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Hudson

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[45] **Dec. 4, 1973**

[54] **COMBUSTION PRODUCTS PRESSURE GENERATORS INTERMITTENT BURNER CYCLE AND ENGINES**

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[52] **U.S. Cl.** **60/39.25,** 60/39.62, 60/39.7, 60/39.8

[51] **Int. Cl.** **F02g 1/02**

[58] **Field of Search** 60/39.25, 39.69, 60/39.76, 39.79, 39.8, 39.81, 39.33, 39.62, 39.7; 277/74; 431/116

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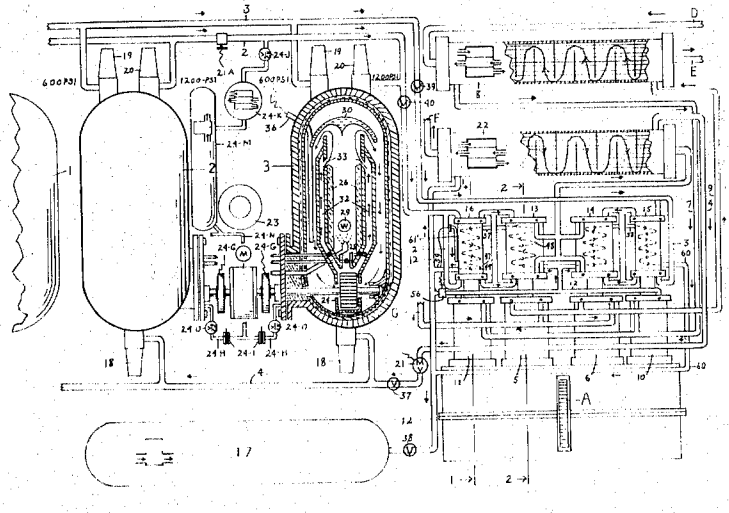
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Assistant Examiner—Robert E. Garrett

[57] **ABSTRACT**

This invention comprises improvements in combustion products pressure generators of the intermittent cycle, two stage type, and reciprotating piston engines which use the combustion products the pressure generators produce for power and to drive the air compressors which supply combustion air to the pressure generators. Improvements of the pressure generator include an improved type burner with forced air circulation and dilution of the hot gases with cooler air making for minimum air pollution. Improvements of the reciprocating piston engines are carbon or other anti-friction material in power piston rings and rod seals. A system of maintaining the power cylinder wall at the highest possible working temperature to cut down on the heat loss from the hot gases to the working parts of the power cylinders. Also, poppet type valves in the cylinder heads to make for minimum clearance. Also, a automatic variable speed governor controlling precision cutoff valve action on the charge valves to the power cylinders. This cutoff action is reversible. Also, an automatic changeover mechanism which changes the automatic governor control to manual throttle control when engine speed falls below predetermined speed, and at the same time changes the engine from compound operation to simple throttle speed. If it again exceeds the predetermined speed, the operation is automatically changed back to the automatic variable speed governor and valve cutoff. The variable speed adjustment is controlled by the manual throttle lever or accelerator pedal which also control the engine throttle valves at low speed.

There are mechanical seals on the fan drive shaft where it comes out of the pressure vessel, which is the pressure generator and a cool air blocking system which blocks the hot gases from the area around the seal. This same seal system is also used on the throttle valves.

