

June 6, 1950

E. MERCIER

2,510,127

FREE PISTON ENGINE COMPRESSOR

Filed Jan. 5, 1948

5 Sheets-Sheet 1

Fig. 1.

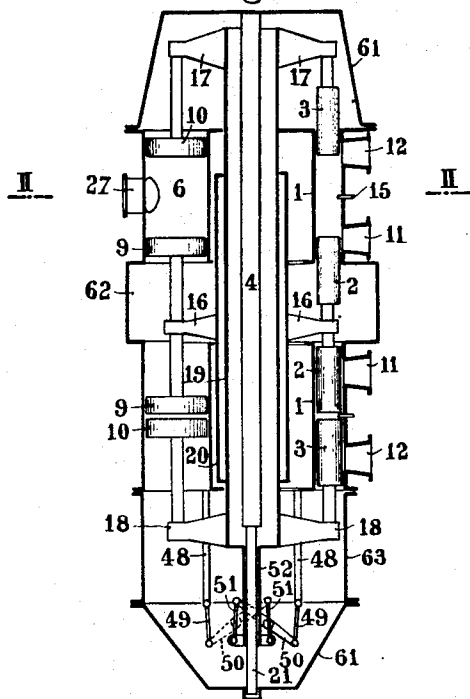
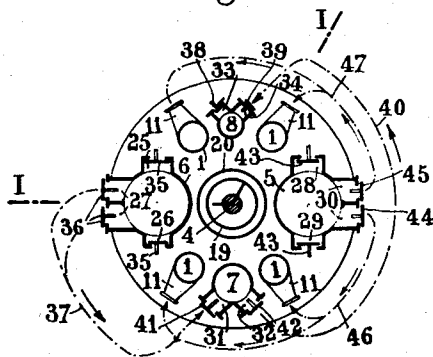


Fig. 2.



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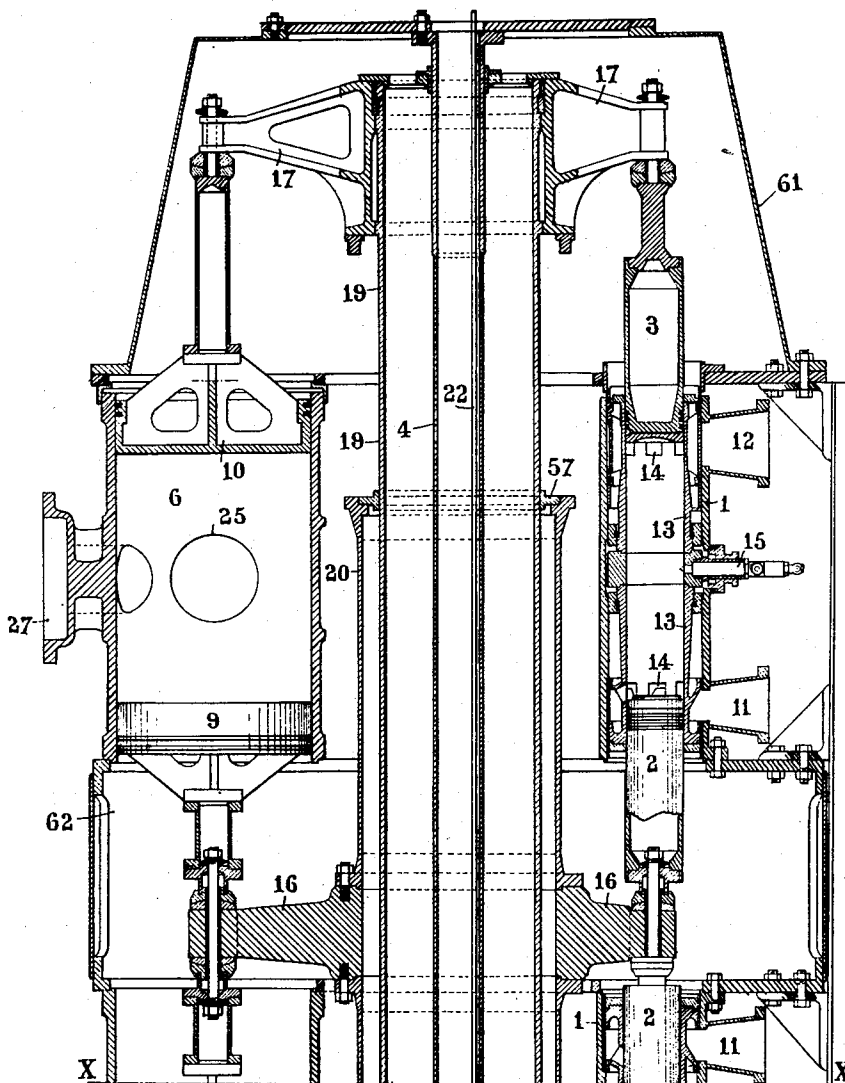
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Fig. 3.



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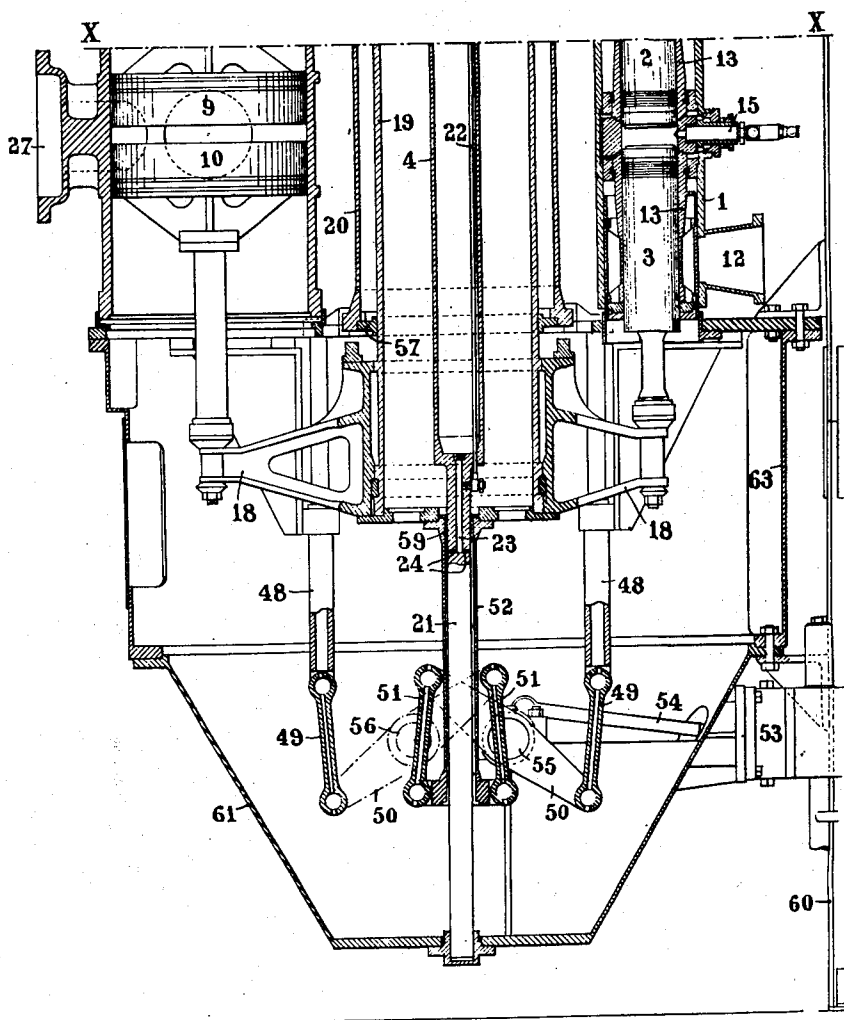
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Fig. 3a.



