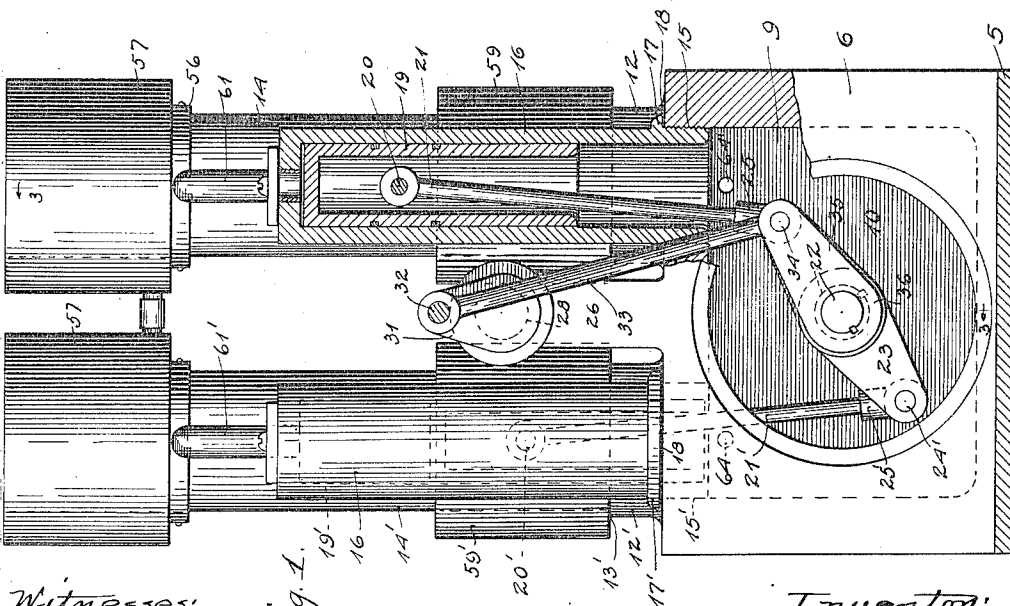
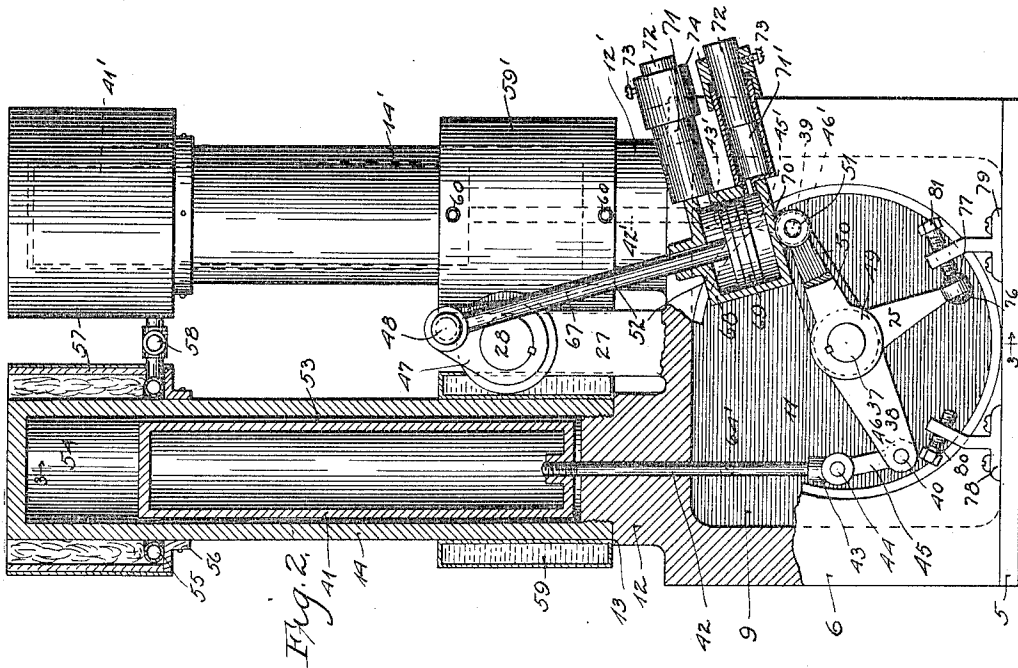


C. A. ANDERSON.
CARBON DIOXID ENGINE.
APPLICATION FILED JAN. 19, 1911.

1,037,190.

Patented Sept. 3, 1912.

2 SHEETS—SHEET 1.



Witnesses:
Charles J. Schmidt.
Nellie B. Dearborn.

