Dec. 5, 1939.　　H. STEINER　　2,182,063

CONTROL SYSTEM FOR FREE STROKE PISTON ENGINES

Filed April 2, 1936　　3 Sheets-Sheet 1

Fig. 1.

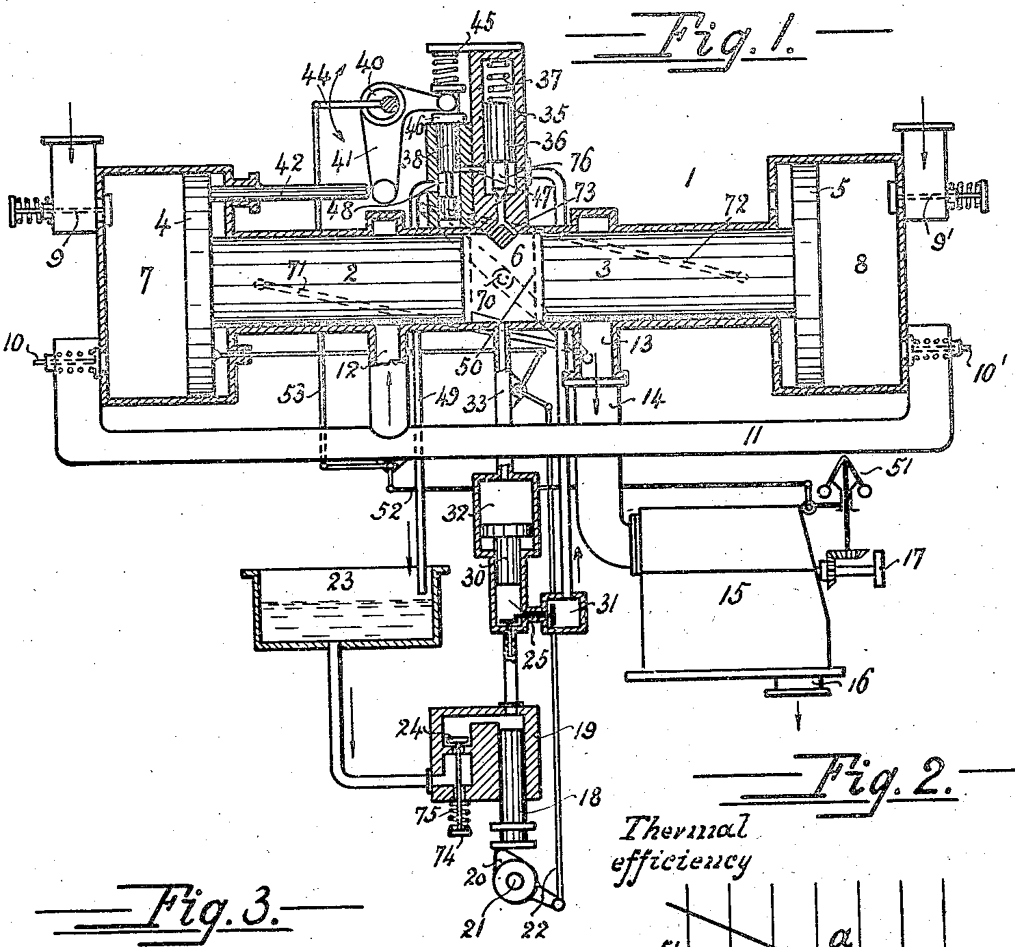

Fig. 2.

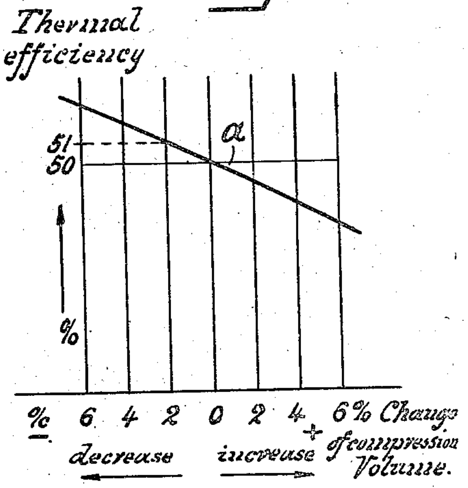

Fig. 3.

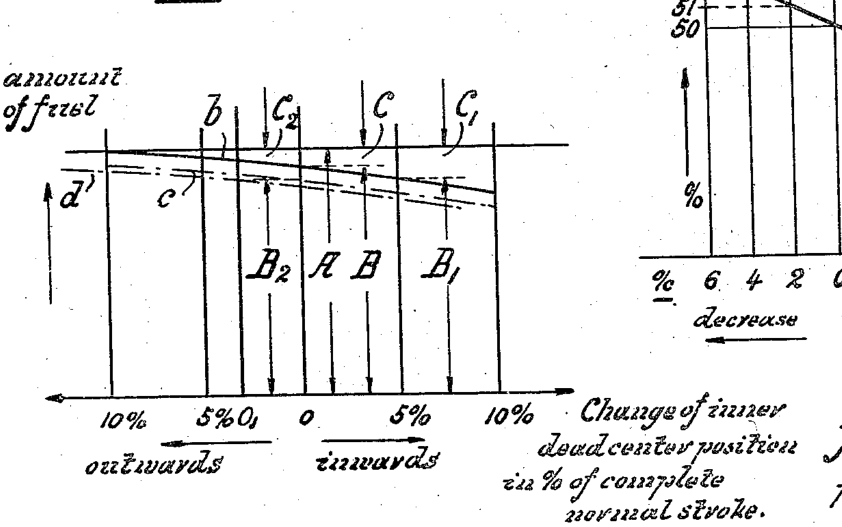

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Fig. 4.

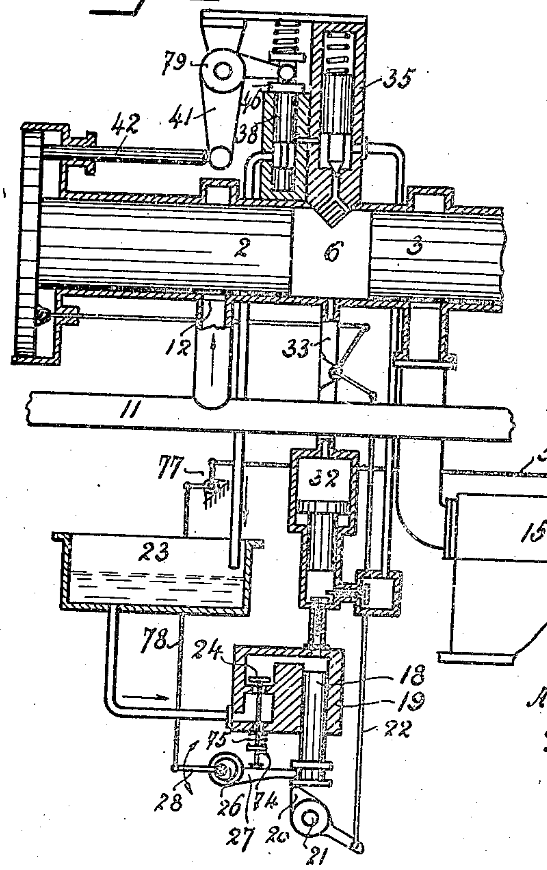

Fig. 5.

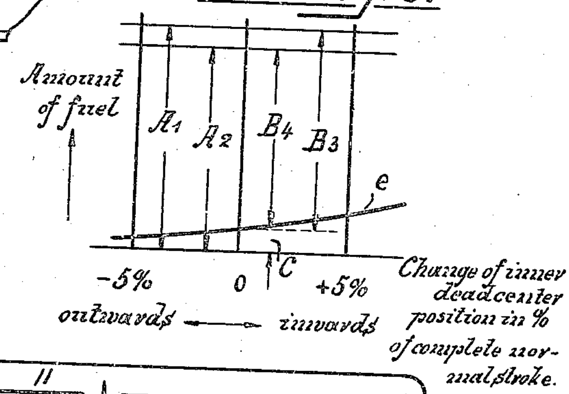

Fig. 6.

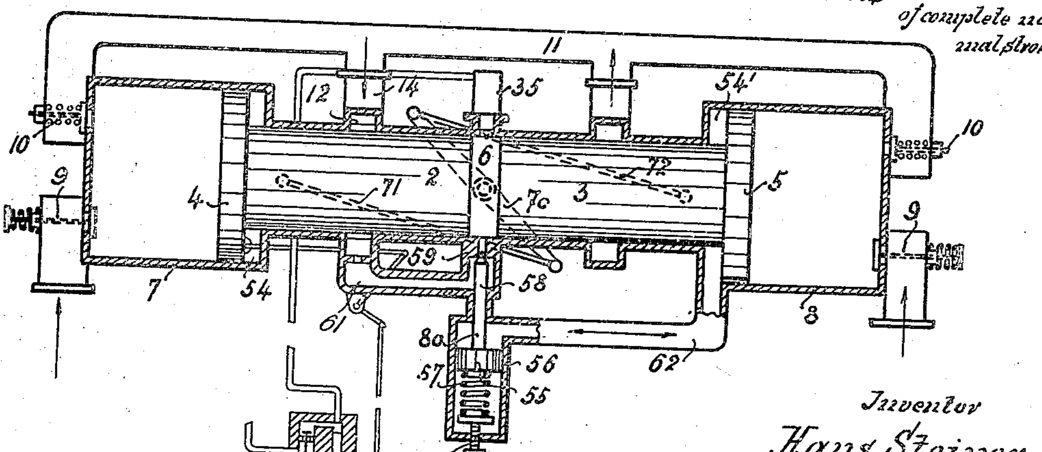

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Fig. 7.

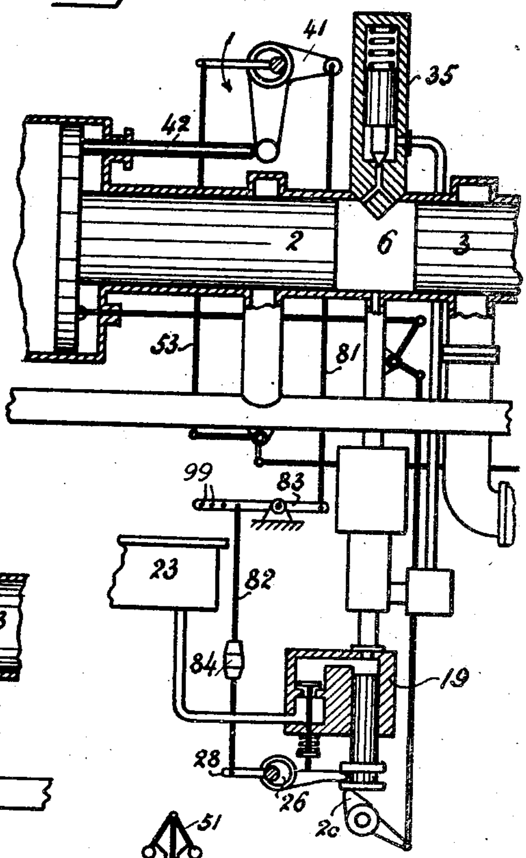
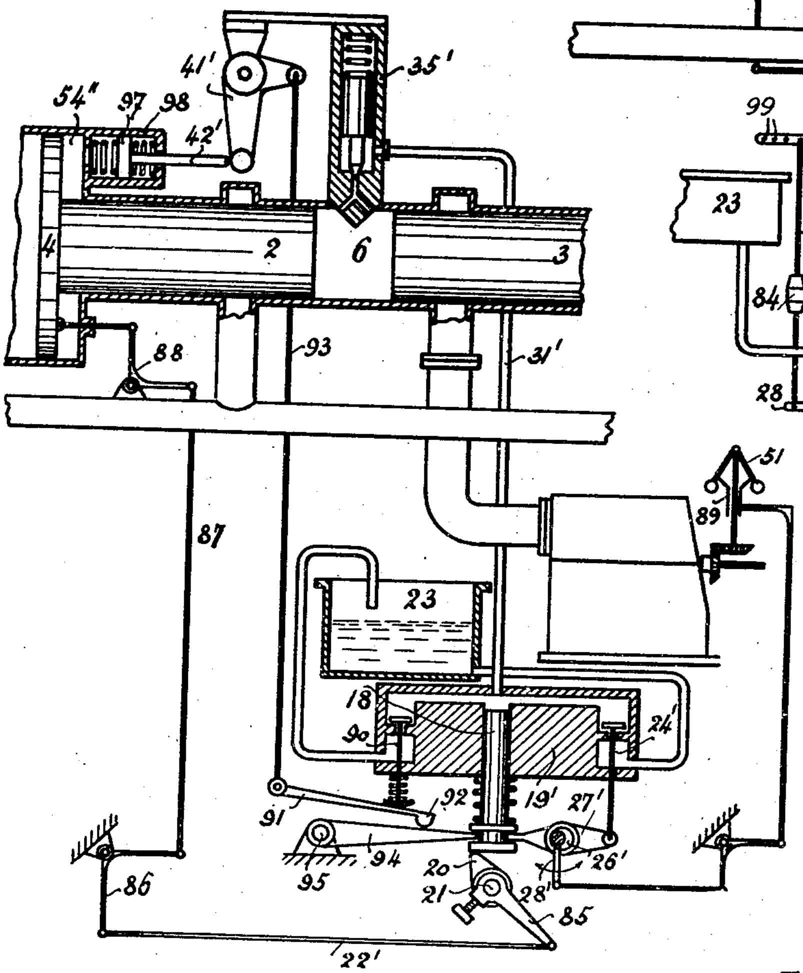


Fig. 8.



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2,182,063

UNITED STATES PATENT OFFICE

2,182,063

CONTROL SYSTEM FOR FREE STROKE PISTON ENGINES

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Application April 2, 1936, Serial No. 72,359
In Switzerland April 3, 1935

14 Claims. (Cl. 60—13)

The present invention relates to free stroke piston internal combustion and air compressor engines, more particularly to such engines in combination with gas consumers, whereby the internal combustion compressor engine serves as gas producer for said gas consumers, and more particularly to control systems for stabilizing the extent of the stroke of the free stroke pistons.

If for any reason in free stroke engines the kinetic energy of the power piston is too great when making a compression stroke, the free stroke piston passes over the normal compression end position and the final compression pressure is also above normal. Therefore also the power produced by the expansion stroke which immediately follows said too great compression stroke is increased; this power is increased because of the increased kinetic energy of the power piston during its compression stroke and also increases because, although the fuel charge is not changed, at increased compression pressure within the combustion cylinder the indicated work of the cylinder increases due to the increased thermal efficency. Too small kinetic energy during the compression stroke has the opposite effect. For these reasons, changes of the extent of the stroke of free stroke piston engines are possible particularly when changing the output of such engines.

It is an object of the present invention to provide a control system for free stroke piston internal combustion compressor engines, whereby changes of the extent of the piston strokes are reduced or eliminated in order to stabilize the operation of the unified motor-compressor.

A further object of the present invention resides in the provision of an apparatus which, in free stroke internal combustion-compressor engines, controls the work produced during the expansion stroke in dependence on the kinetic energy of the power piston making a compression stroke or in dependence on a condition which is dependent on said kinetic energy, for example, the piston speed. Said apparatus is preferably controlled and operated in dependence on the position of a power piston at the end of a compression stroke or in dependence on a pressure which depends on the kinetic energy of a power piston making a compression stroke, for example, the pressure in an air buffer for said piston.

Another object of this invention is to provide in free stroke internal combustion-compressor engines a system for stabilizing the movements of the pistons which prevents increase of the work done during an expansion stroke which takes place right after a compression stroke which was too great due to excessive kinetic energy of the free stroke piston.

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

In the drawings:

Fig. 1 is a diagrammatic part sectional showing of a plant having two counter-moving free stroke pistons and a stabilizing apparatus according to the present invention.

Fig. 2 is a diagram showing the change of the thermal efficiency at a change of the compression volume and compression pressure in an internal combustion piston engine.

Fig. 3 is a diagram which illustrates the change of the amount of fuel required for the expansion stroke and supplied by a fuel supply control system according to the present invention.

Fig. 4 diagrammatically shows a modification of the control system illustrated in Fig. 1.

Fig. 5 is a diagram similar to that of Fig. 3 and illustrating operating conditions of a plant according to Fig. 4.

Fig. 6 is a diagrammatic part sectional showing of a stabilizing apparatus according to the present invention controlling the amount of combustion air and being operated by means of compressed air from an air buffer.

Fig. 7 diagrammatically shows another modification of the control system shown in Fig. 1.

Fig. 8 shows a further modification of the fuel supply control system illustrated in Fig. 1.

Like parts are designated by like letters or numerals in all figures of the drawings.

Referring more particularly to Fig. 1 of the drawings: 1 is the motor-compressor having free stroke, internal combustion power pistons 2 and 3 to which single acting compressor pistons 4 and 5, respectively, are directly connected and which operate, respectively, in the combustion cylinder 6 and in the compressor cylinders 7 and 8 which are directly connected to combustion cylinder 6. A synchronizing mechanism comprising two-arm lever 70 and connecting rod 71 connected to one arm of said lever and free stroke piston 2, 4 and a connecting rod 72 connected to the other arm of said lever and free stroke piston 3, 5 may be provided for assuring counter-movement of the pistons. Air compressor pistons 4 and 5 draw air from the outside through suction valves 9 and 9', respectively, into cylinders 7 and 8, respectively, and press the compressed air through outlet valves 10 and 10', respectively, into pressure conduit 11 which may have large dimensions and act as receiver for reducing pressure variations. From conduit 11, the air passes through inlet openings 12 into the combustion cylinder 6 where it acts as scavenging and charging air. In combustion cylinder 6, the air which has already been precompressed to several pounds pressure is further compressed. When power pistons 2 and 3 reach inner dead center position, fuel is injected through injector nozzle 73 and combustion begins. The exhaust gas and air mixture emerges at elevated pressure through outlet openings 13 into the exhaust gas conduit 14 and into the gas turbine 15 in which it produces useful work and from which it emerges through exhaust conduit 16. The temperature of the gas and air mixture emerging from cylinder 6 is held within a range suitable for the operation of turbine 15 by providing an excess of precompressed scavenging air.

19 is a low pressure fuel pump which is provided with piston 18 which is operated by cam 20 attached to shaft 21 which is driven by compressor piston 4 and connected thereto by the reciprocatingly moving rod mechanism 22. Pump 19 draws fuel from container 23 through suction valve 24 and pushes it into the booster fuel pump 25. Step piston 30 of pump 25 pushes with its lower part the fuel into pressure conduit 31 whenever the upper part of piston 30 which moves in cylinder 32 is forced down by the pressure of the gases compressed in combustion cylinder 6, the compressed gases being transmitted into cylinder 32 by means of conduit 33. Fuel conduit 31 conducts the fuel to the fuel valve 35 which has a fuel needle 76 provided with a piston 36 which is forced downwards—as seen in Fig. 1—by means of spring 37. Needle 76 is lifted from its seat against the pressure of spring 37 whenever the fuel pressure produced in pump 25 is sufficiently high.

Now follows the description of the apparatus for stabilizing the operation of the internal combustion free stroke piston motor-compressor which controls the work done in combustion cylinder 6 during the expansion stroke in dependence on the kinetic energy of the power piston making a compression stroke. The apparatus comprises a fuel by-pass valve member 38 which is actuated by the bell crank lever 41 which is rotatable around eccentric 40 and is periodically driven by pushing rod 42 connected with compressor piston 4. The position of eccentric 40 can be changed by turning lever 44 which is connected thereto. Valve member 38 has a recess 48 the upper edge of which controls the flow of fuel through by-pass channel 47. If, due to a counterclockwise movement of lever 41, valve member 38 is lifted upwards against the pressure of spring 45, channel 47 is opened and fuel passes through conduit 49 back into container 23. Spring 45 tends to close the fuel by-pass valve; in completely closed position, collar 46 connected with valve member 38 rests against the casing of the valve.

The position of the power pistons 2 and 3 at the end of their compression strokes depends on the kinetic energy of these pistons when making a compression stroke. At great kinetic energy, pistons 2 and 3 approach one another more than at medium kinetic energy; at small kinetic energy the space left between pistons 2 and 3 is larger than at medium kinetic energy. Great kinetic energy may, for example, be caused by pressure in the clearance of the compressor and/or other return mechanism for the power pistons, which pressure may for any reason be higher than is normal at a given output of the compressor and/or said other return mechanism. In twin motor-compressors such as I have shown, for example, in my Patent No. 2,115,921, issued May 3, 1938, in which two power pistons in two different cylinders are coupled hydraulically, mechanically or in another manner and which move in such manner that, when the piston in one cylinder makes an expansion stroke, the coupled piston in the other cylinder makes a compression stroke, too great kinetic energy of the piston in one cylinder may be caused by too great fuel admission into the other cylinder. Too small kinetic energy is obviously caused at low pressure in the air compressor, in engines of the type shown in my Patent No. 2,115,921, by too small fuel admission in the other cylinder.

Before proceeding to describe the operation of the stabilizing apparatus, I explain the diagram Fig. 2 of the drawings. Curve *a* shows the thermal efficiency of combustion cylinder 6 at various stroke volumes. The ordinates of this diagram indicate the thermal efficiency in per cent. The abscissae, indicate the changes of the compression in per cent of the normal volume. For example, if, at normal position of the power pistons 2, 3 at the end of a compression stroke—abscissa *o* in Fig. 2—the thermal efficiency is 50%, the latter is increased, for example, by 1% if the compression volume is decreased by 2% by a further inward movement of the power pistons and corresponding increase of the pressure in cylinder 6 at the end of the compression stroke of pistons 2 and 3.

The operation of the stabilizing apparatus can be followed up on diagram Fig. 3. In this diagram, the ordinates represent amounts of fuel, for example, lbs./hour or grains per stroke or the like. The abscissae show the change of the inner dead center position, i. e., the position at the end of a compression stroke of the inner end of the power piston or the change of the compression pressure at the end of a compression stroke. This change is indicated at both sides of a zero line in per cent of the complete stroke of the power pistons or of the normal compression pressure. The zero line *o* corresponds to the end position which is designated by numeral 50 in Fig. 1 of the drawings and which is reached by the power pistons at a certain output at normal operating conditions. Fuel pump 25 then transports the amount of fuel A to fuel valve 35. At the position of the power piston 2 shown in Fig. 1, pushing rod 42 meets the lower end of lever 41 and by-pass valve 38 begins to uncover channel 47 so that an amount of fuel which is indicated by C in Fig. 3 is returned through conduit 49 to container 23 and only the amount of fuel B is injected into combustion cylinder 6 until valve member 38 upon return of piston 2 is closed again. If power piston 2 exceeds its inner dead center position, for example by 5%, the period during which channel 47 is opened is also increased. In order to counterbalance the increase of thermal efficiency according to Fig. 2 because of the decrease of the compression end volume and increase of the compression pressure of the total amount A of fuel supplied to valve 35, the amount C_1 shown in Fig. 3 is returned to container 23 and only the amount B_1 which is smaller than B is injected into cylinder 6 so that the work of the expansion stroke is not at all or only very little changed. The curve *b* at the left of the zero line *o* indicates the condition when piston 2 does not reach the normal inner dead center position 50.

It is obvious that with a stabilizing system as shown in Fig. 1 the expansion stroke which follows immediately after an abnormal compression stroke with too great or too little kinetic energy is stabilized and further undue increase or decrease of the strokes is effectively prevented.

The operation described so far takes place as long as the gas requirements of turbine 15 and the output or load required from said turbine is not changed. If the work demanded from this turbine increases, the speed of the turbine shaft 17 is reduced and eccentric 40 which is connected to governor 51 by means of rods 52 and 53 is turned counterclockwise and the end of lever 41 cooperating with pushing rod 42 is moved to the right and the duration of the periods during which fuel is returned to container 23 is reduced so that more fuel is supplied to cylinder 6 and more gas is produced for the operation of turbine 15.

The cooperation of the stabilizing apparatus and of the output control is as follows:

If at a decrease of the work demanded from turbine 15 eccentric 40 is turned clockwise, the end of the arm of lever 41 which cooperates with the pushing rod 42 is moved to the left. By-pass valve 38 is then already opened when power piston 2 reaches a position which is to the left of the position in which said piston is shown in Fig. 1 and the duration of opening of valve 38 and the amount of fuel returned to container 23 is increased; the work done during the expansion stroke is then reduced. If only the amount of fuel is changed and the pressure of the charging air introduced into cylinder 6 remains the same, the operation is as characterized by curve *c* in Fig. 3, whereby an amount of fuel C_2 is returned to tank 23 at the position of the power piston designated by O and the amount of fuel B_2 is injected into cylinder 6. At a simultaneous change of the charging pressure and of the amount of fuel supplied the zero line in Fig. 3 is moved to the left, for example, to O_1 at increased charging pressure so that the amount of fuel injected corresponds to curve *d* which is drawn parallel to curve *c*.

Instead of providing eccentric 40 and using by-pass valve 38 for stabilizing as well as gas output control, lever 41 may have a fixed fulcrum 79 and the supply of fuel in proportion to the load conditions on turbine 15 is controlled as shown in Fig. 4. Suction valve 24 is provided with a rod 74 resting on arm 27 and pressed thereto by spring 75. Arm 27 rotates about eccentric 26. When arm 27 is rotated counter-clockwise, valve 24 is opened, for example, near the end of the compression stroke of piston 18 and supply of fuel by pump 19 is interrupted. Governor 51 is connected by means of rod 52, bellcrank lever 77 and rod 78 with arm 28 of eccentric 26 as is shown in Fig. 4. The amount of fuel supplied by pump 19 and delivered to cylinder 6 is thus made dependent on the load of turbine 15. The diagram Fig. 5 shows the operating conditions which are effected by an arrangement according to Fig. 4 of the drawings. In this diagram, ordinates and abscissae represent the same values as in diagram Fig. 3. Stabilization takes place according to curve *e*. If the load on turbine 15 is reduced, less fuel need be supplied to cylinder 6 and the fuel supply by pump 19 is reduced from the value represented by ordinate A_1 to the value represented by ordinate A_2. Valve 38 permits return of the fuel amount C to tank 23 and the fuel actually injected is reduced from the value B_3 to value B_4. The work of the expansion stroke is therefore also reduced.

In the arrangement according to Fig. 6, the inner parts 54 and 54′ of cylinders 7 and 8, respectively, serve as air buffers. In this case, the condition depending on the kinetic energy of the power pistons is the pressure within said air buffers. The stabilizing apparatus comprises piston 55 in cylinder 56 which communicates with buffer 54′ by means of conduit 62, spring 57 which holds the position of piston 55 against the air pressure in conduit 62, and valve casing 59 containing valve 58, the stem 80 of which is connected to piston 55. Valve 58 controls the exit of the contents of cylinder 6 through conduit 61 which connects valve casing 59 with the intake openings 12. The tension of spring 57 can be adjusted by manipulation of screw 63.

The apparatus according to Fig. 6 operates as follows: Piston 55 opens valve 58 whenever the air pressure in air buffer 54′ reaches a predetermined value which can be adjusted by means of screw 63. At the normal position of power piston 3 at the end of its compression stroke, the pressure in chamber 54′ is higher than said predetermined value and valve 58 is opened and a small amount of the contents of cylinder 6 is relieved. If the inner dead center position of free stroke piston 3,5 is further out than normal due to too little kinetic energy, valve 58 is opened less because of the smaller pressure in buffer 54′ and less contents are allowed to escape from cylinder 6. At too great kinetic energy, the inner dead center position of piston 3,5 is further inwards and valve 58 is further lifted and more contents of cylinder 6 are removed therefrom so that the compression pressure at the end of the compression stroke of pistons 2 and 3 is reduced and thereby the energy developed at the following expansion stroke. The pressure in cylinder 6 at the end of the compression strokes of the power pistons 2 and 3 is thus maintained and at constant fuel supply also the work of the expansion strokes is maintained almost or completely constant, no matter what kinetic energy may be in the pistons when making an inward stroke.

The more piston 3, 5 moves inwards, the longer and the more valve 58 is opened and the more contents escapes from cylinder 6. Also at normal inner dead center position of piston 3, 5, a certain amount of the contents of cylinder 6 is permitted to escape so that, at too little kinetic energy of piston 3, 5, this amount can be still further reduced and operation of the piston be stabilized at all operating conditions.

In Fig. 7 an arrangement is shown in which, instead of providing by-pass valve 38, the horizontal arm—as seen in Fig. 1—of lever 41 is connected by means of rods 81 and 82 with lever 28 of eccentric 26. A lever 83 is arranged between rods 81 and 82 in order to reverse the direction of movement of rod 82 as compared with that of rod 81. Adjusting means 84 are provided in rod 82 for setting the mechanism to suit operating conditions. Also lever 83 may be so constructed that the leverage can be changed. In the embodiment of my invention shown in Fig. 7, this is done by providing in one arm of lever 83 a plurality of holes 99 to which rod 82 can be individually connected. If, by changing the output of fuel feed pump 19, instead of correcting the expansion stroke which immediately follows an abnormal compression stroke, only the second expansion stroke after such an abnormal compression stroke is corrected, it is advisable to adjust the mechanism in such a manner that the amount of fuel delivered by pump 19 is excessively decreased or increased in order to counterbalance the effect of the intermediate excessive or too small expansion stroke.

Fig. 8 shows an arrangement in which a fuel feed pump 19′ delivers fuel through conduit 31′ directly into fuel injection valve 35′. With this arrangement, stabilization may be accomplished by timing the whole injection period relative to the motion of the power piston. The time of beginning as well as the end of an injection can be changed with respect to the time in which a free stroke piston reaches its inner dead center position. Similarly, as was described in connection with Fig. 1, fuel pump 19′ is provided with a pump piston 18 which is operated by a cam 20 mounted to a shaft 21. To this shaft a lever 85 is so connected that its position can be changed with respect to shaft 21. Lever 85 is connected with piston 4 by means of rods 22′ and 87 and bellcrank levers 86 and 88. By adjusting the position of lever 85 with respect to shaft 21, the action of pump piston 18 can be timed with respect to the movement of piston 2, 4. Pump 19′ is provided with a suction valve 24′ which corresponds to the suction valve 24 in Fig. 1 and is also driven by plunger 18 to which it is operatively connected by two-arm lever 27′. The latter swings about eccentric 26′, the position of which can be changed by moving arm 28′. Arm 28′ is operatively connected with sleeve 89 of turbine governor 51 so that it swings to the right when the speed of the turbine goes up. Valve 24′ is thereby lifted and less fuel pushed into conduit 31′. Pump 19′ is further provided with a fuel return valve 90 which is reciprocatingly operated by lever 91 which swings about point 92 and is moved up and down by means of rod 93 which is connected to the horizontal arm of bellchank lever 41′ which corresponds to lever 41 of Fig. 1. The vertical arm of lever 41′ is operated by pushing rod 42′ connected to piston 97 which operates in a cylinder 98 which is internally connected with air buffer 54′′. The higher the pressure in buffer 54′′, the further to the right are piston 97 and rod 42′ moved. Point 92 rests on lever 94 which swings about stationary fulcrum 95 and is movably connected to and reciprocatingly moved by plunger 18. The further piston 4 and rod 42′ move to the right the more are lever 91 and valve 90 lifted and the more fuel is returned through conduit 96 to fuel storage tank 23 and the less fuel is supplied to injection valve 35′, so that the fuel available for effecting an expansion stroke which follows after an abnormally great compression stroke is reduced.

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

I claim:

1. A control system for the supply of fuel to free stroke piston internal combustion engine having a power piston, said system including fuel by-pass means, connecting means adapted to operatively connect said power piston and said by-pass means whenever said piston approaches the end of its compression stroke, whereby the operation of said fuel by-pass means is controlled in dependence on the position of said free stroke power piston at the end of its compression stroke.

2. A fuel supply control system for free stroke piston internal combustion engines having a power piston, fuel storage means, means for supplying fuel from said storage means to said engine, fuel return means for returning fuel from said supply means to said storage means, said return means being operatively connected with said power piston, whenever said power piston makes a compression stroke, and being responsive to the extent of the compression stroke of said power piston, whereby the amount of fuel supplied to said engine is made dependent on the extent of the compression stroke of said free stroke power piston.

3. A fuel supply control system for free stroke piston internal combustion engines having a power piston, fuel supply means, fuel by-pass means for by-passing fuel to said fuel supply means, said by-pass means being operatively connected with said power piston, whenever it approaches the end of its compression stroke, and being responsive to the extent of the compression stroke of said power piston, whereby the operation of said by-pass means and the amount of fuel supplied to said engine is made dependent on the position of said free stroke power piston at the end of its compression stroke.

4. A fuel supply control system for free stroke piston internal combustion engines having a power piston, fuel storage means, means for supplying fuel from said storage means to said engine, said fuel supply means being operatively connected with said piston, whereby the fuel supply is made periodically and synchronously with the movements of said piston, fuel return means adapted to return fuel from said supply means to said storage means and to determine the end of the fuel supply periods, said return means being operatively connected with said power piston whenever it approaches the end of its compression stroke and being responsive to the extent of the compression stroke of said power piston whereby the amount of fuel supplied to said engine is made dependent on the extent of the stroke of said free stroke power piston and the end of a fuel supply period is determined by the coming into action of said return means.

5. A control system for the supply of fuel to free stroke piston internal combustion engines having a power piston, said system including fuel by-pass means which are temporarily operatively connected with said power piston at the end of its compression stroke and responsive to the extent of the compression stroke of said power piston and adapted to decrease the amount of fuel by-passed at small extent of the compression stroke and to increase the amount of fuel by-passed at great extent of the compression stroke.

6. The combination of a unified internal combustion and compressor engine having a free stroke piston, an exhaust gas machine having a speed governor and being connected for gas

flow with and receiving exhaust gas as operating medium from said engine, and combustion material supply control means which are directly operatively connected with said engine and with said speed governor for controlling the supply of combustion materials to said engine and production of exhaust gas in dependence on the load on said gas machine.

7. The combination of a free stroke piston internal combustion engine having a free stroke piston, an exhaust gas machine having a speed responsive governor and being connected for gas flow with and receiving exhaust gas as operating medium from said engine, and combustion material supply control means temporarily operatively connected with said free stroke piston at the end of its compression stroke and being responsive to the extent of the compression stroke and being also directly connected with said governor for controlling the supply of combustion materials to said engine in dependence on the extent of the compression stroke of said free stroke piston and in dependence on the load on said exhaust gas machine.

8. The combination of a free stroke piston internal combustion engine having a free stroke piston, an exhaust gas machine having a speed responsive governor and being connected for gas flow with and receiving exhaust gas as operating medium from said engine, and combustion material supply control means comprising a fuel pump which is connected with and operated by said free stroke piston, said pump having a fuel flow control valve which is operatively connected with said governor, whereby the supply of combustion material to said engine is controlled in dependence on the stroke of said free stroke piston and on the load on said gas machine.

9. A control system for the supply of combustion material for free stroke piston internal combustion engines having a power piston and combustion material supply control means cooperating abbutingly with said power piston whenever said power piston makes a compression stroke, whereby the amount of combustion material supplied is controlled in dependence on the stroke of said free stroke power piston when making a compression stroke.

10. A control system for the supply of combustion material for free stroke piston internal combustion engines having a power piston and combustion material supply control means cooperating abuttingly with said power piston whenever said power piston approaches the end of its compression stroke, whereby the amount of combustion material supplied is controlled in dependence on the position of said free stroke power piston at the end of its compression stroke.

11. A free stroke piston engine having a free stroke piston, fuel supply means connected with and operated by said piston and being connected for fuel flow with said engine, a fuel flow control valve connected with said supply means and being adapted to control the amount of fuel supplied to said engine, an exhaust gas consumer connected for exhaust gas flow with said engine and being adapted to be operated by the exhaust gases of said engine, load responsive means directly connected with said gas consumer and being directly responsive to the load on said consumer, and being connected with and operating said control valve in response to the load on said gas consumer, whereby the amount of fuel supplied to said engine is controlled in dependence on the load on said consumer.

12. The combination of a free stroke piston engine having a free stroke piston, fuel supply means connected with and operated by said piston and being connected for fuel flow with said engine, a fuel intake valve connected with said supply means and being adapted to control the amount of fuel supplied to said engine, an exhaust gas consumer connected for exhaust gas flow with said engine and being adapted to be operated by exhaust gases of said engine, load responsive means directly connected with said gas consumer and being directly responsive to the load in said consumer, and being connected with and operating said intake valve in response to the load on said gas consumer, whereby the amount of fuel supplied to said engine is controlled in dependence on the load on said consumer, and a fuel relief valve connected with said supply means and being temporarily operatively connected with said piston whenever said piston approaches the end of a compression stroke and being adapted to be opened at excessive extent of a compression stroke of said piston, whereby fuel is relieved and not supplied to said engine.

13. A free stroke piston engine having a free stroke piston and comprising a fuel pump which is connected with and operated by said free stroke piston and which is provided with a relief valve, mechanical means temporarily connecting said relief valve with said free stroke piston whenever said piston makes a compression stroke and being adapted to open said valve when said piston approaches the end of a compression stroke, whereby fuel is relieved from said pump and the fuel discharge of said pump is reduced when the compression stroke of said piston is excessive, and adjusting means connected with said first mentioned means for adjusting the extent of opening of said valve.

14. A free stroke piston engine having a power cylinder and a free stroke power piston operating therein, fuel supply means connected with said power cylinder and comprising fuel supply control means, a compressor cylinder connected with said power cylinder and having a compressed air producing and a control chamber, a double acting compressor piston connected with said power piston and operating in said compressor cylinder and dividing said cylinder into said two chambers, a pressure responsive means connected with said fuel supply control means and with the control chamber of said compressor cylinder and being responsive to the pressure which is built up in said control chamber when said compressor piston makes an expansion stroke and said power piston makes a compression stroke and definitely controlling the amount of fuel supplied to said engine.

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