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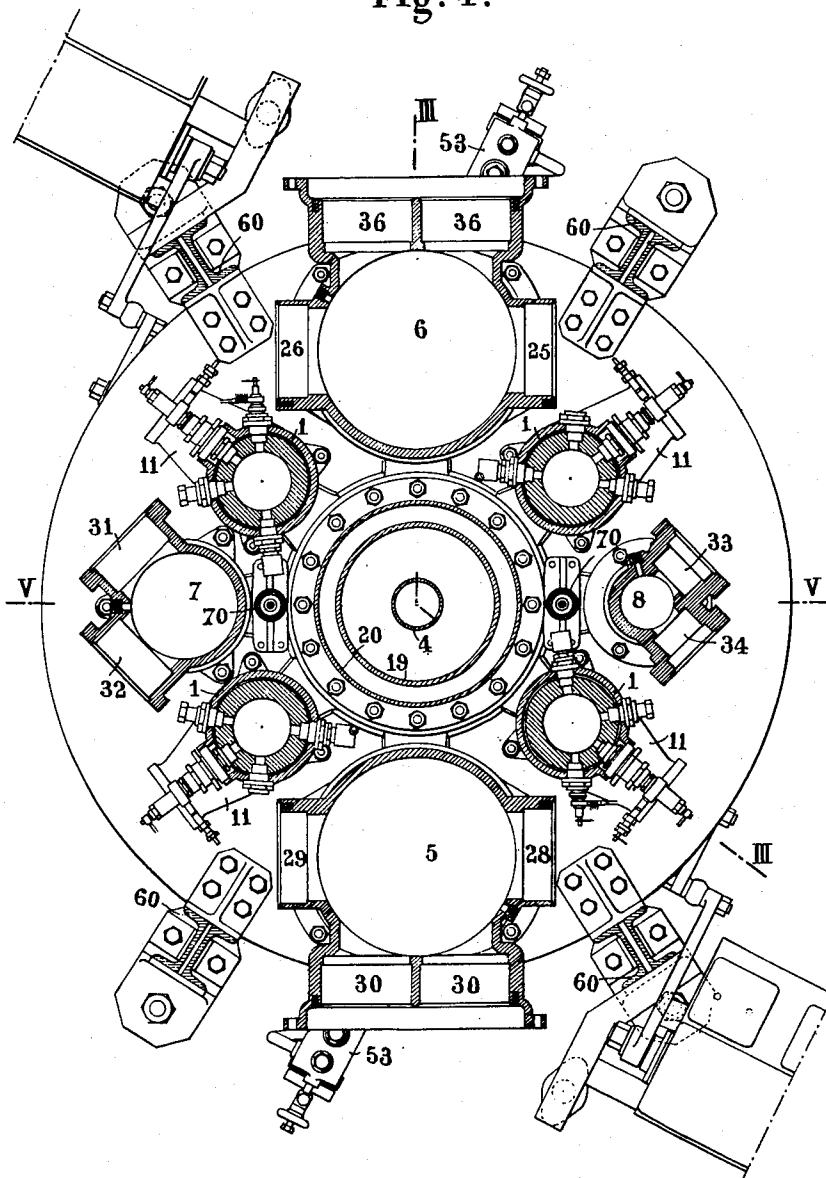
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FREE PISTON ENGINE COMPRESSOR

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Fig. 4.



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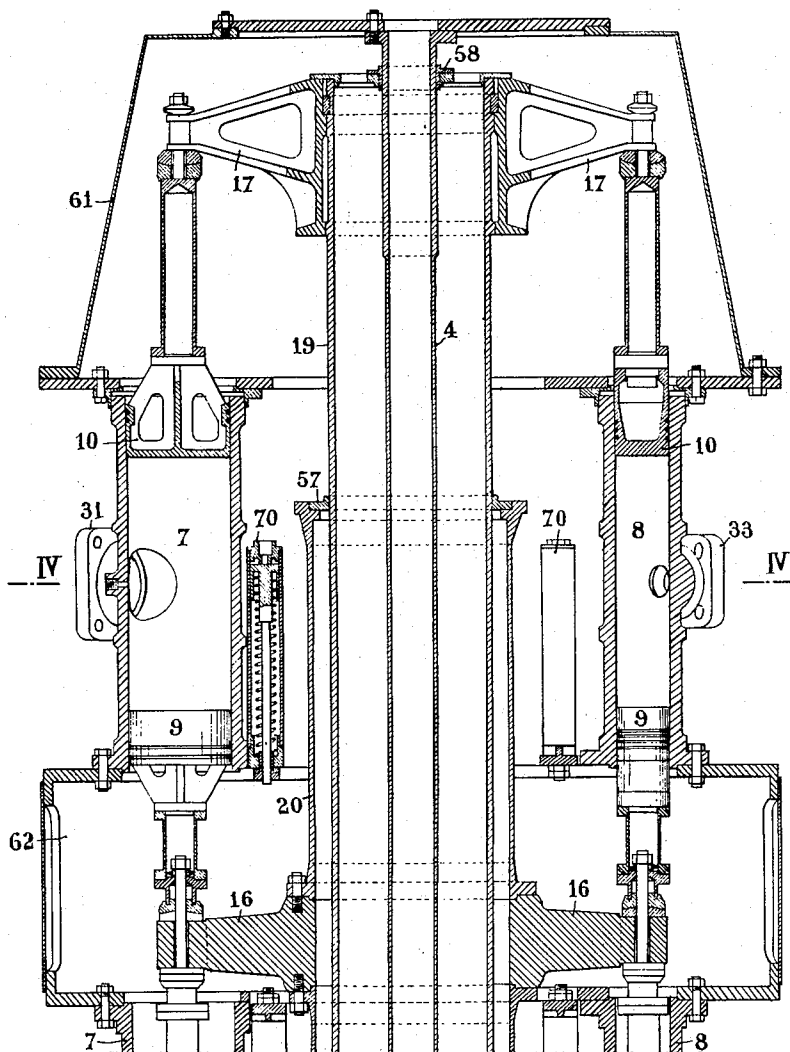
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FREE PISTON ENGINE COMPRESSOR

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Fig. 5.