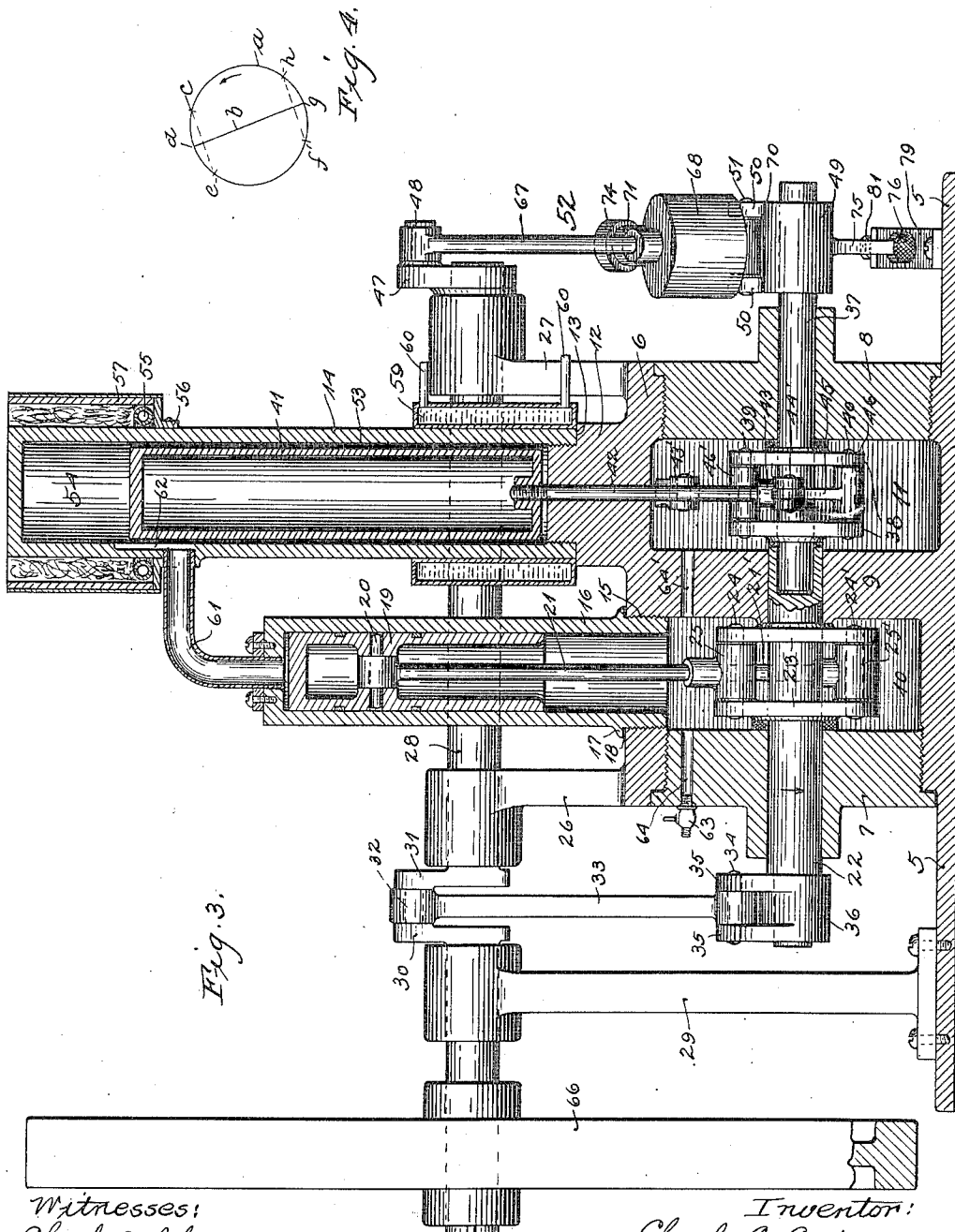
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Witnesses:
 Charles J. Schmitt.
 Willie B. Dearborn.

Inventor:
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UNITED STATES PATENT OFFICE.

CHARLES A. ANDERSON, OF CHICAGO, ILLINOIS.

CARBON-DIOXID ENGINE.

1,037,190.

Specification of Letters Patent.

Patented Sept. 3, 1912.

Application filed January 19, 1911. Serial No. 603,425.

To all whom it may concern:

Be it known that I, CHARLES A. ANDERSON, a resident of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Carbon-Dioxid Engines, of which the following is a specification.

My invention relates to carbon dioxid engines, particularly to that class of engines in which the driving gas is alternately heated and cooled.

