 communicates with the said eccentrically arranged chamber by an opening 87.

Annularly arranged around the structure 96, is a drum 88, upon which are hinged (as shown at 89) a number of curved blades or wings 90, which during the rotation of the drum 88, travel in the eccentrically arranged chamber 85, inclosed by a casing 92, which is rotatably movable within the outer stationary casing 77, of the blower, the two casings 77 and 92, being equipped with bearing rings 93 and 94 respectively, between which are interposed bearing balls 95. At the upper extremity of this chamber, the wings are closely folded against the carrying drum 88, as during this folding operation, the explosive mixture is forced from the eccentric chamber 85, into the compartment 83, of the annular structure 96. The drum 88, is provided with openings 97, through which the explosive mixture passes from the compartment 82, into the eccentric chamber 85, and from the latter to the compartment 83, the said mixture in entering the compartment 83, also passing through an opening 87, within the stationary structure 96. By virtue of the operation heretofore described, the explosive mixture enters the compartment 83, under pressure, and is forced therefrom through elongated openings 98, into the hollow portion of the crank shaft member 9, and thence into the crank case through the open extremity 99, of the said crank shaft member.

The drum 88 is caused to rotate with the crank case and the cylinders, by virtue of the fact that the said drum is secured to the said case by fastening screws 100, which are

passed through engaging flanges formed on the connected parts, (see Fig. 8). The drum 88, extends beyond the rotary casing 92, in the direction of the crank case, and its flange 101 is formed on this protruding part, the last named flange being connected with the flange 102, of the crank case, by means of the screws 100, as heretofore explained. This protruding part of the drum 88 is surrounded by a relatively wide collar 103, which is interiorly grooved to receive packing 104, whereby a fluid tight joint is formed between the drum and this collar, the latter being secured to the stationary casing member 77, of the blower by means of screws 105, passing through a flange 106, which is eccentrically arranged with reference to the axis of the stationary crank shaft member 9, to coincide in area with one of the ends of the stationary member 77, of the blower, the said flange 106, in fact closing the eccentric chamber 85 of the blower at one end thereof. The casing 92 is caused to rotate with the drum 88 by virtue of the fact that the blades or wings 90 of the rotary drum engage the inner surface of the said casing whereby the latter is carried along with the drum, ball bearings being interposed between the casing 92 and the outer stationary casing 77 as heretofore described. By virtue of this fact the friction between the blades or wings 90 and the casing 92 is practically overcome as the casing and wings move together.

In order to regulate the introduction of the explosive mixture to the crank chamber through the medium of the blower constructed as heretofore explained, a valve 107 is located within the hollow crank shaft member 9, the said valve forming a stop or plug whereby the explosive mixture, as it enters the outer extremity of the crank shaft member 9, is caused to pass through the slots 81 and 79, formed in the shaft, and sleeves 78, respectively, and thence through the blower and through the openings 98, of the crank shaft, back into the latter, and thence into the crank chamber, on the opposite side of the valve 107, from which it entered the crank shaft member 9. This valve 107, is reduced in diameter intermediate its extremities as shown at 108, this reduced part being of sufficient length to place the adjacent extremities of the openings 81 and 98, of the crank shaft member 9, in communication with each other and when the valve is so adjusted, it allows a portion of the explosive mixture to pass from the compartment 83, to the compartment 82, of the stationary structure 96. By virtue of this feature it becomes practicable to vary the pressure in the crank chamber. Hence, if the pressure within the crank chamber is too great, the valve 107, is adjusted, as shown in Fig. 8, whereby the space 110, due to the re-

duction in diameter of the valve 107, between its extremities, is placed in communication with both sets of slots or elongated openings 81 and 98, thus allowing a portion of the explosive mixture which has been forced into the compartment 83, of the structure 96, to return from the compartment 83, to the compartment 82, through the medium of the space 110, between the extremities of the valve 107. When, however, it is not desired to reduce the pressure in the crank chamber, the valve 107, is so adjusted as to place its extremity in the direction of the crank case far enough in the opposite direction, to cut off the passage of fluid from the openings 98, to the openings 81, of the crank shaft member 9.

In order to accurately measure the pressure of the explosive mixture within the crank chamber, the valve 107, is provided with a longitudinal perforation 112, which is in communication with a pipe 113, leading to a pressure gage 114. This pressure gage is supported upon the rigid outer extremity 115, of the said pipe. This pipe is threaded as shown at 116, and passes through a stuffing box gland 117, which is threaded into a nipple 118, formed on an elbow 119, which connects the outer extremity of the crank shaft member 9, with a pipe 80, leading from a carbureter (not shown). Outside of the gland 117, a nut 120, is screwed on the threaded part 116, of the pipe 113. This nut is in engagement with the outer extremity of the stuffing box gland and when it is desired to move the valve 107, toward the left, referring to Figs. 2 and 8, the nut 120, is turned in the proper direction to move the pipe 113, toward the left, the valve in this event acting to compress a spiral spring 121, located within the crank shaft member 9, and surrounding the pipe 113, the opposite extremities of this spring being engaged by the valve 107, and a shoulder 122 formed by reinforcing the elbow 119, interiorly. In order to move the valve 107 in the opposite direction, it is only necessary to reverse the movement of the nut 120, whereby the tension of the spring 121, will act on the valve to move the latter toward the right, (see Fig. 2) as fast as the turning of the nut 120 will permit.

