J. C. BONNETT.

GASOLENE ENGINE.

APPLICATION FILED MAR. 5, 1909.

956,881.

Patented May 3, 1910.

4 SHEETS—SHEET 1.

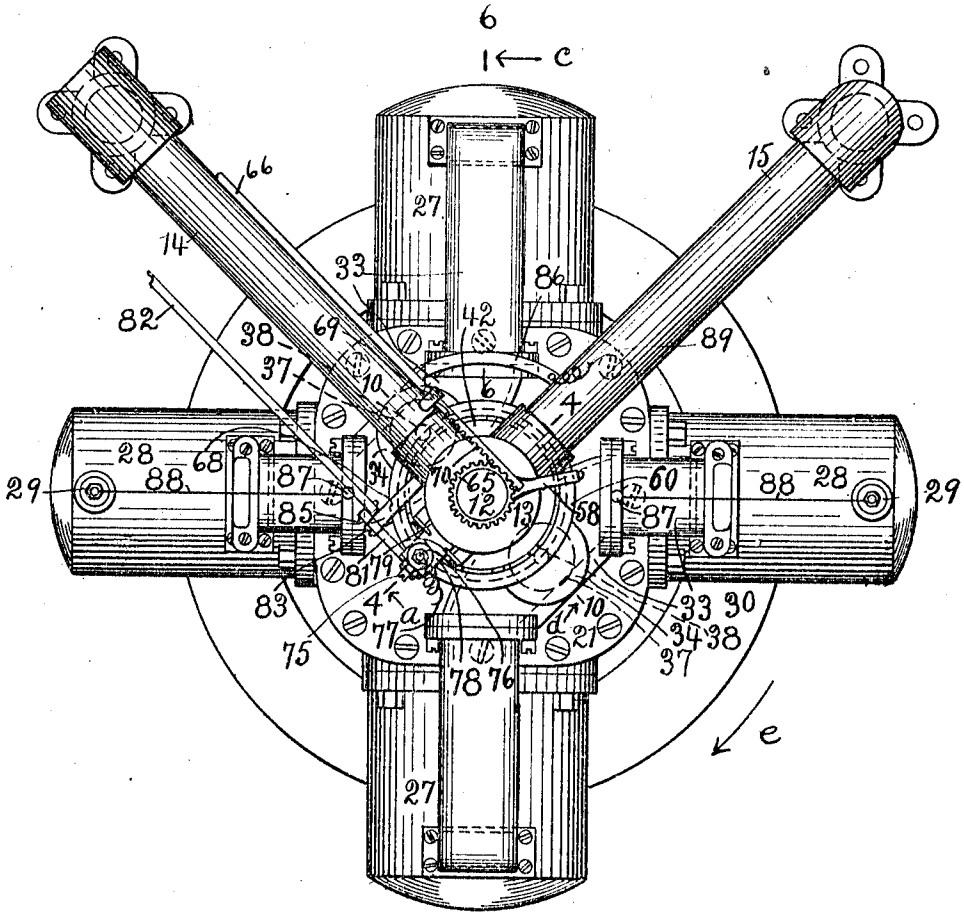

FIG. 1.

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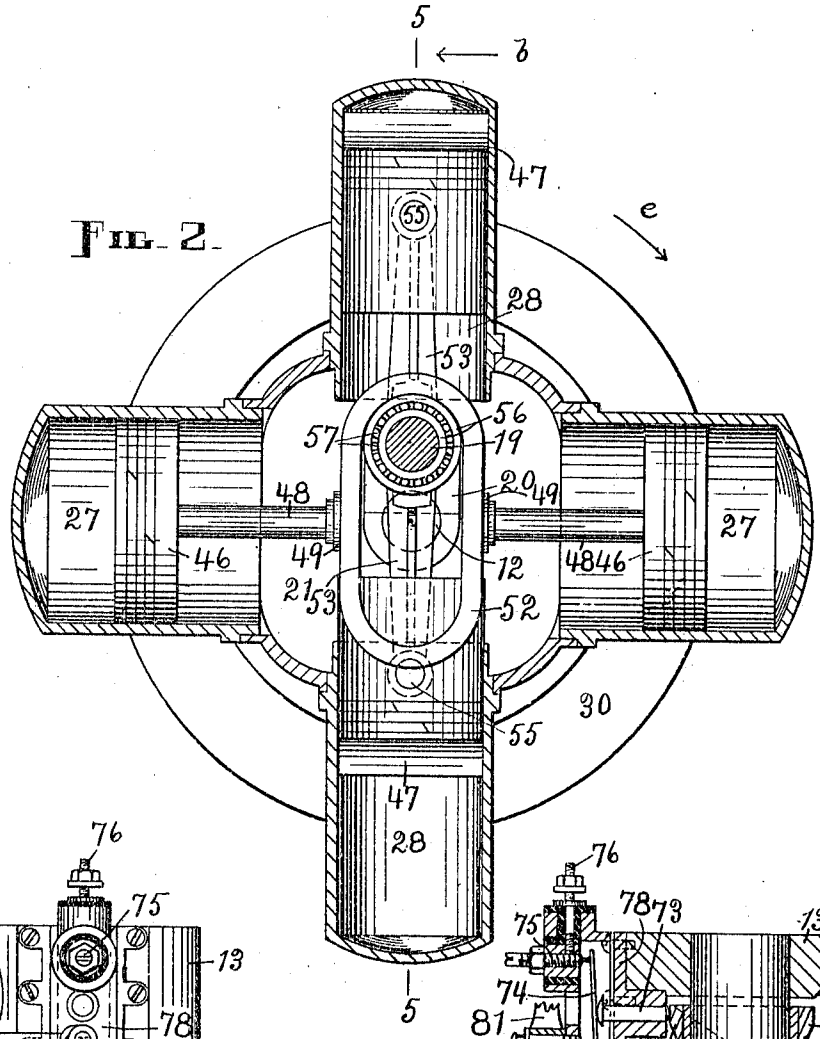
4 SHEETS—SHEET 2.

FIG. 2.



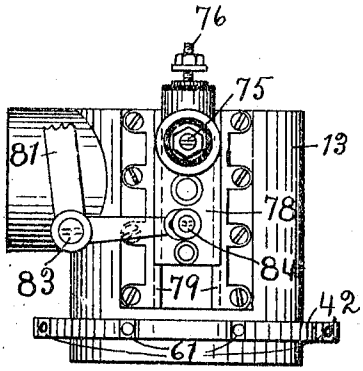


FIG. 3.

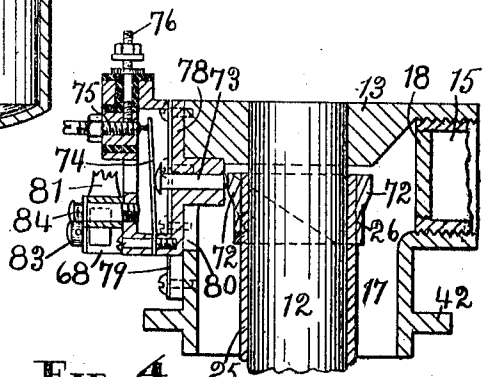


FIG. 4.