10 Claims, 12 Drawing Figures



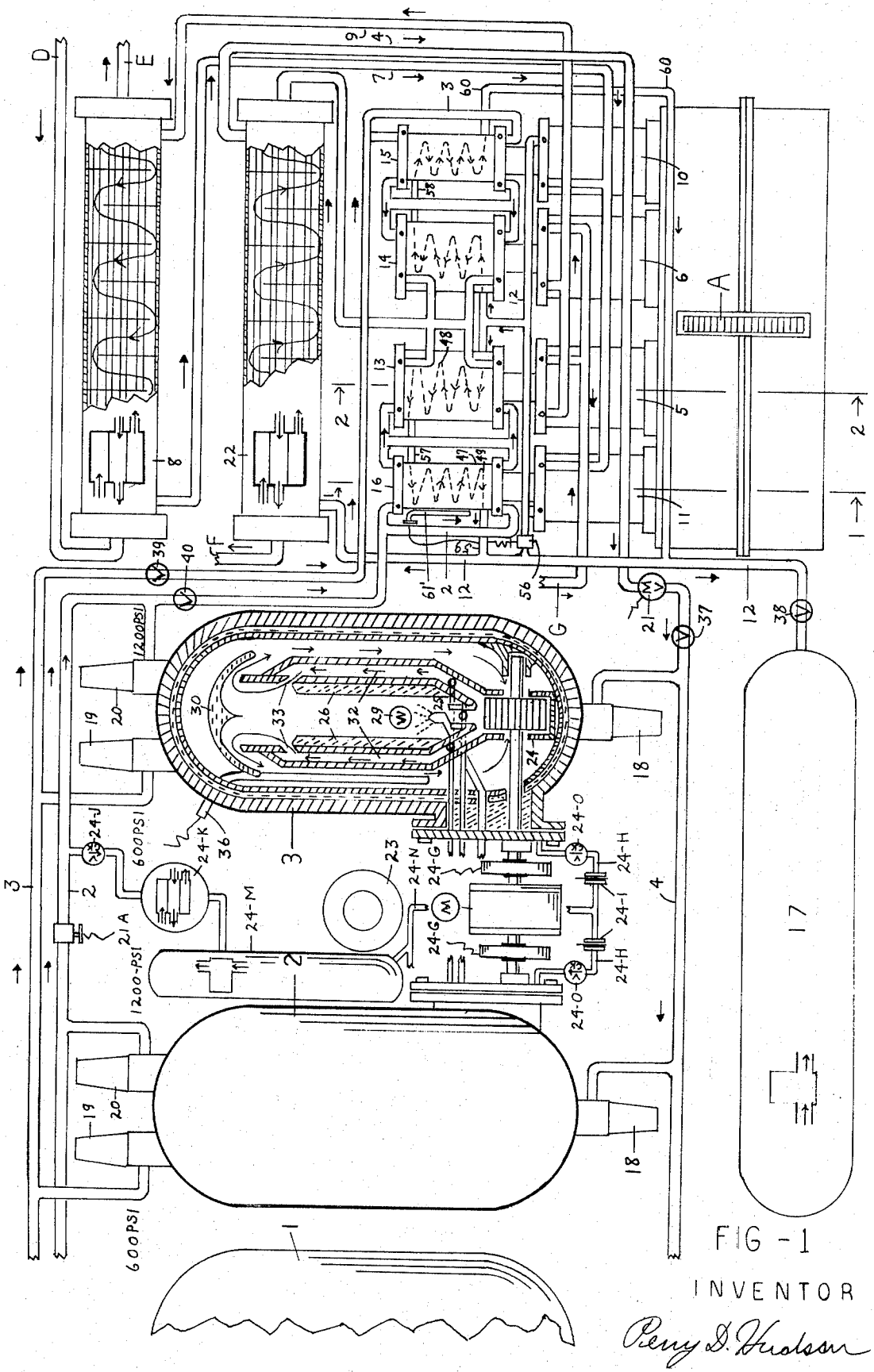

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INVENTOR
Perry D. Hudson

FIG -1

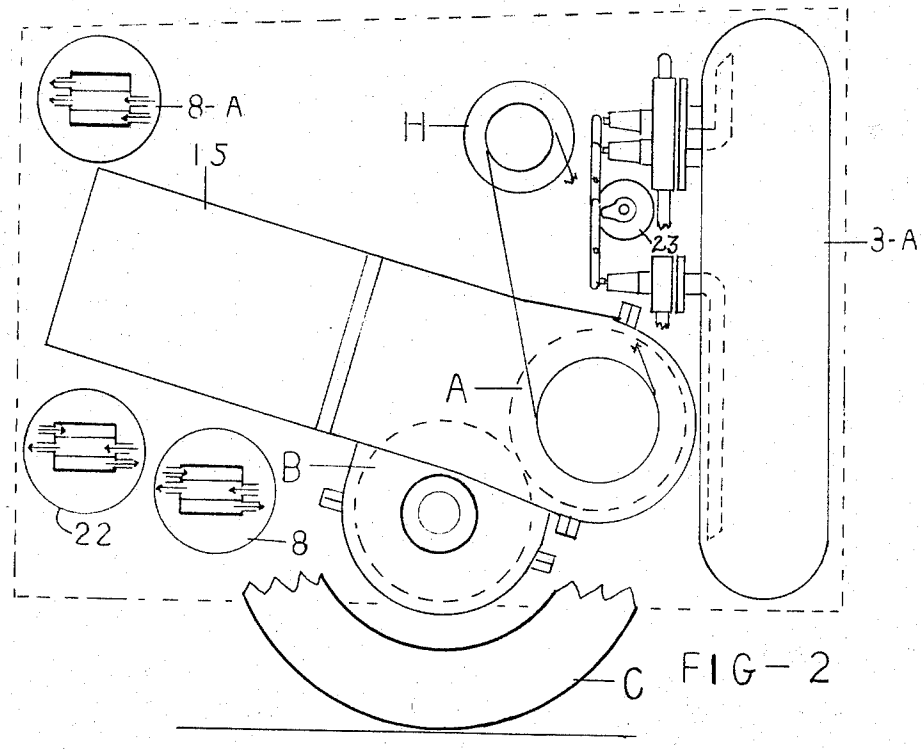


FIG-2

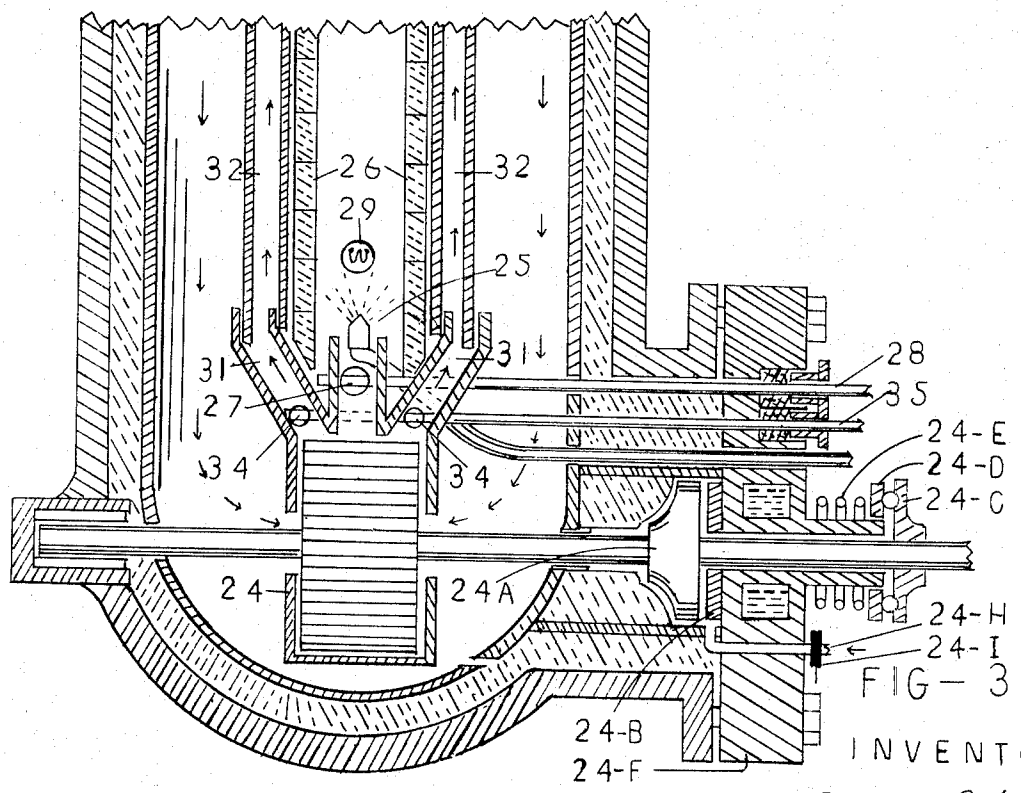


FIG-3

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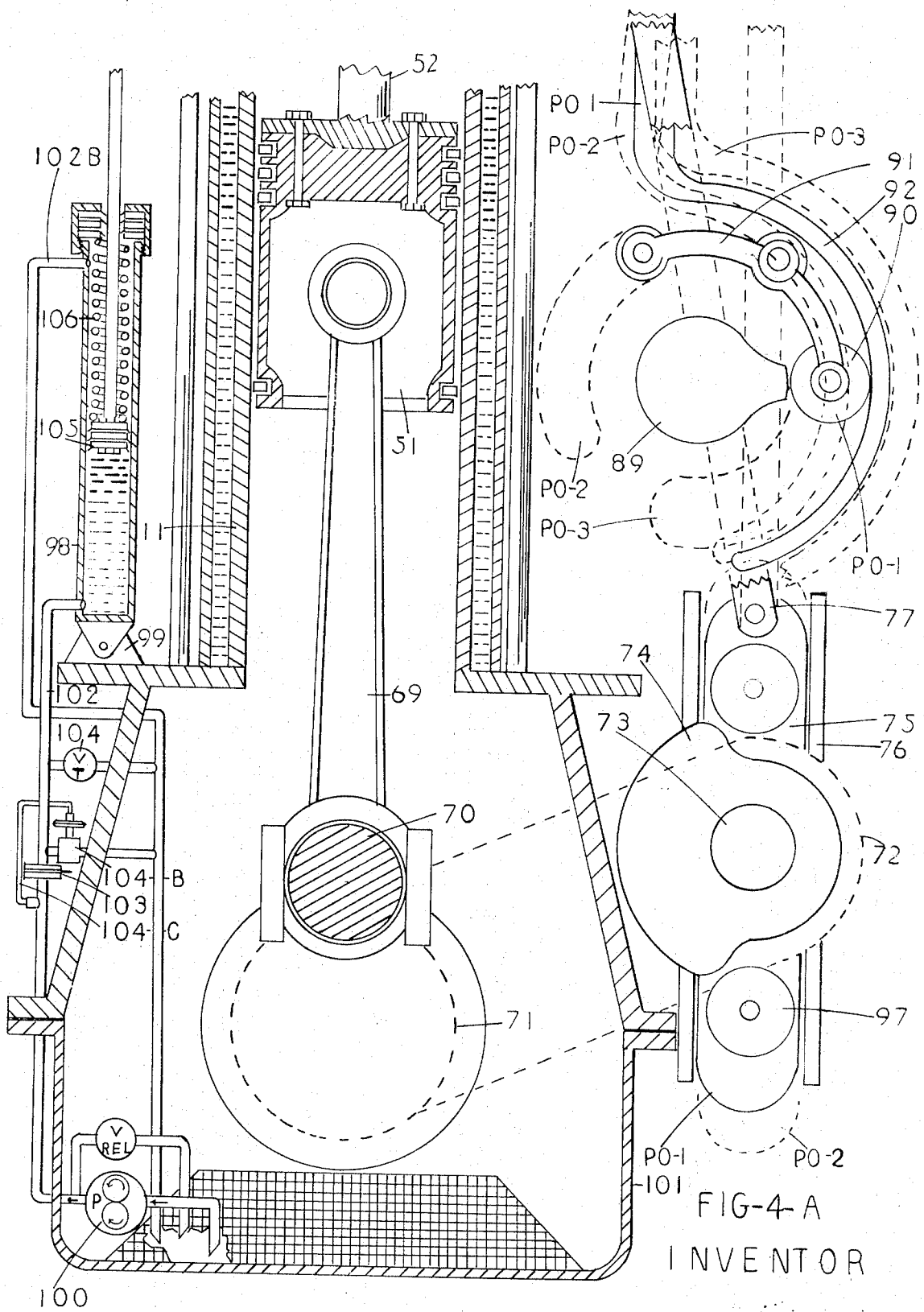


FIG-4-A

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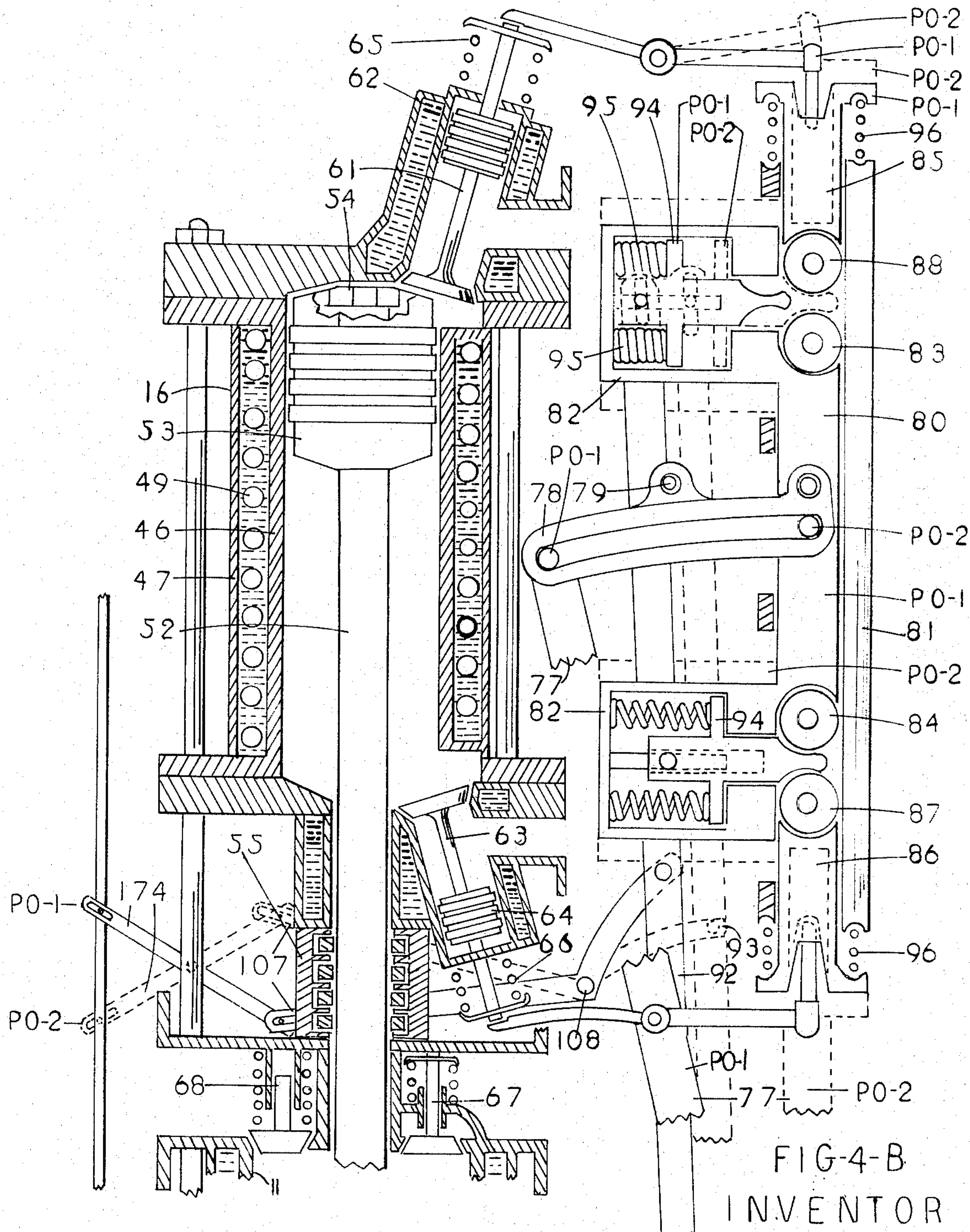