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UNITED STATES PATENT OFFICE

2,510,127

FREE PISTON ENGINE COMPRESSOR

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Application January 5, 1948, Serial No. 501

24 Claims. (Cl. 230—56)

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The present invention relates to a fluid pressure machine of the reciprocating type.

In this machine a plurality of pairs of cylinders are arranged with the axes thereof extending in the same general direction and with the cylinders of each pair in opposed spaced relation to each other in this direction, each cylinder having a pair of pistons adapted for reciprocating movement along the axes of these cylinders, means being provided operatively connecting the adjacently disposed pistons and means being also provided for connecting the remotely disposed pistons.

A feature of the present invention lies in the fact that some of the pairs of cylinders are compressor cylinders and others are prime mover cylinders.

At least one of the pairs of cylinders receives between the respective pistons thereof a fluid pressure medium for producing power developing movement of the pistons in said cylinders and at least another of the pairs of cylinders is adapted to confine a fluid pressure medium to be compressed between the respective pistons thereof.

Means are provided for effecting concomitantly the movement of the different sets of pistons to produce compressor action in the compressor cylinders when the prime mover cylinders are energized to produce opposite movement of the two pistons therein.

In the accompanying drawings:

Fig. 1 is a diagrammatical vertical section taken on line I—I in Fig. 2;

Fig. 2 is a diagrammatical plan section;

Figs. 3 and 3a are to be juxtaposed along line X—X and they show a vertical section taken on line III—III in Fig. 4;

Fig. 4 is a plan section; and

Fig. 5 is a vertical section taken on line V—V in Fig. 4.

For the sake of clearness the valves in the different ports of the cylinders and the connections between these ports are shown only on Fig. 2.

The fluid pressure machine shown in the accompanying drawings comprises four pairs of prime mover cylinders 1 which are arranged with the cylinders of each pair coaxial and in opposed spaced relation along the common axis thereof. Each cylinder 1 is provided with a pair of free pistons 2, 3. The axes of the pairs of prime mover cylinders 1 are parallel and distributed about a central axis of the machine.

The machine comprises also a pair of low pres-

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sure compressor cylinders 6, a pair of intermediate pressure compressor cylinders 7 and a pair of high pressure compressor cylinders 8, and a pair of compressor cylinders 5 providing scavenging air for the prime mover cylinders 1. Each of the compressor cylinders 5, 6, 7, 8 is provided with a pair of free pistons 9 and 10. The compressor cylinders are arranged with the cylinders of each pair coaxial and in opposed spaced relation along the common axis thereof, the axes of said pairs of gas compressor cylinders being parallel and distributed about said central axis of the machine in interspersed relation to the axes of the prime mover cylinders 1.

The adjacently disposed pistons 2 of the prime mover cylinders 1 and the adjacently disposed pistons 9 of the interspersed gas compressor cylinders 5, 6, 7, 8 are connected together to form a first rigid unit, by means of a common spider 16 rigid with an outer tubular member 20.

The remotely disposed pistons 3 of the prime mover cylinders 1 are connected to the remotely disposed pistons 10 of the gas compressor cylinders to form a second rigid unit, by means of spiders 17 and 18 which are rigid with an inner tubular member 19.

All of the pistons operating in the portions of the opposed spaced cylinders which are in adjacently disposed relation being connected together, they form the first rigid unit of which the pistons at one side of a median plane between the opposed spaced cylinders transverse to said central axis of the machine respectively move outwardly and inwardly of their respective cylinders as the pistons of the same unit in the cylinders disposed at the other side of said transverse central plane respectively move inwardly and outwardly of their respective cylinders. The remotely disposed pistons of the second rigid unit disposed at one side of the median transverse plane respectively move outwardly and inwardly of their respective cylinders as the remotely disposed pistons of said second unit at the other side of the median transverse plane respectively move inwardly and outwardly of their respective cylinders.

The two tubular members 19 and 20 are arranged coaxially with the central axis of the machine in telescoping relation to each other for reciprocating sliding movement with respect to each other along said central axis of the machine.

The outer tubular member 20 is provided with shoes 57 adapted to slide on the outer surface of the inner tubular member 19 about which the outer tubular member 20 extends and is itself provided with shoes 58 and 59 adapted to slide

on a central guide member 4 and its extension 21 arranged coaxially with said central axis of the machine.

The tubular members 19 and 20 constitute the guiding and rigidifying means for the two units of pistons.

The surface of the central guide member 4 on which the shoes 59 are adapted to slide is lubricated with a suitable lubricant through the pipe 22 and passages 23 and 24.

A kinematic connection is provided between the two guiding tubular members 19 and 20.

Links 51 of this connection have one of their ends pivotally connected to the lower end of a member 52 which is rigid with the lower end of the inner tubular member 19.

The other ends of said links 51 are pivotally connected to levers 50 adapted to rock about axes 55 and 56. Other links 49 are pivotally connected on the one hand to members 48 which are rigidly connected to the tubular member 20 and on the other hand to the rocking levers 50. The rocking movement of the shaft 55 is transmitted by a rod and link mechanism to a stroke regulator 53.

Each of the compressor cylinders 5, 6, 7, 8 centrally of the length thereof is provided with ports for admission of the fluid thereto between the pistons thereof and with ports for exhaust of the fluid therefrom.

Means are associated with said ports for controlling the flow of the fluid to and from the respective cylinders and for confining the fluid to be compressed between the pistons. These means may be valves of any conventional type. The compressor cylinders 5 are provided with admission ports 28, 29, exhaust ports 30 and with admission valves 43 and exhaust valves 44, 45 (Figure 2). The low pressure compressor cylinders 6 are provided with admission ports 25, 26, exhaust ports 27, admission valves 35 and exhaust valves 36. The intermediate pressure compressor cylinder 7 is provided with an admission port 31, and exhaust port 32, an admission valve 41 and an exhaust valve 42. The high pressure compressor cylinder is provided with an admission port 34, an exhaust port 33, an admission valve 39 and an exhaust valve 38.