Among the important objects of my invention are to provide an arrangement in which a number of driving sets can be used, each involving a power element for driving a common main shaft and a displacement element in which the gas is alternately heated and cooled and the resultant pressure applied to the power elements; to provide an arrangement in which the displacement elements are controlled from the power delivered by the power elements; to provide an arrangement in which displacement pistons are quickly moved from one end to the other of their stroke and are caused to remain at rest for a period of time after reaching the limits of their strokes, in order to allow more efficient application and use of the heated or cooled gas by the power elements; to provide improved adjustable flexible or yielding mechanism for controlling the operation of the displacement pistons; and in general to provide for improved and more efficient construction and operation of engines of the class referred to.

In the accompanying drawings, which illustrate all the features of my invention, Figure 1 is a side elevational view of the engine looking from the left, parts being removed and broken away, Fig. 2 is a side elevational view looking from the right, with parts removed and broken away, Fig. 3 is a sectional view taken substantially on planes 3—3, Figs. 1 and 2, and Fig. 4 is a diagrammatic view illustrating the movements of the engine parts.

The main supporting bed plate 5 of the engine supports a casing 6 whose left and right ends have removable circular wall sections 7 and 8 respectively having threaded engagement with the casing, as shown. An intermediate wall 9 divides the casing into chambers 10 and 11. As best shown in Fig. 2, similar cylindrical bosses 12 and 12' extend upwardly from the top wall of the casing, their upper ends being of reduced

diameter so as to leave annular seats 13 and 13' for receiving the displacement cylinders 14 and 14' respectively, the lower ends of the cylinders being internally threaded to engage the threaded upper ends of the bosses, as shown, the bosses then forming the lower wall of the displacement cylinders. As best shown in Fig. 1, the top wall of the casing at the opposite end from the bosses has threaded openings 15 and 15' communicating with chamber 10, and in these openings are threaded the lower ends of the power cylinders 16 and 16', the lower open ends of these power cylinders then communicating with chamber 10. The power cylinders are preferably provided in their lower ends with annular flanges 17 and 17' respectively for seating against the casing top with gaskets 18 interposed. Within the power cylinders are the pistons 19 and 19' respectively, which are hollow, as shown, and which support pivot pins 20 and 20' respectively for pivotally receiving the upper ends of pitman rods 21 and 21', these rods extending downwardly through openings 15 and 15' and into chamber 10. Journaled axially in end wall 7 and intermediate wall 9 is a shaft 22 to which is keyed a walking beam structure 23 supporting pivot pins 24 and 24'. The lower end of pitman rod 21 terminates in a head 25 which is pivoted to pin 24 between the walking beam sides, and pitman rod 21' terminates in a head 25' which pivots to pin 24' of the walking beam, the pivot centers of the pins being diametrically opposite and equidistant from the center of the shaft supporting the walking beam. Journaled in bearing extensions 26 and 27 extending upwardly from the casing 6 is the main shaft 28 which extends parallel with shaft 22 and midway between the power cylinders and the displacement cylinders. The shaft at its left end is further journaled in a standard 29 extending upwardly from the bed of the machine, and between the bearing supports 26 and 29 the main shaft carries the crank arms 30 and 31 connected by a crank pin 32. This crank pin pivotally receives the upper end of a connecting rod 33 whose lower end is pivoted by means of pin 34 to the arms 35 of a crank frame 36 secured to the left end of shaft 22 outside of the walking beam casing. The adjustment is such that the radius of rotation of pin 32 is less than the radius of rotation of pins 24 and 24', so

that pin 32 and the main shaft will make complete revolutions while the walking beam 23 will merely oscillate. As shown, the radial distance of pin 34 is equal to that of pins 24 and 24' from the center of shaft 22, while the radial distance of pin 32 from the center of the main shaft is less. As the power pistons are reciprocated in opposite directions walking beam 23 will oscillate and the main shaft will receive full revolutions.

A shaft 37 of less diameter than shaft 22 is journaled axially in end wall 8, and in the inner end of shaft 22, as indicated in Fig. 3. Keyed to this shaft is a walking beam frame 38 supporting between the ends of its side walls pins 39 and 40, which are diametrically opposite and equi-distant from the shaft center. Within displacement cylinder 14 is a hollow closed displacement cylinder 41 from whose lower end extends a piston rod 42 which extends through and has sliding bearing in the boss 12, the piston rod terminating at its lower end in a bifurcated head 43 supporting pivot pin 44 to which is pivoted the upper end of a link 45 whose lower end terminates in the hub 46 pivoted to pin 40 between the sides of walking beam 38. Likewise, in displacement cylinder 14' is the displacement piston 41' from whose lower end extends piston rod 42' which extends through and has sliding bearing in the boss 12', the lower end of this piston rod terminating in a bifurcated head 43' which pivots the upper end of link 45' whose lower end terminates in the hub 46' receiving the pivot pin 39 of the walking beam 38. Secured to the right end of main shaft 28 is a crank frame 47 having the crank pin 48, and secured to the right end of shaft 37 is a hub 49 having parallel crank arms 50 carrying a crank pin 51. Between crank pins 48 and 51 is interposed pitman or connecting rod mechanism characterized as a whole 52, and the details of which will be explained later. The radius of rotation of crank pin 48 is less than that of the walking beam pins 39 and 40 so that while the crank frame 47 and crank frame 48 will rotate through complete revolutions with the main shaft 28, the walking beam frame 38 will merely oscillate. As the main shaft is therefore positively rotated upon oscillation of walking beam 23 driven by the power pistons, the walking beam 38 will be oscillated, due to its connection with the main shaft just described, and the displacement pistons will be reciprocated in opposite directions in their cylinders. The relative angular position of the walking beams is also such that a power piston and its associated displacement piston will always be moving in opposite direction, as clearly shown in Fig. 3.