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4 SHEETS—SHEET 3.

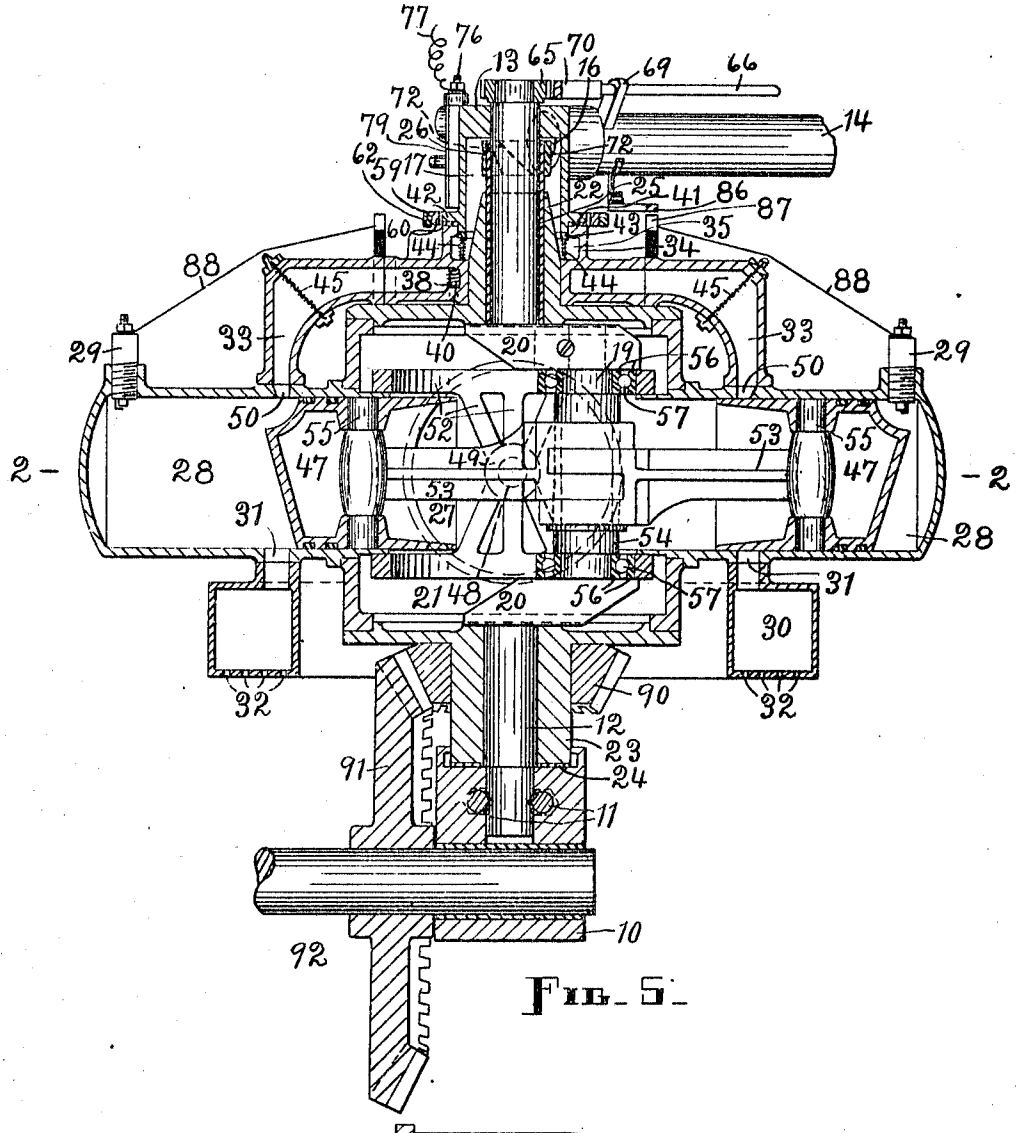

FIG. 5.

FIG. 6.

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4 SHEETS—SHEET 4.

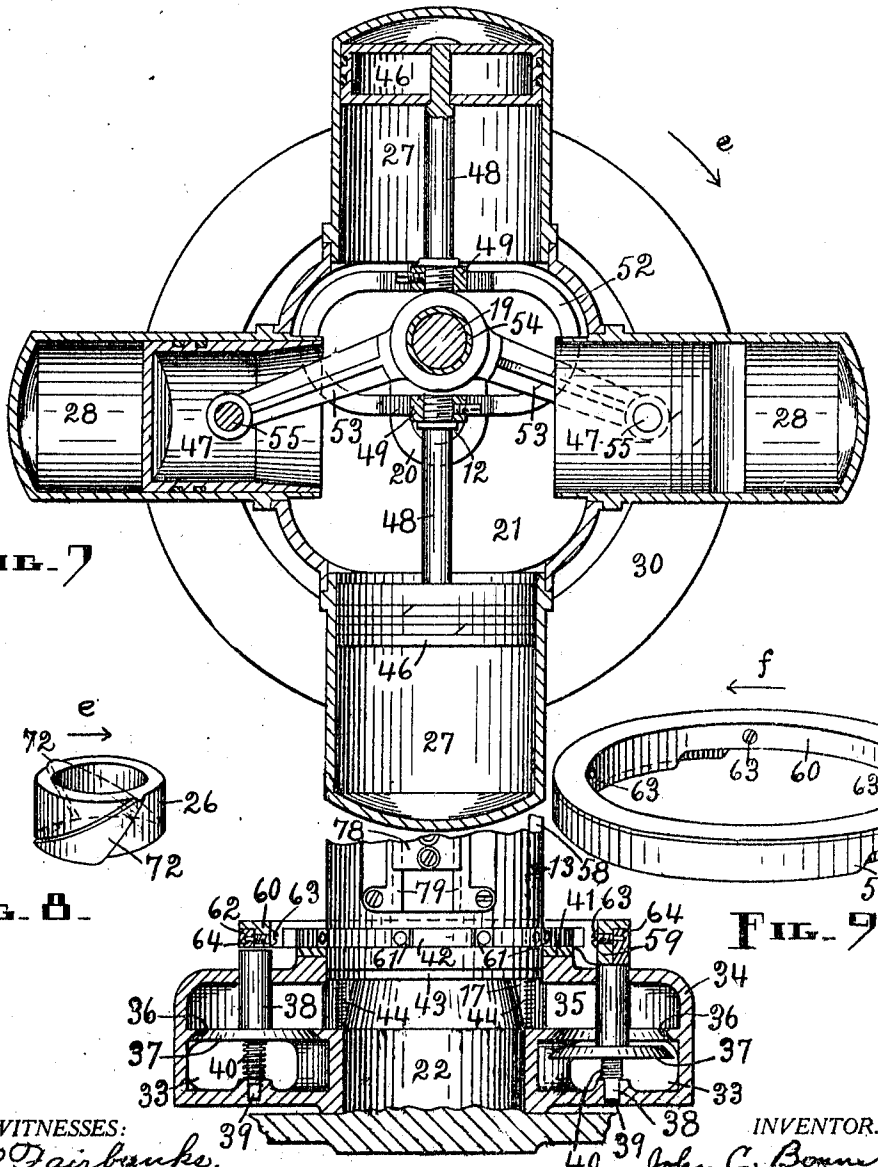

FIG. 7

FIG. 8

FIG. 9

FIG. 10

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UNITED STATES PATENT OFFICE.

