

UNITED STATES PATENT OFFICE

2,163,767

FLOATING PISTON ENGINE PLANT

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Original application March 8, 1935, Serial No.
10,081. Divided and this application June 9,
1937, Serial No. 147,316. In Switzerland
March 13, 1934

6 Claims. (Cl. 230—56)

The present application is a divisional appli-
cation to my copending application Ser. No.
10,081, filed March 8, 1935.

The present invention relates to a united re-
ciprocating internal combustion engine and com-
pressor of the floating piston type having a plu-
rality of power and compressor cylinders for gen-
erating hot high pressure gases which may be
used for operating, for example, a gas turbine
and for producing compressed air which is used
as combustion air in said apparatus and/or may
also be used for other purposes, more particu-
larly to methods and apparatus for synchroniz-
ing the operation of the individual pistons and
for controlling the stroke of the individual pis-
tons.

An object of the present invention resides in
the provision of means interconnecting the pis-
tons operating in different cylinders of a united
reciprocating internal combustion engine and
compressor having floating pistons, whereby, at
a change of the length of the stroke of the pis-
tons operating in one cylinder, the length of the
stroke of the pistons operating in another cylin-
der is automatically changed, too.

A further object of this invention is to provide
a unified internal combustion-compressor engine
having floating pistons and in which the power
and compressor pistons are directly connected
and in line with one another and in which also
the power and compressor cylinders are directly
connected and in line with one another, and of
means assuring that, when the stroke of a com-
bined power and compressor floating piston is
changed, the stroke of the power piston is
changed to a length different from that of the
compressor piston.

Another object of this invention is the provi-
sion of a unified internal combustion-compressor
engine of the type set forth with means assur-
ing that, when the position of a piston at one end
of its stroke is changed, for example, due to vary-
ing forces acting on said piston, the position of
the piston at the other end of the stroke is
changed to an extent which is different from the
extent to which the position is changed at the
opposite end of the stroke.

A further object of this invention resides in the
provision of a unified internal combustion-com-
pressor engine of the type set forth with means
assuring that, when the position of a piston at one
end of its stroke is changed, for example, due to
varying forces acting on said piston, the position
of the piston at the other end of the stroke is
maintained.

Further and other objects of the present inven-
tion will be hereinafter set forth in the accom-
panying specification and claims and shown in the
drawing which, by way of illustration, show what
I now consider to be a preferred embodiment of
my invention.

In the drawing:

Fig. 1 is a diagrammatic showing of a power
and compressed air producing plant according to
my invention.

Fig. 2 is a crank diagram of an engine as illus-
trated in Fig. 1.

Fig. 3 is another crank diagram of an engine
as shown in Fig. 1.

Fig. 4 shows indicator diagrams of engines ac-
cording to my invention and forming the prin-
cipal part of the plants shown in Figs. 1 to 3, in-
clusive.

Like parts are designated by like numerals in
all figures of the drawing.

Referring more particularly to Fig. 1 of the
drawing: 1 and 2 are the power pistons operating
within combustion cylinder 5; 3 and 4 are power
pistons operating within combustion cylinder 6.
To the ends of combustion cylinder 5, compres-
sor cylinders 7 and 8 are attached and, to the
ends of combustion cylinder 6, compressor cyl-
inders 9 and 10. Compressor pistons 11, 12, 13,
and 14 are connected to the power pistons 1, 2, 3,
and 4, respectively. Combustion and scavenging
air is conducted into cylinder 5 through conduit
15 and into cylinder 6 through conduit 16. Fuel
is introduced into cylinder 5 through feeder 17
and into cylinder 6 through feeder 18. These
feeders are not shown in detail as they are not
part of the present invention. The exhaust gases
of cylinder 5 are removed through conduit 19 and
those of cylinder 6 through conduit 20. Both
conduits may be connected to a conduit 21 which
conducts the exhaust gases of cylinders 5 and
6 into a gas turbine 22. The gas to be com-
pressed, for example air, is drawn into single
acting compressor cylinders 7 and 9 from filter
23 through duct 24 and into single acting com-
pressor cylinders 8 and 10 from filter 25 through
duct 26. The air compressed in cylinder 7
passes through duct 27 into receiver 28 and there-
from through conduit 29 into cylinder 5 serving
as charging and scavenging air. Likewise, the
air compressed in cylinder 9 passes through con-
duit 30 into receiver 31 and therefrom through
conduit 32 into cylinder 6. The air compressed
in cylinders 8 and 10 passes through conduits 33
and 34 into common receiver 35 and therefrom

to consumers, for example, pneumatic hammer 87 and/or compressed air turbine 88.

A rod 23 is connected to compressor piston 11, a rod 25 to piston 13, a rod 24 to piston 12, and a rod 26 to piston 14. These piston rods are each movably connected with a connecting rod, namely, 23 with 27, 25 with 29, 24 with 28, and 26 with 30. Connecting rods 27 and 29 operate crank shaft 31, and connecting rods 28 and 30 operate crank shaft 32. The individual cranks on each shaft and the cranks of two different shafts but associated with the same cylinder are set at an angle of 180° with respect to one another so that the pistons associated with the cranks move in opposite directions. The radius of the cranks may be made so large as compared with the stroke of the pistons that the crank shafts do not rotate but carry out a swinging motion, whereby the cranks never reach the crank dead center position proper. Crank shafts 31 and 32 may be coupled together by means of bevel gears 109, 111 and 110, 112 and shaft 113 arranged between these gears, whereby the counter movement of the pistons in the individual cylinders is synchronized.