FIG-4-B

INVENTOR

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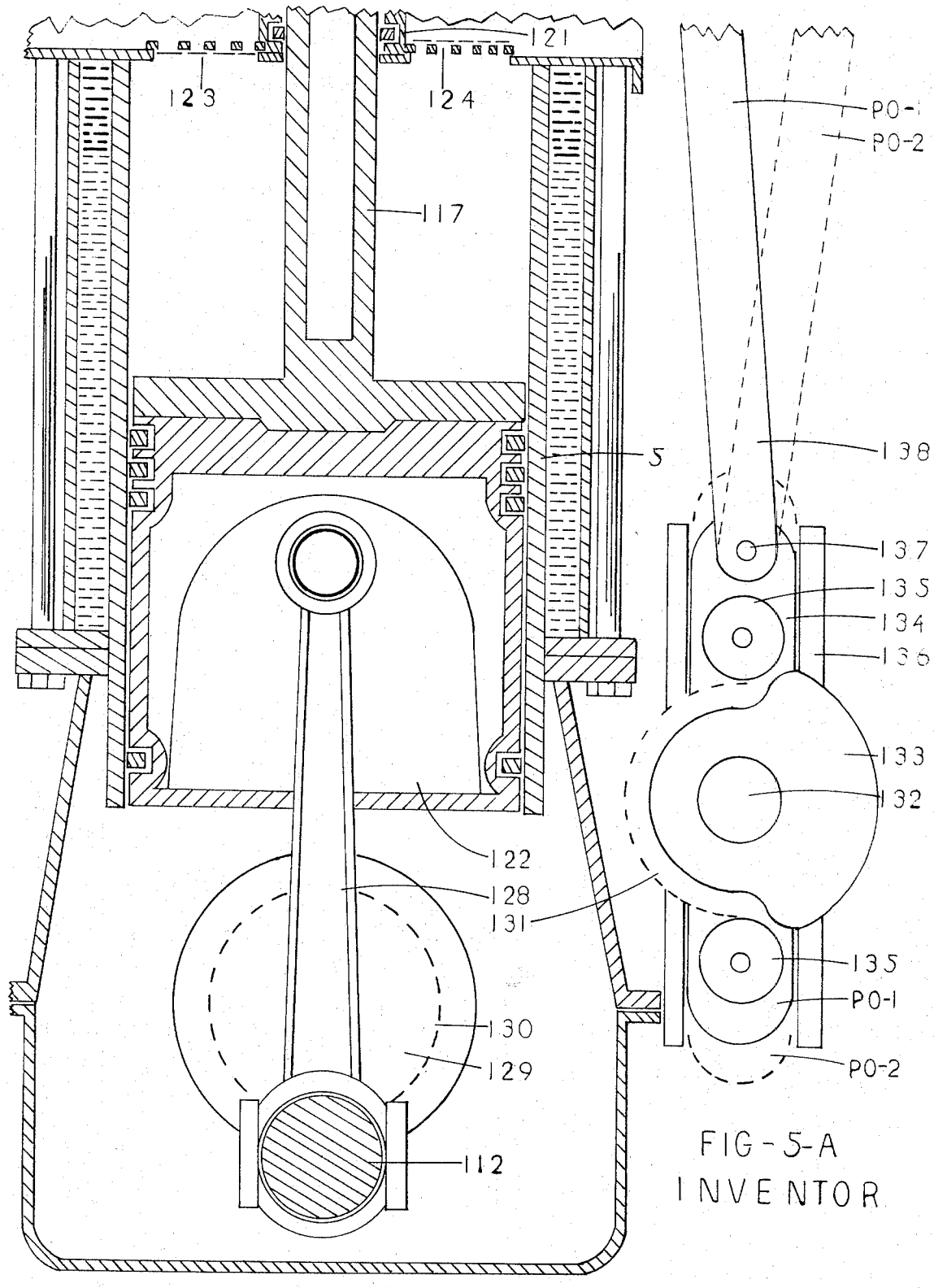


FIG-5-A

INVENTOR

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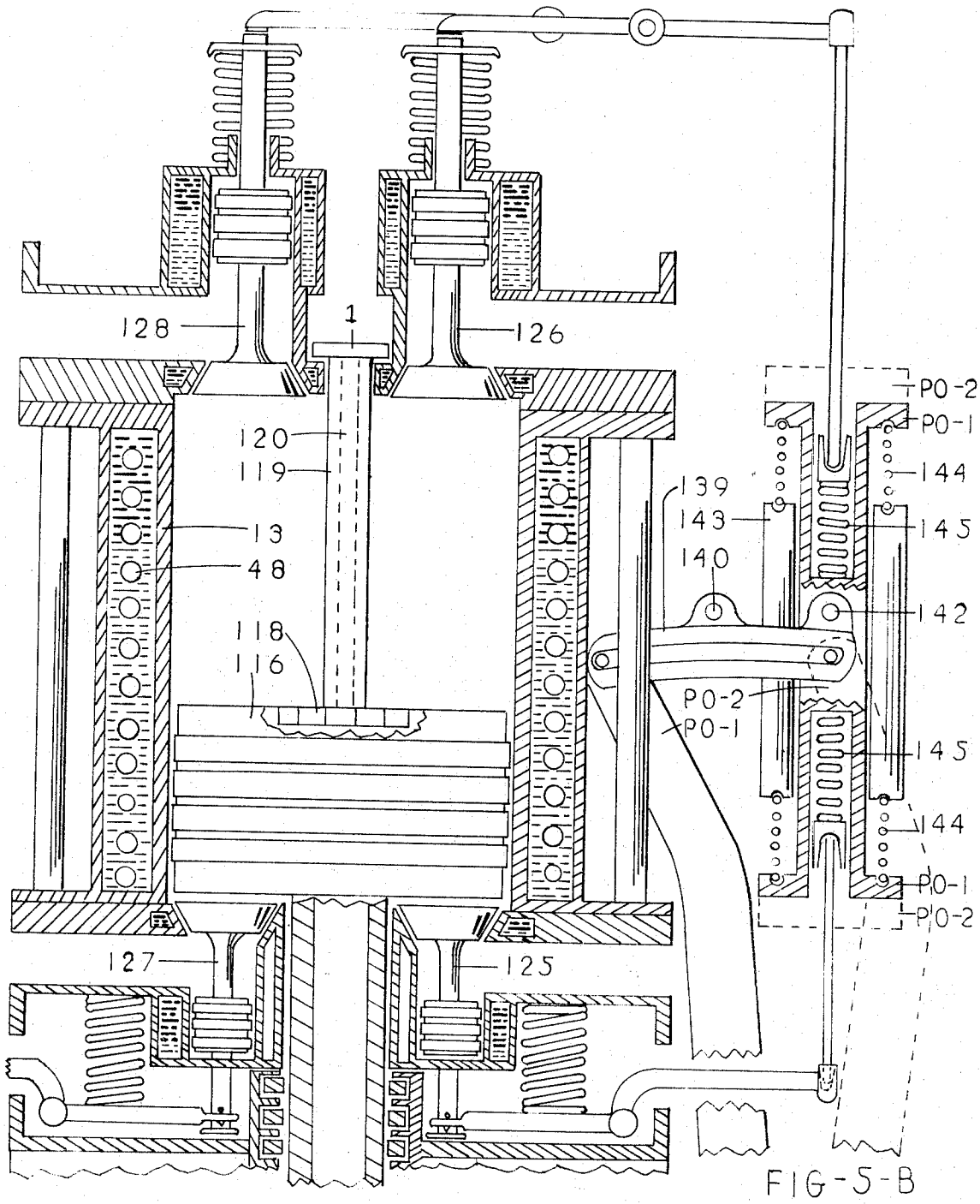


