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FREE PISTON ENGINE STARTING SYSTEM

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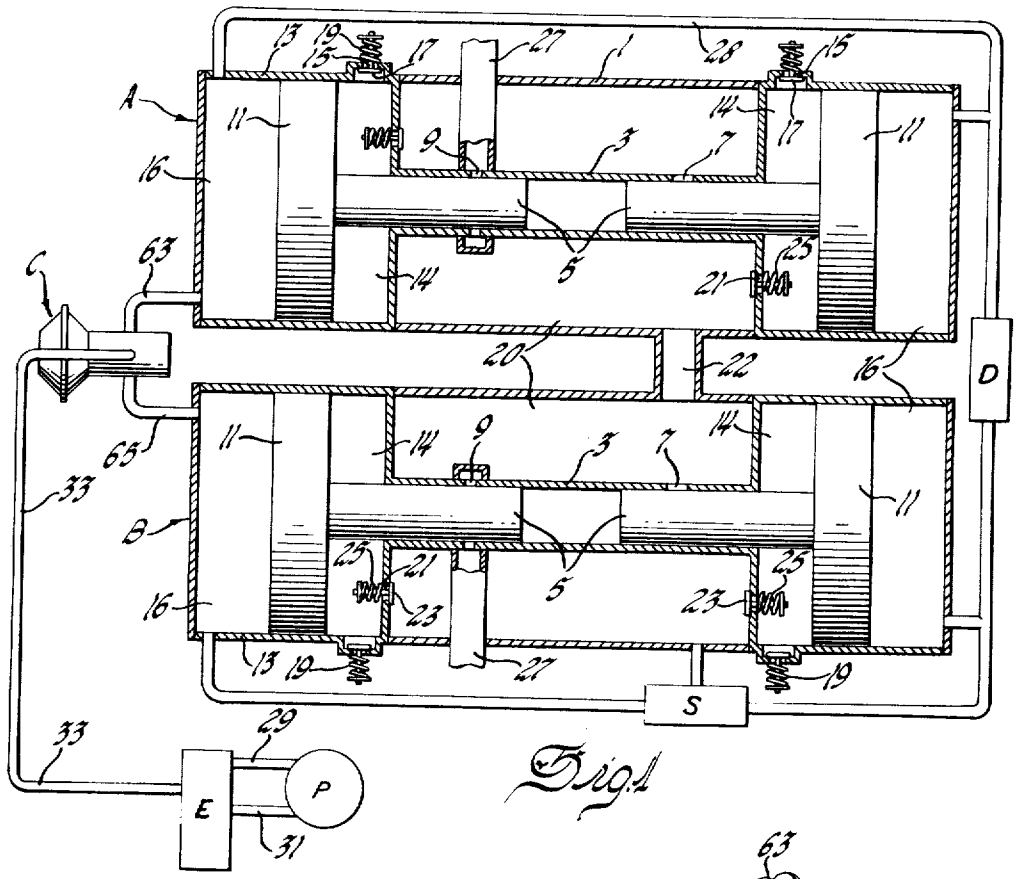

Fig. 1

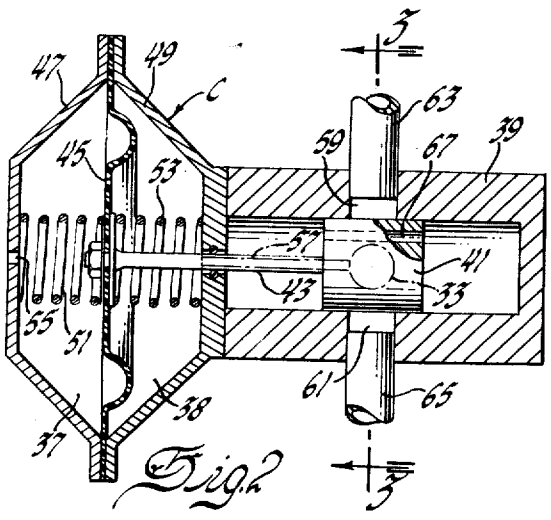

Fig. 2

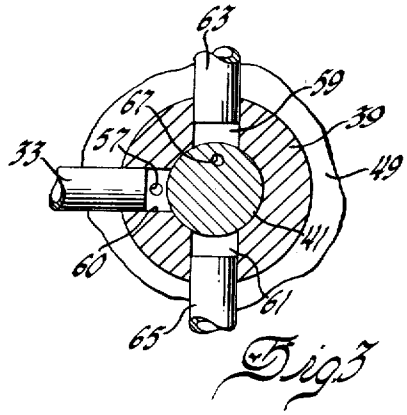

Fig. 3

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FREE PISTON ENGINE STARTING SYSTEM

