Oct. 25, 1932. A. F. MICHLUN 1,884,077

COMBINED AIR COMPRESSOR AND GAS ENGINE

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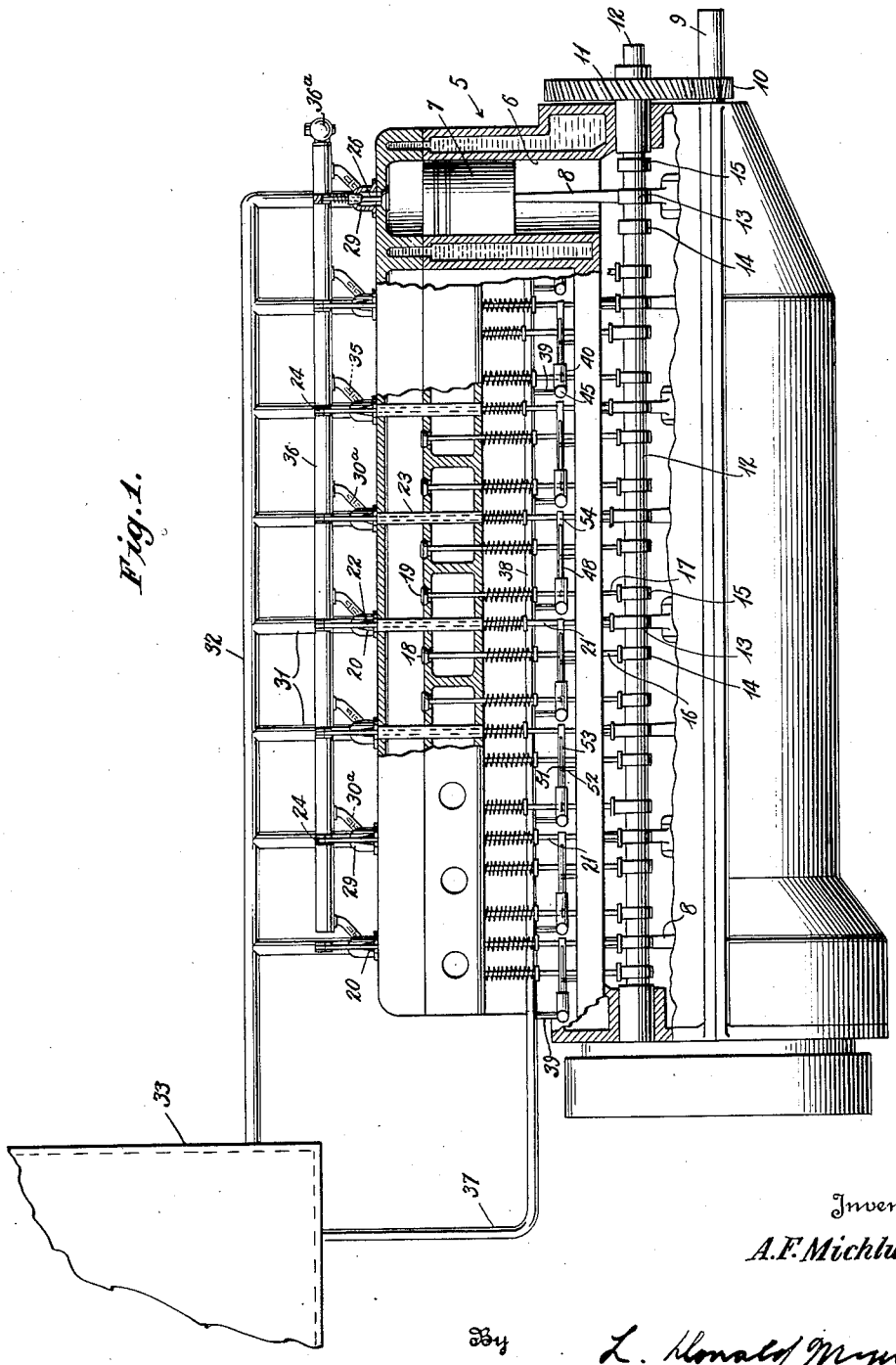


Fig. 1.