The cylinders 1 adapted to receive between the pistons 2, 3 thereof a fluid pressure medium for producing power developing movement of said pistons are provided with admission ports 11 and exhaust ports 12 respectively adjacent the opposite ends thereof for admission of the fluid medium, e. g., the combustion and scavenging air, and for removal therethrough of the exhaust fluid pressure medium from said cylinders.

Fuel, gas oil for instance, is injected between the pistons 2, 3 of the prime mover cylinders through injectors 15.

The cylinders 1 are provided with inner sleeves 13 having ports 14 respectively adjacent the opposite ends thereof and communicating with the admission and exhaust ports 11 and 12.

With regard to the prime mover cylinders 1, the operation is as follows:

When the ports 14 are closed by pistons 2, 3 in the upper cylinders 1 and these pistons are adjacent the centers of the cylinders 1, gas oil is injected into these upper cylinders between the pistons from a suitable pump through the corresponding injectors 15. The pistons 2, 3 are moved outwardly by the power produced within the upper cylinders 1 and at the same time the pistons 2, 3 in the lower cylinders 1 are moved

inwardly concomitantly compressing therebetween the power producing fluid medium or air, the gas oil being injected into these lower cylinders 1 for mixture with this compressed air for the combustion of the oil.

When the pistons 2, 3 reach the opposite ends of the upper cylinders 1, the ports 14 are uncovered and the fluid is scavenged by compressed fluid or air flowing from the compressor cylinders 5, which flow is admitted through the admission ports 11 of the upper prime mover cylinders 1 and is exhausted through the exhaust ports 12 of these cylinders.

At this moment power is produced similarly in the lower prime mover cylinders 1, and the pistons 2, 3 in the upper prime mover cylinders 1 are moved inwardly and close the ports 14, thereafter compressing the air therebetween preparatory to injection and ignition of the fuel, as above mentioned, for the next power stroke.

With regard to the compressor cylinders 6, 7, 8 the operation is as follows:

A fluid pressure medium, e. g., air, is delivered alternately to the low pressure compressor cylinders 6. The fluid delivered to one of the cylinders 6, the upper one for instance, flows as follows:

When the pistons 9, 10 in the upper low pressure compressor cylinder 6 are nearly adjacent the opposite ends of this cylinder, the fluid or air is admitted in this cylinder through admission ports 25, 26, which admission is controlled by means of valves 35. This fluid is confined in this cylinder 6 by means of the valves 35 and 36 which then are closed. When the compression stroke in this upper cylinder 6 approaches completion and the pistons 9, 10 therein are adjacent each other at the center of the cylinder the valves 36 are opened and the fluid flows through the ports 27, the valves 36, a pipe 37, the valve 41 and the port 31 into the lower intermediate pressure cylinder 7 the pistons 9, 10 of which at that time are in spaced relation to each other. Thereupon the fluid is confined in this cylinder 7 by closing the valves 41 and 42 and is compressed between the pistons 9, 10 in this cylinder 7 when the following stroke occurs. When this stroke approaches completion the valve 42 is opened and the fluid flows through the port 32, the valve 42, a pipe 40, the valve 39 and port 34 into the upper high pressure compressor cylinder 8 the pistons 9, 10 of which now are in spaced relation to each other. The fluid then is confined in this upper high pressure compressor cylinder 8 by closing of valves 38 and 39. When the immediately following stroke approaches completion in this upper cylinder 8, the valve 38 is opened and the compressed fluid is discharged.

The fluid which is initially delivered to and compressed in the lower low pressure compressor cylinder 6 flows in a similar way to and is compressed in the upper intermediate pressure cylinder 7 and then to the lower high pressure cylinder 8 to be compressed therein and discharged therefrom.

With regard to the operation of the compressor cylinders 5, when the pistons 9, 10 in a compressor cylinder 5, the upper one for instance, are in opposed relation to each other at the opposite ends of the cylinder admission of fluid or air to be compressed into this cylinder is effected through admission ports 28 and 29, which admission is controlled by means of valves 43. Then the fluid is confined in this upper cylinder 5 by closing valves 43, 44 and 45 and this fluid is com-

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pressed by an inward stroke of the pistons 9, 10 immediately following in this cylinder 5. Thereupon the valves 44 and 45 are opened and the fluid is delivered through ports 30, valves 44 and 45, pipes 46 and 47 to the admission ports 11 of the lower prime mover cylinders 1. Thus the lower prime mover cylinders 1 are supplied with combustion and scavenging air compressed in the upper cylinder 5.

The upper prime mover cylinders 1 are similarly supplied with the air compressed in the lower cylinder 5.

Jacks 70 (Figs. 4 and 5) are provided for producing small displacements of the pistons of the machine at low speed, for instance for controlling the starting position.

The whole machine is supported by a frame 60, the spiders 16, 17, 18 and the kinematic connection at the lower end of the machine being enclosed in casings 61, 62, 63.

It is emphasized that the number of gas compressor cylinders which are in interspersed relation to the pairs of prime mover cylinders is in such relation to the number of pairs of prime mover cylinders that the power producing force developed in a given stroke of the prime mover free pistons is in a balanced relation about the central axis to the force produced by the free pistons in the compressor cylinders for compression of the gas therein distributed about said central axis.

This application is a continuation in part of my copending application Serial No. 590,918, filed April 28, 1945, now U. S. Patent No. 2,491,679 of December 20, 1949.

I claim:

1. A fluid pressure machine of the reciprocating type comprising at least two prime mover cylinders arranged with their axes extending in the same general direction and in opposed spaced relation in said direction, a pair of pistons in each cylinder adapted for reciprocating movement thereof along the axes of the respective cylinders, means operatively connecting a piston of one of said two prime mover cylinders with a piston of the other prime mover cylinder as a set for concomitant reciprocating movement of said pistons axially in their respective cylinders, means operatively connecting the other pistons respectively in said prime mover cylinders as a set for concomitant reciprocating movement of said other pistons axially in their respective cylinders, means operatively connecting said first set of connected pistons and said other set of connected pistons to provide for movement of said first set of connected pistons in a given direction in said prime mover cylinders concomitantly with movement of said other set of connected pistons in the opposite direction in said prime mover cylinders, at least two gas compressor cylinders arranged with their axes extending in the same general direction and in opposed spaced relation in said direction, a pair of pistons in each gas compressor cylinder adapted for reciprocating movement thereof along the axes of the respective cylinders, means operatively connecting a piston of one of said two gas compressor cylinders with a piston of the other gas compressor cylinder as a set for concomitant reciprocating movement of said pistons axially in their respective gas compressor cylinders, means operatively connecting the other pistons respectively in said gas compressor cylinders as a set for concomitant reciprocating movement of said other pistons axially in their respective gas

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compressor cylinders, means operatively connected between said first set of connected gas compressor pistons and said other set of connected gas compressor pistons to provide for movement of said first set of connected pistons in a given direction in said gas compressor cylinders concomitantly with movement of said other set of connected pistons in the opposite direction in said gas compressor cylinders, and means co-operating with said respective operative connections to produce gas compressing movement of said pistons in said gas compressor cylinders concomitantly with power producing movement of said pistons in said prime mover cylinders.