The generator 123, for furnishing the current to supply the cylinders with the spark for explosion purposes, is mounted on an upward extension 124, of the stationary members 78, of the blower, the same being secured thereto by bolts or cap screws 125. A shaft 126, passing through the generator, is journaled in boxes 127, mounted on the blower casing. This shaft 126, extends beyond the box 127, nearer the engine, and upon this protruding extremity is mounted a gear 128, meshing with a relatively larger gear 129, formed on the crank case. Hence,

as the crank case rotates with the cylinders, the gear 128, is operated, and the shaft 126, rotated, whereby the current is generated for the purpose stated. There is a suitable connection from the generator by means of a conductor 139, and binding posts 130, a contact pin 131, contacts 132, carried by the crank case and suitably spaced, conductors 133, binding posts 134, and spark plugs 135, whereby the sparks at the inner extremities of the spark plugs are produced at intervals properly timed for producing the explosions within the outer extremities of the cylinders. As this feature cannot be claimed in its application it will not be necessary to describe the same more in detail.

From the foregoing description the use and operation of my improved engine will be readily understood.

Assuming that the parts are assembled as illustrated in the drawing, the engine may be started by priming the cylinders or in any suitable manner. As soon as the engine starts, the cylinders and the crank case rotate together upon the axes of the crank shaft member 9, and the bearing of the stub shaft 8, which axes are in alinement as heretofore described. During this rotary action of the crank case and cylinders, the reciprocating movement is imparted to the cylinder pistons 26, by virtue of the fact that their inner extremities are connected with the spool 36, annularly arranged with reference to the crank pin, which is offset from the axis of the crank case sufficiently to give the pistons the desired length of stroke, the crank pin being stationary with the hollow crank shaft member 9. As soon as the engine is started the explosive mixture is drawn into the compartment 82, of the stationary structure 96, of the blower, whence it passes to the eccentric chamber 91, where it is acted on by the blades 90, and finally forced into the compartment 83, of the structure 96, whence it passes to the hollow crank shaft member 9, on the opposite side of the valve 107, from which it entered the said shaft. In this way the crank chamber is kept supplied with explosive mixture under the necessary pressure. This explosive mixture first enters the inner compartment 14, of the crank chamber and passes therefrom through the filter members 16, into the chamber 15, whence it passes through the induction ports 17, into the cylinders, as fast as the pistons are withdrawn sufficiently to permit such entrance of the explosive mixture to the cylinders between the pistons and the outer extremities of the cylinders. As soon as the explosive mixture enters a cylinder, the piston begins its outward stroke compressing the mixture in the outer extremity of the cylinder, and when the piston has reached its outward limit of movement whereby the maximum or ap-

proximately the maximum pressure is given to the explosive mixture the spark is produced and the explosion follows, driving the piston inwardly and uncovering the exhaust ports 23, through which the burnt gases or products of combustion exhaust simultaneously with the entrance of the explosive mixture to the cylinders, the mixing of the products of combustion and the rich explosive mixture being prevented by the deflectors 30, with which the piston is provided, as heretofore explained.

I claim as my invention:

1. In an explosive engine the combination with a crank shaft of a crank case, cylinders secured thereto, pistons in the cylinders having pitmen connected with the crank pin, the inner extremities of the cylinders being inclosed by the crank case whose transverse depth beyond the inclosed extremities of the cylinders is reduced to expose segments of the cylinders, the said exposed portions of the cylinders being provided with exhaust ports, while the portions of the cylinders inclosed by the outer reduced portion of the crank case, are provided with induction ports in communication with the crank case.

2. In an explosive engine the combination of a crank case whose outer portion is of less transverse depth than its inner portion, cylinders whose inner extremities are inclosed by the crank case and whose outer portions beyond the inclosed portions have segments exposed by reason of the reduced transverse depth of the outer portion of the case, the exposed portions of the cylinders having exhaust ports and the cylinders having induction ports in communication with the crank case and means for supplying the crank case with explosive mixture under pressure.