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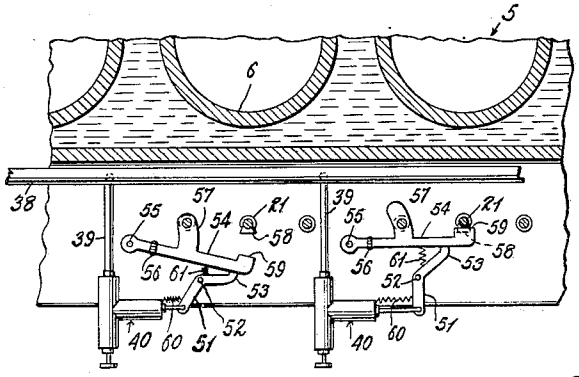
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Fig. 2.



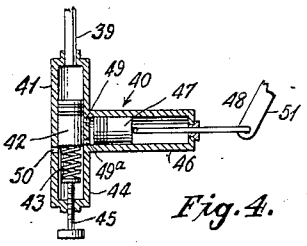


Fig. 4.

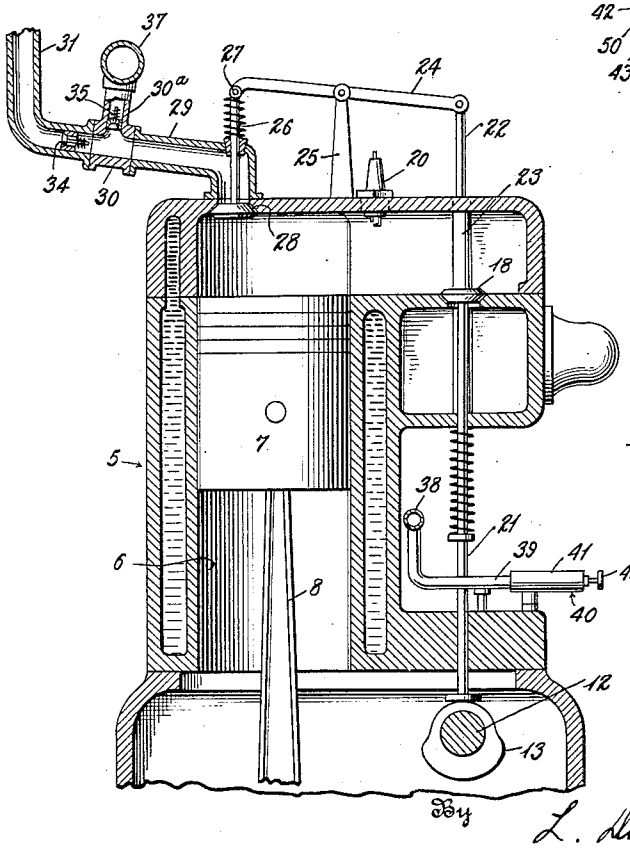


Fig. 3.

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Patented Oct. 25, 1932 1,884,077

UNITED STATES PATENT OFFICE

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COMBINED AIR COMPRESSOR AND GAS ENGINE

Application filed January 24, 1929. Serial No. 334,823.

This invention relates to a combined air compressor and gas engine.

The primary object of this invention is to provide a single unit by means of which motive power may be developed and air may be compressed simultaneously.

A further object of the invention is to produce a power unit which takes the form of an internal combustion engine and to so modify the engine structure as to permit air to be compressed successively in all of the cylinders of the engine without affecting the operation of the engine.

A still further object of the invention is to provide controlling means for a combined air compressor and gas engine of the type referred to above whereby the portion of the total amount of power, developed by the engine, to be used for compressing air may be governed and varied at will.

Another important object of the invention is to connect a combined unit of the above referred to type to a storage system and to provide automatic controlling means which will render the said combined unit inoperative to compress air when the pressure within the storage system reaches a predetermined maximum.

Other objects and advantages of the invention will be apparent during the course of the following description:

In the accompanying drawings forming a part of this specification and in which like numerals are employed to designate like parts throughout the same,

Figure 1 is a side elevational view, partly broken away, of a combined air compressor and gas engine embodying this invention, the said figure further illustrating the manner in which the unit is connected to a storage system,

Figure 2 is a fragmentary horizontal sectional view, illustrating control mechanism employed for rendering the combined unit inoperative to compress air when the pressure within the system has reached a predetermined maximum.

Figure 3 is a vertical sectional view taken through one of the cylinders of the engine illustrated in Fig. 1, and

Figure 4 is a detail sectional view of a portion of the control mechanism illustrated in Fig. 2.