2. A fluid pressure machine of the reciprocating type comprising at least two prime mover cylinders arranged coaxially and in opposed spaced relation along the common axis thereof, each cylinder having a pair of pistons therein for reciprocating movement thereof along said axis, the adjacently disposed pistons in said two cylinders being connected to move together and the remotely disposed pistons in said cylinders being connected to move together respectively as rigid units in the two directions of reciprocating movement along said common axis of said prime mover cylinders, at least two gas compressor cylinders arranged coaxially and in opposed spaced relation along the common axis thereof, each gas compressor cylinder having a pair of pistons therein for reciprocating movement thereof along said axis, the adjacently disposed pistons in said two gas compressor cylinders being connected to move together and the remotely disposed pistons in said gas compressor cylinders being connected to move together respectively as rigid units in the two directions of reciprocating movement along said common axis of said gas compressor cylinders, and means operatively connecting said rigid units associated with said prime mover cylinders respectively with said rigid units associated with said gas compressor cylinders to produce gas compressing movement of said compressor pistons respectively in said gas compressor cylinders concomitantly with power producing movement of said prime mover pistons respectively in said prime mover cylinders.

3. A fluid pressure machine of the reciprocating type comprising at least two prime mover cylinders arranged coaxially and in opposed spaced relation along the common axis thereof, each cylinder having a pair of pistons therein for reciprocating movement thereof along said axis, at least two gas compressor cylinders arranged coaxially and in opposed spaced relation along the common axis of said gas compressor cylinders, each gas compressor cylinder having a pair of pistons therein for reciprocating movement thereof along said axis of said gas compressor cylinders, the adjacently disposed pistons in said two prime mover cylinders and the adjacently disposed pistons in said gas compressor cylinders being connected to move together as a rigid unit, whereby a prime mover piston and a gas compressor piston of said rigid unit move outwardly and inwardly of their respective cylinders respectively concomitantly with movement of the other prime mover piston and the other gas compressor piston of said rigid unit inwardly and outwardly of their respective cylinders, the remotely disposed pistons of said two prime mover cylinders and the remotely disposed pistons in said two compressor cylinders being connected to move together as another rigid unit, whereby a remotely disposed prime mover piston and a remotely dis-

posed gas compressor piston of said other rigid unit move outwardly and inwardly of their respective cylinders respectively concomitantly with movement of the other remotely disposed prime mover piston and the other remotely disposed compressor piston inwardly and outwardly of their respective cylinders, and means operatively connecting said rigid units to effect reciprocating movements of the two pistons in each of said prime mover and compressor cylinders in opposite directions.

4. A fluid pressure machine of the reciprocating type comprising a plurality of pairs of cylinders arranged with the axes of all of the cylinders extending in the same general direction and with the cylinders of each pair in opposed spaced relation to each other in said direction, a pair of pistons in each cylinder adapted for reciprocating movement thereof along the axes of the respective cylinders, means operatively connecting the adjacently disposed pistons of a pair of said cylinders to the adjacent disposed pistons of another pair of said cylinders to form a set of pistons for reciprocating movement thereof concomitantly with reciprocating movement of said adjacently disposed pistons axially in their respective cylinders, means operatively connecting the remotely disposed pistons of said two pairs of cylinders to form another set of pistons for reciprocating movement thereof concomitantly with the reciprocating movement of said remotely disposed pistons axially in their respective cylinders, and means operatively connecting said sets of pistons to provide for movement of said first set of pistons in a given direction in their respective cylinders concomitantly with movement of said other set of pistons in the opposite direction in their respective cylinders, at least one of said pairs of cylinders the cylinders of which are in opposed spaced relation to each other being adapted to receive between the respective pistons thereof a fluid pressure medium for producing power developing movement of said pistons respectively in said cylinders, at least another of said pairs of cylinders the cylinders of which are in opposed spaced relation to each other being adapted to confine a fluid pressure medium to be compressed between the respective pistons thereof upon movement of said sets of pistons in said opposite directions in their respective cylinders.

5. A fluid pressure machine of the reciprocating type comprising a plurality of pairs of cylinders arranged with their axes of all of the cylinders extending in the same general direction and with the cylinders of each pair in opposed spaced relation to each other in said direction, a pair of pistons in each cylinder adapted for reciprocating movement thereof along the axes of the respective cylinders, means operatively connecting the adjacently disposed pistons of a pair of said cylinders to the adjacently disposed pistons of another pair of said cylinders to form a set of pistons for reciprocating movement thereof concomitantly with reciprocating movement of said adjacently disposed pistons axially in their respective cylinders, means operatively connecting the remotely disposed pistons of said two pairs of cylinders to form another set of pistons for reciprocating movement thereof concomitantly with the reciprocating movement of said remotely disposed pistons axially in their respective cylinders, means operatively connecting said sets of pistons to provide for movement of said first set of pistons in a given direction in their respective cylinders concomitantly with movement of said

other set of pistons in the opposite direction in their respective cylinders, means for delivering a fluid pressure medium alternately to the cylinders of at least one of said pairs of cylinders and developing pressure between the pistons thereof to effect said reciprocating movements of said sets of pistons in their respective cylinders, and means for confining a fluid pressure medium alternately between the pistons of at least one other of said pairs of cylinders to develop pressure therein.

6. A fluid pressure machine of the reciprocating type comprising a plurality of pairs of cylinders arranged with the axes of all of the cylinders extending in the same general direction and with the cylinders of each pair in opposed spaced relation to each other in said direction, a pair of pistons in each cylinder adapted for reciprocating movement thereof along the axes of the respective cylinders, means operatively connecting the adjacently disposed pistons of a pair of said cylinders to the adjacently disposed pistons of another pair of said cylinders to form a set of pistons for reciprocating movement thereof concomitantly with reciprocating movement of said adjacently disposed pistons axially in their respective cylinders, means operatively connecting the remotely disposed pistons of said two pairs of cylinders to form another set of pistons for reciprocating movement thereof concomitantly with the reciprocating movement of said remotely disposed pistons axially in their respective cylinders, means operatively connecting said sets of pistons to provide for movement of said first set of pistons in a given direction in their respective cylinders concomitantly with movement of said other set of pistons in the opposite direction in their respective cylinders, means for delivering a fluid pressure medium alternately to the respective cylinders of certain of said pairs of cylinders and developing pressure between the pistons thereof to effect said reciprocating movements of said sets of pistons in their respective cylinders, and means for controlling delivery and discharge of a fluid pressure medium to and from the respective cylinders of said other pairs of cylinders alternately concomitantly with said reciprocating movements of said sets of pistons to effect compression of said fluid pressure medium.