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GASOLENE-ENGINE.

956,881. Specification of Letters Patent. **Patented May 3, 1910.**

Application filed March 5, 1909. Serial No. 481,300.

To all whom it may concern:

Be it known that I, JOHN C. BONNETT, a citizen of the United States of America, residing at New Haven, in the county of New Haven and State of Connecticut, have invented a new and useful Gasolene-Engine, of which the following is a specification.

My invention relates to improvements in two-cycle, gasolene engines having a vertical, fixed crank-shaft around which the cylinders revolve with such shaft as an axis, the cylinders themselves serving as a fly-wheel and being self-cooling, and each explosion cylinder receiving an explosive charge and transmitting power at each revolution. And said invention resides in the peculiar combination of moving elements for the purpose of balancing reciprocating and revolving parts, in the particular charging means for the explosion cylinders, in the particular igniting mechanism, and in the novel construction of the engine as a whole, all as hereinafter set forth.

In this engine, the charge is measured and compressed in a separate or charging cylinder, and then admitted to an explosion cylinder where it is further compressed before being fired, hence the maximum charge is determined or fixed by the size of said charging cylinder and is not limited to the amount of displacement of the piston in said explosion cylinder. When limited to the amount of the aforesaid displacement, the available charge is below or less than the full charge necessary in order to obtain the maximum effect from the piston driven thereby, and it is this lack of effectiveness that I overcome or avoid by compressing the charge in a separate charging cylinder in the way I do.

The object of my invention is to produce a light and simple, though strong and durable, gasolene engine, in which provision is made for the perfect balance of all reciprocating and revolving parts, also for the proper distribution of the explosive mixture. The perfect balance above referred to is secured by arranging the two pairs of pistons, with which this engine is equipped, so that although they are out of balance and in balance twice in each revolution of the cylinders one pair neutralizes the other pair and thus the balance is maintained at all speeds. The two sets of said pistons neutralize each other because when out of balance to the fullest extent they are 180° apart.

Other objects of my invention are to provide such an engine with means for delivering enough explosive mixture to an explosion cylinder to completely fill the same, without being limited in this matter by the amount of piston displacement, as hereinbefore noted; to rapidly and completely scavenge the explosion cylinders of the engine after the explosions therein take place, or, in other words, to remove the spent charges therefrom quickly and in a most thorough manner; to provide for a variable compression of the explosive mixture, so that the power of the engine can be varied to suit the load; and to afford full control of the ignition, or of the mechanism by means of which the spark is communicated to the charge, so that such spark can be advanced or retarded at will.

Provision is made, in this engine, to obviate back pressure, when a charge is throttled, by allowing the charging cylinder at all times to take unrestricted full charges, and providing for the escape of any excess when a full charge is not demanded at the moment, such excess passing into a chamber common to both of the charging cylinders. As a result of this, it is possible for the piston in one of the charging cylinders, while making its suction stroke to draw into its cylinder or inhale the surplus charge rejected by and expelled from the other charging cylinder during the action of the piston, in said last-mentioned cylinder, while making its compression stroke, consequently there may be no draft on the carbureter at the cycle of the engine in which this condition is present and this action occurs. The engine may be run, however, by throttling the charge at the carbureter in the usual way.

This engine is especially well adapted for automobile use, owing to its light weight and simple construction, and because the amount of adjustment required is so slight comparatively.

This type of engine, wherein the cylinders revolve instead of the crank-shaft, possesses advantages not found in the conventional type, one such advantage being that the

wear on the crank- and wrist-pins is reduced to the minimum, owing to the fact that the force of the explosion is largely neutralized by the centrifugal force of the pistons. Moreover, in this particular style of engine, an unusually large area of wearing surface is afforded by furnishing a crank-pin the length of which is equal to the diameter of the explosion-cylinder pistons.

By following the lines herein laid down, I am able to produce an exceedingly light and simple engine from which all but two valves and all auxiliary shafts and interior gears have been dispensed with, and wherewith as already intimated no fly-wheel is required, and no system of circulating water or other medium for cooling purposes, the high rate of speed of the cylinders at their outer ends insuring thorough cooling, which cooling, by the way, is in no sense dependent upon vehicle motion.

Either a frictional or gear drive of suitable construction may be applied to the engine, also suitable reversing mechanism, but it has been deemed necessary for the purposes of this application, merely to show a simple bevel-gear drive.

Further objects and advantages will appear in the course of the following description.

I attain the objects and secure the advantages of my invention by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a top plan view of an engine embodying a practical form of my invention; Fig. 2, a horizontal section through said engine, on lines 2—2, in Fig. 5, looking down and taken in the center just under the upper crank-arm and above the yoke, with the cylinders one-quarter of a revolution in advance of their positions in the first view; Fig. 3, an enlarged detail, in elevation, of the head-support, and of the sliding block and its operating bell-crank-lever which form parts of the ignition or sparking mechanism; Fig. 4, an enlarged detail, in section, on lines 4—4, looking in the direction of the arrow *a*, in Fig. 1, of the aforesaid head-support and sliding block, together with their sparking-mechanism members; Fig. 5, a central, vertical section through the engine, on lines 5—5, looking in the direction of the arrow *b*, in Fig. 2; Fig. 6, a longitudinal section through one of the charging cylinders, taken on lines 6—6, looking in the direction of the arrow *c*, in Fig. 1; Fig. 7, a horizontal section similar to that shown in Fig. 2, excepting that the cylinders are here disposed as in Fig. 1, one of the charging-cylinder pistons and one of the explosion-cylinder pistons are sectioned, and the cut in the center is made through the yoke eyes into which the connected piston-rods are screwed and through the crank-pin immediately above the uppermost plane at this point of the explosion-cylinder piston-rods; Fig. 8, an enlarged, perspective view of the operating cam for the explosive-mixture valves; Fig. 9, an enlarged, perspective view of the split cam, and, Fig. 10, an enlarged detail, in partial section, through portions of the head-support and head of the engine, taken on lines 10—10 below the supply pipe, looking in the direction of the arrow *d*, in Fig. 1, and showing the chamber which first receives the explosive mixture from the supply pipe and the distributing passages below, also the valves which control the escape of said mixture from said chamber to said passages, and the means for operating such valves.