The length of each displacement piston is less than the length of its associated cylinder,

and the external diameter of each piston is slightly less than the internal diameter of its cylinder. Therefore when either displacement piston is at one end of its cylinder there will be a compartment at the other end of the cylinder, and the difference in diameters will provide a narrow annular space or by-pass 53 between each piston and its cylinder. Referring to Fig. 1, piston 41 is at the lower end of its cylinder 14 to leave a compartment 54 between the top of the piston and the top of the cylinder. The upper part of the cylinder adjacent this compartment is surrounded by heating mechanism for highly heating the cylinder walls adjacent the compartment. As shown, the heating mechanism comprises a circular burner 55 mounted on the annular shelf 56 secured to the cylinder, and the flames from the burner are confined against the cylinder walls by an annular inclosure 57 mounted on the shelf 56. The top of cylinder 14' is similarly surrounded by heating mechanism, and these heating mechanisms may in gas burners be supplied from a common pipe 58 (Fig. 2). The lower end of cylinder 14 is surrounded by an annular water jacket 59 resting on the shoulder 13 of the boss 12 supporting the cylinder, and likewise the lower part of cylinder 14' is surrounded by a water jacket 59' resting on boss 12', piping 60 being suitably connected with the upper and lower parts of the jackets in the manner well understood, to cause circulation through the jackets of cooling medium, such as water. In practice, therefore, the upper end of each displacement cylinder will be highly heated and the lower part thereof will be cold, these extremes in temperature acting on the driving gas of the engine to cause great expansion and contraction thereof. As best shown in Fig. 3, a pipe 61 connects the upper part of power cylinder 16 with the top of the associated displacement cylinder 14, and where such connection is made below the heating compartment 54 of the displacement cylinder the wall of the cylinder may be grooved to form a port 62 for more rapidly conveying the hot high pressure gas from compartment 54 to the power cylinder. Likewise, a pipe 61' connects the upper end of power cylinder 16' with the heating compartment of the associated displacement cylinder 14'.

From the description thus far the operation of the engine can be clearly understood. The engine shown of course has two operating sets, each comprising a power element and an associated displacement element, and it will be necessary only to describe the cycle of operation of one set, which is shown in section in Fig. 3. To start the engine it is first charged with gas under pressure. Different kinds of gas could of course be used, but on account of its inert chemical

nature and its high co-efficient of contraction and expansion I preferably employ carbondioxid gas. The valve 63 shown as mounted on end wall 7 is connected with a source of compressed gas and is open to allow the gas to enter first compartment 10 through the passageway 64 and then compartment 11 through the passageways 64' extending to intermediate wall 9 between the compartments. This gas, say 800 pounds per square inch pressure, will force its way between the various bearing surfaces to the power cylinders and displacement cylinders until the pressure is of 800 pounds throughout the chambers and cylinders, whereafter valve 63 is closed, the crank chambers as well as the cylinders being then entirely sealed. The burners are now lighted and the water circulated through the cooling jackets. As indicated in Fig. 3, the power piston is up and the displacement cylinder down. As the gas in compartment 54 becomes highly heated its volume is very much increased and its pressure correspondingly raised say to about 1200 pounds per square inch. During operation of the engine there will therefore be 400 pounds per square inch initial pressure on the pistons. Piston 19 being forced downwardly by the expanding gas will turn the shaft 22, which rotation is transmitted through connecting rod 33 to main shaft 28, the walking beam 23 being oscillated and the main shaft revolved. This rotation of the main shaft is transmitted to crank frame 47 and through connecting mechanism 52 to shaft 37 to oscillate walking beam frame 38 and to reciprocate the displacement pistons. Therefore, as piston 19 moves downwardly the displacement piston 41 is carried upwardly. As the displacement piston moves upwardly the hot gases remaining in compartment 54 are displaced and flow downwardly through the thin annular space 53 and through the cooling compartment now formed at the bottom of the displacement cylinder adjacent the water jacket, the gas being primarily rapidly cooled by passing as a thin film through annular passageway 53 adjacent the water jacket, and then finally cooled by the surrounding water jacket, and its volume and pressure greatly diminished. The main shaft carries a fly wheel 66, and the inertia of this fly wheel will of course tend to cause the power piston to return to its upward position. However, the pressure of the cooled gas quickly falls below that of the gas in the walking beam compartments, and the difference in pressure acting on the lower part of the power piston will force this piston upwardly, the resultant rotation of the main shaft being transmitted to the walking beam 38 and the displacement pistons, the piston 41 being returned to its lower position to force the cold gases upwardly back to com-