FIG-5-B

INVENTOR

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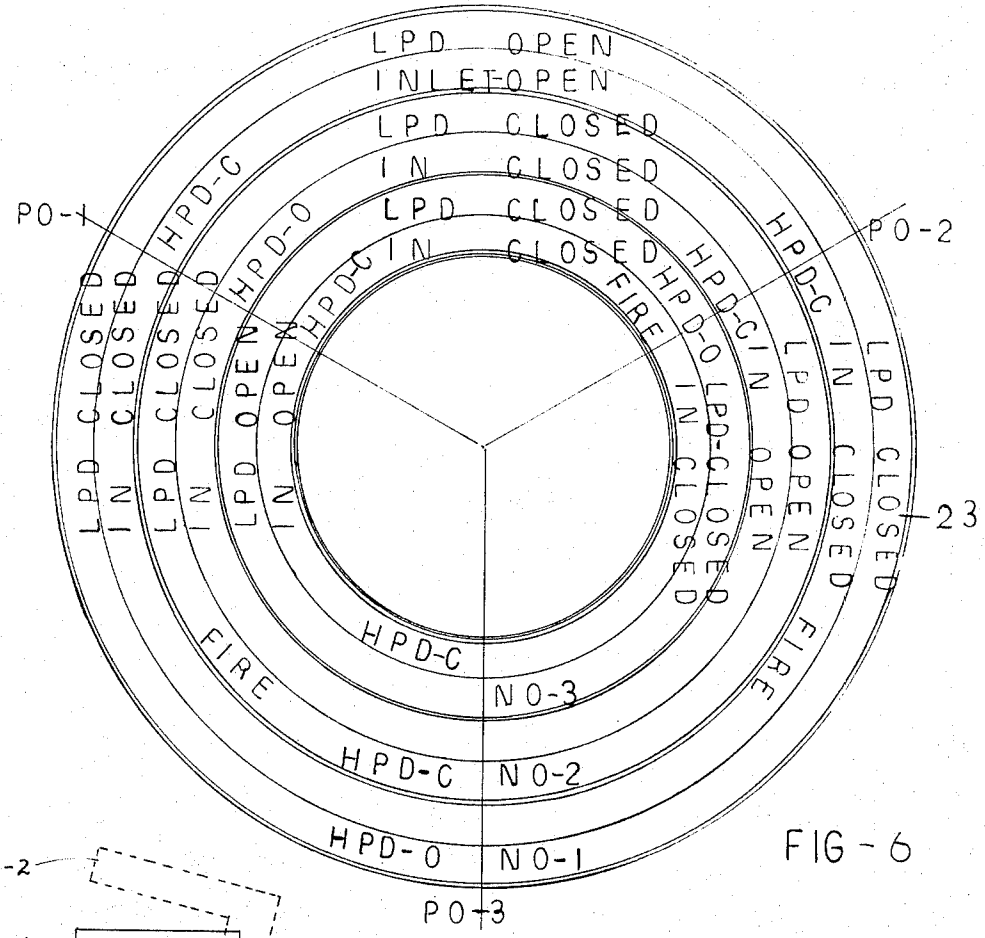


FIG-6

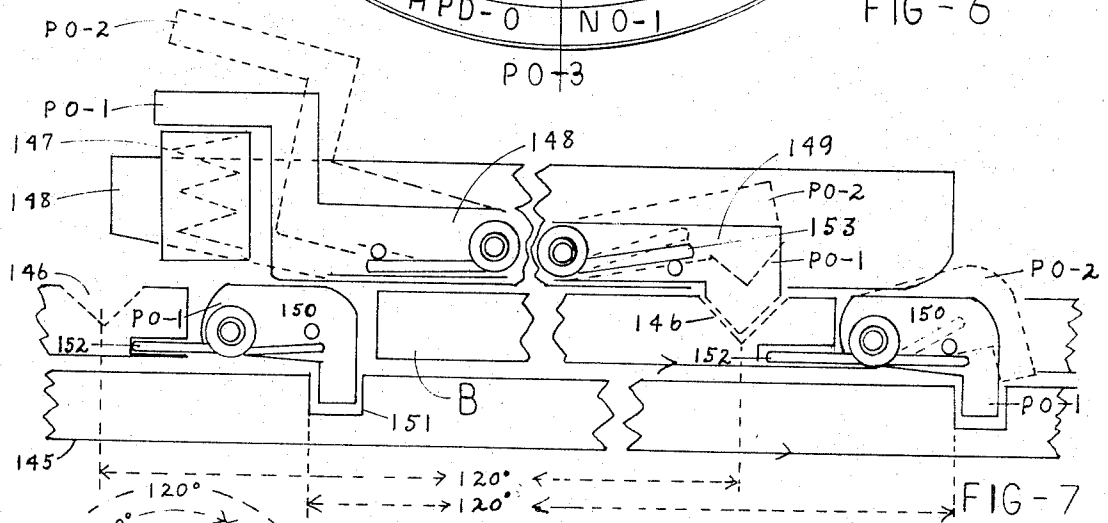


FIG-7

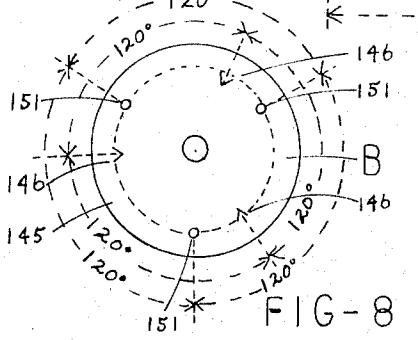


FIG-8

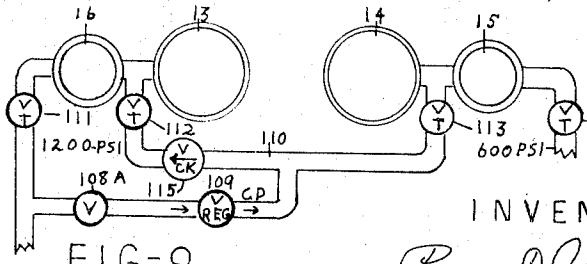


FIG-9

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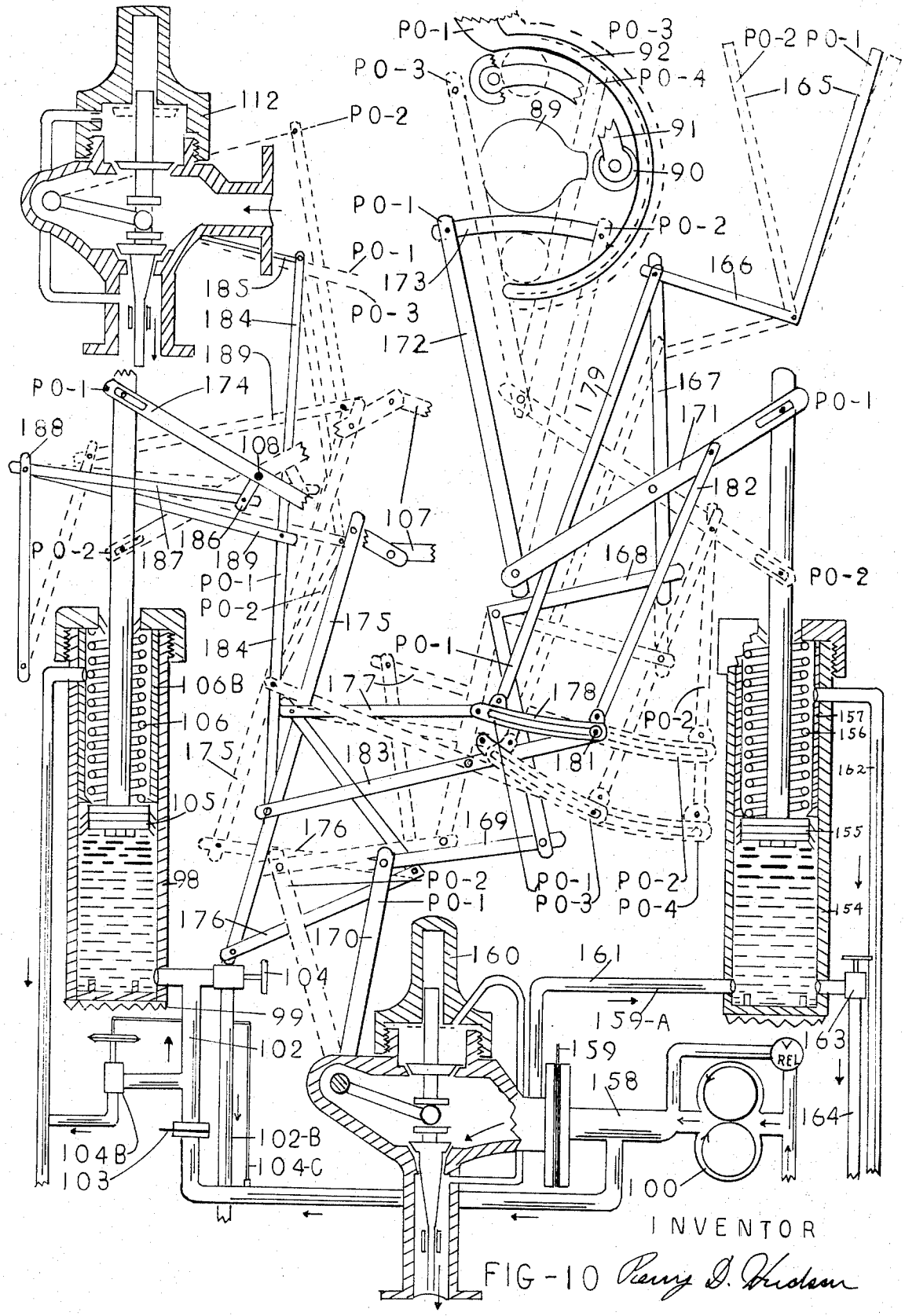


FIG-10 Perry D. Hudson

COMBUSTION PRODUCTS PRESSURE GENERATORS INTERMITTENT BURNER CYCLE AND ENGINES

This invention relates to heat engines of the pressure generator type having combustion chambers separate from the power cylinders or turbine. Said combustion chambers are of sufficient volume capacity to supply hot gases under pressure to the power cylinders or turbine to operate said engine or turbine several revolutions to each cycle of each combustion chamber so as to enable ignition and combustion to be extended over any desired period independent of the speed of the engine or turbine thus giving the combustion within said combustion chamber to have the time to reach a temperature whereby as near a complete combustion of the fuel is reached as possible. This should give minimum air pollution from the exhaust.

A further object of this invention is to provide a way and means of dilution of said hot gases within the combustion chamber with air to reduce the temperature of the gases to workable limits.

A further object of this invention is to provide improved pressure generators which can be operated at full load fuel charge on light loads through to full loads. This maintains near perfect combustion conditions as to temperature, pressure, etc., with near complete combustion and great economy. This is accomplished by changing the number of cycles per minute in ratio to the load the pressure generator is operated at rather than a lighter or heavier fuel charge per cycle. This is an advantage where the load or both load and speed varies widely, and also saves on the amount of compressed air used on light loads.