7. A fluid pressure machine of the reciprocating type comprising at least two prime mover cylinders arranged coaxially and in opposed spaced relation along the common axis thereof, each cylinder having a pair of pistons therein for reciprocating movement thereof along said axis, at least two gas compressor cylinders arranged coaxially and in opposed spaced relation along the common axis of said gas compressor cylinders, each gas compressor cylinder having a pair of pistons therein for reciprocating movement thereof along said axis of said gas compressor cylinders, the axes of said prime mover cylinders and of said compressor cylinders being parallel to and oppositely disposed with respect to a central axis of said fluid pressure machine, all of the pistons operating in the portions of said opposed spaced cylinders which are in adjacently disposed relation being connected together to form a rigid unit of which the pistons at one side of a median plane between said opposed spaced cylinders transverse to said central axis of the machine respectively move outwardly and inwardly of their respective cylinders as the pistons in the cylinders disposed at the other side of said transverse median plane respectively move inwardly and outwardly of their respective cylinders, the pistons in the remotely disposed portions of the

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respective cylinders being connected together to form a second rigid unit the pistons of which at one side of said median transverse plane respectively move outwardly and inwardly of their respective cylinders as the remotely disposed pistons of said second unit at the other side of said median transverse plane respectively move inwardly and outwardly of their respective cylinders, and means operatively connecting said rigid units for concomitant reciprocating movements thereof and of the pistons in the respective portions of said prime mover cylinders and in the respective portions of said compressor cylinders in opposite directions.

8. A fluid pressure machine of the reciprocating type comprising a plurality of groups of stationary cylinders distributed in each group about a central axis of the machine with the axes of the cylinders extending parallel to said central axis, the cylinders of each group being arranged in pairs with the cylinders of said pairs coaxial and in opposed spaced relation to each other in the direction parallel to said central axis, each cylinder of each pair having a pair of pistons therein for reciprocating movement thereof in said direction parallel to said central axis of the machine, the adjacently disposed pistons of each pair of cylinders in each group being connected together and being connected to said connected adjacently disposed pistons of the other pairs of cylinders of said group to form a rigid unit, whereby said adjacently disposed pistons of said group move together in the same directions of said reciprocating movement parallel to said central axis inwardly and outwardly of their respective cylinders, the remotely disposed pistons of each pair of cylinders in each group being connected together and being connected to said connected remotely disposed pistons of the other pairs of cylinders of said group to form a second rigid unit, whereby said remotely disposed pistons of said group move together in the same directions of said reciprocating movement parallel to said central axis inwardly and outwardly of their respective cylinders, means operatively connecting the rigid unit which includes the adjacently disposed pistons of one group with the rigid unit which includes the adjacently disposed pistons of the other group to produce reciprocating movement of said adjacently disposed pistons in said first group concomitantly with reciprocating movement of said adjacently disposed pistons in the other group, means operatively connecting the rigid unit which includes the remotely disposed pistons of the first group with the rigid unit which includes the remotely disposed pistons of said other group to produce reciprocating movement of said remotely disposed pistons of said first group concomitantly with reciprocating movement of said remotely disposed pistons in the other group, means operatively connecting said rigid units for reciprocating movements of the two pistons in each of said cylinders in opposite directions concomitantly with said reciprocating movements of said rigid units, and means for confining different fluids under pressure in the cylinders of the respective groups between the pistons thereof.

9. A fluid pressure machine of the reciprocating type comprising a plurality of stationary prime mover cylinders distributed about a central axis of the machine with the axes of the cylinders extending parallel to said central axis, said prime mover cylinders being arranged in pairs with the cylinders of each pair in opposed spaced relation in the direction parallel to said central axis

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and coaxial with each other, each prime mover cylinder having a pair of pistons therein for reciprocating movement thereof along the axis of said pair, a plurality of stationary gas compressor cylinders distributed about said central axis with the axis of the cylinders extending parallel to said central axis, said gas compressor cylinders being arranged in pairs with the cylinders of each pair in opposed spaced relation in the direction parallel to said central axis and coaxial with each other, each gas compressor cylinder having a pair of pistons therein for reciprocating movement thereof along the axis of said pair of gas compressor cylinders, the adjacently disposed pistons of said prime mover cylinders being connected together and being connected to the adjacently disposed pistons of said gas compressor cylinders to form a rigid unit for reciprocating movement thereof concomitantly with reciprocating movement of said adjacently disposed pistons in their respective cylinders, the remotely disposed pistons of said prime mover cylinders being connected together and being connected to the remotely disposed pistons of said gas compressor cylinders to form a rigid unit for reciprocating movement thereof concomitantly with reciprocating movement of said remotely disposed pistons in their respective cylinders, and means operatively connecting said rigid units for movement of the pistons respectively connected thereto inwardly and outwardly of their respective cylinders in opposite directions concomitantly with said reciprocating movements of said units.

10. A fluid pressure machine of the reciprocating type as defined in claim 9 which comprises means for producing power developing fluid pressure between the pistons of said prime mover cylinders which are in spaced relation and coaxial respectively with others of said prime mover cylinders, and means for controlling delivery and discharge of a gas to be compressed to and from the space between the pistons of said gas compressor cylinders which are in spaced relation and coaxial respectively with others of said gas compressor cylinders.