The arrows *e* indicate the direction of rotation, of the parts to which they apply, around the axis of the engine.

Similar characters of reference designate like parts throughout the several views.

Although the engine herein illustrated and described is a practical embodiment of my invention, it is to be understood that I may depart more or less from the exact construction thereof as herein presented, more especially in the matter of shape, size, and minor details of construction and arrangement, and this without violating the spirit of said invention or exceeding the scope of the appended claims.

Passing now to a consideration of the engine as illustrated in the drawings, I will proceed to describe the same in detail, both as to construction and operation.

Supported at the lower end in and by a suitable base-block 10, Fig. 5, and secured thereto against rotation by means of oppositely-disposed pins 11 is a vertical crank-shaft 12. The crank-shaft 12 is firmly and securely held at the top by means of a head-support 13, which latter in turn is supported at the adjacent ends of two pipes 14 and 15 arranged at right-angles to each other and securely fastened in place at their rear ends. The pipe 14 brings the supply of explosive mixture from the carbureter (not shown) and empties at 16, Fig. 5, into a chamber 17 in the head-support 13 around the crank-shaft 12. The inner end of the pipe 15 is closed, as shown at 18, in Fig. 4, and the outer end of such pipe may be closed also and the pipe used as an oil tank, if desired. The crank-pin is represented at 19, and the crank-arms are represented at 20—20.

A crank-case 21 has upper and lower hubs 22 and 23, respectively, mounted to revolve on the crank-shaft 12. The lower hub 23 bears on the base-block 10, with a packing-ring 24 between, and the upper hub 22 extends into the chamber 17. The hub 22 is provided with a bearing bushing 25 which is between said hub and the crank-shaft and extends above the hub. The bushing 25 re-

volves and has a cam collar 26 tight on its upper end, such collar forming part of the ignition mechanism to be described hereinafter. Two oppositely-disposed compression or charging cylinders 27 and two oppositely-disposed firing or explosion cylinders 28 radiate from the four sides of the crank-case 21 and open into the same, the axes of the two pairs of cylinders being at right-angles to each other. At the upper end of each explosion cylinder 28, on top, is a spark-plug 29. An annular chamber 30, which constitutes a muffler for the exhaust, is supported below the cylinders. This chamber or muffler communicates with the interior of the explosion cylinders 28 through outlet or exhaust ports 31—31 located in the bottoms of said cylinders at the proper points to permit the spent charges to escape into said muffler, such points being adjacent to the inner end of the strokes of the pistons in said cylinders. The bottom of the muffler 30 is perforated, as shown at 32, to afford egress from said muffler for the spent gases which enter the same.

What may be termed the head of the engine, comprises two angular, hollow members 33 which have intermediate curved portions mounted on top of the crank-case 21 and downwardly-extending terminals mounted on the cylinders, and a hollow cap piece 34 which surrounds the hub 22 and extends over onto the aforesaid intermediate curved portions of said members 33. Each member 33 opens at one of its lower outer terminals through an inlet port 50 into one of the explosion cylinders 28, and through its opposite corresponding terminal in like manner into one of the charging cylinders 27. The inlet ports 50 are over the outlet ports 31, hence the horizontal branches of the members 33 which lead to the explosion cylinders are shorter than the horizontal branches which lead to the charging cylinders at or adjacent to their extreme outer ends. The inlet port to one of the charging cylinders appears at 51, in Fig. 6, and the inlet port to the other charging cylinder is similar in position, etc. The members 33 constitute distributers for the explosive mixture, and within the cap piece 34 is a receiving chamber 35 for such mixture, communication between said chamber and said distributers being through two oppositely-disposed valve-seats 36. Horizontal valves 37—37 are provided for the valve-seats 36, and these valves have vertical stems 38 which extend below said valves into recesses 39 in the floors of the distributers 33, and above said valves through openings in the top of the chamber 35. Spiral-springs 40 encircle the valve-stems 38 between the floors of the distributers and the valves to retain the latter normally in their closed positions against their seats. See Fig. 10. The office of the valves 37 will be made clear farther on in this description. The chamber 35 is below the chamber 17, and the latter opens freely into the former.

Since the head of the engine revolves while the head-support 13 with which said head contacts does not, it is necessary to provide tight joints between the two, and this I do in this case by inserting a packing-ring 41 between the central annular part of the cap piece 34 below and an external flange 42 which surrounds said head-support above, and by introducing an expansible packing-ring 43 within the bore in said cap piece, for the head support, against the bottom edge of the latter, springs 44 being employed to support said packing-ring 43 from the floor of the chamber 35 and to hold said ring tightly in place.

Strainers in the distributers 33, for the explosive mixture, are represented at 45—45. See Figs. 5 and 10.

From the description thus far given, it is plain that free communication may be had from the supply pipe 14 to the four cylinders through the chambers 17 and 35, the valve-seats 36 when open, and the distributers 33, and that one of each of the charging cylinders 27 and one of each of the explosion cylinders 28 are in communication with each other through the connecting distributer, or, in other words, the two charging cylinders are in communication with the two explosion cylinders, and vice versa, through the two distributers.

The oppositely-disposed cylinders of this engine are provided with pistons, and two of these pistons are directly connected by piston-rods with the crank-pin and two are indirectly connected by piston-rods with said crank-pin through some suitable means, as by a yoke; that is to say, the inner ends of two of said piston-rods are mounted on the crank-pin itself, while the inner ends of the other two piston-rods are not mounted on the crank-pin, but are connected with an intervening element, a yoke in this case, which latter is mounted on the crank-pin. It is by this construction and arrangement of the crank-pin connections, and by the general construction of the engine whereby such connections are made possible, that I am able to obtain the results elsewhere pointed out. These features as found in the present engine are described below.

Within each of the charging cylinders 27 is a piston 46, and within each of the explosion cylinders 28 is a piston 47. The two pistons 46 are provided with connecting rods 48—48 which have their inner terminals screwed into eyes 49 of a yoke 52 fulcrumed on the crank-pin 19, and the two pistons 47 are provided with connecting rods 53 which interlock at their inner terminals and are mounted on said crank-pin, the latter having

a bushing 54 which intervenes between it and inner ends of said rods 53, as best shown in Fig. 5. The outer ends of the rods 48 are rigidly attached to the pistons 46, while the outer ends of the rods 53 are pivotally connected with the pistons 47 by means of wrist-pins 55. The yoke 52 consists of two horizontal bands one above the other and each having parallel sides and semi-circular ends, which bands are connected at the sides in the center by suitable stays in which are formed the before-mentioned eyes 49. The axes of the charging cylinders and their pistons and piston-rods and of the eyes 49 all coincide at all times. The area inclosed by either band of the yoke 52 is that which is required for the crank-pin 19 in order to enable the pistons 46, attached to the piston-rods 48 which in turn are attached to said yoke, to make their full strokes as the cylinders 27 revolve about the crank-shaft 12 with such shaft as the axis of their revolution, and to make such full strokes, both of them, once at each of such revolutions. The construction and arrangement of the piston-rods 53 and of the coacting and coöperating parts, the latter including both active and inactive elements, are such as to enable both pistons 47 to make their full strokes at every revolution of the cylinders 28, as in the other case.