In the drawings, wherein for the purpose of illustration is shown a preferred embodiment of this invention, the numeral 5 designates in its entirety the combined air compressor and gas engine unit. This unit possesses all of the principal characteristics of an ordinary internal combustion engine of the multi-cylinder type. In the embodiment illustrated herein, the engine is provided with eight cylinders. It is to be understood, however, that I do not desire to limit myself to any particular number of cylinders but it has been determined that an eight cylinder engine will operate to the best advantage. Each cylinder 6 is of uniform diameter throughout its length and has movably mounted therein a piston 7 of ordinary construction, the said piston being of substantially uniform diameter throughout its length. Each piston is provided with a connection rod 8 which is operatively connected with a crank shaft 9 in the usual manner. The crank shaft is provided with a pinion 10 which meshes with a gear 11 mounted upon a cam shaft 12. This form of gear connection provides a four to one operating ratio between the crank shaft and the cam shaft, the said crank shaft making four complete revolutions to every single revolution of the cam shaft.

The cam shaft 12 is provided with twenty-four cams, or three cams for each cylinder. In the particular lay-out illustrated, the central cam 13 will be termed the air valve cam while the cams 14 and 15 will be termed the exhaust and intake valve cams respectively. Each cylinder is provided with an exhaust valve push rod 16 and an intake valve push rod 17 which operate exhaust and intake valves 18 and 19 respectively. These valves 18 and 19 may be of the usual poppet type and may be provided with any desired form of seating spring. Each cylinder has operatively associated therewith an igniter 20.

With the exception of the operating ratio between the crank and cam shafts and the extra cam for each cylinder, the mechanism so far described is to be found in practically

every form of internal combustion engine and forms no part of this invention except as to the manner in which it cooperates with the structure now to be described for producing an entirely new combined type of air compressor and engine. No attempt has been made to illustrate all of the different parts or accessories necessarily employed to produce an operative and complete internal combustion engine and it is to be understood that these essential devices would be provided in a commercial structure.

The various cylinders will be supplied with fuel through the intake valves 18 and the exploded gases will be discharged by means of the exhaust valves 19 in the customary manner for providing a so called four cycle engine. In other words, both the intake and exhaust valves will be closed during the power stroke of the piston. During the next upward stroke, or the exhaust stroke, of the piston, the exhaust valve will be open for relieving the cylinder of exploded gases. Upon the completion of the exhaust stroke of the piston, the exhaust valve will close and the intake valve will be opened. The piston will then make its suction stroke for drawing in combustible gases and after completing the suction stroke, the piston will return for compressing the gas within the cylinder whereupon the igniter 20 will be supplied with current for exploding the gases. This in a general way describes the usual operation of a four cycle engine.

Due to the four to one ratio of rotation between the crank shaft and cam shaft in the illustrated structure, the crank shaft will rotate four times to every complete revolution of the cam shaft and for this reason the pistons will make eight complete strokes during the time the cam shaft makes one complete revolution. Four of the eight piston strokes have been described as being employed for developing power in the usual manner of a four cycle engine. The remaining four strokes of each piston are to be utilized for compressing air and the mechanism now to be referred to makes it possible to utilize these four extra strokes of each piston for this purpose.

Each air valve cam 13 has operatively associated therewith a valve push rod 21 employed for operating a tappet rod 22 which passes upwardly through a rod guide 23 mounted within the block and head of the engine in any desired manner so as to permit the tappet rod to emerge from the upper wall of the cylinder head and project thereabove to be pivotally connected to a rocker arm 24. This rocker arm is supported by a suitable mounting 25 and is operatively connected with the air valve 26. It is to be understood that a pivotal connection 27 may be provided between the rocker arm 24 and the stem of the air valve 26, sufficient play being allowed for permitting relative movement between these pivotally connected ends, or the rocker arm may be operatively connected with the air valve 26 in any other desired manner, such as having a sliding engagement with the end of the valve and providing the valve stem with a returning spring of the type illustrated in connection with the intake and exhaust valves.

The air valve 26 controls a port 28 formed in the head of the engine and this port establishes communication between the interior of the cylinder and a conduit 29. The cam 13 for each air valve is intended to unseat its respective valve and to retain it unseated or open during substantially one-half of a complete revolution of the cam shaft 12. Each cam 13, therefore, will hold its respective air valve 26 open during four of the strokes of the piston mounted within its respective cylinder.