partment 54. The cold gases passing in a thin film through annular space 53 adjacent the hot power end of the cylinder will be primarily quickly heated and then finally heated in compartment 54 by coming in contact with the highly heated adjacent walls of the cylinder, and the pressure quickly exceeding that of the pressure in the walking beam compartments, the power piston is again driven downwardly. Thus, the gas is alternately highly heated and greatly cooled at opposite ends of the cylinder, and the resulting difference in pressure acting on the power piston will cause reciprocation thereof to drive the main shaft. Both engine sets of course operate simultaneously to drive the main shaft, the two power pistons operating always in opposite direction, and likewise the two pistons always operating in opposite direction on account of the interconnections hereinbefore described.

It is very desirable that the full volume of gas be retained in either the heating or cooling compartments until the pressure resulting from heating or cooling will have had ample time to thoroughly and efficiently act on the power pistons. I have therefore devised the improved form of connecting rod mechanism 52 between the main shaft and shaft 37 for causing the displacement cylinders to undergo periods of rest when at their uppermost or lowermost positions within the displacements cylinders so as to give the heated or cooled gas ample time to become effective in driving the power pistons. The connecting rod 67 pivots at its upper end to the crank pin 48, the lower end of the rod extending through the head of a closed cylinder 68 and terminating therein in a piston 69. The base of the cylinder has the bearing lug 70 which pivots on the pin 51 on crank frame 49 secured to shaft 37. As before stated, the radius of revolution of pin 51 is greater than the radius of revolution of pin 48, and therefore shaft 37 will oscillate and the main shaft will freely revolve if the connecting mechanism 67 were of the ordinary kind and of the proper length. However, the connecting rod mechanism 52 is yieldably shortened so that part of the main shaft revolution will be resisted by the pneumatic mechanism comprising the cylinder 68 and piston 69. As shown in Fig. 2, the piston is midway in the cylinder 68, and walking beam 38 has been rotated in one direction to carry cylinder 16 to its lowermost position and cylinder 16' to its upper position, and the beam can rotate no farther in this direction. However, the crank pin 48 has not yet finished its complete revolution, and can only finish its revolution by compressing the air in the cylinder 68 between the head thereof and the piston. The walking beam and consequently the displacement pistons remain

at rest until the crank pin 48 has passed through the dead center and the piston 69 has again reached its intermediate position. The walking beam will then be rotated in opposite direction to raise piston 16 and to lower piston 16', whereupon the pistons will again remain at rest during the interval that crank pin 48 passes through the opposite dead center, and piston 69 travels toward the bottom of cylinder 68 and back again to intermediate position. Thus when the displacement pistons reach their upper or lower positions they remain in these positions for a short time to give the heated and cooled gas ample time to thoroughly act on the power pistons. In Fig. 4 these movements are diagrammatically illustrated. The circle *a* represents the path of crank pin 48, and line *b* represents the harmonic movement of the pin. Point *c* represents the position of pin 48, as shown in Fig. 2, in which position the piston is midway in cylinder 68 and the walking beam 38 at the limit of its movement in the one direction. When the pin *c* reaches the dead center *d* the piston 69 will be at the upper end of the cylinder, and the main shaft during this movement is retarded by the compression of the air between the piston 69 and the head of its cylinder. Immediately after the pin passes the dead center *d* the reaction of the air in cylinder 68 becomes effective, and the retardation to the main shaft is compensated for during the time that the pin passes from the dead center *d* to the point *e*, at which point the piston again assumes its middle or neutral position. Now as the pin *c* travels from *e* to *f* the walking beam 38 will rock in the opposite direction and will again come to rest when the pin reaches the point *f*, and the displacement cylinders will again remain at rest during the time that the pin travels from the point *f* through the opposite dead center *g* and to point *h*, the main shaft being again retarded as the pin travels from *f* to *g* and accelerated when the pin travels from *g* to *h* and the pressure in cylinder 68 equalizes. Now as the pin travels from point *h* back to the point *c* the walking beam is again rocked in the first direction, and the pistons are returned to the positions indicated on the drawing. Thus the displacement pistons are held at rest while the crank pin 48 is traveling through those parts of its path adjacent its dead centers, and are moved rapidly from one end of their cylinders to the other, while the pin 48 travels through the remaining portions of its path. There is consequently no thermal disturbance in the heating or cooling compartments during initial movement of the power pistons, except that from the expansion or contraction of the gas, and the pressure will have ample time to become

fully effective on the pistons before displacement takes place.