11. A fluid pressure machine of the reciprocating type comprising a set of prime mover cylinders distributed about a central axis of the machine with the axes thereof parallel to said central axis, a set of gas compressor cylinders distributed about said central axis in interspersed relation to said prime mover cylinders and with axes of said gas compressor cylinders parallel to said central axis of the machine, another set of prime mover cylinders distributed about said central axis of the machine with the axes thereof parallel to said central axis, another set of gas compressor cylinders distributed about said central axis in interspersed relation with said other set of prime mover cylinders and with the axes of said other gas compressor cylinders parallel to said central axis of the machine, the prime mover cylinders of one set being coaxial with the prime mover cylinders of the other set and respectively in spaced relation thereto in the direction parallel to said central axis, the gas compressor cylinders of one set being coaxial with the gas compressor cylinders of the other set and in spaced relation thereto in said direction parallel to said central axis, a member supported for reciprocating movement thereof in the direction parallel to said central axis, a piston in each prime mover cylinder and in each gas compressor cylinder reciprocable in the portions of the respective cylinders which are adjacently disposed in the direction parallel to said central

axis and operatively connected to said reciprocable member for movement of said adjacent pistons associated with the cylinders of one set inwardly and outwardly thereof concomitantly with movement of said adjacent pistons associated with the axially aligned cylinders of the other set outwardly and inwardly of said axially aligned cylinders, another member supported for reciprocating movement thereof in the direction parallel to said central axis, a piston in each prime mover cylinder and in each gas compressor cylinder reciprocable in the portions of the respective cylinders which are remotely disposed in the direction parallel to said central axis and operatively connected to said other member for movement of said remotely disposed pistons associated with the cylinders of one set inwardly and outwardly thereof concomitantly with movement of said remotely disposed pistons associated with the axially aligned cylinders of said other set outwardly and inwardly of said axially aligned cylinders, and means operatively connecting said members for reciprocating movement thereof in opposite directions one with respect to the other concomitantly with movements of the two pistons in the respective cylinders in opposite directions.

12. A fluid pressure machine of the reciprocating type comprising a plurality of groups of stationary cylinders distributed in each group about a central axis of the machine with the axes of the cylinders extending parallel to said central axis, the cylinders of each group being arranged in pairs with the cylinders of said pairs coaxial and in opposed spaced relation in the direction parallel to said central axis, each cylinder of each pair having a pair of pistons therein for reciprocating movement thereof in said direction parallel to said central axis of the machine, the adjacently disposed pistons of each pair of cylinders in each group being connected together for movement in the same directions of said reciprocating movement thereof along their common axis inwardly and outwardly of their respective cylinders, the remotely disposed pistons of each pair of cylinders in each group being connected together for movement in the same directions of said reciprocating movement thereof along their common axis inwardly and outwardly of their respective cylinders, a pair of cylindrical members arranged with the axes thereof coaxial with said central axis and in bearing relation to each other for reciprocating sliding movement thereof relative to each other along said central axis, the adjacently disposed pistons of each pair of cylinders in each group being connected to one of said cylindrical members as a rigid unit for reciprocating movement thereof and of said member concomitantly with said inward and outward movements of said adjacently disposed pistons in their respective cylinders, the remotely disposed pistons of each pair of cylinders in each group being connected to the other cylindrical member as a rigid unit for reciprocating movement thereof and of said other member concomitantly with said inward and outward movements of said remotely disposed pistons in their respective cylinders, and a kinematic connection between said members for movement of said members in opposite directions of said reciprocating movements thereof in sliding relation to each other along said central axis.

13. A free piston engine-compressor comprising a plurality of pairs of prime mover cylinders

having a pair of free pistons in each cylinder and arranged with the cylinders of each pair extending in the same general direction and in opposed spaced relation in said direction, said pairs of prime mover cylinders being distributed about a central axis of said free piston engine-compressor, a plurality of pairs of gas compressor cylinders having a pair of free pistons in each cylinder and arranged with the cylinders of each pair extending in the same general direction and in opposed spaced relation in said direction, said pairs of gas compressor cylinders being distributed about said central axis in interspersed relation to said prime mover cylinders, the adjacently disposed pistons of said prime mover cylinders being connected to pistons which respectively are in the cylinders of said pairs of gas compressor cylinders so as to produce respectively compression and suction strokes of said pistons in said gas compressor cylinders concomitantly respectively with power producing and exhaust strokes of said adjacently disposed prime mover pistons, the remotely disposed pistons of said prime mover cylinders being connected to other pistons which respectively are in the cylinders of said pairs of gas compressor cylinders so as to produce respectively compression and suction strokes of said other pistons in said gas compressor cylinders concomitantly respectively with power producing and exhaust strokes of said remotely disposed prime mover pistons, a pair of tubular members arranged coaxially with said central axis in telescoping relation to each other for reciprocating sliding movement with respect to each other along said central axis, the outer tubular member being connected to the adjacently disposed pistons of said pairs of prime mover cylinders and to the compressor pistons connected thereto to form a unit for reciprocating movement thereof and of said outer member along said central axis concomitantly with reciprocating movement of said pistons connected thereto in their respective cylinders, the other tubular member being connected to the remotely disposed pistons of said prime mover cylinders and to the compressor pistons connected thereto to form a unit for reciprocating movement thereof and of said other tubular member along said central axis concomitantly with reciprocating movement of said pistons connected thereto in their respective cylinders, and means operatively connecting said tubular members for reciprocating movement thereof in opposite directions one with respect to the other concomitantly with the opposite movement in the respective cylinders of the pistons connected thereto.

14. A free piston engine compressor as defined in claim 13 in which the number of pairs of gas compressor cylinders which are in interspersed relation to said pairs of prime mover cylinders is in such relation to the number of pairs of prime mover cylinders that the power producing force developed in a given stroke of said prime mover free pistons is in balanced relation about said central axis to the force produced by the free pistons in said compressor cylinders for compression of the gas therein distributed about said central axis.

15. A free piston engine-compressor comprising a plurality of pairs of prime mover cylinders having a pair of free pistons in each cylinder and arranged with the cylinders of each pair coaxial and in opposed spaced relation along the common axis thereof, the axes of said pairs of prime mover cylinders being parallel and distributed about a

central axis of said free piston engine-compressor, a plurality of pairs of gas compressor cylinders having a pair of free pistons in each cylinder and arranged with the cylinders of each pair coaxial and in opposed spaced relation along the common axis thereof, the axes of said pairs of gas compressor cylinders being parallel and distributed about said central axis in interspersed relation to said axes of said prime mover cylinders, the adjacently disposed pistons of said prime mover cylinders being connected to the adjacently disposed pistons of the interspersed gas compressor cylinders to form a first rigid unit, the remotely disposed pistons of said prime mover cylinders being connected to the remotely disposed pistons of said interspersed gas compressor cylinders to form a second rigid unit, a first tubular member coaxial with said central axis, a second tubular member coaxial with said central axis and extending about said first tubular member in bearing sliding relation to each other for reciprocating movement of said tubular members relative to each other along said central axis, said tubular members respectively being rigidly connected to said second and first rigid units, and means operatively connecting said units to produce respectively upon separating and approaching movements of the free prime mover pistons in a given cylinder of a pair of prime mover cylinders approaching and separating movement of a pair of free pistons in a gas compressor cylinder and concomitantly therewith approaching and separating movements of the free prime mover pistons in the other cylinder of said pair of prime mover cylinders and separating and approaching movements of the pistons in the other gas compressor cylinder of said pair of gas compressor cylinders.