It is advantageous to make the length of the connecting rods as small as possible as compared with the radius of the associated cranks because, with such a construction, a change of the position of a power piston at the end of its compression stroke entails only little change of the position at the end of the compression stroke of the associated compressor piston. This is obvious from Fig. 2. If the swing of the crank shaft is reduced from angle α to angle β , i. e., when the load and consequently the fuel supply is increased, the length of the stroke of the united power and compressor piston is reduced from a to b ; the position of the power piston at the end of its compression stroke is changed by the distance d , whereas the position of the compressor piston at the end of its compression stroke is changed by the shorter distance c . The shorter the connecting rod, the greater is the difference between d and c . In this way, even a great change of the position of the power pistons at the end of their compression strokes has but little effect on the position of the associated compressor pistons at the end of their compression strokes and also has but little effect on the pressure of the gas in the compressor cylinders.

Fig. 3 diagrammatically shows an arrangement in which the crank passes outer dead center position, and the connecting rod 28 moves on both sides of the center line of the cylinder so that, for each position of the piston, two positions of the connecting rod are possible, whereas, in the arrangement shown in Fig. 2, the connecting rod 28 moves always on one side of the center line of the cylinder, and only one position of the connecting rod is possible for each position of the piston. For an operation according to the diagram Fig. 3, the crank shafts 31 and 32 are provided with fly wheels 122 and 123 so that the crank shafts swing beyond dead center position as diagrammatically shown in Fig. 3. If the extent of the swing of a shaft is reduced from angle γ in Fig. 3 to angle δ , the inner dead center position of the piston associated with this crank is changed by the distance e , whereas the outer dead center position is not changed at all.

The operation of the apparatus according to Figs. 1 and 3 is as follows:

If more power is required from gas turbine 90, more fuel is supplied through nozzles 17 and 18.

The supply of fuel may be adjusted by hand or automatically; this adjustment per se is not part of the present invention. An increased fuel supply to cylinders 5 and 6 causes increased pressure within these cylinders and a shortening of the compression stroke of the power pistons. Before the increase of fuel supply, shaft 32 swings, for example, as far as angle γ in Fig. 3; after the increase of fuel supply, the shaft only swings as far as the smaller angle δ in Fig. 3, and the stroke of a combined power and compressor piston is decreased by the distance e , and the space available for combustion is increased accordingly. The work done per stroke of a power piston is thereby considerably increased, as is obvious from and will be described later in connection with the diagram Fig. 4. As soon as more power is available from the power pistons, the movement of said pistons is sped up and more air is compressed per time unit; as long as the consumption of gases produced in the combustion cylinder and/or the amount of compressed air required for purposes other than combustion purposes is not increased, higher pressure in the air compressors associated with the combustion cylinders and of the charging and scavenging air is obtained automatically. As is also obvious from the diagrams in Fig. 4, a shortening of the suction stroke of the air compressor pistons is of little influence on the air pressure obtained, and it is desirable to maintain the outer dead center position of the associated pistons 1, 11, 2, 12, 3, 13, and 4, 14 and to arrange for wide variations of the inner dead center positions in order to obtain highest efficiency in the operation of the power part as well as of the compressor part of the engine. This condition is assured by a machine according to Fig. 1 of the drawing to a great extent if operated according to Fig. 3 and, to a modified extent, if operated according to Fig. 2.

The upper part of Fig. 4 shows indicator diagrams of the combustion cylinders 5 and 6. The dotted line diagram shows the conditions with far inward moving pistons, as is the case when shaft 32 swings around angle α in Fig. 2 or angle γ in Fig. 3. Charging pressure and compression pressure are small, and the volume V_0 available for combustion amounts to only 6% of the total volume available for the expansion stroke. The solid line diagram shows the conditions with the inner dead center position of the piston further out, as is the case when shaft 32 swings around angle β in Fig. 2 or angle δ in Fig. 3. Charging pressure and compression pressure are high, and the combustion volume V_1 amounts to 13% of the total expansion volume.

The lower part of Fig. 4 shows two indicator diagrams of the compressors corresponding to the operating conditions of the power pistons shown in the upper part of Fig. 4. In both cases, the compression volume V_c is approximately the same, whereas the compression pressure—in the case of the dotted line diagram—amounts to 1.2 atmospheres and—in the case of the solid line diagram—amounts to 4.0 atmospheres.