In order to increase or decrease the pneumatic effect in cylinder 68 air reservoirs 71 and 71' are provided communicating respectively with the cylinder at opposite sides of the piston. Each cylinder has an adjustable plug or piston 72 locked into position by a set screw 73 engaging through a stuffing box 74 having threaded engagement with the reservoir end. By adjusting the pistons or plungers in or out the volume can be decreased or increased. I also preferably provide cushioned stop mechanism for preventing pounding of the displacement pistons against the cylinder ends. This abutment mechanism is best shown in Fig. 2. An arm 75 extends downwardly from the hub 49 and at the opposite sides of its end carries cushions 76 and 77 preferably of rubber. Mounted on the bed frame 5 of the machine are standards 78 and 79 whose ends carry adjustable abutment screws 80 and 81 against which the cushions 76 and 77 impinge, cushion 77 striking abutment screw 81, as shown, just before the displacement pistons reach the position indicated, and cushion 76 striking abutment screw 80 just before the pistons reach their opposite positions. By adjusting these screws the angle of oscillation of walking beam 38 can also be adjusted, and thereby the stroke of the displacement pistons and the speed and power of the engine regulated.

I do not desire to be limited to the precise construction, arrangement and operation shown, as changes are of course possible which would still come within the scope of my invention, and I therefore claim the following:

1. In a carbon dioxid engine, the combination of a displacement cylinder having a displacement piston therein of less length than the cylinder to leave compartments at the ends of the cylinder upon reciprocation of the piston, means for heating one end of the cylinder, means for cooling the other end of the cylinder whereby gas within the cylinder is alternately heated and cooled and its pressure increased and decreased upon reciprocation of the piston, a power cylinder connected with the displacement cylinder for interflow of gas, a power piston within said power cylinder, a main crank shaft connected with said power piston to be driven thereby, a second crank shaft connected with said displacement piston to control the reciprocation thereof, and a longitudinally elastic connecting rod mechanism connecting said main shaft with said second crank shaft for controlling the operation of said second crank shaft.

2. In a carbon dioxid engine, the combination of a displacement cylinder, a displacement piston within said cylinder of less

axial length than said cylinder whereby compartments are alternately formed at the ends of the displacement cylinder upon reciprocation of the piston therein, means for heating one end of the cylinder and means for cooling the other end thereof whereby gas within the cylinder is alternately heated and cooled and its pressure varied upon reciprocation of the piston, power mechanism connected with the displacement cylinder to be operated by the effect of the varying pressure of the gas, a shaft revolved by said power mechanism, a crank arm secured to said shaft and having a crank pin, a secondary shaft, connecting mechanism between said secondary shaft and displacement cylinder for controlling the reciprocation of said piston upon rotation of said secondary shaft, the stroke length of said piston being less than the diameter of revolution of said crank pin, and yieldable connecting mechanism between said crank pin and secondary shaft for controlling the operation of said secondary shaft.

3. In a carbon dioxid engine, the combination of a displacement cylinder, a displacement piston within said cylinder of less axial length than said cylinder whereby compartments are alternately formed at the ends of the displacement cylinder upon reciprocation of the piston therein, means for heating one end of the cylinder and means for cooling the other end thereof whereby gas within the cylinder is alternately heated and cooled and its pressure varied upon reciprocation of the piston, power mechanism connected with the displacement cylinder to be operated by the effect of the varying pressure of the gas, a shaft revolved by said power mechanism, a crank arm secured to said shaft and having a crank pin, an oscillatory shaft, a walking beam on said oscillatory shaft, connecting mechanism between said walking beam and piston whereby said piston is reciprocated upon oscillation of said oscillatory shaft, a crank arm extending from said oscillatory shaft and having a crank pin, the chord of oscillation of said oscillatory crank pin being less than the diameter of revolution of the first mentioned crank pin, and yieldable connecting rod mechanism connecting said pins.

4. In a carbon dioxid engine, the combination of a displacement cylinder, a displacement piston within said cylinder of less axial length than said cylinder whereby compartments are alternately formed at the ends of the displacement cylinder upon reciprocation of the piston therein, means for heating one end of the cylinder and means for cooling the other end thereof whereby gas within the cylinder is alternately heated and cooled and its pressure varied upon reciprocation of the piston, power mechanism connected with the displacement cylinder to

be operated by the effect of the varying pressure of the gas, a shaft revolved by said power mechanism, a crank arm secured to said shaft and having a crank pin, and a train of connecting mechanism between said shaft and piston for causing reciprocation of said piston within said cylinder upon rotation of said shaft and for causing said piston to assume periods of rest when at the ends of the cylinder.