With two stage pressure generators, best results are obtained by using three pressure generators operating in rotation, alternating in the steps of the cycle to supply the engine or turbine a steady supply of the pressure fluid medium in both the high and low pressure ranges. This arrangement also gives several seconds of time for the burning fuel to heat the air, which makes for good clean combustion. While overall efficiency is higher with higher compression, 600 PSI to 1500 PSI compression may prove to be the most practical area. As an example in this specification, I am using 600 PSI compression.

A further object of this invention is to provide a four cylinder reciprocating piston engine designed to work on high temperature pressure fluid medium at two pressure levels simultaneous from a two stage pressure generator. Said engine has one high pressure and one low pressure double acting cylinder for the higher range pressure fluid medium and one high pressure cylinder and one low pressure double acting cylinder for the lower range pressure fluid medium.

A further object of this invention is to provide a reciprocating piston engine designed to handle high temperature gases without lubrication consisting of the piston having carbon or other anti-friction material in the power piston rings and piston rod seals, a means of maintaining the cylinder wall at the highest possible workable temperature, and a means to control and maintain that temperature, making possible minimum heat loss from the pressure fluid medium to the working parts of the cylinder.

A further object of this invention is to provide a reciprocating piston engine designed to operate on high temperature gases which has the valves in the cylinder heads so as to cut the clearance loses to a minimum.

A further object of this invention is to provide a reciprocating piston engine with extra large valve opening and extra large manifolds to cut moving pressure fluid medium moving friction to a minimum.

A further object of the invention is to provide a reciprocating piston engine with a variable cut off of the pressure fluid medium inlet with a range of, "off to 50percent," of the stroke on the high pressure power cylinder. This makes maximum use of the expansion of the hot gases. The variable cut off can be used as a throttle valve or connected to a variable speed governor, making for great economy of the consumption of the pressure fluid medium. When used on a vehicle, the off position of the cutoff enables the engine to be used a brake when said vehicle is running or coasting. Friction brakes would have to be used to stop or hold the vehicle stationary.

A further object of this invention is to provide a variable capacity air compressor to supply combustion air to the pressure generators. This is done by using single acting air compressor pistons in place of cross heads on each of the four power cylinders. A large diameter low pressure air compressor piston on each of the low pressure power cylinders and a smaller diameter high pressure piston on each of the high pressure power cylinders are employed. This makes two two-stage air compressors which can be used one at a time or both together in parallel. This control by an automatic unloading system and a variable clearance means on the low pressure cylinders makes a wide variation possible in capacity. With the vehicle brake controlling the unloading system, this makes a powerful running or coasting braking system.

A further object of this invention is to provide an automatic or manual means to start the engine as a simple throttle controlled engine, then at a predetermined RPM to change the operation to an automatic cutoff engine, or, in the case of a multiple cylinder simple engine or a compound engine, start as a multiple cylinder simple throttle engine and at the predetermined RPM automatically or manually change the operation of the engine to a compound engine with automatic cutoff. This feature makes it possible to start the engine from a cold start smoothly and with great power.

A further object of this invention is to provide a combined reciprocating piston engine and air compressor designed to supply the combustion air to pressure generators and use the pressure fluid medium produced by them to drive vehicles or produce other work. Said engine utilizes a preheater using the hot exhaust from the engine to preheat the combustion air before it enters the pressure generators thereby saving on the fuel required to heat the air in the pressure generators.

A further object of this invention is to provide a power plant incorporating all the aforementioned features into a very versatile, economical, and virtually pollution free power producing unit.

A further object of this invention is a seal cooling and blocking system for the fan driving shafts on the pressure generators and the throttle valve operating shafts to effectively seal the hot gases in and provide a means of keeping the hot gases away from the seals, and a means of cooling the seals themselves.

FIG. 1 is a schematic view of a four cylinder double acting reciprocating piston engine with air compressor

pistons in place of crossheads. This engine is designed to use pressure fluid medium generated in pressure generators and supply said pressure generators with combustion air. This engine is designed to drive automotive vehicles or produce other work. This figure shows the flow of the compressed air from the compressor cylinders to the pressure generators on the left and back to the power cylinders.

FIG. 2 is a schematic side view of the engine in FIG. 1 installed in a automotive vehicle to either drive the front or back wheels. The dotted line represents the space limits in a 1969 automobile engine compartment.

FIG. 3 is an enlarged view of a pressure generator of FIG. 1 showing the lower part of the pressure generator, circulating fan, and burner construction.

FIGS. 4A and 4B are sectional views of the engine in FIG. 1 on section lines 1 — 1 through the high pressure cylinderand compression cylinder.

FIGS. 5A and 5B are sectional views of the engine in FIG. 1 on sectional lines 2 — 2 through the low pressure cylinder and compression cylinder.

FIG. 6 shows the cycle timer of three two stage pressure generators operated with a engine or turbine.

FIG. 7 is a flattened out view of the two stage valve, fuel and ignition timer operating wheel.

FIG. 8 is an elevation of the face of the timer driven wheel.

FIG. 9 is a top view of the engine shown in FIG. 1 showing the throttle valves and the automatic bypass arrangement for simple engine start which can be changed manually or automatically to a compound engine.

FIG. 10 shows the control linkage and hydraulic power cylinders of the variable speed hydraulic governor. Also, the automatic change over mechanism from simple to compound and automatic cutoff operation of the engine at a predetermined speed or back to simple engine operation if engine falls below predetermined speed is shown.

Referring to the drawings, FIG. 1 is a schematic side view in elevation of the four cylinder double acting reciprocating piston engine. FIG. 2 is a side view of the same engine mounted in a vehicle with direct gearing to the drive axle for either a front or rear axle drive. The main drive or sprocket A, FIGS. 1 and 2 is mounted in the center of the engine crankshaft and engages main drive gear or sprocket B, FIG. 2, on the differential which in turn drives the wheels C, FIG. 2, via a drive axle in the case of a front wheel drive with the conventional universals and steering mechanism. The cooling medium to the interstage cooler 8 of FIG. 1 comes in line D and comes out line E to the radiator or other source of cooling medium. The exhaust from the engine goes to the atmosphere through line F or through condenser 8A FIG. 2 which would condense all the condensables out of the exhaust, further cutting the air pollution. The intake to the compressors is through line G. The accessory drive FIG. 2 is H, which drives an electric generator, air conditioner compressor, etc. The pressure generator 3 A in FIG. 2 has a slightly different valve location.

Referring to the drawings, FIG. 1 is a schematic side view in elevation of the four cylinder double acting reciprocating piston engine. Pressure generators 1 – 2 – 3 — FIG. 1 and 2 are the pressure generators which are supplied with preheated compressed air from preheater 22 by line 4. The air comes from the low pressure compressor cylinders 5 and 6 via line 9 through interstage cooler 8 via line 7 to high pressure compressor cylinders 10 and 11, thence to preheater 22 via line 12 through preheater 22 where hot exhaust from low pressure power cylinders 13 and 14 preheater the combustion air to approximately 800° F, thence to the pressure generators via line 4. Air receiver 17 floats on the line and stores a reserve of compressed air for starting purposes. This also keeps a constant pressure on the pressure generators being charged.

Whenever two stage pressure generators are used, three two stage pressure generators must be used to get a steady flow of pressure fluid medium to the engine or turbine.

FIG. 3 is a cross section of the lower part of one of the pressure generators. The operation of this burner, etc, will be explained in detail subsequently. The fan 24 drive shaft has a seal plate 24 A secured to and turning with it which is of hard highly polished metal, and bears against seal plate 24 B, which is carbon or other non friction material, secured to the head 24 F.

The pressure flange 24C secured to and turning with the shaft has a ball or roller thrust bearing. Bearing 24 D is held against flange 24C by spring 24 E, which holds flange 24 A tightly against seal plate 24 B making a pressure tight running seal.

To keep the hot gases away from the seal, a small quantity of cool high pressure air is injected around the seal and pushes the hot gases back into the combustion chamber around the shaft of fan 24. This air comes in through line 24 H and is controlled by orfice plate 24–I. This air could come from the 1200 PSI high pressure discharge on line 2, FIG. 1, from the pressure generators and through a check valve 24 J, through a cooling exchanger 24– K, into receiver 24 – M, out through line 24 – N, through orfice 24 - I, into lines 24-H, FIGS. 1 and 3, through check valves 24–0 FIG. 1, into seals 24–A – B FIG. 3. Since the pressure in the 1200 PSI discharge manifold line 2 FIG. 1 is above the generator pressure, working pressure two thirds or more of the time would give effective cooling and blocking of the hot gases from the seal area. An extension of line 24 N would go to number 1 pressure generator and to the seals on throttle valves 111, 112, 113 and 114, FIG. 9 and the throttle valve 112 shown in FIG. 10.

The magnetic clutches 24–G to start and stop the fans 24, FIG. 1, are controlled by timer 23, FIGS. 1 and 6.

Referring to FIGS. 4A, 4B, 5A, and 5B, these are sectional views of a four cylinder engine in FIG. 1 on sectional lines 1 and 2 respectively. This engine is designed to use pressure fluid medium of 1000° to 2000° F from two stage pressure generator as shown in FIG. 1 and 3. It is really two two cylinder compound double acting engines designed to operate on two different pressure ranges of hot pressure fluid medium simultaneous with compressor pistons in place of cross heads to supply combustion air to the three pressure generators shown in FIG. 1.