The upper diagrams of Fig. 4, which represent indicator diagrams taken in the combustion or power cylinders, show that an increase of the combustion space at the inner dead center position of the power pistons together with an increase in fuel supply greatly increase the work per stroke of the power pistons, which is represented by the area enclosed by the indicator diagrams; the work available for air compression

is, of course, also increased; the lower diagrams of Fig. 4, which represent indicator diagrams taken in the air compressor cylinders, show that a change of the inner dead center position—
 5 which is represented by the left side of Fig. 4—of the air compressor piston has little effect on the work required by the compressor, which is represented by the area enclosed by the indicator diagrams, whereas, for example, an outward move-
 10 ment of the inner dead center position of the air compressor pistons would greatly increase the area of the indicator diagrams and the work required by the compressor; if this increased work is not supplied, the height of the diagram
 15 and the pressure of the compressed air is reduced.

While I believe the above described embodiments of my invention to be preferred embodiments, I wish it to be understood that I do not
 20 desire to be limited to the exact details of design and construction shown and described, for obvious modifications will occur to a person skilled in the art.

What I claim is:

25 1. In a united reciprocating internal combustion and compressor engine, a combustion cylinder having at one end a compressor cylinder directly connected thereto, a floating piston comprising a power piston situated in said combustion
 30 cylinder and a compressor piston situated in said compressor cylinder, crank means connected with said piston and having an operating diameter which is greater than the longest possible stroke of said piston, said crank means oscillating
 35 about its outer dead center position whereby the position of said piston at one end of its stroke is maintained also when the force acting on said piston and thereby the position at the other end of its stroke are changed.

40 2. In a united reciprocating internal combustion and compressor engine, a plurality of cylinder units, each unit comprising a compressor and combustion cylinder, a floating piston situated in
 45 each of said cylinder units and comprising a power piston operating in said power cylinder and a compressor piston operating in said compressor cylinder, oscillating means being connected
 50 to and interconnecting the floating pistons of two different cylinder units and oscillating about an axis which crosses the longitudinal axis of said
 55 cylinder units and which is disposed in the same plane in which the longitudinal axes of said cylinder units are located, said oscillating means having an operating diameter which is greater
 60 than the longest possible stroke of said connected pistons and which is in such proportion to the longest possible piston stroke that the position of said interconnected floating pistons at one
 65 end of a stroke is automatically changed to a different extent than the position is changed at the other end of the stroke when the forces acting on said pistons and the position of said
 70 pistons at the other end of the stroke are changed.

3. In a united reciprocating internal combustion and compressor engine, a plurality of cylinder
 75 units, each unit comprising a compressor and a combustion cylinder, a floating piston situated in each of said cylinder units and comprising a
 80 power piston operating in said power cylinder and a compressor piston operating in said compressor cylinder, oscillating crank means being connected to and interconnecting the floating
 85 pistons of two different cylinder units and oscillating about an axis which crosses the longitudinal axis of said cylinder units and which is disposed in the same plane in which the longitudinal axes of said cylinder units are located, said oscillating means having an operating diameter which is greater than the longest possible stroke of said connected pistons, said oscillating means oscillating about its outer dead center position whereby the position of said interconnected floating pistons at one end of a stroke is maintained also when the forces acting on said pistons and thereby the position at the other end of the stroke of said pistons are changed.

4. In a united reciprocating internal combustion and compressor engine, a plurality of cylinder
 90 units, each unit comprising a compressor and a combustion cylinder, a floating piston situated in each of said cylinder units and comprising a
 95 compressor piston operating in said compressor cylinder and a power piston operating in said power cylinder, oscillating means being connected to and interconnecting the floating pistons
 100 of two different cylinder units and oscillating about an axis which crosses the longitudinal axis of said cylinder units and which is disposed in the plane in which the longitudinal axes of said
 105 cylinder units are located, said oscillating means having an operating diameter which is greater than the largest possible stroke of said connected pistons, said oscillating means oscillating about
 110 its outer dead center position whereby the position of said interconnected floating pistons at one end of a stroke is maintained also when the forces acting on said pistons and thereby the position at the other end of the stroke of said
 115 pistons are changed.

5. In a united reciprocating internal combustion and compressor engine, a combustion cylinder
 120 having at one end a compression cylinder directly connected thereto, a floating piston comprising a power piston situated in said combustion cylinder and a compressor piston situated in said
 125 compressor cylinder, oscillating means connected with said piston which means oscillate on a diameter which is greater than the largest possible stroke of said piston and which oscillate about a dead
 130 center position corresponding to the outer dead center position of said piston whereby the position of said piston at one end of its stroke is maintained also when the force acting on said
 135 piston and thereby the position at the other end of its stroke are changed.

6. In a united reciprocating internal combustion and compressor engine, a combustion cylinder
 140 having at one end a compressor cylinder directly connected thereto, a floating piston comprising a power piston situated in said combustion cylinder and a compressor piston situated in said
 145 compressor cylinder, oscillating means connected with said piston which means oscillate on a diameter which is greater than the largest possible stroke of said piston and which oscillate about a
 150 dead center position corresponding to the outer dead center position of said piston, whereby the position of said piston at one end of its stroke is maintained also when the force acting on said
 155 piston and thereby the position at the other end of its stroke are changed, and fly masses connected with said oscillating means for assuring
 160 reliable and predetermined operation of said oscillating means.

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