The yoke 52, which revolves about the crank-shaft 12 or its axis as the center of revolution, is located in the crank-case 21 between the crank-arms 20, and the interlocking terminals of the piston-rods 53 are situated between the horizontal planes of the bands of said yoke. The somewhat unusual form which I have adopted for the yoke is for the double purpose of economizing space and equalizing pressure. In order to reduce the friction between the crank-pin 19 and the yoke 52, ball-bearings consisting of rings 56 and balls 57 are provided. The lower rings 56 are on the crank-pin between the bottom crank-arm 20 and the bushing 54, and the upper rings 56 are supported on said pin by said bushing. The rings 56 are between the crank-pin and the bands of the yoke, with the balls 57 separating the outer rings from the inner in the usual manner.

The valve-stems 38, which are carried around with the head of the engine which revolves, may be depressed to open sequentially both valves 37 once at each revolution which the engine makes, through the medium of a split cam 59 supported from the non-rotary head-support 13, such cam projecting from above into the path of travel of said valve-stems, or the latter may be only held open by said cam, the act of opening having resulted from internal pressure thereon before the cam is reached. This cam is split so that its length can be increased or decreased for the purpose of maintaining each valve 37 open for a longer or shorter period as may be required for the proper running of the engine, it being possible to so arrange said cam that the valves 37 can not close at all. Part of the cam 59 is on the bottom of a ring 60 which is fastened to lugs 61 on the flange 42, and the other part of the cam is on the bottom of a ring 62 which fits the outside of said ring 60, the part of the cam on said ring 62 being outside of and lapping onto the other part of the cam. The ring 62 is under an outwardly extending flange on the ring 60, and is held up by means of a plurality of screws 63 inserted in said ring 60 from the inside and projecting into an annular channel 64 in said ring 62. These members are clearly illustrated in Fig. 10. Adjustment of the split cam 59 is effected through the medium of an angular arm 58, a pinion 65, and an operating rod 66 which latter, in practice, extends to a position where it can be actuated by the operator of the engine. The pinion 65 is revolubly mounted on the upper end of the crank-shaft 12 above the head-support 13, and one end of the arm 58 is rigidly attached to said pinion while the other end of said arm is rigidly attached to the ring 62, said arm extending out over the parts below and then downward for this last attachment. The rod 66 is slidingly-mounted in a support 69 which rises from the supply pipe 14, and on the inner terminal of said rod is a rack 70 which meshes with the pinion 65. See Figs. 1, 5, 9 and 10. By actuating the rod 66 outward, the ring 62 is partially rotated in the direction of the arrow *f*, in Fig. 9, through the medium of the rack 70, pinion 65, and arm 58, said ring rotating outside of the ring 60 on the outer, smooth terminals of the screws 63, and the split cam 59 is shortened; and by actuating said rod inward, the ring 62 is partially rotated in the opposite direction, through the same medium, and said cam is lengthened.

The jump-spark system of ignition is employed with this engine, and the mechanism therefor is described as follows, reference being had more particularly to Figs. 1, 3, 4 and 8: There are two oppositely-disposed cams 72, wider at the bottom and narrower at the top, on the rotary collar 26, and extending into the path of these cams is a horizontal, sliding plunger 73. It is the inner end of the plunger 73 which contacts with the collar 26 and its cams 72, while the outer end or head of said plunger impinges against a vertical spring 74 which carries at is upper free terminal a contact-point to close the circuit, at the time determined by said cams, by contacting with the inner end of a screw 75. A vertical binding-post 76 is arranged in contact with the screw 75, and a wire 77 leads from said binding-post to the coil (not shown), the circuit back

to the engine frame being completed through a battery or other source of electrical energy (not shown), as is customary. The screw 75 and the binding-post 76 are insulated, of course, and these together with the plunger 73 and the contact spring 74 are carried by and in a vertical block 78 slidingly-mounted on or in guides 79—79 attached to the outside of the head-support 13 above the flange 42 and opposite to the pipe 15. An opening 80 in the side of the head-support 13 behind the block or slide 78 admits the plunger 73 and some of the support therefor to the chamber 17, and is of sufficient length to allow for the necessary amount of vertical movement on the part of said plunger and support. The joints should be sufficiently tight in and around the slide and its connections to prevent the infusion of air from the outside into the explosive mixture in the chamber 17. The slide 78 is raised and lowered, by the operator of the engine, through the medium of a bell-crank-lever 81 and an operating rod 82. The bell-crank-lever 81 is pivoted at 83 to the end of a bar 68, attached to the underside of that part of the head-support 13 into which the supply pipe 14 is screwed. The forward terminal of the horizontal arm of the bell-crank-lever is operatively connected at 84 with the slide 74, and the upper terminal of the vertical arm of said lever is pivoted at 85 to the rod 82. With the slide 78 set, as shown in the drawings, it locates the plunger 73 in the path of the narrowest parts of the cams 72, so that the spark is late, as is best for slow speed, but by pushing inward the rod 82 and thus rocking the bell-crank-lever to depress said slide so as to bring said plunger into the path of wider parts of said cams, the spark lead is advanced accordingly, because the plunger is sooner contacted with by the cams, owing to the shape of the latter, and said speed is accelerated. In this last event, the contact between the plunger and each cam is longer, since the contacting portion of said cam is wider, hence the time of said contact is approximately the same as in the first instance, because the engine is now rotating faster—thus it is that this mechanism serves to maintain the time of contact approximately the same for all engine speeds. At each revolution of the engine and consequently of the cam collar 26, the plunger 73, which does not rotate with the revoluble parts of said engine, is actuated outward by first one cam 72 and then the other, and so causes the contact spring 74 to close the circuit twice, said circuit being broken each time that one of the cams passes beyond and clears said plunger and allows the latter to move inward under the influence of said spring. The tendency of the spring 74 is constantly to separate from the screw 75 and to press the plunger against the collar 26 and its cams, but the latter, nevertheless, when they encounter said plunger overcome the resistance offered by said spring and momentarily close the circuit, as explained.

Since the spark-plugs 29 revolve with the explosion cylinders 28 upon which they are mounted, it becomes necessary to provide some means for taking the electric current from its source and conducting it to said plugs, or, to state it differently, to complete the circuit, when closed by the spring 74, to one or the other of the two spark-plugs. To this end I suspend an insulated fixed plate 86, in the form of an arc of a circle, from the pipes 14 and 15, and mount an insulated upright 87 on each distributer 33 in position to pass beneath and in circuit-closing or circuit-forming relation to said plate as such upright is carried around by said distributer. Wires 88—88 connect the uprights 87 with the spark-plugs 29, and a wire 89 connects the plate 86 with one terminal of the usual secondary circuit.