5. In a carbon dioxid engine, the combination of a displacement cylinder, a displacement piston within said cylinder of less axial length than said cylinder whereby compartments are alternately formed at the ends of the displacement cylinder upon reciprocation of the piston therein, means for heating one end of the cylinder and means for cooling the other end thereof whereby gas within the cylinder is alternately heated and cooled and its pressure varied upon reciprocation of the piston, power mechanism connected with the displacement cylinder to be operated by the effect of the varying pressure of the gas, a shaft revolved by said power mechanism, a crank arm secured to said shaft and having a crank pin, an oscillatory shaft, a walking beam on said oscillatory shaft, connecting mechanism between said walking beam and piston whereby said piston is reciprocated upon oscillation of said oscillatory shaft, a crank arm extending from said oscillatory shaft and having a crank pin, the chord of oscillation of said oscillatory crank pin being less than the diameter of revolution of the first mentioned crank pin, a connecting rod pivoted at one end to the shaft crank pin and terminating at its other end in a piston, and a cylinder pivoted to said oscillating crank pin and receiving said piston, said connecting rod, piston, and cylinder forming yieldable connecting rod mechanism between said pins.

6. In a carbon dioxid engine, the combination of a displacement cylinder, a displacement piston within said cylinder, said piston being shorter than said cylinder in order to leave a compartment at each end of the cylinder when the piston is at the opposite end, means for heating one end of the cylinder and means for cooling the other end whereby the gas within said cylinder will be alternately heated and cooled in the compartments and its pressure alternately increased and decreased, a power cylinder having connection with said displacement cylinder for interflow of gas, a power piston reciprocable in said power cylinder, power transmitting mechanism driven by the reciprocating power piston, means for reciprocating said displacement piston from one end to the other of this displacement cylinder, and means for causing said displacement piston to assume periods of rest

when at the ends of its cylinder whereby the gases within the compartments of said displacement cylinder will have ample time to be heated or cooled and to give its changed pressure ample time to operate on said power piston.

7. In a carbon dioxid engine, the combination of a displacement cylinder, a displacement piston within said cylinder of less axial length than said cylinder whereby compartments are alternately formed at the ends of the displacement cylinder upon reciprocation of the piston therein, means for heating one end of the cylinder and means for cooling the other end thereof whereby gas within the cylinder is alternately heated and cooled and its pressure varied upon reciprocation of the piston, power mechanism connected with the displacement cylinder to be operated by the effect of the varying pressure of the gas, a shaft revolved by said power mechanism, a crank arm secured to said shaft and having a crank pin, an oscillatory shaft, a walking beam on said oscillatory shaft, connecting mechanism between said walking beam and piston whereby said piston is reciprocated upon oscillation of said oscillatory shaft, a crank arm extending from said oscillatory shaft and having a crank pin, the chord of oscillation of said oscillatory crank pin being less than the diameter of revolution of the first mentioned crank pin, a connecting rod connected at one end with one of said pins, a cylinder pivoted to the other pin, and a piston reciprocable within said cylinder and connected to the other end of said connecting rod whereby air at opposite sides of the piston will be alternately compressed upon passage of the shaft crank pin through its paths adjacent its dead centers.

8. In a carbon dioxid engine, the combination of a displacement cylinder, a displacement piston within said cylinder of less axial length than said cylinder whereby compartments are alternately formed at the ends of the displacement cylinder upon reciprocation of the piston therein, means for heating one end of the cylinder and means for cooling the other end thereof whereby gas within the cylinder is alternately heated and cooled and its pressure varied upon reciprocation of the piston, power mechanism connected with the displacement cylinder to be operated by the effect of the varying pressure of the gas, a shaft revolved by said power mechanism, a crank arm secured to said shaft and having a crank pin, an oscillatory shaft, a walking beam on said oscillatory shaft, connecting mechanism between said walking beam and piston whereby said piston is reciprocated upon oscillation of said oscillatory shaft, a crank arm extending from said oscillatory shaft and having a crank pin, the chord of oscillation

of said oscillatory crank pin being less than the diameter of revolution of the first mentioned crank pin, a connecting rod connected at one end with one of said pins, a cylinder pivoted to the other pin, a piston reciprocable within said cylinder and connected to the other end of said connecting rod whereby air at opposite sides of the piston will be alternately compressed upon passage of the shaft crank pin through its paths adjacent its dead centers, and means for increasing or decreasing the available volumes of air to be compressed upon reciprocation of said piston.