FIGS. 4A and 4B are sectional views of the engine in FIG. 1 on section line 1 — 1 through the high pressure cylinder 16. In FIG. 4B, the high pressure piston is 53, which has carbon or other anti-friction material rings not requireing lubrication.

Compressor piston 51, which is a conventional type with steel or cast iron rings, is lubricated by the oil spray from the crankshaft bearings.

Piston rod **52**, which connects to the top of piston **51** with bolts as shown, extends through high pressure piston **53** and is secured to rod by recessed unit **54** on top of piston. The piston rod seal unit **55** is a conventional design using carbon or other anti-friction material in seal rings. High pressure cylinder wall **46** is jacketed by jacket wall **47** for temperature control.

Cooling coil **49** is inside the jacket through which a cooling fluid medium is circulated to control the temperature of the high temperature heat medium with which the jackets are filled. This heat medium can be a type of sodium compound or other such high temperature heat medium.

The cooling medium used is compressed air from the high pressure compressor cylinders **10** and **11** going through the double coils **48** on low pressure power cylinder **13** FIG. **1** and **5** and coil **49** on high pressure cylinder **16**, FIGS. **1** and **4B**. The flow is shown in FIG. **1**. High pressure air from compressor cylinders **10** and **11** goes through line **12** until stopped by motor valve **56** which causes it to go through double coils around low pressure power cylinders **13** and **14** through line **57** and **58** through double coils around high pressure power cylinders **15** and **16** thence out line **59** on cylinder **16** or out line **60** on cylinder **15** into line **12** into preheater **22.** Motor valve **56** is controlled by thermostatic control **61'** which is attached to jacket **47** of cylinder **16**, FIG. **1**, and is controlled by the temperature of said jacket which is the temperature of the heat medium inside said jacket and cylinder wall **16.** Thus the temperature of the cylinder walls on the power cylinders is controlled within workable limits and the waste heat is collected by the compressed combustion air used as a cooling medium. This results in saving the heat lost to the cylinder walls from the pressure fluid medium and reducing the heat loss. This type of sodium compound has a melting point of 350° to 400° F and works well as a heat medium from 400° up to 1600° F.

Valves **61** and **63**, FIG. **4B**, are the high pressure inlet valves to the high pressure cylinder **16.** These are balanced puppet type valves having pistons **62** and **64** of about the same area as the head end of valves **61** and **63**, and the springs **65** and **66** hold them closed. Compressor cylinder **11**, FIGS. **1** and **4A**, has inlet valve **67** and outlet valve **68.**

The connecting rod is **69**, which connects piston **51** to crankshaft **70.** Sprocket **71** on the crankshaft drives sprocket **72** on the cam shaft **73**, FIG. **4A**, at crankshaft speed (this valve operating mechanism is enlarged for better illustration). Cam **74** operates cam follower **75** in guide **76** and, via push rod **77**, operates rocking reverse link **78** which is pivoted on pivot **79.** Said link **78** operates valve operating slide **80** in guide **81** and in turn opens and closes valves **61** and **63.** Slide **80** has valve cutoff trips **82** and **82** attached to it and travels up and down with said slide. Slide **80** has rollers **83** and **84** attached to it. Valve followers **85** and **86** slide up and down in guide **80** and has rollers **87** and **88** attached there.

To describe the cutoff action I will describe cutoff mechanism for valves **61** and **63.** The high pressure inlet valves to the power cylinder have a cutoff cam **89**, cutoff operating lever **92**, and cutoff trips **82-82.** A variable cutoff cam follower **91** oscillates on camshaft axis counter clockwise from position **1** in which valve **61** would not open to position **2** which would operate "valve cutoff trip" at 90° after top dead center on the crank or **50%** of the stroke in counter clockwise rotation. Also, the variable cutoff cam follower can be oscillated clockwise to position **3** which would operated "valve cutoff trip" at 90° after top dead center or 50 percent of stroke in clockwise rotation. This oscillation can be accomplished by the throttle or accelerator on a vehicle or it can be connected to a variable speed governor FIG. **10.** This would act to control the engine instead of a manual throttle except at slow speeds when the control would be automatically changed to 100 percent throttle control by automatic change over mechanism by cylinders, etc, shown as **98**, FIG. **4A**, and to be explained subsequently.

The tripping or cutting off of the pressure fluid medium going to the power cylinder is accomplished thus: Cam **89** strikes roller **90** which comes against lever **92** forcing it into PO – **1.** Lever **92** is pivoted on pivot **93** and moves trip block **94** to PO–**1.** Thus, when cam **74** strikes roller **97** (counter clockwise rotation of engine) moving it from PO – **1** (or neutral PO) to PO–**2**, this motion is transmitted via push rod **77** to reverse link **78**, moving slide **80** up into PO–**2**, but as this trip block **94** is in PO – **1**, it cannot open valve **61.** If cam follower **91** was in PO - **2** cam **89** rotating counter clockwise would not pull trip block **94** into PO – **1** until the piston was 90° past top center or 50 percent of the stroke. If the cam follower was any position between PO - **1** and Po - **2**, the cutoff would occur at that point, anywhere from 0° to 90° after top center or counter clockwise rotation. Likewise, if the cam follower was oscillated anywhere from PO – **1** to PO – **3**, the cutoff would be at that point anywhere from 0° to 90° after top center on clockwise rotation. When cam follower **75** is in PO – **1** and variable cutoff cam follower **91** is in any position but PO – **1**, springs **95** – **95** would return trip block **94** to PO – **2.** Springs **96** — **96** keep valve followers **85** and **86** against the valve rocker arms and valve springs so that rollers **83** and **88** and **84** and **87** are held apart, and trip blocks **94** and **96** can return to PO – **2** when cams **74** and **89** are in the right or neutral positions.

When valve push rod **77** is moved from PO –**1** to PO – **2** on reverse link **78**, this reverses the valve action and reverses the engine. This makes a rather simple, reversable, variable cutoff valve gear for the pressure power medium to the high pressure power cylinders.

Describing the automatic change over system from start as a simple engine to automatic cut off compound engine, the hydraulic cylinder **98**, FIGS. **4A** and **10**, is supported by bracket **99** and is pressured by gear pump **100**, pumping oil from the engine oil pan **101** via line **102** through orfice plate **103** and controlled by automatic by pass **104** B and adjustable bypass throttle valve **104.** Overflow line **108** B drains into oil base **101**, this oil pressure acting against piston **105** is counter acted by spring **106.** When the engine speed is high the oil pressure is great enough to overcome the spring **106** and hold piston **105** in position PO –**1** against stop **106** B FIG. **10** which, via lever **174**, FIG. **10**, and **107**, FIG. **4B**, is pivoted on pivot **108** and holds valve trip lever **77** in position **1** which operates the valve cutoff **94** and **96.** When speed is low or stopped, oil volume and pressure is such that spring **106** pushes piston **105** to bottom of the cylinder **98**, pushing levers **174** and **107** into PO – **2**, which moves valve trip lever **92** into PO – **3** which puts valve trip gear **96** out of operation and opens valve **108** – A, FIG. **9.** This also unloads the compressor regardless of receiver pressure. This allows

1200 PSI gases to flow through pressure reducing valve **109** into low pressure manifold **110** at "example 100 PSI" against throttle valves **112** and **113** to low pressure power cylinders **13** and **14** FIG. **1.** As low pressure power cylinder **13** uses exhaust gas from high pressure power cylinder **16,** this exhaust could, under heavy load, be more than the "100 PSI example." Check valve **115** prohibits gases from coming back to low pressure power cylinder **14.**

Thus, in starting up cold or operating below predetermined RPM, all four power cylinders act as simple power cylinders giving great torque, controlled by valves throttle **111–112 –113 –114.** When engine RPM increases above predetermined RPM, the oil pressure increases and overcomes the spring **106,** and the piston moves the lever **107** to PO–1 which in turn puts the valve cutoff gear into operation and closes valve **108A,** FIG. **9,** putting the engine into compound operation and releasing the compressor unloader to receiver pressure control.

Automatic bypass valve **104B** acts to make the changes from simple to compound and back to simple take place quickly. This valve has a diaphragm operating against an adjustable spring tension and its normal position is open (that is little or no pressure on diaphragm from control line **104C**). When engine RPM is below predetermined RPM, pressure against the diaphram is not enough to close valve **104B.** Hence, pressure in the cylinder **98** is nill, and control lever **107** stays in PO–**2.** When engine speed increases above the predetermined RPM, pressure against the diaphragm increases and closes valve **104B,** causing pressure to build rapidly and piston **105** and lever **107** to return to PO–**1,** closing valve **108A,** FIG. **9,** and putting the engine into compound cutoff operation. This system makes for smoother start from standing with great torque, if needed, and shifting to a smoother economy at the predetermined RPM.

Describing FIGS. **5A** and **5B,** and **13,** the low pressure cylinder representitive of either power cylinder **13** and compressor cylinder **5** or low pressure power cylinder **14** and compressor cylinder **6** FIG. **1** is shown. The low pressure power piston **116** has rings made of carbon or other anti-friction material. Piston **116** is secured on rod **117** by recessed nut **118.** This piston rod is hollow to take piston guide rod **119** in a slideable fit. Guide rod **120** is rifle drilled for compressed air to come in at and come out into rod at J, and into the piston behind the rings to expand the rings against the cylinder walls and cool piston rod **117** and piston **116.** Piston rod seal **121** is conventional, with seal rings made of carbon or other anti-friction material. Compressor piston **122** is of conventional design, and piston rod **117** is secured to it by bolts as shown.