The method of providing electric energy for firing purposes and the system of wiring for the same are common to engines of ordinary construction, with the exception of the circuit-forming members shown and to which particular attention has been called, and for this reason it has not been deemed necessary or desirable to illustrate or further describe such method and system. The arrangement and timing of parts is such that, whenever one of the uprights 87 is beneath the plate 86, the circuit is closed by the action of one of the cams 72 on the plunger 73 and the action of the latter on the contact spring 74, the electric current passes along the wire 88, which leads from the particular upright that is in circuit-forming relation to said plate, to the spark-plug 29 which is associated with said upright, and fires the charge in the cylinder 28 with the interior of which said plug communicates, the act of firing being accomplished or the actual explosion being produced in the usual way. The circuit-forming members with which this invention has to do especially may be said to comprise the contact spring 74, subject to the action of the cams 72 through the medium of the intervening plunger 73, the screw 75, the binding-post 76, the plate 86, the uprights 87, the wires 88, the spark-plugs 29, and the engine frame itself from which said contact spring and the spark-plug casings or shells are not insulated. It is not necessary that the circuit-forming uprights 87 touch the circuit-forming plate 86 when passing under it, so long as they pass close enough to complete the circuit.

Simple power-transmission mechanism, comprising a bevel-gear 90 tight on the hub 22 at the base of the crank-case 21, and a bevel-gear 91 tight on a horizontal shaft 92

having one terminal journaled in the base-block 10, the two gears being in mesh, is illustrated in Fig. 5.

Passing now to the consideration of the operation of the engine as a whole, it will be assumed that the parts are disposed as shown in Figs. 2 and 5, wherein the piston 47 in one of the explosion cylinders 28, the upper one in Fig. 2 and the right-hand one in Fig. 5, has fully compressed the charge in said cylinder and is on the point of passing the dead-center when it will be ready for the explosion to take place; the other piston 47, has uncovered both the exhaust port 31 and the inlet port 50 in the other explosion cylinder, the opening of said port 31, which occurs ahead of the opening of said port 50, having resulted first in reducing the pressure in said last-mentioned cylinder to atmospheric pressure, by reason of the escape of the gases confined in said cylinder into the muffler 30, and then when said port 50 is uncovered in expelling completely the little residue left of the old charge, by the incoming fresh charge of explosive mixture through said port 50, which forces said residue out through the port 31 into said muffler so that the cylinder is thoroughly scavenged, (in this connection it should be noted that the relative arrangement of the companion ports 31 and 50 and the construction of the pistons 47 insure the movement of the gases just explained); the aforesaid fresh charge from the charging cylinder 27 which is the companion of the second explosion cylinder, the left-hand one in Fig. 2, has been compressed by the piston 47 in said companion or second charging cylinder, and is now being forced through the open port 50 into the second explosion cylinder by said piston; and the piston 46 in the first or right-hand (Fig. 2) charging cylinder 27 has drawn and will draw in still more of the carbureted mixture which enters the chamber 17 at the opening 16, passes downward into the chamber 35, and from thence through the now open valve 37 in the distributer 33, which connects the first explosion cylinder with its charging cylinder, into said distributer. This valve 37 is forced downward against the resiliency of its spring 40, either by suction (or vacuum) or by the split cam 59, and is so held by said cam while the stem 48 of said valve passes beneath the same. The valves 37 are now disposed as shown in Fig. 10.

Although it is true that the suction produced by the charging pistons 46 would open the valves 37 without the aid of the cam 59, and may open them before said cam becomes effective, as hereinbefore intimated, said cam affords positive means of control for said valves; it holds each of them open a predetermined length of time, and provides, through the medium of its adjustable feature, for decreasing the amount of explosive mixture which the charging cylinders would probably inhale in the absence of this means of control at such times as it is desired to have the engine run light, more especially when traveling on grade with a comparatively light load or descending a hill.

Returning to the general operation of the engine again, let it be presumed that the jump-spark circuit is closed for an instant by one of the cams 72, and that in consequence the fully compressed charge in the first explosion cylinder 28 is fired just after said cylinder passes in the direction of the arrow *e*, beyond the position which it occupies in Fig. 2, and it will be clear that the impact of the explosion will cause the engine frame, including the case 21 and the four cylinders, to rotate on the crank-shaft 12 in the direction of said arrow. By the time the cylinders arrive at the positions which they occupy in Figs. 1 and 7, or at the end of about one-fourth of a revolution, the first explosion cylinder, that is, the one in which the discharge has just taken place, has commenced to exhaust into the muffler, its companion charging cylinder has inhaled a fresh charge through the open valve 37 and is full, the second charging cylinder piston has reached the end of its outward stroke after having compressed and forced into the second explosion cylinder, by way of the second distributer, the full charge for the same, and the piston in said second explosion cylinder is engaged in still further compressing such last-mentioned charge. At the next quarter revolution of the engine, the second explosion cylinder passes into position to be fired or rather to have its charge fired by the spark induced by the closing of the circuit by the second cam 72, its companion charging cylinder is sucking in a fresh charge through the second valve 37, which is the valve that was previously closed, the stem 38 of this second valve now being beneath the split cam, the first explosion cylinder has exhaled and is taking in through the first distributer the charge from the first charging cylinder, the piston in this the first charging cylinder having begun to compress the mixture previously sucked in to said cylinder as soon as the stem 38 of the first valve 37 rode clear of the split cam and said valve was closed by its spring 40 or by the back pressure on the valve of the mixture in said first distributer, and said first charging-cylinder piston is pushing the compressed charge in its cylinder into said first explosion cylinder by way of said first distributer.

The foregoing describes what takes place at one half of a revolution of the engine, and need not be restated to describe what takes place at the other half of the same revolution for the reason that the former operations are then repeated, there being two

explosions and two pulsations imparted to the engine thereby at each cycle of said engine.

It will be understood that, when the jump-spark circuit is closed by one or the other of the cams 72, one or the other of the uprights 87 is in circuit-forming relation to the plate 86. The spark is advanced by depressing the slide 78 so as to cause the circuit to be closed quicker by the earlier contact of one of the cams 72 with the plunger 73, and to remain closed a sufficient length of time for the current to produce the spark required. The peculiar shape of the cams 78 is responsible for the quicker closing and the longer contact in point of degree when the slide 78 is depressed, as is obvious. This change or adjustment is resorted to when greater speed is desired, since less time elapses between the pulsations when the wide portions of the cams 78 are in service.

By arranging and connecting the cylinders as I do, neither charging-cylinder piston reaches the end of its compression stroke until the piston in the associated or companion cylinder has reached the inner end of its stroke and commenced to return, consequently the charging-cylinder charge is compressed slightly and then delivered through one of the distributers, to the proper explosion cylinder while the inlet port to said cylinder is uncovered to receive it, and this charge is actually pushed, to use a term which has already been employed in this connection, in to said explosion cylinder through said port, from the time said port is opened until it is again closed by the piston in said cylinder, by the piston that originally compressed the charge, and it is in this manner that a very much larger charge can be introduced into an explosion cylinder than is possible with crank-case compression. This combination of piston-rods and yoke working on a single crank effects the thorough balancing of all rotary and reciprocating parts to which attention was drawn in the early part of this specification. In Figs. 1 and 7, the pistons 47 have reached their maximum unbalanced condition, which condition immediately commences to improve and continues to improve gradually until said pistons arrive at the positions which they occupy in Fig. 2, where they are in perfect balance. Similarly, in Figs. 1 and 7, the pistons 46 have reached their maximum unbalanced condition, and like the other two pistons said pistons 46 reach a perfectly balanced condition in 90° of revolution, or when they stand as shown in Fig. 2. The axes of the two sets or pairs of balanced pistons and of their cylinders are at right-angles to each other and each cylinder is opposite to or has its axis in line with the other cylinder of like character. Thus it will be readily seen that the combined unbalanced forces oppose each other at diametrically opposite points, and that they approach and recede in exact synchronism and so neutralize each other. A more perfect balance is here obtained than is possible with any other type of engine.

Although illustrated and described as a vertical engine, it is conceivable that the same might be converted into a horizontal engine without materially affecting or changing the invention, at least not from a patentable standpoint.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. A rotary engine comprising a fixed crank-shaft, a rotary crank-case on said shaft and provided with a plurality of charging and explosion cylinders, the two types of cylinders being separate from and independent of each other, pistons in said cylinders, a member mounted to rotate and reciprocate on the crank-pin, piston-rods connecting certain of said pistons with said member, and piston-rods connecting certain others of said pistons with said pin.

2. A rotary engine comprising a fixed crank-shaft, a rotary crank-case mounted on said shaft and provided with alternately-arranged charging and explosion cylinders, pistons in said cylinders, and connecting means between said pistons and the crank-pin of said shaft, such means comprising a member mounted to rotate and reciprocate on the crank-pin, piston-rods connecting the charging-cylinder pistons with such member, and piston-rods connecting the explosion-cylinder pistons with said pin, and being arranged and adapted to reach a perfectly balanced condition in every 90° of revolution, whereby an approximately perfectly balanced condition of the engine obtains at each degree of revolution.

3. The combination, in a rotary engine, of a fixed crank-shaft, a rotary crank-case mounted on such shaft and provided with oppositely-disposed charging cylinders and oppositely-disposed explosion cylinders, pistons in said cylinders, a yoke mounted to rotate and reciprocate on the crank-pin of said shaft, with the latter as its center of rotation, piston-rods connecting the charging-cylinder pistons with said yoke, and piston-rods connecting the explosion-cylinder pistons with said pin.

4. The combination, in a two cycle rotary engine, with a double-banded yoke having parallel sides and semi-circular ends to receive a crank-pin, of piston-rods attached to said yoke intermediate of its ends and bands and standing at right-angles to a line connecting the axes of such ends.

5. The combination, in a two-cycle rotary engine, of a vertical fixed crank-shaft, a rotary crank-case mounted on such shaft and provided with oppositely-disposed

charging cylinders, pistons in said cylinders, a yoke mounted to rotate and reciprocate on the crank-pin of said shaft, such yoke being out of contact with said crank-case, rings separated by balls between said yoke and pin, and piston-rods connecting the charging-cylinder pistons with said yoke.

6. The combination, in a rotary engine, with a fixed crank-shaft, a rotary crank-case mounted on such shaft and provided with oppositely-disposed cylinders for charging purposes only and oppositely-disposed explosion cylinders, pistons in such cylinders, and piston-rod connections with the crank-pin of said shaft, said connections including a yoke mounted to rotate and reciprocate on said crank-pin and with which the charging-cylinder piston-rods are connected, of distributers carried by rotary parts of the engine, each of said distributers opening at opposite ends into companion charging and explosion cylinders.

7. The combination, in a rotary engine, with a fixed crank-shaft, a rotary crank-case mounted on such shaft and provided with oppositely-disposed charging cylinders and oppositely-disposed explosion cylinders, pistons in such cylinders, and piston-rod connections with the crank-pin of said shaft, of distributers carried by rotary parts of the engine, each of said distributers opening at opposite ends into companion charging and explosion cylinders, and a chamber common to both of said distributers and opening into the latter intermediate of their ends.

8. The combination, in a rotary engine, with a fixed crank-shaft, a rotary crank-case mounted on such shaft and provided with oppositely-disposed charging cylinders and oppositely-disposed explosion cylinders, pistons in such cylinders, and piston-rod connections with the crank-pin of said shaft, of distributers carried by rotary parts of the engine, each of said distributers opening at opposite ends into companion charging and explosion cylinders, a chamber common to both of said distributers and opening into the latter intermediate of their ends, and valves in the openings between said chamber and the distributers.

9. The combination, in a rotary engine, with a fixed crank-shaft, a rotary crank-case mounted on such shaft and provided with oppositely-disposed charging cylinders and oppositely-disposed explosion cylinders, pistons in such cylinders, and piston-rod connections with the crank-pin of said shaft, of distributers carried by rotary parts of the engine, each of said distributers opening at opposite ends into companion charging and explosion cylinders, a chamber common to both of said distributers and opening into the latter intermediate of their ends, valves in the openings between said chamber and the distributers, and normally fixed means arranged to sequentially open said valves as they revolve with the parts which carry them.

10. The combination, in a rotary engine, with a fixed crank-shaft, a rotary crank-case mounted on such shaft and provided with oppositely-disposed charging cylinders and oppositely-disposed explosion cylinders, pistons in such cylinders, and piston-rod connections with the crank-pin of said shaft, of distributers carried by rotary parts of the engine, each of said distributers opening at opposite ends into companion charging and explosion cylinders, a chamber common to both of said distributers and opening into the latter intermediate of their ends, valves in the openings between said chamber and the distributers, normally fixed means arranged to sequentially open said valves as they revolve with the parts which carry them, and means to so adjust said valve-opening means as to increase or decrease the length of time during which the valves will be held open.

11. The combination, in a rotary engine, with a distributer for the explosive mixture, a chamber opening into such distributer, a valve adapted normally to be operated by the action of the gases in the engine to open and close such opening, and a stem for such valve, these members being rotatable about a common center, of a speed-regulating cam positioned in the path of travel of said valve-stem.

12. The combination, in a rotary engine, with a distributer for the explosive mixture, a chamber opening into such distributer, a valve adapted to close such opening, and a stem for such valve, these members being rotatable about a common center, of a split cam positioned in the path of travel of said valve-stem.

13. The combination, in a rotary engine, with a distributer for the explosive mixture, a chamber opening into such distributer, a valve adapted to close such opening, and a stem for such valve, these members being rotatable about a common center, of two rings provided with overlapping cam members which extend into the path of travel of said valve-stem and constitute a cam adapted to cause the valve-stem to be actuated inward and so to open its valve, one of such rings being adjustable for the purpose of lengthening or shortening said cam.