16. A free piston engine compressor as defined in claim 15 in which the masses of said rigid units and the members respectively connected thereto are substantially equal, and a kinematic connection between said rigid units adapted for movement of said masses in opposite directions along said central axis concomitantly with reciprocating movements of said free pistons in their respective cylinders.

17. A fluid pressure machine of the reciprocating type as defined in claim 4 in which each of said cylinders centrally of the length thereof are provided with ports for admission of the fluid thereto between the pistons thereof, and means associated with said ports for controlling the flow of the fluids to the respective cylinders.

18. A fluid pressure machine of the reciprocating type as defined in claim 4 in which each of said cylinders centrally of the length thereof are provided with ports for admission of the fluid thereto between the pistons thereof, and means associated with said ports for controlling the flow of the fluids to the respective cylinders, said cylinders which are adapted to receive between the pistons thereof a fluid pressure medium for producing power developing movement of said pistons being provided with ports respectively adjacent the opposite ends thereof for removal there-through of the exhaust fluid pressure medium from said cylinders.

19. A fluid pressure machine of the reciprocating type as defined in claim 5 in which said means for delivering a fluid pressure medium alternately to the cylinders of at least one of said pairs of cylinders is arranged in relation to said cylinders to deliver said fluid centrally of the length of the respective cylinders, said means for con-

fining the fluid pressure medium alternately between the pistons of at least one other of said pairs of cylinders to develop pressure therein being arranged in relation to said cylinders to effect delivery and discharge of said fluid pressure medium centrally of the length of the respective cylinders.

20. A fluid pressure machine of the reciprocating type as defined in claim 1 which comprises a plurality of sets of said prime mover cylinders having their axes extending in the same general direction and in opposed spaced relation in said direction, said sets being disposed in symmetrical relation to each other about a common central axis extending in said general direction, and a plurality of sets of said gas compressor cylinders arranged with their axes extending in said general direction and in opposed spaced relation in said direction, said sets of compressor cylinders being distributed in symmetrical relation to each other about said common central axis and in interspersed relation to said sets of prime mover cylinders.

21. A fluid pressure machine of the reciprocating type as defined in claim 1 which comprises a plurality of sets of said prime mover cylinders having their axes extending in the same general direction and in opposed spaced relation in said direction, said sets being disposed in symmetrical relation to each other about a common central axis extending in said general direction, and a plurality of sets of said gas compressor cylinders arranged with their axes extending in said general direction and in opposed spaced relation in said direction, said sets of compressor cylinders being distributed in symmetrical relation to each other about said common central axis and in interspersed relation to said sets of prime mover cylinders, two of said sets of compressor cylinders being low pressure cylinders and being oppositely disposed with respect to said common axis, two others of said sets of compressor cylinders being respectively intermediate and high compression compressor cylinders and being in interspersed symmetrical arrangement with respect to said low pressure compressor cylinders.

22. A fluid pressure machine as defined in claim 21 in which one of said sets of low pressure cylinders is connected to said prime mover cylinders to supply combustion supporting gas to said prime mover cylinders operating as an internal combustion engine.

23. A fluid pressure machine of the reciprocating type comprising a plurality of groups of stationary cylinders distributed in each group about a central axis of the machine with the axes of the cylinders extending parallel to said central axis, the cylinders of each group being arranged in pairs with the cylinders of said pairs coaxial and in opposed spaced relation to each other in the direction parallel to said central axis, each cylinder of each pair having a pair of pistons therein for reciprocating movement thereof in said direction parallel to said central axis of the machine, the adjacently disposed pistons of each pair of cylinders in each group being connected together and being connected to said connected adjacently disposed pistons of the other pairs of cylinders of said group to form a rigid unit, whereby said adjacently disposed pistons of said group move together in the same directions of said reciprocating movement parallel to said central axis inwardly and outwardly of their respective cylinders, the remotely disposed pistons of each pair of cylinders in each group being con-

nected together and being connected to said connected remotely disposed pistons of the other pairs of cylinders of said group to form a second rigid unit, whereby said remotely disposed pistons of said group move together in the same directions of said reciprocating movement parallel to said central axis inwardly and outwardly of their respective cylinders, means operatively connecting the rigid unit which includes the adjacently disposed pistons of one group with the rigid unit which includes the adjacently disposed pistons of the other group to produce reciprocating movement of said adjacently disposed pistons in said first group concomitantly with reciprocating movement of said adjacently disposed pistons in the other group, means operatively connecting the rigid unit which includes the remotely disposed pistons of the first group with the rigid unit which includes the remotely disposed pistons of said other group to produce reciprocating movement of said remotely disposed pistons of said first group concomitantly with reciprocating movement of said remotely disposed pistons in the other group, and means for confining different fluids under pressure in the cylinders of the respective groups between the pistons thereof for change in the pressures and volumes of said fluids in the respective cylinders concomitantly with the reciprocating movements of said units.

24. A free piston engine-compressor comprising a plurality of pairs of prime mover cylinders having a pair of free pistons in each cylinder and arranged with the cylinders of each pair extending in the same general direction and in opposed spaced relation in said direction, said pairs of prime mover cylinders being distributed about a central axis of said free piston engine-compressor, a plurality of pairs of gas compressor cylinders having a pair of free pistons in each cylinder and arranged with the cylinders of each pair extending in the same general direction and in opposed spaced relation in said direction, said pairs of gas compressor cylinders being distribut-

ed about said central axis in interspersed relation to said prime mover cylinders, the adjacently disposed pistons of said prime mover cylinders being connected to pistons which respectively are in the cylinders of said pairs of gas compressor cylinders so as to produce respectively compression and suction strokes of said pistons in said gas compressor cylinders concomitantly respectively with power producing and exhaust strokes of said adjacently disposed prime mover pistons, the remotely disposed pistons of said prime mover cylinders being connected to other pistons which respectively are in the cylinders of said pairs of gas compressor cylinders so as to produce respectively compression and suction strokes of said other pistons in said gas compressor cylinders concomitantly respectively with power producing and exhaust strokes of said remotely disposed prime mover pistons, a pair of tubular members arranged coaxially with said central axis in telescoping relation to each other for reciprocating sliding movement with respect to each other along said central axis, the outer tubular member being connected to the adjacently disposed pistons of said pairs of prime mover cylinders and to the compressor pistons connected thereto to form a unit for reciprocating movement thereof and of said outer member along said central axis concomitantly with reciprocating movement of said pistons connected thereto in their respective cylinders, the other tubular member being connected to the remotely disposed pistons of said prime mover cylinders and to the compressor pistons connected thereto to form a unit for reciprocating movement thereof and of said other tubular member along said central axis concomitantly with reciprocating movement of said pistons connected thereto in their respective cylinders.

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No references cited.