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This invention relates to the starting of free piston engines, gasifiers and compressors. The invention relates more particularly to an improved arrangement for isolating dual free piston gas generators after they have been started.

Where two or more free piston gas generators are employed to supply gas under pressure to a power conversion device such as a turbine, it is desirable to run the gas generators out of phase to provide a more uniform gas discharge. During starting of the generator however, it is more suitable to have the units connected so as to be in phase. It is therefore desirable to provide an automatic valve to isolate the engines by breaking the connection between the two engines after they have been started, and one such arrangement is shown in co-pending application S.N. 584,744 by Warren H. Smith, filed May 14, 1956 now Patent No. 2,839,911, issued June 24, 1958. The arrangement shown in said Patent No. 2,839,911 utilizes air box pressure to operate the isolating valve. In a fully automatic starting system utilizing alternate suction and pressure to maneuver the pistons, such as that shown in my co-pending application S.N. 620,972, filed Nov. 7, 1956, now Patent No. 2,956,396, issued Oct. 18, 1960, it is desirable to provide a system having an automatic isolating valve controlled by the alternative suction and pressure that is both simple and effective. This invention relates to such a starting system employing such an automatic isolating valve.

It is therefore an object of this invention to provide a free piston engine starting system having an automatic isolating valve for connecting two or more independent gasifier units during starting and to isolate the units after the starting operations have been completed.

This and other objects and advantages of the invention will be readily apparent from the following specification and drawings which illustrate a preferred embodiment of the invention but which are not to be considered as limiting the invention.

The preferred embodiment of the invention comprises a diaphragm operated valve that normally isolates the cushion chambers of independent free piston units but is actuated to connect the chambers either by vacuum utilized to move the compressor pistons to their outer positions or by positive pressure utilized to move the pistons inwardly. The valve is effective also to connect the maneuvering vacuum or pressure to the individual cushion chambers only during the starting procedure.

Referring to the drawings, FIGURE 1 is a diagrammatical sectional view of a dual free piston machine;

FIGURE 2 is an enlarged cross-sectional view of the isolating valve employed in the invention; and

FIGURE 3 is a cross-sectional view taken on the line 3—3 of FIGURE 2.

FIGURE 1 of the drawings diagrammatically shows a gas turbine free piston machine that could be used as a gasifier for providing a continuous supply of gases under high pressure and temperature to a prime mover such as a gas turbine; also the machine could be adapted for use as a gas compressor or for other purposes.

The engine includes a case or housing **1**, a portion of which defines two motor cylinders **3** in which are reciprocably mounted opposed motor pistons **5**. Each motor cylinder **3** has inlet ports **7** and exhaust ports **9** at opposite ends of the cylinder.

These ports are opened and closed by the motor pistons **5** which are rigid with large compressor pistons **11** adapted to reciprocate in cylinder **13** also formed by the engine case **1**. Each compressor cylinder has an inlet port **15** controlled by a valve **17** normally urged to closed position by a spring **19**. Each compressor cylinder also has an exhaust port **21** controlled by a valve **23** normally closed by a spring **25**. The opposed movable masses of the pistons **5** and **11** of each unit are kept in proper relationship with each other by a separate synchronizing linkage, not shown, which may be of any known type, for example that shown in my co-pending application S.N. 620,972 referred to above. The upper and lower individual units are designated by A and B, respectively, in FIGURE 1.

The two units of the engine are operated by known supercharged two stroke diesel engine principle. Initial movement of the movable masses **5—11** towards each other causes entrapment of supercharged air and further compression of this air in the motor cylinders **3**. At the proper time fuel is injected by known means, not forming part of the invention, but which may be such as that shown in Patent No. 2,811,958. The fuel injected into the compressed air between the motor pistons is ignited by the heat of compression. The increase in pressure created by the burning fuel acts on the opposed faces of the motor pistons **5** and forces the movable faces **5—11** away from each other.

Each compressor cylinder **13** is divided by the compressor piston **11** into a compression chamber **14** and a cushion or rebound chamber **16**. As the movable masses **5—11** move outwardly their motion is checked by air entrapped in the cushion chamber **16**, which then possesses practically all the energy developed by the motor cylinder **3** and restores this energy to the movable masses **5—11** during the next inward stroke. Motor cylinders **3** are scavenged by air which is drawn in past the inlet valves **17** during outward movement of the masses **5—11**, compressed in chamber **14** during the inward stroke of the masses **5—11**, and delivered past the discharge valves **23** into the case chamber **20**. A connecting passage **22** equalizes the pressure on the respective chambers **20** of the units A and B. On the next outward stroke of the masses **5—11**, compressed air in chamber **20** enters the motor cylinder **3** through inlet ports **7** and travels through the motor cylinder **3** and out exhaust ports **9** into an exhaust collector **27** and then to some power generating device such as a gas turbine.

The rebound chambers **16** of unit A are connected together by a passage **28** to equalize the pressures in the opposite chambers. The cushion chambers **16** of unit B are similarly connected together by a stabilizer S, of any known type, for example that shown in U.S. Patent No. 2,355,924. The stabilizer, which forms no part of this invention, operates only after the starting cycle is completed.

The starting system in the preferred embodiment comprises a unidirectional pump P having a pressure discharge passage **29** and a suction passage **31** leading to a positioning control valve E, the details and operation of which are fully described in my co-pending application S.N. 620,972 referred to above. The positioning control valve E acts to connect either the discharge passage **29** or the suction passage **31** to a starting pressure passage **33** that leads to an isolating valve C. It is understood that a bi-directional pump may be utilized to provide the suction and positive pressures for maneuvering the pistons. In such a system the direction of rotation of the pump is reversed to change from suction to positive pressure. Similarly two pumps, one a vacuum and one a positive pressure pump, could be alternately connected to passage **33**.

The isolating valve C, seen in detail in FIGURES 2 and 3, comprises a valve body **39** having a reciprocating valve member **41** connected to a rod **43** that is attached to a flexible diaphragm **45**. The outer periphery of the diaphragm **45** is held between cover members **47** and **49**. Chamber **37** is always connected to the atmosphere by hole **55**. The diaphragm and the covers act to form two chambers **37** and **38**. A pair of springs **51** and **53** normally hold the diaphragm in its center position thereby holding the valve member **41** in the position shown in FIGURE 2. The valve body **39** has three radially drilled holes **59**, **60** and **61**. Hole **59** forms a port connected to a pipe **63** leading to the cushioning chamber **16** of unit A, and hole **61** similarly forms a port connecting with a pipe **65** leading to the cushion chamber **16** of unit B. The third hole **60** forms a port connected with the starting fluid passage **33** leading from the positioning control valve E.

A connecting passage **57** continually connects the chamber **38** with the passage **33** so that whatever pressure exists in passage **33** will exist in chamber **38**. A drilled hole **67** in the valve member **41** acts to connect the chambers on either side of the valve member **41**.

Operation

Operation of the starting system is as follows: Valve E is initially in a position to connect the suction passage **31** with the pipe **33** and when the pump P is operated a vacuum will be created in passage **33** and by means of connecting hole **57** in the valve C, a vacuum will be created in chamber **38**. Atmospheric air pressure entering chamber **37** through the hole **55** will act on the diaphragm to move it and the rod **43** against the spring **53** thereby moving the valve member **41** to the right to connect the passage **33** with the pipes **63** and **65**. As the pump P continues to operate, air is drawn out of the cushion chambers **16** and when the pistons have moved to their outermost positions, mechanisms, of known type and not shown, but which may be of the type shown in my above-mentioned application S.N. 620,972, acts to operate the positioning control valve E to connect the discharge or pressure passage **29** with the pipe **33**.

With passage **33** no longer having a vacuum, differential pressure no longer acts on diaphragm **45** and spring **53** returns the diaphragm and valve **41** to its position of FIGURE 2 blocking passages **33**, **63** and **65** from each other. Valve E now directs positive pressure into pipe **33** and by means of passage **57** acts on diaphragm **45** to move it and valve **41** to the left against spring **51**. Passages **63** and **65** are then connected with pipe **33** and the fluid under pressure flows to chambers **16** to act on pistons **11**. A latching or holding mechanism, not shown and of known type, such as that shown in my application S.N. 620,972, holds the masses **5—11** in an outer position until a predetermined pressure exists in chambers **16**. The latching mechanism then is released and masses **5—11** allowed to move inwardly by the high pressure in chambers **16**. The pump P is automatically stopped when the latch mechanism releases the masses **5—11** and with absence of pressure from the pump and with the expansion of the pressure in chambers **16**, the compressed spring **51** returns diaphragm **45** and valve **41** to their neutral position of FIGURE 2 sealing off passages **63** and **65** from each other and from passage **33** during the running of the gasifier.

The invention provides an improved control apparatus suitable for use in many applications in the art of free piston machine control and the principles of the invention may be utilized in other arts through the use of ordinary skill.

It will be apparent to those skilled in the art that modications of the system and components thereof may be made within the scope of the invention which is not to be considered as limited by the detailed description of the embodiment shown.

I claim:

1. A free piston power plant comprising, in combination, a pair of independent free piston units each including a first cylinder and piston means defining a power cylinder, and a second cylinder and piston means defining a compressor cylinder having a compressor chamber and a rebound chamber, means operatively connecting said first piston means and said second piston means, first and second conduits each connected to one of said rebound chambers, valve means between said conduits having a normally closed condition isolating the conduits from each other and an open condition connecting said rebound chambers with each other and with a third conduit, an air starter pump having a pressure discharge conduit and a suction conduit, means for alternatively connecting said third conduit with said discharge conduit or said suction conduit, closing means for moving said valve means to its closed condition, and valve operating means operatively connected to said valve means to open the same and connect said first, second and third conduits with each other, said valve operating means responsive to operation of said starter pump to open said valve and responsive to cessation of operation of said pump to allow said closing means to move said valve to its closed condition to disconnect said first, second and third conduits.

2. A starter system for a free piston power plant having a plurality of individual independent power units each having a power cylinder and a compressor cylinder interconnected together and a power piston and a compressor piston interconnected together and movable in said respecspective cylinders and a rebound chamber formed by said compressor cylinder and said compressor piston, the combination including rebound conduits leading to each of said rebound chambers arranged to supply air to or exhaust air from said chambers, a starter means for supplying air under pressure to or exhausting air from a starter conduit, a three position valve between said rebound conduits and said starter conduit, said valve having a first normal position wherein said rebound conduits are disconnected from each other and from said starter conduit, and second and third positions wherein said conduits are connected to each other and to said starter conduit, and means connected to said valve to normally move said valve to said first position and responsive to operation of said starter means for supplying air to said starter conduit to move said valve to said second position and responsive to operation of said starter means to exhaust air from said starter conduit to move said valve to said third position

3. A free piston power plant comprising, in combination, two independent free piston units each including a power cylinder and a compressor cylinder interconnected together and a power piston and a compressor piston interconnected together and movable in said respective cylinders and a rebound chamber formed by said compressor cylinder and said compressor pistion, means to establish dephased operation of said power units, first and second conduits each connecting to the rebound chamber of one of the units, a starter arranged to alternatively provide positive presure air to or evacuate air from a third conduit, a normally closed valve between said first, second and third conduits, said valve having an open condition connecting said first, second and third conduits to each other and a closed condition isolating said first, second and third conduits from each other, and means responsive to positive pressure on to negative pressure in said third conduit connected to said valve to move the valve to said open position.

References Cited in the file of this patent

UNITED STATES PATENTS

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