3. In an explosive engine the combination of a crank case having inner and outer compartments of varying transverse depth, cylinders whose inner extremities are inclosed within the inner compartment whose walls fit closely around the cylinders, the partition separating the compartments between the cylinders having openings to allow explosive mixture to pass from the inner to the outer compartment, the outer compartment being in communication with the cylinders by induction ports formed in the latter, the portions of the cylinders exposed to the atmosphere being provided with exhaust ports.

4. In an explosive engine the combination of a crank case having inner and outer compartments of varying transverse depth, cylinders whose inner extremities are inclosed within the inner compartment whose walls fit closely around the cylinders, the partition separating the compartments between the cylinders having openings to allow explosive mixture to pass from the inner to the

outer compartment, the outer compartment being in communication with the cylinders by induction ports, portions of the cylinders being exposed to the atmosphere and provided with exhaust ports, pistons located in the cylinders, a crank shaft with whose pin the pistons are connected, the said ports being so arranged that the pistons during each inward movement uncover the induction and exhaust ports whereby the cylinders receive a supply of explosive mixture, and exhaust the burnt gases simultaneously.

5. In an explosive engine the combination with a crank shaft, of a crank case inclosing a crank pin which is suitably offset from the axis of the shaft, the crank case having inner and outer compartments of unequal transverse depth, the depth of the outer compartment being less than that of the inner compartment, cylinders whose inner extremities are concealed within the deeper compartment of the crank case, the cylinders being of greater diameter than the transverse depth of the outer compartment of the crank case, whereby segments of the cylinder walls are exposed while portions at approximately the same distance from the shaft are inclosed, the inclosed portions having induction ports and the exposed portions exhaust ports, substantially as described.

6. In an explosive engine the combination with a crank shaft having a crank pin suitably offset from the axis of the shaft, a crank case inclosing the crank pin, cylinders whose inner extremities are inclosed within the crank case which fits closely therearound, the crank case having inner and outer compartments, the outer compartment being of less transverse depth than the inner compartment, the diameter of the cylinders being greater than the transverse depth of the outer compartment whereby portions of the cylinders on two opposite sides are exposed while portions on two other sides are inclosed within the outer compartment, the exposed portions of the cylinders being provided with exhaust ports and the inclosed portions within the zones being provided with induction ports whereby the cylinders are in communication with the outer compartment of the crank case, the partition between the inner and outer compartments between the cylinders being provided with openings for the passage of explosive mixture to the outer compartment, and means for supplying the explosive mixture to the inner compartment of the crank case under pressure, substantially as described.

7. The combination with a crank shaft having a crank pin suitably offset from the axis of the shaft, cylinders, a crank case completely inclosing the inner extremities of the cylinders and having an outer portion of less transverse depth than the diameter of the cylinders, whereby parts of the cylinders

ders are exposed and other portions covered in the zone of the reduced portion of the crank case, the said exposed portions of the cylinders having exhaust ports and the said covered portions induction ports, substantially as described.

8. The combination with a crank shaft having a crank pin suitably offset from the axis of the shaft, a crank case completely inclosing the inner extremities of the cylinders and having an outer portion of less transverse depth than the diameter of the cylinders, whereby parts of the cylinders are exposed and other parts covered in the zone of the reduced portion of the crank case, the said exposed portions of the cylinders having exhaust ports and the said covered portions induction ports, the crank case having openings between the cylinders through which the explosive mixture passes to the induction ports of the cylinders.

9. The combination with a crank shaft having a crank pin suitably offset from the axis of the shaft, a crank case inclosing the crank pin, cylinders whose inner extremities are inclosed by the crank case, the said case having an inner compartment in which the inclosed extremities of the cylinders are located, the said case also having an outer compartment of less transverse depth than the inner compartment, the transverse depth of the outer compartment being less than the diameter of the cylinders, whereby portions of the cylinders upon opposite sides are exposed in the zone of the outer compartment of the case, while other portions in the same zone are covered, the exposed portions hav-

ing exhaust ports and the covered portions induction ports, the crank case having openings between the cylinders, whereby the two compartments are placed in communication with each other, and filter members located in said openings for the purpose set forth.

10. The combination with a crank shaft of a crank case having inner and outer compartments, cylinders entering the crank case and passing through the two compartments, the cylinders having induction ports in communication with the outer compartment, and filter members located in openings formed in the partition between the two compartments through which the explosive mixture passes to supply the cylinders, substantially as described.

11. In an explosive engine, the combination of a crank shaft, a crank case having inner and outer compartments, cylinders passing through said compartments, the partition separating the compartments having openings between the cylinders, whereby the two compartments are placed in communication with each other and filtering members for the explosive mixture, removably mounted in said openings, the cylinders having induction ports in connection with the outer compartment of the crank case, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

EDWARD L. AURAND.

Witnesses:

A. J. O'BRIEN,  
ANNA LOUISE LEHMAN.