9. In a carbon dioxid engine, the combination of a displacement cylinder, a displacement piston within said cylinder of less axial length than said cylinder whereby compartments are alternately formed at the ends of the displacement cylinder upon reciprocation of the piston therein, means for heating one end of the cylinder and means for cooling the other end thereof whereby gas within the cylinder is alternately heated and cooled and its pressure varied upon reciprocation of the piston; power mechanism connected with the displacement cylinder to be operated by the effect of the varying pressure of the gas, a shaft revolved by said power mechanism, a crank arm secured to said shaft and having a crank pin, an oscillatory shaft, a walking beam on said oscillatory shaft, connecting mechanism between said walking beam and piston whereby said piston is reciprocated upon oscillation of said oscillatory shaft, a crank arm extending from said oscillatory shaft and having a crank pin, the chord of oscillation of said oscillatory crank pin being less than the diameter of revolution of the first mentioned crank pin, a connecting rod connected at one end with one of said pins, a cylinder pivoted to the other pin, a piston reciprocable within said cylinder and connected to the other end of said connecting rod whereby air at opposite sides of the piston will be alternately compressed upon passage of the shaft crank pin through its paths adjacent its dead centers, a reservoir connected with said cylinder at each side of the piston, and means for adjusting each reservoir to increase or decrease the available volume of gas to be compressed by the reciprocating pistons.

10. In a carbon dioxid engine, the combination of a displacement cylinder, a piston reciprocable within said cylinder, said piston being shorter than said cylinder whereby a compartment is left at each end of the cylinder when the piston has traveled toward the other end of the cylinder, means for heating one end of the cylinder, and means for cooling the opposite end thereof whereby gas within said cylinder will be alternately heated and cooled within said

compartments formed by the reciprocation of the piston and the pressure of the gas thereby alternately increased and decreased, power mechanism connected with said cylinder to be acted upon by the varying gas therefrom and thereby operated, a main shaft connected with said power mechanism to be revolved upon operation thereof, an oscillatory shaft, an arm secured to said shaft and connected at its end with said piston to cause reciprocation of said piston upon oscillation by said shaft, a crank arm on said oscillatory shaft, a crank arm on said main shaft having a crank pin, a second arm on said oscillatory shaft having a pivot pin at its end, adjustable mechanism for limiting the arc of oscillation of said oscillatory shaft and thereby limiting the stroke of said piston, said adjustment being such that the oscillation of said second arm will always be less than would cause complete revolution of said main shaft if said crank pin and oscillating arm pin were connected together by a rigid connecting rod, and longitudinally yieldable connecting rod mechanism connecting said crank pin with said oscillatory arm pin whereby said main shaft may continue its rotation to carry the crank pin over the dead centers when the oscillatory arm reaches the ends of its oscillations.

11. In a carbon dioxid engine, the combination of a crank case, a cylinder communicating with the crank case, a crank shaft in said crank case, a piston in the cylinder connecting with said crank shaft, said crank case and cylinder forming an inclosed space for receiving and retaining carbon dioxid gas under heavy pressure, means for heating one end of the cylinder, and means for cooling the other end thereof whereby the gas within the cylinder is alternately heated and cooled and its pressure varied to cause reciprocation of the piston within the cylinder.

12. In a carbon dioxid engine, the combination of a crank case, a displacement cylinder, a power cylinder supported on said casing and communicating with the interior thereof, said crank case and cylinders forming an inclosed space for receiving and retaining carbon dioxid gas under heavy pressure, a displacement piston within the displacement cylinder, a power piston within the power cylinder, crank shaft mechanism in the crank case and connected with said pistons, means for heating one end of the displacement cylinder and means for cooling the other end thereof whereby the carbon dioxid within the displacement cylinder is alternately heated and cooled upon displacement of the piston and its pressure varied.

13. In an engine, the combination of a power cylinder, a piston reciprocable within said cylinder, a main crank shaft connected with said piston to be rotated upon reciprocation of said piston, a gas reservoir for supplying gas under pressure to said power cylinder, a displacing member within said gas reservoir, a secondary crank shaft, a crank arm on said secondary crank shaft connected with said displacement member, a second crank arm on said secondary shaft, a crank arm on said main crank shaft, the length of stroke of said displacement member being less than the diameter of revolution of said crank arm on the main crank shaft, and longitudinally elastic connecting rod mechanism between said main crank shaft crank arm and said second crank arm on said secondary shaft.

In witness hereof, I hereunto subscribe my name this 17th day of January, A. D. 1911.

CHARLES A. ANDERSON.

Witnesses:

CHARLES J. SCHMIDT,
NELLIE B. DEARBORN.