14. The combination, in a rotary engine, with a fixed crank-shaft and a fixed head-support therefor, such head-support having a supply chamber therein, of a rotary crank-case mounted on such shaft and provided with radial alternately arranged charging and explosion cylinders having pistons therein connected with the crank-pin of said shaft, distributers carried by rotary parts of

the engine and each opening into companion charging and explosion cylinders, and a cap piece rotatably mounted in operative relation to said distributers and having a chamber that opens into the distributers and is in open relation to said first-mentioned chamber.

15. The combination, in a rotary engine, with a fixed crank-shaft, a fixed head-support for such shaft, such head-support having a receiving chamber therein for the explosive mixture, and a supply pipe opening into such chamber, of a rotary crank-case mounted on such shaft and provided with radial alternately arranged charging and explosion cylinders having pistons therein connected with the crank-pin of said shaft, distributers carried by rotary parts of the engine and each opening into companion charging and explosion cylinders, and a cap piece rotatably mounted in operative relation to said distributers and having a chamber that opens into the distributers and is in open relation to said first-mentioned chamber.

16. The combination, in a rotary engine, with tubular supporting members and a head-support attached to adjacent ends of such members, such head-support having a chamber therein for the explosive mixture, a fixed crank-shaft having one terminal within such head-support, and rotary mixture-receiving members mounted on said shaft in operative relation to the chamber in said head-support.

17. The combination, in a rotary engine, of a fixed crank-shaft, a revoluble crank-case mounted on said shaft and provided with oppositely-disposed cylinders for charging purposes only and oppositely-disposed explosion cylinders, pistons in said cylinders, connecting means between said pistons and the crank-pin of said shaft, and distributers mounted on rotary parts of the engine, each of such distributers opening at one terminal into one of said charging cylinders at its outer end, and opening at the other terminal into one of said explosion cylinders at a point adjacent to the inner end of the stroke of the piston therein.

18. The combination, in a rotary engine, of a fixed crank-shaft, a revoluble crank-case mounted on such shaft and provided with oppositely-disposed cylinders for charging purposes only and oppositely-disposed explosion cylinders, pistons in said cylinders, connecting means between said pistons and the crank-pin of said shaft, and distributers mounted on said case and opening at their ends into the two pairs of associated charging and explosion cylinders, the openings from said distributers into said explosion cylinders being at points adjacent to the inner ends of the strokes of the pistons therein, the explosion cylinders also opening for the exhaust at points adjacent to the inner ends of the strokes of the aforesaid explosion-cylinder pistons.

19. The combination, in a rotary engine, with a fixed crank-shaft, the revoluble members of the engine, fixed and revoluble jump-spark circuit-forming members supported and carried by fixed and revoluble parts of the engine, and means to complete at regular intervals the circuit between said fixed and revoluble circuit-forming members, of a member mounted on a revoluble part of the engine and provided with a cam which is wider in some parts than in others, a yielding circuit-closing member in the path of said cam, and means to adjust said circuit-closing member in a direction substantially parallel with the axis of the cam member.

20. The combination, in a rotary engine, with a fixed crank-shaft, and the revoluble members of the engine, of fixed and revoluble jump-spark circuit-forming members supported and carried by fixed and revoluble parts of the engine, means to complete at regular intervals of time the circuit between said fixed and revoluble circuit-forming members, and means, including a rotary double cam member and a slidingly-adjustable circuit-closing plunger in the path of the cams on such member, to make and break the jump-spark circuit twice at each revolution of the engine, at longer or shorter intervals in which both time and space are factors.

21. The combination, in a rotary engine, with the revoluble parts of the engine, and spark-plugs and circuit-forming members, in circuit, carried by said revoluble parts, such circuit-forming members including insulated uprights, of a stationary plate supported in the path, electrically, of said uprights, and means to complete the circuit to said plate.

22. The combination, in a rotary engine, with the revoluble parts of the engine, and spark-plugs and circuit-forming members, in circuit, carried by said revoluble parts, of a stationary plate in the path, electrically, of said circuit-forming members, and means, including a rotary cam member and a slidingly-adjustable circuit-closing plunger in the path of the cam on such member, to complete the circuit to said plate.

23. The combination, in a rotary engine, with the revoluble parts of the engine, and spark-plugs and circuit-forming members, in circuit, carried by said revoluble parts, of a stationary plate in the path, electrically, of said circuit-forming members, and means, including a rotary double cam member and a slidingly-adjustable circuit-closing plunger in the path of the cams on such member, to make and break the circuit to said plate twice at each revolution of the engine.

24. The combination, in a rotary engine,

with the revoluble parts of the engine, spark-plugs and circuit-forming members, in circuit, carried by said revoluble parts, and a stationary plate in the path, electrically, of said circuit-forming members, of means, comprising two rotary cams and a spring-pressed plunger in the path of such cams, to make and break the circuit to said plate twice at each revolution of the engine, and means to change the position of said plunger relative to the cams to advance in point of time the making of such circuit, the plunger-contacting portion of each of said cams varying in width.

25. The combination, in a rotary engine, with a fixed crank-shaft, a revoluble crank-case mounted on such shaft and provided with explosion cylinders having pistons therein and spark-plugs thereon, and driving connections between said pistons and the crank-pin of said shaft, of a revoluble sleeve on said shaft and attached to said crank-case, cams mounted on said sleeve, circuit-closing means, an operating plunger for such circuit-closing means, such operating plunger being mounted in a non-rotary part of the engine and extending into the path of said cams, and circuit-forming connections between said circuit-closing means and said spark-plugs.

26. The combination, in a rotary engine, with a fixed crank-shaft, a revoluble crank-case mounted on such shaft and provided with explosion cylinders having pistons therein and spark-plugs thereon, and driving connections between said pistons and the crank-pin of said shaft, of cams mounted to revolve with said case, such cams being wider at some points than at others, a non-rotary longitudinally-movable slide, circuit-closing means consisting in part of a movable plunger carried by said slide and extending into the path of said cams, the time of contact with the cams and the duration of such contact in point of degree being determined by the position of the slide, and circuit-forming connections between said circuit-closing means and said spark-plugs.

27. An engine comprising a crank-shaft, a crank-case provided with a plurality of cylinders oppositely disposed, the axes of said shaft and case coinciding, pistons in such cylinders, a yoke mounted on the crank-pin, piston-rods connecting two of said pistons which are oppositely disposed with said yoke, and piston-rods connecting the other two pistons which are oppositely disposed with said crank-pin, whereby the pistons are so positioned at the time of their maximum unbalanced condition as to bring the forces exerted by them at diametrically opposite points, and whereby such forces are caused to approach and recede in practically exact synchronism.

JOHN C. BONNETT.

Witnesses:
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CHAS. A. PATCHEN.