Flat type reed intake valves to the compressor cylinder are **123.** The flat reed type exhaust valves to the compressor cylinder are **124.** The valves **125** and **126** are inlet valves to low pressure power cylinder **13.** The exhaust valves to low pressure power cylinder **13** are **127** and **128.** The connecting rod **128** connects piston **122** to crankshaft **129.** The sprocket **130** drives sprocket **131** on camshaft **132** by silent chain and drives cam **133** on camshaft **132.** Cam follower **134** carries cam follower rollers **135 — 135** and slides in guide **136.** Attached to cam followers **134** by pin **137** is valve operating rod **138,** which actuates reverse link **139.** Link **139** is pivoted on anchor pin **140** and is moveably secured to valve follower slide **141** by pin **142.** Valve follower **141** slides up and down to operate valves **125** and **126** in guide **143.** Springs **144—144** return valve follower to PO – **1** when cam **133** is not engaging either roller **135 — 135.** Springs **145 — 145** in valve follower **141** are strong enough to open valves **125** or **126,** but will give in case valves are hit by piston **116,** thus preventing damage to valve operating mechanism. When valve operating rod **138** is moved to PO – **2** in reversing link **139,** the engine would turn clockwise. In PO – **1** the engine would turn counter clockwise.

Please refer to FIG. **6** for timing of valves on two stage pressure generators. While these pressure generators can be made in any desirable size, these pressure generator cycles and explanations are based on one half cubic foot per cycle, volume displacement capacity pressure generators, using 10.7 cubic feet at 100° F of free air compressed to 600 PSI and preheated to 800° F after compression as the charge. This charge heated to 1600° in a pressure generator would give a pressure of 1158 PSI. Describing the cycles and valve timing controlling the same, refer to FIG. **6.** In position **1,** pressure generator **1** has its high pressure discharge valve closed, with the low pressure discharge valve open and inlet valve open. Gases within the pressure generator are 1600 degrees and 600 PSI or less (refer to FIG. **1** for flow directions). Inlet pressure from the bottom pushes valve **18** open, and the hot gases flow out into the engine intake manifold at 600 PSI via valve **19** and line **2** FIG. **1** into cylinder **16.** The inlet air, being cooler, stays on the bottom and pushes the hot gases up and out until the volume measuring meter **21,** FIG. **1,** signals that the pressure generator is full of fresh air. This signal, electric or mechanical, together with an electric or mechanical signal from pressure switch **21** A that the pressure in high pressure manifold **2** has dropped to 650 PSI, act via electric solenoid **147,** FIG. **7** to trip the catch on timer **23,** FIGS. **1, 2, 6,** and **7.** This moves the timer and camshaft to PO – **2.**

The cams on the timer shaft close the low pressure discharge valve on pressure generator **1** and the inlet valve, blocking in the pressure generator full of fresh air at 600 PSI and 800° F. This timer action lights burner **25,** FIGS. **1** and **3,** by spraying into the air an exactly measured amount of fuel at a measured rate of flow against hot refactory material **26,** FIG. **3** (cold start ignition is by spark plug or flow plug **29**). Fan **24** is started to give a flow of air through the burner. This flow is regulated by damper **27** actuated from the outside of the pressure generator by shaft **28.** Properly regulated, this burner should burn hot enough to make a clean burn, that is burn up all the elements that pollute the air as clean as is possible. The burner is regulated to produce a short hot flame so that no flame reaches the divertor **30** FIG. **1** at the top of the burner. The outlet of fan **24** is divided so that most of the air is diverted up passage ways **31** into the burner jacket **32** where it goes up to the top of the burner and into the stream of combustion products coming out of the burner through openings **33 — 33,** cooling them down to workable temperatures. This flow of cooler air is regulated by dampers **34 — 34** on shaft **35.** The burner is shut off by thermostatic element **36** when 1600° is reached or by the measured amount of fuel being consumed. The fuel is injected by a metering plunger pump, such as used on diesel engines, having an adjustable limit stop as to how

much fuel is injected. Also, an automatic means to adjust the amount of fuel injected in ratio to the amount of air in the pressure generator, consisting of a piston or diaphram loaded with an adjustable spring tension acting against air pressure in pressure generator, is provided.

Thus, as the amount of air supplied and the temperature rise needed are known, then the exact amount of fuel is injected to heat that quantity of air to the required temperature.

Thus when burning is completed and the air is to the required temperature, the timer awaits the signal that the engine has consumed the high pressure gases from pressure generator **3**, and pressure in manifold **2** drops to 650 PSI. When this occurs, then the timer moves to PO – **3** and the high pressure discharge valve is opened to manifold **2** and pressure generator **2** is fired. This system furnishes the engine the hot gases under pressure when and in what quantity needed. If the engine is stopped, the pressure generator waits with pressure ready. When the starting key switch is turned off to stop the engine, solenoid or pneumatic operated block valves **37, 38, 39,** and **40** are closed automatically, blocking in the pressure generators and the air pressure accumulator. Also, this automatically opens bleeders on each engine cylinder to stop creep from possible leaky valves.

Thus you have two pressure generators with 600 PSI and one pressure generator with some where between 650 and 1100 PSI, less what ever cooling and leakage around pressure generator valve stem seals has occured, plus the 1 cu ft accumulator full of cold air at 600 PSI to start up on. Hot, this should give you one-half cu. ft. in each of the three pressure generators, and 1 cu ft in the accumulator, for a total of 2½ cu ft of gases to start on, and, if cold, would be somewhat less.

Thus when starting cold you would have enough pressure to move the engine with load several hundred revolutions without pressure generator firing. However, when the switch key is turned to the on position, for a cold start, pressure in the high pressure manifold would be down, so that pressure switch to the timer turning means would be closed. Thus, the timer would turn to the next position, firing the pressure generator which is ready to be fired. As the pressure in the high pressure manifold would still be down, the timer would move to the next position, firing the next pressure generator standing ready. In these **2** positions from cold to start, the high pressure discharge valve on the pressure generator fired in **1** position from cold start would be opened to the high pressure manifold, thus raising the pressure in the high pressure manifold and opening the high pressure timer activating switch, until such time as the pressure falls below the predetermined point of 650 PSI. In this case, a timer relay switch would close the circuit around meter switch **21,** FIG. **1,** for a period of 1 to 2 minutes to allow warm up time on the engine, etc.

FIGS. **7** and **8** show the mechanism which turns the valve and fuel cams one third turn on signal from pressure switch **21** A FIG. **1**

FIG. **7** is a flattened out top view of the power fly wheel **145** which turns at a constant speed of 30 to 50 RPM driven by an electric motor or other means. The timer cam shaft operating the fly wheel is **146A**, which turns clockwise one-third of a revolution for each step of operation of the **3** pressure generators. The stationary bracket holding the solenoid **147** and catch engaging mechanism is **148.** This supports catch engaging mechanism **148–B** and holding stop latch **149.** When the pressure switch **21–A** FIG. **1** is on high pressure, pressure fluid medium line **2** closes, signaling pressure drop to a predetermined point. This energizes solenoid **147** which draws **148** down from PO – **2** to PO – **1,** striking latch **150** and forcing it into hole **151** in the face of fly wheel **145,** which is turning to the right clockwise. This puts pressure on holding catch **149** forcing it into PO – **2,** disengaged from **146.** Stationary bracket **148** is spaced from fly wheel **146A** and covers enough of the fly wheel to keep catches **150** engaged in the power fly wheel **145** for one-third of a revolution. The backside of the catch slides against the face of bracket **148** holding it engaged with power fly wheel **145** until it emerges from the right hand end of bracket **148.** Spring **152** urges catch **150** from PO – **1** to PO – **2.** At this time, one of the stop notches **146** indexes with catch **149,** and spring **153** forces catch **149** from PO – **2** to PO – **1** stopping and holding cam fly wheel in PO – **2.**

There are three catches **150** in cam fly wheel **146,** positioned 120° apart in line with the catch holes **151** in power fly wheel **145,** FIG. **8,** and there are three stop notches **146B** in cam fly wheel **145** spaced 120° apart. Thus the valve, fuel and ignition timer is turned according to the chart of FIG. **6,** and moved from PO – **1** to PO – **2** to PO – **3** and back to PO – **1** to start all over again.

Referring to FIG. **10,** the hydraulic cylinder **98** is the automatic changeover mechanism described with FIG. **4,** with the same reference numbers brought forward to FIG. **10,** which shows the interconnecting lever system between the changeover mechanism and the variable speed governor, and the valve cutoff mechanism and cam **89,** also described with FIG. **4.**

Throttle valve **112** can be any one of the four throttle valves **111, 112, 113** or **114** shown in FIG. **9.** All would be controlled off the same shaft and all are closed at the same time to give accurate control of the engine at low speed or maneuvering.

The variable speed governor has a hydraulic cylinder **154,** piston **155,** counter acting spring **156,** and piston stop **157.** It is supplied hydraulic fluid under pressure by pump **100** via line **158.** The flow is controlled by orifce plate **159** and variable flow throttle valve **160** and line **161.** Overflow line **162** returns leakage to the pump suction reservoir. Adjustable bypass throttle valve **163** returns hydraulic fluid to pump suction reservoir via line **164.**

The combined operation of the interlocking changeover mechanism and the hydraulic governor will now be described. For example let the predetermined changeover speed be 100 RPM. Below 100 RPM, the engine would be controlled by manual throttle or accelerator pedal operating throttle valves **111, 112, 113,** and **114** as a four cylinder simple engine. Above 100 RPM, the engine would be controlled by the hydraulic governor which sets the automatic cutoff at the point required to give the speed to the hydraulic pump **100** driven by engine crankshaft to overcome the flow through the throttle controlled bypass **160** and adjustable bypass **163** and spring **156** to maintain a balance between the opposing forces. If the throttle valve **160** is opened wider, the engine pump must speed up to balance pump output volume against opposing forces. If

valve **160** is closed more, pump pressure forces piston toward PO – **1**, or closed position, until a balance is once again obtained. Thus, you have a rather simple variable speed governor.