The conduit 29 has connected therein a T coupler 30 having one branch connected with a conduit 31 leading to a manifold 32 which in turn is connected with a storage tank, or the like 33. Positioned at any desired point within the conduit 31 is an outwardly opening check valve 34 which will permit air to flow toward the manifold 32. Another branch of the coupler 30 is provided with an inwardly opening check valve 35 which will function to permit air to travel inwardly through the conduit 29 and into the cylinder 6. The outer end of this branch 30*a* is connected with a manifold 36 having at one end a valve device 36*a* which may be manually regulated to control the amount of air which may pass from the atmosphere into the manifold. It is to be understood that the casing for the valve device 36*a* communicates with the atmosphere.

From the above description, it will be understood that four strokes of each piston are employed for compressing air, the said air being stored in the tank 33. The two downward or suction strokes of the piston will draw air through the manifold 36, by the check valve 35 and into the conduit 29 from which it will pass into its respective cylinder 6. On each of the two compression strokes of the piston, the air will be compressed and forced through the conduit 29, by the check valve 34, and through the conduit 31 and manifold 32 respectively until it reaches the storage tank 33.

It is to be understood that the four strokes of each piston employed for compressing air will be four successive strokes of a piston and they will occur between a power exhaust stroke and an intake stroke. I have illustrated and described this engine as being of the eight stroke cycle type so that two air compressing strokes may be provided for each complete cycle of operation of each cylinder. It is to be understood, however, that

two air compressing strokes have been provided instead of one because of the greater economy in operation provided thereby.

The valve device 36 has been provided for controlling the amount of air admitted to each cylinder during each air suction stroke. It will be understood that if a piston were permitted to suck into its cylinder as much air as the cylinder would hold, a great amount of power would be required to compress this air and feed it from the cylinder into the storage tank. By reducing the amount of air admitted to the cylinder, or by starving each cylinder during the suction stroke of its piston, less power is required to move the piston during the air compressing stroke. The provision of a control on the air intake will permit the operator of the unit to govern the amount of the total power developed by the engine which will be used for compressing air. For example, if the engine develops forty horse-power and the valve device 36 is set to require one-half of the total power or twenty horse-power to compress the air admitted to the cylinders, the remaining half of the total power is left to drive some external device.

It will be understood, of course, that the continued operation of the engine will supply the storage tank 33 with air compressed at a higher pound per square inch pressure than is desired for most purposes. For this reason, the pressure within the tank 33 should not exceed a predetermined maximum. A safety or blow-off valve might be provided for the tank which would open when the maximum pressure is reached. Such a control, however, would not relieve the engine for it would continue to compress air and this unnecessary air would just be exhausted from the tank with a resulting waste in power. I therefore have provided an automatic control which will operate to prevent this loss of power when the maximum air pressure has been reached.

Connected to the tank 33 is a line 37 which leads to a manifold 38 extending lengthwise of the engine block. This manifold 38 has a branch 39 for each engine cylinder. Each branch 39 (see Fig. 4) is connected with a compound cylinder casing 40 at one end of a branch 41. Positioned within this branch is a piston 42 which has bearing against one end thereof a spring 43 seated upon a follower 44 which in turn is connected to an adjusting screw 45 by means of which the position of the spring 43 may be varied with respect to the length of the branch 41. The branch 46 of the compound cylinder casing 40 is provided with a piston 47 having a rod 48 slidably extending through the outer end wall of the branch 46. The ports 49 and 49*a* are formed in the casing 40 and provide means of communication between the interiors of the branches 41 and 46. The branch 41 has a port 50 which is spaced longitudinally of the branch 41 with respect to the port 49.

The piston rod 48 is connected to a bell crank lever 51 pivoted at 52 to the engine block. The remaining arm 53 of the bell crank lever slidably engages an arm 54 which is pivoted at 55 to the engine block. The arm 54 is provided with a hinged joint 56 to permit relative movement between the parts of the said arm. A lip 57 projects laterally from the arm 54 and is arranged in alignment with and is interposed between the adjacent ends of the exhaust valve push rod and the valve stem. The air valve push rod 21 is provided with a shoulder or ledge 58 which registers with a projection 59 formed on the end of the arm 54 and extending in the same lateral direction as that of the lip 57. A spring 60 connects the operating arm of the bell crank lever 51 to the casing 40 while a spring 61 connects the arm 53 of the lever 51 to the arm 54. It will be understood that the pivot mounting 55 for the arm 54 will permit this arm to swing, under the influence of the bell crank lever 51, from the position shown at the left of Fig. 2, that is with the projection 59 spaced from the ledge 58, to the position shown at the right of Fig. 2, or with the projection 59 resting upon the ledge 58. The hinge joint 56 will permit the outer portion of the arm 54 to rise and fall with respect to the portion of said arm which extends from the pivot 55 to the hinge 56. This vertical swinging movement of the outer portion of the arm is necessary to permit it to follow the movements of the valve stem.

The operation of this control device may be described as follows: The pressure within the line 37 and the manifold 38 will correspond for all practical purposes with the pressure within the tank 33. This air pressure will be communicated to the piston 54 within the branch 41 of the casing 40. Air pressure being applied to the end of the piston 42 will tend to move the latter longitudinally through the branch 41 against the tension of the spring 43. It is to be understood of course that adjustment of the said screw 45 will vary the operative tension of the spring 43. When a predetermined maximum pressure occurs in the tank 33 and thereby in the branch 41, the piston 42 will be moved against the tension of the spring 43 until the port 49 is opened to provide communication between the branches 41 and 46 of the compound cylinder casing 40.

The admission of air to the branch 46 will cause the piston 47 to be moved longitudinally of the branch 46. This operation of the piston 47 will rock the bell crank lever 51 which in turn will move the arm 54 laterally whereby the projection 59 will be positioned to rest upon the ledge 58 formed on the air valve push rod 21. This arrangement of the arm 54 will cause the exhaust valve to be un-

seated whenever its respective air valve is unseated whereby air drawn into the cylinder by the air suction stroke of its piston will be exhausted from the cylinder through the exhaust valve port for said cylinder and not through the line of connection with the storage tank. This quick and rapid exhausting of the air will relieve the engine of practically all unnecessary load during such times as the pressure of the air within the storage tank is at its desired maximum.

When the air pressure in the system drops below the desired maximum, the pressure within the branch 41 likewise will drop and will permit the spring 43 to move the piston 42 longitudinally of the branch 41 and as the air pressure continues to drop, the piston 42 is moved farther through the branch 41. When the piston 42 has finally been moved to such an extent that it is located beyond the port 49*a*, the branch 46 is again in communication with the branch 41 but it is in communication with the portion of the branch 41 having the port 50 therein. The air within the branch 46, therefore, will be exhausted through the port 50 and the springs 60 and 61 will be permitted to return the elements 51 and 54 to the positions illustrated in the left hand mechanism disclosed in Fig. 2. After the arm 54 has been moved into its inoperative position, as illustrated by the mechanism located on the left of Fig. 2, air again will be forced into the storage tank 33 when the air valves are lifted.

While the arm 54 is resting upon the ledge 58 formed on the air valve tappet rod, the unseating of the air valve of course will unseat the exhaust valve. It is to be understood, of course, that the engine keeps right on operating on its power strokes. During these power strokes, the exhaust valves for the various cylinders necessarily must be raised to permit the exhaust gases to be discharged from the cylinders. Due to the fact that the projection 59 of the arm 54 rests upon the top of the ledge 58, the lifting of an exhaust valve will merely cause the outer portion of the arm 54 to pivot upon the hinge 56 for being raised with the exhaust valve and without affecting its respective air valve.

While this combined device has been described as including four power strokes for each piston and four air compressing strokes, it is to be understood that the ratio between the gear elements 10 and 11 may be changed to a three to one ratio and the air valve cams 13 may be changed to produce a six stroke cycle mechanism so that only two strokes will be used for compressing air. It has been pointed out above, however, that the use of four strokes for compressing air to every four power strokes permits of a far more economical operation of the device.

It is believed that the above description will enable any one skilled in the art to construct and operate the type of combined air compressor and gas engine disclosed herein. It therefore only remains to be said that this combined unit may be used wherever motive power and compressed air are necessary on any one job. Without attempting to limit the use of this device, it will be noted that very efficient service may be rendered by the same in connection with power shovels used for excavating purposes, air jacks and pile drivers, and the like.

It is to be understood that the form of this invention herewith shown and described is to be taken as a preferred example of the same, and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described the invention, I claim:—

1. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively interconnecting said pistons, means for employing four strokes of each piston for developing power, means for employing four additonal strokes of each piston for compressing air and pressure controlled means for rendering said last mentioned means operative and inoperative.

2. A power plant including a unit having a plurality of cylinders each of which has a bore of uniform diameter throughout its length, a piston for each cylinder having a uniform diameter throughout its length, means for operatively connecting said pistons, means for employing four strokes of each piston for developing power, and for employing four additional strokes of each piston for compressing air and pressure controlled means for rendering said last mentioned means operative or inoperative.

3. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively interconnecting said pistons, means for employing four strokes of each piston for developing power and four additional strokes of each piston for compressing air during each cycle of operation of all of the cylinders, and manually operable means for controlling the percentage of the total power developed by said plant to be used for compressing air.

4. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively interconnecting said pistons, means for employing four strokes of each piston for developing power, means for employing four additional strokes of each piston for compressing air, and means to vary the amount of air admitted to the cylinder for controlling the amount of the total power, developed by said plant, to be used for compressing air.

5. A power plant including a unit having

a plurality of cylinders each of which has a bore of uniform diameter throughout its length, a piston for each cylinder having a uniform diameter throughout its length, means for operatively connecting said pistons, means for employing four strokes of each piston for developing power and four additional strokes of each piston for compressing air during each cycle of operation of all of the cylinders, and means for controlling the admission of air to the cylinders to vary the portion of the total power, developed by said plant, to be used for compressing air.

6. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively connecting said pistons, a storage system connected to all of the cylinders, means for employing some of the strokes of each piston during each cycle of operation of all of the cylinders for compressing air in said system and the remaining strokes of each piston for developing power to operate the unit, and means for rendering said first mentioned strokes inoperative to compress air when the pressure in the system reaches a predetermined maximum.

7. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively interconnecting said pistons, means for employing four strokes of each piston for developing power, means for employing four additional strokes of each piston for compressing air and the remaining strokes of each piston for developing power to operate the unit, and means for rendering said last mentioned means inoperative when the pressure in the system reaches a predetermined maximum.

8. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively interconnecting said pistons, means for employing four strokes of each piston for developing power and four additional strokes of each piston for compressing air during each cycle of operation of all of the cylinders, means for controlling the admission of air to the cylinders for varying the portion of the total power developed by said plant to be used for compressing air, and means for rendering the said four additional strokes inoperative to compress air when the pressure in the system reaches a predetermined maximum.

9. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively interconnecting said pistons, means for employing at least two strokes of each piston during each cycle of operation of all of the cylinders for compressing air, and means for varying the amount of air admitted to the cylinders during the air compressing strokes for controlling the amount of the total power developed by said plant to be used for compressing air.

10. A power plant including a relatively movable cylinder and piston, means for timing the admission to the cylinder of a driving medium during each cycle of operation of the plant so as to utilize certain of the relative movements of the cylinder and piston for developing power and the remaining movements for compressing air, and pressure responsive means for rendering the plant inoperative to compress air during the air compressing movements of the cylinder and the piston without affecting the relative power developing movements of said cylinder and piston.

11. A power plant including a relatively movable cylinder and piston, means for timing the admission to the cylinder of a driving medium during each cycle of operation of the plant so as to utilize certain of the relative movements of the cylinder and piston for developing power and the remaining movements for compressing air, and means for varying the amount of air admitted to the cylinder during the cycles to control the amount of the total power developed by said plant to be used for compressing air.

12. A power plant including a relatively movable cylinder and piston, means for timing the admission to the cylinder of a driving medium during each cycle of operation of the plant so as to utilize certain of the relative movements of the cylinder and piston for developing power and the remaining movements for compressing air, means for varying the amount of air admitted to the cylinder during the cycles to control the amount of the total power developed by said plant to be used for compressing air, and pressure responsive means for rendering the plant inoperative to compress air during any of the relative movements of the cylinder and piston.

13. A power plant including a relatively movable cylinder and piston, means for timing the admission to the cylinder of a driving medium during each cycle of operation of the plant so as to utilize certain of the relative movements of the cylinder and piston for developing power and the remaining movements for compressing air, a storage system connected to the cylinder, and pressure responsive means for rendering the plant inoperative to compress air during air compressing movements of the cylinder and piston without affecting the power developing movements of the piston and cylinder when the pressure in the system reaches a predetermined maximum.

14. A power plant including a relatively movable cylinder and piston, a driving medium admission valve, an air admission and discharge valve, means for controlling the operation of said valves so that certain relative movements of the cylinder and piston will be utilized for developing power and the

remaining movements will be utilized for compressing air, and means independent of the air valve for controlling the amount of air admitted to the cylinder during the compressing movements.

15. A power plant including a relatively movable cylinder and piston, a driving medium admission valve, a discharge valve for the spent driving medium, an air admission and discharge valve, means for controlling the operation of said valves so that certain relative movements of the cylinder and piston will be utilized for developing power and the remaining movements will be utilized for compressing air, and pressure responsive means for causing the discharge valve and the air valve to be opened simultaneously for rendering the plant inoperative to compress air.

16. A power plant including a relatively movable cylinder and piston, a driving medium admission valve, a discharge valve for the spent driving medium, an air admission and discharge valve, means for controlling the operation of said valve so that certain relative movements of the cylinder and piston will be utilized for developing power and the remaining movements will be utilized for compressing air, pressure responsive means for causing the discharge valve and the air valve to be opened simultaneously for rendering the plant inoperative to compress air, and means independent of the air valve for controlling the amount of air admitted to the cylinder during the compressing movements.

17. A power plant including a unit having a plurality of cylinders, a piston for each cylinder, means for operatively connecting said pistons, a storage system connected to all of the cylinders, means for employing some of the strokes of each piston during each cycle of operation of all of the cylinders for compressing air in the system and the remaining strokes of each cycle for developing power, and pressure controlled means for rendering said first mentioned strokes inoperative to compress air by opening the cylinders to the atmosphere during the air compressing strokes only.

18. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively interconnecting said pistons, means for employing four strokes of each piston for developing power, means for employing four additional strokes of each piston for compressing air, an air supply manifold common to all of the cylinders having a single admission opening, and means for varying the amount of air passing through said opening for controlling the amount of the total power, developed by said plant, to be used for compressing air.

19. A power plant including a unit having a plurality of cylinders each of which has a bore of uniform diameter throughout its length, a piston for each cylinder having a uniform diameter throughout its length, means for operatively connecting said pistons, means for employing four strokes of each piston for developing power and four additional strokes of each piston for compressing air during each cycle of operation of all of the cylinders, an air supply manifold common to all of the cylinders having a single admission opening, and means for varying the amount of air passing through said opening for controlling the amount of the total power, developed by said plant, to be used for compressing air.

20. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively interconnecting said pistons, means for employing four strokes of each piston for developing power and four additional strokes of each piston for compressing air during each cycle of operation of all of the cylinders, an air supply manifold common to all of the cylinders having a single admission opening, and means for varying the amount of air passing through said opening for controlling the amount of the total power, developed by said plant, to be used for compressing air.

21. A power plant including a multi-cylinder unit, a piston for each cylinder, means for operatively interconnecting said pistons, means for employing at least two strokes of each piston during each cycle of operation of all of the cylinders for compressing air, an air supply manifold common to all of the cylinders having a single admission opening, and means for varying the amount of air passing through said opening for controlling the amount of the total power, developed by said plant, to be used for compressing air.

22. A power plant including a relatively movable cylinder and piston, means for timing the admission to the cylinder of a driving medium during each cycle of operation of the plant so as to utilize certain of the relative movements of the cylinder and piston for developing power and the remaining movements for compressing air, and a manually operable valve for varying the amount of air admitted to the cylinder during the cycles to control the percentage of the total power developed by said plant to be used for compressing air.

23. A power plant including a relatively movable cylinder and piston, means for timing the admission to the cylinder of a driving medium during each cycle of operation of the plant so as to utilize certain of the relative movements of the cylinder and pistons for developing power and the remaining movements for compressing air, a manually operable valve for varying the amount of air admitted to the cylinder during the

cycles to control the amount of the total power developed by said plant to be used for compressing air, and pressure responsive means for rendering the plant inoperative to compress air during the air compressing movements of the cylinder and piston without affecting the power developing movements of the piston and cylinder.

In testimony whereof, I affix my signature.

ANDREW F. MICHLUN.