Manual controlled throttle or accelerator pedal **165** in PO – 1 is nearly closed. Movement to PO – **2** opens bypass throttle valve **160** via lever **166**, rod **167**, quadrant **168**, and rod **169** to control lever **170** on valve **160**. As the governor piston is up against stop **157**, the cutoff control lever **171** is in PO – **1**. Via rod **172**, variable cutoff cam follower is in PO – **1**, which puts roller **90** in contact with cam **89**, and puts cutoff lever **92** in PO – **1**. This position leaves valve **61**, FIG. **4**, closed, so that the engine would have to be coasting above 100 RPM. As engine speed decreases pump **100** puts out less hydraulic fluid volume, and pressure drops via bypass **163** causing the spring to push piston **155** down bringing lever **171** into PO – **2** and cam follower **91**, FIG. **4**, to PO – **3** during clockwise rotation of the engine, thus admitting fluid pressure medium to the power cylinder for 90° or 50 percent of the piston stroke. In position **1**, the cam **89** and cam follower roller **90** and the crank and piston of the engine, FIG. **4**, are on top dead center.

For counter clockwise rotation rod, **172**, FIG. **10**, is put over in the reverse slide **173** to PO – **2**. When governor piston **155** goes to PO – **2** or open position, cam follower **91** is rotated counter clockwise 90° admitting pressure fluid medium to the power cylinder for 50 percent of the stroke.

When the engine is turning above 100 RPM and change over cylinder piston **105** is in PO – **1**, this position, via lever **174** and rod **175**, quadrant **176** and rod **177**, puts slide link **178** in PO – **1**. Manual throttle lever **165** is connected to the left hand end of link **178** by rod **179**. Link **178** is slideable and rotatably secured to lever **183** by pin **181**. Thus when manual throttle lever **165** is moved from PO – **1** to PO – **2**, link **178** swings with rod **179** on pin **181**. This effectually disconnects manual throttle **165** from engine throttle **112** and lets the governor handle the engine speed by changing the cutoff point in the piston stroke. Subject to speed change by the manual throttle **165**, engine speed is adjusted via bypass valve **160**, adjusting the point at which the governor cuts off the charge valves according to speed and load.

Lever **171**, FIG. **10**, is connected to the right hand end of link **178** by rod **182**. When link **178** is in PO – 1 the governor control is transmitted via lever **183** and hinged rod **184 – 184** to valve control lever **185** of throttle valve **112** which is in PO – **1**, or slightly open. The reason that this valve is slightly open is to insure that full pressure generator pressure is on the charge valve manifolds, and that when the governor opens the charge valves that the charge is at full pressure against the power piston until cutoff by the governor, which cuts the charge valve off at the point in the power stroke that the need dictates. As the governor piston and rod moves from PO – **1** toward PO – **2**, the linkage just described keeps the throttle valve opening wider to insure full pressure exists on the charge valve manifolds.

When engine speed falls below 100 RPM, for example, changeover cylinder piston **105** moves from PO – 1 to PO – **2**. Lever **174**, via rod **175**, quadrant **176**, and rod **177**, moves link **178** in PO – **2** which effectually disconnects the governor control from the engine throttles **111**, **112**, **113**, and **114** and connects them to the manual control lever or accelerator **165**. This changeover is also effected by lever **186**, which is secured to and moves with lever **174** via rod **187** and idle arm **188**, and rod **189** moves hinged rods **184 – 184** from PO – **1** to PO – **2**, thus shortening the distance from lever **177** to valve control lever **185** and placing it into the closed position PO – **3** so that manual control lever **165** has exact control of throttles **111**, **112**, **113** and **114**, making the engine under complete control of lever **165**. This same changeover movement of piston **105** from PO – **1** to PO – **2** via lever **174**, FIGS. **4** and **10**, moves lever **107** to PO – **2**, which moves valve cutoff lever **92** into PO – **3**, FIG. **4**. This changeover movement disconnects the valve cutoff system as it moves lever **92** clear of the cam follower collar **90** and cam **89**. This lets cam **74**, FIG. **4**, open charge valve **61** and **63** for the full **180** degrees of the power stroke. The changeover movement also opens valve **108**–A (leverage not shown), FIG. **9**, which pressures the low pressure cylinder. Valve **108**A is operated by an extension of the piston rod **105** of changeover cylinder **98**, shown in broken lines in FIGS. **4**–A and **10**.

When the engine is used for vehicle propulsion this makes for smooth powerful starts when the engine is cold.

The possible applications of the described pressure generators are very versatile. Engines using pressure generators can be built in many types and sizes, using the type of compressor suitable for the use the engine is designed for. They can be built for a charge pressure of pressures from 50 PSI up. Theoretically, the higher the charge pressure the greater efficiency. The pressures and temperatures used can be suited to the use of the engine, the fuel used, and conditions operated under.

With the foregoing and other objects in view, the invention resides in the novel arrangement and combination of parts and in details of construction hereinafter described and claimed, it being understood that changes in the precise embodiment of the invention herein disclosed may be made within the scope of what is claimed without departing from the spirit of the invention. Therefore, the invention is not limited by what is shown in the drawings and described in the specification, but only as indicated by the appended claims.

What I claim and desire to secure by Letters Patent of the United States of America is:

1. In combination, a multiple cylinder reciprocating piston engine designed to operate on hot pressure fluid medium from a pressure generator, and having a reversible automatic cutoff of the valves controlling the charge to the one-half power cylinders, comprising a means to open the valves, a means to close the valves at the point of cutoff necessary to control the speed of the engine, a means to change the point of cutoff from the valves not opening at all to cutting off at the end of the stroke swiftly and smoothly by a variable cutoff point control means.

2. In combination, a reciprocating piston engine with automatic reversable cutoff as described in claim **1** having an automatic means to disengage the automatic cutoff when the speed of the engine falls below a predetermined speed and reverting the engine to a simple engine controlled by throttle valve alone, if the engine speed again exceeds the predetermined speed then the

automatic means again changes the operation back to automatic cutoff.

3. In combination, a reciprocating piston engine to operate on hot pressure fluid medium produced by combustion products pressure generators, controlled by a variable speed governor with instantly variable range of one to 10 or more, example 100 RPM to 1000 RPM, a means to change said engine from governor control to manual control automatically when said engine speed falls below a predetermined speed; if said engine speed again exceeds the predetermined speed, said automatic means again changes said engine operation back to governor control.

4. In combination, a multiple cylinder reciprocating piston engine designed to operate on hot pressure fluid medium from pressure generators having anti-friction material compression rings on the piston and anti-friction material ring in the piston rod seal and high temperature cooling of the cylinder walls in the power cylinders whereby some of the pistons acts as power pistons and some of the pistons act as air compressors to supply combustion air to said pressure generator, said engine having a reversible automatic cutoff of the valves controlling the charge to the power cylinders comprising a means to open the valves, a means to close the valves at the point of cutoff necessary to control the speed of said engine, a means to change the point of cutoff from valves not opening at all to cutting off at the end of the power stroke swiftly and smoothly by a variable cutoff point control means.

5. In combination, a multiple cylinder reciprocating piston engine designed to operate on the hot fluid medium supplied by a multiple of two stage pressure generators, in two pressure ranges at the same time, said engine having a reversible automatic cutoff of the valves controlling the charge to the power cylinders, comprising a means to open the valves, a means to close the valves at the point of cutoff necessary to control the speed of said engine, a means to change the point of cutoff from the valves not opening at all to cutting off at the end of the power stroke swiftly and smoothly by a variable cutoff point control means.

6. In combination, a multiple cylinder reciprocating piston engine, designed to operate on the hot pressure fluid medium supplied by a multiple of two stage pressure generators in two pressure ranges at the same time, to have a means of measuring the high pressure charge to the power cylinders taken each stroke in both pressure ranges to be exactly the same volume, said engine having a reversible automatic cutoff of the valves controlling the charge to the power cylinder, comprising a means to open the valves a means to close at the point of cutoff necessary to control the speed of the engine, a means to change the point of cutoff from the valves not opening at all to cutting off at the end of the power stroke swiftly and smoothly by a variable cutoff point control means.

7. In combination, a multiple cylinder reciprocating piston engine as described in claim 1, wherein the piston of said engine has compression rings made of heat resistant anti-friction materials so as to need no lubricant, together with a means of controlling the temperature of the cylinder walls at the highest possible workable temperature.

8. In combination, a multiple cylinder reciprocating piston engine as described in claim 1 wherein the pistons in the power cylinders have compression rings of anti-friction material, a means a maintaining the cylinder walls at the highest possible workable temperatures, and using the exhaust gases to preheat the combustion air to the pressure generators after compression.

9. In combination, a multiple cylinder reciprocating piston engine as described in claim 4 wherein said engine is a double acting reciprocating engine with poppet valves in the cylinder heads and compressor pistons in place of cross heads.

10. In combination, a multiple cylinder reciprocating piston engine as described in claim 1 wherein said engine uses the hot exhaust from the power cylinders to preheat the combustion air for the pressure generators after compression, and has a condenser on the exhaust to cut down air polluting emissions.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,775,973 Dated December 4, 1973

Inventor(s) Perry D. Hudson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 12, line 54, cancel "one-half" .

Signed and Sealed this

ninth Day of *March 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks