Nov. 28, 1944. K. M. URQUHART 2,363,708

GAS PRODUCER SYSTEM

Original Filed Oct. 11, 1935 3 Sheets-Sheet 1

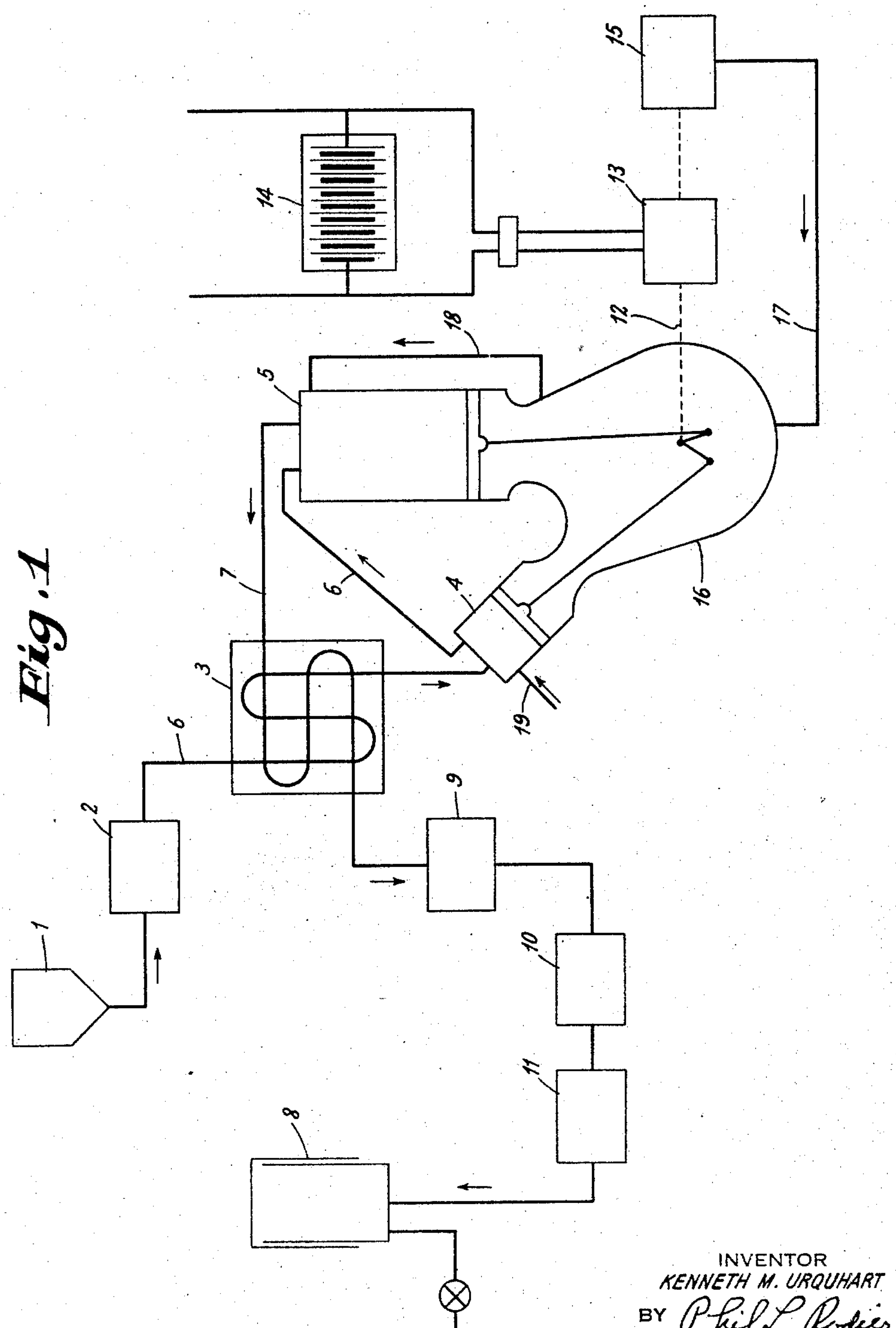

Fig. 1

INVENTOR
KENNETH M. URQUHART
BY Phil L. Rodier
ATTORNEY

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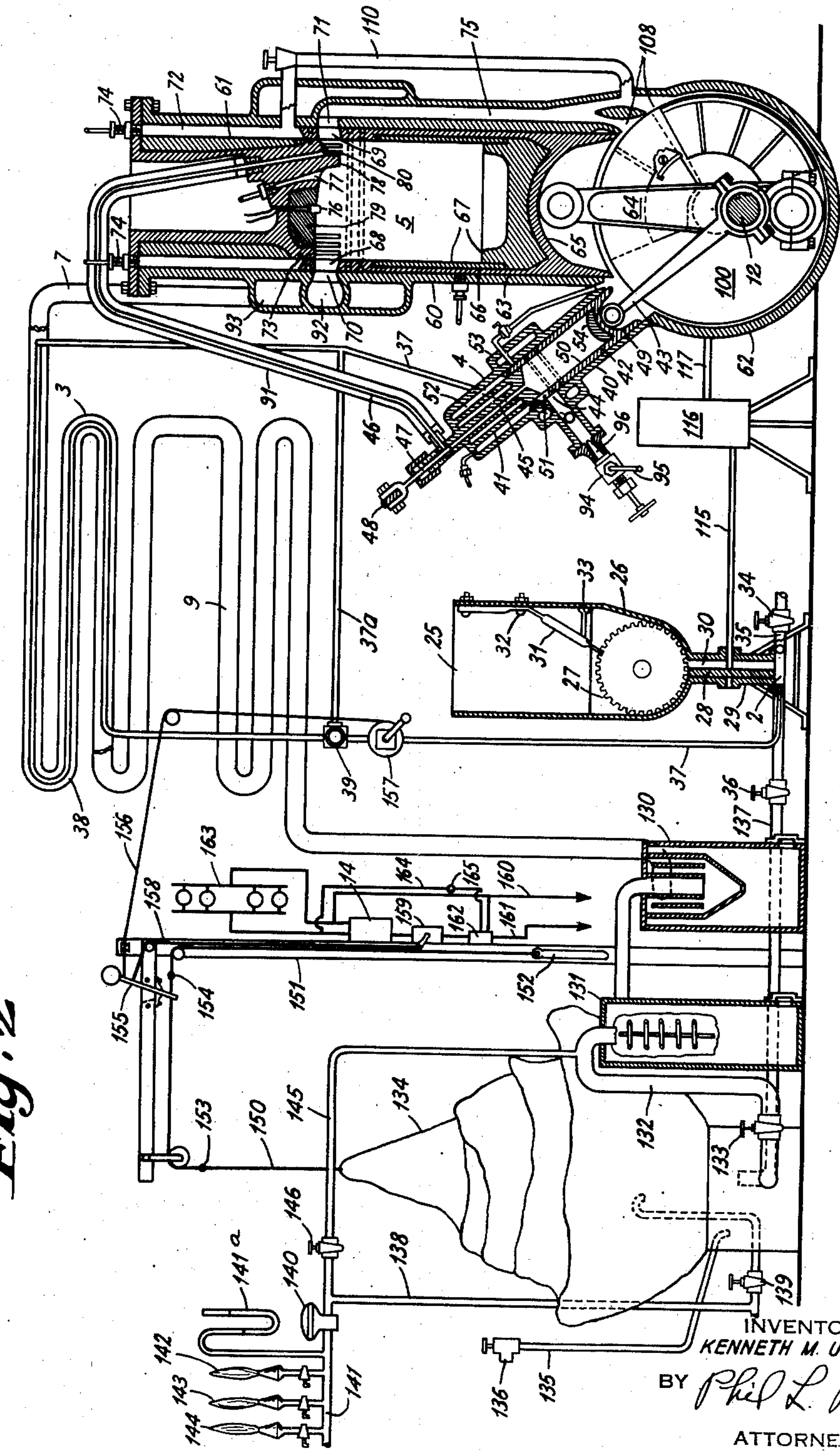

Fig. 2

INVENTOR
KENNETH M. URQUHART

BY Phil L. Rodier

ATTORNEY

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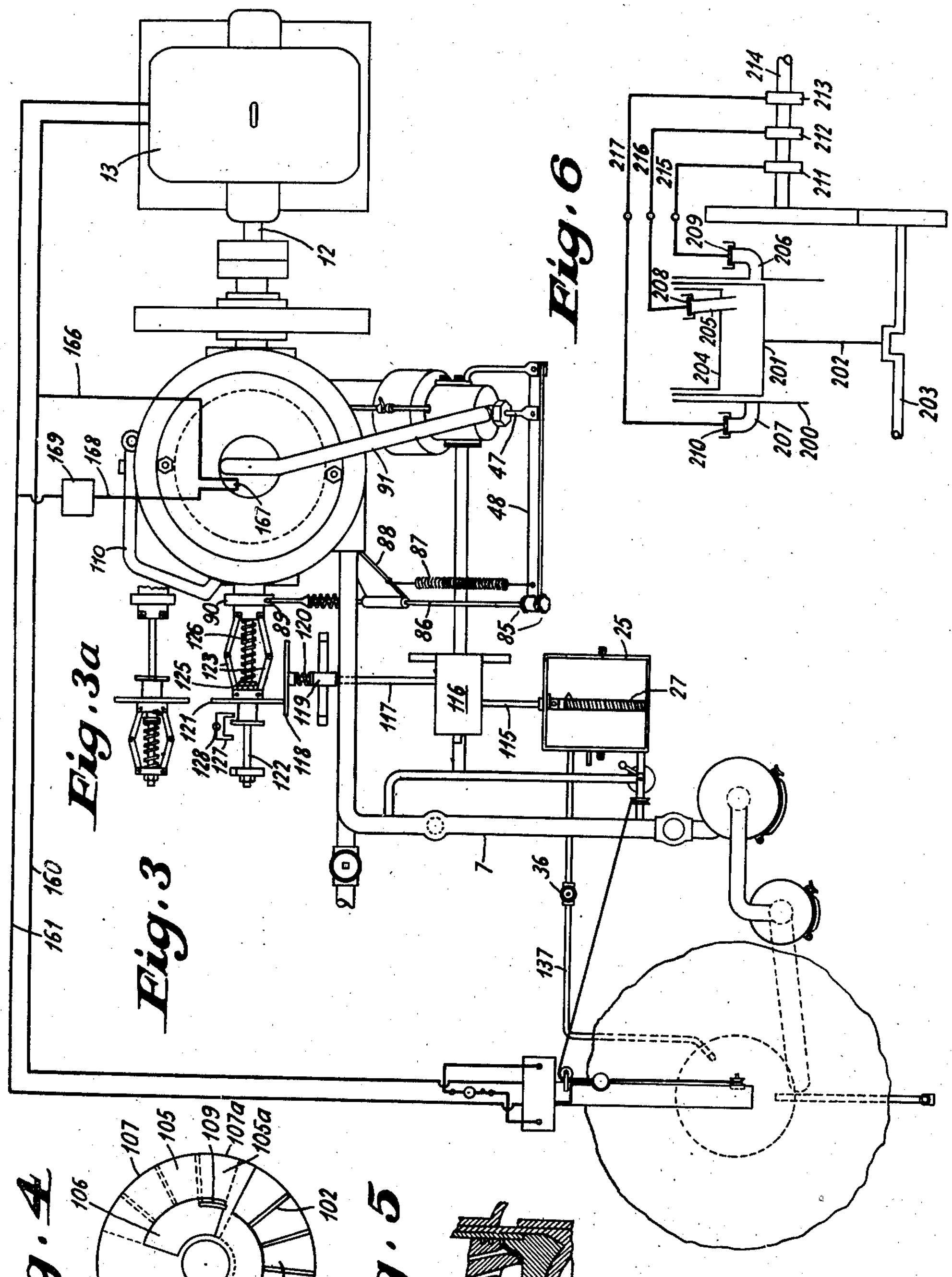

Fig. 3

Fig. 3a

Fig. 4

Fig. 5

Fig. 6

INVENTOR
KENNETH M. URQUHART
BY Phil L. Rodier
ATTORNEY

Patented Nov. 28, 1944

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GAS PRODUCER SYSTEM

Kenneth M. Urquhart, New York, N. Y.

Continuation of application Serial No. 44,564, October 11, 1935. This application February 28, 1941, Serial No. 381,202

24 Claims. (Cl. 123—3)

This application is a continuation of my copending application S. N. 44,564, filed October 11, 1935.

This invention relates to a system for producing combustible gases, motive power, or combustible gases and motive power simultaneously. More particularly, the invention relates to a gas producer system in which a finely divided solid fuel is caused to react with oxygen in the cylinder of an internal combustion engine to form a combustible gas having a high carbon monoxide content, the power developed by reciprocation of the piston in the cylinder being utilized both within and without the system.

Gas producers constructed and operated in accordance with the principles of my invention are especially adapted for use in isolated localities such as farms in sparsely settled districts, where there is no available source of power or energy such as gas mains or power lines. Such localities usually have available large supplies of solid fuels of relatively low B. t. u. content such as cotton stalks, corn stalks, hay, wood, peat or lignites.

I have found that solid fuels of low B. t. u. content which are not usually considered adaptable for use in power generating devices, may be powdered or finely divided and utilized efficiently in a gas and power producing system embodying the principles of my invention. As a result, a cheap source of combustible gas and power is made available for outlying farms and other isolated localities whereby modern heating, lighting, household and commercial apparatus may be used without the necessity of installing expensive pipe lines or power transmission systems.

Although my invention is especially adapted to be embodied in small units for isolated localities, it can also be used efficiently as a source of combustible gas and power for a small community. Gas mains and power lines extending from a central power plant to nearby commercial and domestic users can be readily and cheaply installed, and when a large supply of low grade solid fuel is available at small cost the system will be found more economical than when the power and fuel are obtained from other sources.

My invention is also especially useful where large quantities of high grade fuel, such as coke and coal, are available, for example, at coal mines where screenings and powdered coal are available in large quantities. Fuel of this nature may be readily and efficiently converted into power and combustible gas by means of apparatus embodying my invention. The power and combustible gas may be conveyed by pipe lines and the like to nearby towns and cities.

An object of my invention is to provide apparatus which will produce a combustible gas efficiently and economically.

Another object of the invention is to provide apparatus in which a combustible gas is efficiently produced by the partial combustion of a solid fuel.

Another object of the invention is to provide apparatus in which a finely divided solid fuel of low B. t. u. value may be efficiently converted into a combustible gas.

Another object of the invention is to provide apparatus in which a combustible gas is produced by the incomplete combustion of fuel in an expansible reaction chamber and in which the power resulting from the expansion of the gas is utilized.

Another object of the invention is to utilize an internal combustion engine as a producer of useable combustible gas.

Another object of the invention is to provide apparatus for pre-treating a solid fuel so that it can be combined with oxygen in a reaction chamber to generate a useable combustible gas without producing tarry derivatives.

Another object of the invention is to provide convertible apparatus capable of being used as a producer of combustible gas for commercial or domestic uses, or as an internal combustion engine to produce power.

Another object of the invention is to provide a solid fuel, internal combustion engine with means for keeping ash resulting from the combustion of the solid fuel, out of contact with the cylinder walls and other friction surfaces of the engine.

Another object of the invention is to generate a producer gas which has a higher B. t. u. content than the producer gas generated in modern producer gas systems.

Another object of the invention is to provide a producer gas system in which mechanical power is added to the system to assist in the economical production and transportation of high pressure producer gas.

Another object of the invention is to provide a self-contained, automatic, gas producer system adapted for use in isolated localities.

Other and more specific objects of and uses for the invention will become apparent upon reading the following specification and appended claims in connection with the accompanying drawings which illustrate an approved form of apparatus embodying the invention.

Fig. 1 is a flow chart of a gas producer system embodying my invention.

Fig. 2 is a view, partly in section, of the apparatus of my gas producer system.

Fig. 3 is a plan view of the apparatus shown in Fig. 2.

Fig. 3*a* is a sectional view of a modification of the governing system illustrated in Fig. 3.

Fig. 4 is a plan view of the air impeller illustrated in Fig. 2.

Fig. 5 is a sectional view of a part of the reaction cylinder illustrated in Fig. 2.

Fig. 6 is a diagrammatic illustration of a modification.

My gas producer consists essentially of a reaction chamber in which the gas is generated, apparatus for supplying fuel to the reaction chamber and apparatus for treating and storing the combustible gas. Mechanical power obtained from the reaction chamber is utilized in a suitable manner.

Any available solid fuel capable of being readily divided or broken up into fine particles, may be used efficiently in my gas producer. It is not necessary for the fuel to have a high B. t. u. content although in general a richer gas may be obtained from a high B. t. u. content fuel than from a low B. t. u. content fuel. Examples of the kinds of fuel that can be used in my gas producer are corn stalks, cotton stalks, hay, wood, peat, lignites, coal and coke.

Referring to the flow chart, Fig. 1, for a more detailed description of my gas producer system, a fuel hopper **1** contains a fuel feeding mechanism which feeds the finely divided particles of solid fuel to a mixing chamber **2** where it is mixed with a small amount of air or suitable gas. The fuel is then conveyed from the mixer **2** through a heat exchanger **3** to a fuel injector **4**.

The mixture of air and finely divided fuel particles is compressed in injector **4** and injected at regular intervals and in predetermined regulated charges into a reaction chamber **5**. The feed lines through which the fuel is supplied from the hopper **1** to the reaction chamber are indicated at **6**.

The reaction chamber **5** comprises an internal combustion engine. It consists of a cylinder, a piston movable in the cylinder, inlets for fuel and air, (or pure oxygen) and an outlet for the exhaust gases which, in this case, constitute combustible producer gas. The richness of the gas generated in the reaction chamber depends on the nature of the fuel and on other conditions to which reference will hereinafter be made.

The combustible gas generated in reaction chamber **5** is exhausted through a pipe line **7** to a suitable storage tank **8**, being passed through the heat exchanger **3**, a cooling system **9**, and cleaning devices **10** and **11**.

The piston of the internal combustion engine which constitutes the reaction chamber **5**, is connected with a crank shaft **12** to which the piston of the fuel injector **4** is also connected. A motor-generator **13** is connected with the crank shaft. When the internal combustion engine is operated the motor-generator **13** functions as a generator to convert mechanical power from the internal combustion engine into electrical energy which may be supplied to a storage battery **14**. The storage battery may act as a source of electrical energy for starting and controlling operation of the gas producer system and as a source of commercial and domestic electrical energy.

A compressor **15** may also be driven from the crank shaft **12**. The purpose of the compressor is to supply air at a high pressure to the crank case **16** of the internal combustion engine through the air conduit **17**. The compressed air is fed to the reaction chamber **5** from the crank case by means of air conduit **18**. The compressor is used when it is desired to super-charge the fuel in the reaction chamber. It is not necessary to use compressor **15** when the system is operated at what may be considered average working pressures as the air for combustion is compressed to the desired pressure in crank case **16** and supplied through suitable valving arrangements and air conduit **18** to the reaction chamber. Under some operating conditions it is desirable to inject steam into the reaction chamber, a steam inlet **19** being provided for that purpose.

The apparatus illustrated diagrammatically in the flow chart, Fig. 1, is illustrated in detail in Figs. 2 and 3. The fuel hopper **1** has an upper part **25** and a lower part **26**. The upper part of the hopper acts as a storage space for the finely divided particles of solid fuel. The lower part **26** houses the fuel feeding mechanism.

The fuel feeding mechanism consists of a worm wheel **27** and a worm **28** which is driven in a manner hereinafter described. Worm wheel **27** is mounted in the lower part **26** of the fuel hopper with its axis perpendicular to the vertical axis of the fuel hopper. The lower part of the fuel hopper is shaped to conform with worm wheel **27** so that the powdered fuel can not pass between the casing and the worm wheel. Worm **28** is enclosed in a casing **29** which may be either a continuation of the housing for worm wheel **27**, or a separate housing. Casing **29** is provided with a passageway or conduit **30** which extends downwardly from worm wheel **27** to a mixing chamber **2**.

When worm wheel **27** is rotated by worm **28** particles of finely divided solid fuel from the upper part of the fuel hopper are carried in the spaces between the teeth of the worm wheel until they are stripped therefrom and pushed into conduit **30** by worm **28** when it meshes with the worm wheel. The feeding mechanism maintains a steady and measured feed of fuel into the mixing chamber.

A spring member **31** secured to the fuel hopper at **32** is provided with a portion **33** adapted to knock against the side of the hopper. The free end of the spring **31** engages the teeth on the worm wheel and, as the wheel rotates, the end of the spring slides off each tooth and causes knocker **33** to strike against the side of the hopper. The constant impact of the knocker against the side of the hopper jars the fuel down on to the worm wheel and causes the fuel particles in the upper part of the hopper to fill the spaces between the teeth of the worm wheel.

While I have shown and described an approved form of apparatus for feeding the particles of solid fuel into mixing chamber **2** at a steady and predetermined rate it is to be understood that various other forms of fuel feeding mechanisms may be used in my gas producer system.

The fuel particles from conduit **30** are mixed in mixing chamber **2** with a gaseous medium containing oxygen. The gaseous medium may be air introduced through valve **34** located in one arm of a branched conduit **35**, or a combustible gas introduced through valve **36** located in the other arm of conduit **35**, or a mixture of both. The mixture of fuel and gas is carried from chamber **2** through conduit **37** to the heat transfer tubes **38** of heat exchanger **3** where hot gases flowing through the outer tube heat the mixture of fuel and gas in the inner tube.

As the mixture of fuel and gas is heated in the heat exchanger the moisture in the mixture is vaporized and the fuel carbonized. Some oxidation of the fuel also takes place because of the oxygen in the gas or air which is mixed with the fuel. The oxidation of the fuel prevents it from becoming gummy and blocking the conduit. It also prevents the fuel from forming gummy deposits in the fuel injector and reaction chamber.

After being heated in the heat exchanger the mixture of fuel and gas is introduced into the cylinder of fuel injector 4 through a continuation of conduit 37. The mixture is drawn from mixing chamber 2 through conduit 37 which is comparatively small in diameter, by suction generated in the cylinder of the fuel injector. A valve 157 is adapted to be operated either automatically or manually to permit or prevent the flow of the mixture of fuel and gas to the fuel injector. The automatic operation of the valve will be described hereinafter. If it is not desired to pre-heat the fuel, the heat exchanger is by-passed by a conduit 37*a*. The flow of fuel through the heat exchanger or through by-pass conduit 37*a* is controlled by a two-way valve 39.

Fuel injector 4 consists of a cylinder 40 having a cylinder head 41 at one end thereof and a piston 42 movable therein. The piston is driven from crank shaft 12 through a connecting rod 43. A fuel inlet port 44 is located in the side wall of the cylinder. The compressed mixture is exhausted from the injector through a passage 45 in the cylinder head, and a conduit 46, to reaction chamber 5. The instant at which the fuel is injected into the reaction chamber, is determined by a valve 47 actuated from a pivoted arm 48.

Piston 42 includes a piston head 49 to which the connecting rod is pivoted, and a tubular portion 50 extending from the piston head in the direction of the cylinder head. Tubular portion 50 fits snugly within the cylinder and is provided with piston rings in the usual manner. A port 51 in the tubular portion is adapted to register with intake port 44 when the piston is at a predetermined position in its stroke. At all other times intake port 44 is closed by the tubular portion 50. The tubular portion is of such length that it extends beyond the cylinder head for all positions of the piston. This construction prevents the fuel from coming in contact with the wall of the cylinder.

The cylinder head extends within the cylinder and is spaced from the wall thereof sufficiently to form a tubular chamber 52 sufficiently large to accommodate the tubular portion of the piston when the piston is at the end of its compression stroke. The clearance between the piston and the cylinder head at the end of the compression stroke is very small and thus a high compression is obtained in the cylinder. A cooling jacket 53, such as a water jacket, surrounds the cylinder. A layer of insulating material 54 is preferably applied to the bottom of the cup-shaped piston and may also be applied to the side walls.

Reaction chamber 5 into which the fuel is injected from the injector, comprises the cylinder of an internal combustion engine of the Diesel type. Cylinder 60 is provided at one end with a cylinder head 61 and is connected at its other end with a crank case 62 which also serves as the crank case for the injector. A piston 63 reciprocates within the cylinder in the usual manner. A connecting rod 64 connects piston 63 to crank shaft 12 which is housed within crank case 62. The crank shaft is designed so that the stroke of the injector piston is about 15 degrees ahead of the stroke of piston 63.

Piston 63 is cup-shaped like the injector piston. It consists of a piston head portion 65 and a tubular portion 66 extending from the head portion in the direction of the cylinder head. Insulating material 67 is arranged within the cup-shaped piston to protect the walls and bottom thereof from damage by excessive heat and ash resulting from the combustion of the solid fuel. The insulation at the bottom of the piston is provided with a pocket to increase the turbulence at the time the fuel is burning. A small recess is also provided at a point on the periphery of the pocket directly below the nozzle to act as a deflecting surface for the fuel and gas jetted into the cylinder. Piston rings of any well known type are mounted on the tubular part of the piston adjacent exhaust and inlet ports 68 and 69 provided in the tubular part near its open end. These ports are adapted to register with ports 70 and 71 in cylinder 60.

Cylinder head 61 is similar to the cylinder head of the injector. It extends into the cylinder and is spaced from the inner wall thereof to form a tubular chamber 72 of just sufficient size to receive the tubular portion of the piston. Grooves 73 provided in the cylinder head, form a seal between the inner surface of tubular projection 66 and the cylinder head. The seal is formed by carbon or ash deposits in the grooves. In a modification, piston rings are inserted in the grooves in the usual manner. This arrangement differs from the usual engine construction in that the piston rings are mounted in the stationary part of the engine, i. e. the piston head.

The purpose of the seal between the cylinder head and the piston is to prevent ashes formed by the combustion of fuel in the cylinder from getting into tubular space 72. Any ashes or combustible gases which get into this tubular space are forced therefrom either by upward movement of tubular portion 66 or by supplying air under pressure to the top of the tubular space through suitable ports or nozzles 74 or through a conduit or air duct 110.

Conduit 110 extends from air supply conduit 75 hereinafter described, to a port in the cylinder wall which is above and out of line with ports 70 and 71. Conduit 110 furnishes air under pressure from crank case 62 either for the purpose of blowing ashes or exhaust gases from tubular chamber 72 or to supply oxygen for the combustion of the fuel injected through ports 74.

In some instances it may be desirable to inject a combustible mixture into tubular chamber 72 through ports or nozzles 74 and to cause combustion of this mixture in the tubular chamber. Fuels satisfactory for burning in the tubular chamber include light oils, petroleum gases or gas from the reaction chamber. The expansion of the gases resulting from the combustion of the fuel, will force back into the cylinder, any ashes which may have leaked into the tubular channel through the clearance between the inner surface of tubular portion 66 and the surface containing grooves 73. By properly timing the injection of the combustible fuel into the tubular chamber, additional power may be derived from the action of the gas generated by the combustion, against the end of the tubular portion of the piston.

Cylinder head 61 is provided with glow plug 76 which is adapted to be heated from any available source of electrical energy such as storage battery 14. The purpose of the glow plug is to initiate combustion in the reaction chamber. After the apparatus has been operated for a short period of time sufficient heat will be generated within the reaction chamber to insure continued operation of the device.

In case the fuel being utilized is of extremely low B. t. u. content and it is desired to produce a richer gas than that which can only be produced from the low B. t. u. content fuel, additional fuel of much richer B. t. u. content such as Diesel oil, petroleum gases and the like may be injected into the reaction chamber through an expansion nozzle 77 located in the cylinder head. The auxiliary fuel inlet nozzle 77 is located at one side of a projection or ridge 78 on the cylinder head (or on the heat insulating material 79 applied to the cylinder head) and the expansion nozzle 80 for conduit 46 is located at the other side of projection 78 adjacent the air inlet port 71. Projection 78 is of such size and shape as to divert the flow of air from the air intake toward the bottom of the cylinder thus blowing the exhaust gases remaining in the cylinder out through exhaust port 70.

If the engine is to be used with very quick burning fuel, or primarily for power production as distinguished from gas generation, the insulating surfaces may be omitted from the cylinder head and the inside of the cup-shaped piston. The metal surfaces of the piston and cylinder head will then be formed with the same contours as the insulating surfaces.

As crank shaft 12 rotates, injector piston 42 is reciprocated. Intake port 51 in the side wall of the piston lines up with port 44 in the cylinder wall at the end of the piston stroke, permitting the mixture of fuel and gas from conduit 37 to be drawn through the aligned ports into the cylinder. As the piston goes up the mixture of fuel and gas is strongly compressed between the bottom of the cup-shaped piston and the head of the cylinder.

Injector piston 42 has a stroke less than that of power piston 63 but it is secured to the same throw of crank shaft 12 and as cylinder 40 is disposed at an angle to the main power cylinder the injector piston necessarily reaches the top of its stroke several degrees ahead of the power piston. Just before piston 42 reaches the top of its stroke, valve 47 located in the head of cylinder 40 opens and permits expulsion of the mixture of fuel and gas from the cylinder. As the piston starts down the valve closes. At the bottom of the piston stroke ports 44 and 51 are again aligned permitting intake of another charge of fuel and gases.

Valve 47 is actuated by suitable mechanism deriving its motion from crank shaft 12. An arm 48 is pivoted to a bracket suitably bolted to the injection cylinder or supported in any other desired manner. The arm is suitably connected to an extension of valve 47 (see Fig. 3) and is adjustably connected by means of nuts 85 to pusher rod 86. The pusher rod is positioned by suitable grids and brackets affixed, for example, to the main cylinder. A coil spring 87 is connected between the arm and a stationary part such as bracket 88. The lower end of rod 86 terminates in a cam follower 89 of hardened metal positioned to contact a cam 90 keyed to crank shaft 12. Coil spring 87 holds valve 47 in closed position when not thrust open by the cam and pusher rod. Valve 47 is provided with a suitable stuffing box to prevent gas leakage around the stem. The cam can be rotatably adjusted on the crank shaft to change the instant at which the valve opens.

The fuel and gases expelled from the injection cylinder pass through conduit 46 suitably externally insulated by tube 91, to expansion nozzle 80 located in the head of the power cylinder. At the proper time the fuel and gas jet with high velocity into the cylinder of the gas generator engine which is of the two-stroke cycle crankcase compression type.

The mixture of fuel and gas is injected into the cylinder when the piston reaches the end of its compression stroke or just before the compression stroke is finished. The fuel is mixed with the air which has been compressed on the compression stroke and the reaction is started by the high temperature of the compressed air and/or of the piston and cylinder head. The temperature of the compressed air is dependent on the initial temperature of the air, the degree of compression, and the amount of heat absorbed from surrounding hot surfaces of the engine. Glow plug 76 is provided to insure easy starting when the engine is cold. The reaction continues until the oxygen in the air compressed in the cylinder is combined with the carbon in the fuel to form a mixture of carbon monoxide and carbon dioxide. When sufficient moisture is present, hydrogen may be generated in appreciable quantities during the reaction. Other gases may be formed depending on the composition of the fuel being used but their presence or absence may usually be disregarded.

The reaction is completed by the time the piston reaches the end of its expansion stroke and the exhaust port 68 in the piston registers with the exhaust port 70 in the cylinder. The gases in the cylinder are then exhausted through an exhaust manifold 92 to the pipe line or gas conduit 7. The exhaust conduit is illustrated as being contained in the water jacket 93 which maintains the cylinder at the proper temperature, but it can be located outside of the water jacket if desired.

Just after exhaust ports 68 and 70 register, the air inlet ports 69 and 71 start to register. This permits a charge of compressed air from the crank case to be jetted into the cylinder when a valving arrangement (hereinafter described) connects conduit 75 to a source of compressed air. The air stream is deflected by projection 78 toward the bottom of the cup-shaped piston and it blows the exhaust gases remaining in the cylinder up to the exhaust ports and into the exhaust manifold. When the air is first introduced into the cylinder there is a slight reaction with the outgoing producer gas. This tends to accelerate the exhaust of gases from the cylinder. By the time the stream of incoming air reaches the exhaust ports the greater part of the exhaust gases have been blown out of the cylinder and the movement of the piston on its compression stroke has closed the exhaust ports.

The amount of fuel and the volume of air introduced into the cylinder for each cycle is predetermined so that the desired reaction will take place, the desired reaction being the partial combustion of the fuel to generate the desired ratio of carbon monoxide and hydrogen to carbon dioxide. Sufficient air is introduced into the cylinder during each cycle to insure that all of the carbon in the fuel is combined with oxygen to form either carbon monoxide or carbon dioxide. Manual and automatic means are provided for varying the amount of fuel with respect to the volume of air to thereby vary the ratio of carbon monoxide and hydrogen to carbon dioxide, that is, to vary the B. t. u. content of the exhaust gas. Decreasing the ratio of fuel to air will result in a more complete combustion of the fuel and a lower ratio of carbon monoxide and hydrogen to carbon dioxide. This will decrease the B. t. u. content of the exhaust gas. Increasing the ratio of fuel to air will result in a less complete combustion of the fuel thereby increasing the carbon monoxide and hydrogen content and the B. t. u. value of the exhaust gas. The engine speed will tend to vary with the completeness of combustion, increasing as the combustion is made more complete and decreasing as the combustion is made less complete.

Adding a charge of an enrichening fuel through auxiliary nozzle 77 tends to decrease the completeness of combustion and to raise the B. t. u. value of the exhaust gas. Lighter hydrocarbon gases are formed from the enrichening fuel through cracking reactions well known in the art. The high B. t. u. value of the enrichening fuel further raises the B. t. u. value of the exhaust gas.

The B. t. u. value of the gas generated in the reaction chamber may also be raised by adding steam to the mixture injected into the cylinder. The ratio of the B. t. u. value of the fuel converted into mechanical power in the engine, to the B. t. u. value of the fuel in the exhaust gas, may be controlled by injecting more or less steam into the reaction chamber, a larger amount of steam resulting in less mechanical power. In a preferred form of the invention, the steam is added to the mixture of fuel and gas in the injector cylinder 40. The steam obtained from any suitable source is introduced into cylinder 40 through a valve arrangement 94 and ports 44 and 51. The steam supply may be controlled by an off and on valve 95 and a manually adjustable needle valve 96 for controlling the rate at which the steam is introduced into the cylinder. The steam is preferably superheated and supplied at a high pressure. Suitable means are also provided for supplying the mixture of fuel and gas to the injector under high pressure and a compressor 15 is provided for supplying air at high pressure to the reaction chamber.

When the mixture of fuel, air and steam is injected into the reaction chamber the steam is broken down by the high temperature and high pressure into hydrogen and oxygen. The oxygen combines with the carbon in the fuel in the usual manner and the hydrogen is exhausted with the other gases. Some of the hydrogen may recombine with the oxygen to form water vapor and some of the steam may not be broken down but the presence of this moisture in the exhaust gas is not detrimental.

Crank shaft 12 is supported by suitable bearings in the crank case which forms a gas tight vessel capable of withstanding internal pressure or vacuum. The inside of the crank case is machined at the end of the engine away from the injection cylinder, to accurately fit the end and peripheral surfaces of a machined rotary disc 100 (see Fig. 4) which is an integral part of crank shaft 12. The crank case is provided in its end face adjacent the rotary disc, with a cut out portion over which air vanes are secured. This cut out portion forms an air inlet port which is adapted to align at certain times with axial inlet ports 101 cut in rotary disc 100. A passageway 102 extending from ports 101 to outlet ports 103 near the periphery of the opposite face of the rotary disc. Radial members separate the passageway 102 into a plurality of air ducts 104. The action of the inlet port in the crank case and ports 101 is that of a rotary valve, while ducts 104 act as an impeller hurling air into the crank case.

Booster ducts 105 have an axial inlet 106 near crank shaft 12 in the face of the rotary disc and extend through the rotary disc to radial discharge ports 107. Ports 107 are adapted to align with ports 108. The action of ports 107 and 108 is that of a rotary valve while ducts 105 act as an impeller to hurl air into air duct 75. There are four booster ducts 105 cut in rotary disc 100. Duct 105a is provided with slots cut through the axial face of the rotary disc adjacent a cut out portion of the crank case cover. These slots are adapted to receive a thin rectangular metal strip 109 which may be inserted into the slots and locked there by suitable locking means. This strip is used to seal booster duct 105a when the engine is used as a gas generator. The duct is opened when the engine is to be used as a straight internal combustion engine.

When power piston 63 reaches the end of its expansion stroke, exhaust fuel gases are passing through aligned ports 68 and 70 into exhaust passage 92. With pistons 63 and 42 at the bottom of their in-strokes the air in the crank case is under substantial compression. At this instant booster ducts 105 in the rotary disc are in such position that booster discharge port 107a is in alignment with air duct ports 108 but metal strip 109 is blocking the duct. As piston 63 starts on its upstroke, ports 68 and 70 begin to close. Before they are closed, ports 107 of the booster ducts begin to register with ports 108 and compressed air from the crank case is hurled up the duct and through aligned ports 69 and 71 into the reaction cylinder.

After air inlet ports 69 and 71, booster duct ports 107 and air duct ports 108 are closed, compressed air is trapped in air duct 75 between ports 108 and 71. The air is held in this duct until the piston has completed its compression stroke and has nearly returned to the end of its expansion stroke at which time the end of the tubular portion of the piston uncovers a port connected to air conduit or duct 110. Conduit 110 is connected to duct 75. The air entrapped in duct 75 is released into the tubular space 72 where it blows ashes and exhaust gases collected in the tubular space into the cylinder through the clearance space between the inner surface of the cup-shaped piston and the cylinder head.

After booster duct ports 107 are closed and pistons 63 and 42 continue on their upstrokes, a vacuum begins to be created in the crank casing. As the vacuum increases the axial inlet ports 101 of impeller ducts 104 register with the vaned air inlet ports in the crank case, and air is drawn into the crank case. This action continues until shortly after pistons 63 and 42 reach the top of their upstrokes.

When the supercharger is used, compressed air from compressor 15 is introduced into the crank case either directly or through the impeller and booster ducts. If the compressor is of the piston type it can be synchronized with the engine to inject the compressed air into the crank case at the proper period in the engine cycle. Otherwise, valving is accomplished by inlet ports 101 in the same manner as when air is drawn in from the atmosphere.

The heretofore mentioned worm 28 is driven from a shaft 115 which extends to a speed reducer gear box 116. A drive shaft 117 suitably journaled in brackets, extends from the other side of the gear box. A flat disc 118 is keyed to the end of the drive shaft so that it rotates with the shaft but is free to move axially thereof. A thrust collar 119 secured to shaft 117 forms a stop for a coil compression spring 120 compressed between the collar and the disc. The spring pushes the disc toward the end of the shaft.

The flat face of disc 118 is held in frictional contact with the rim of a speed governor wheel 121 by the thrust of spring 120. The governor wheel is keyed to an extension 122 of crank shaft 12 so that it is free to move axially of the shaft but rotates with the shaft. A pair of pivoted arms 123 pivotally connected to the hub of wheel 121 are responsive to centrifugal force when the shaft and arms are rotated. The other ends of the arms are pivoted to a collar secured to the shaft. The hub of the governor wheel adjacent pivoted arms 123 is threaded to receive lock nuts 125 which form an adjustable stop for a coiled compression spring 126. The hub of wheel 121 terminates in a flange located between fingers provided on a manual control lever 128. Movement of the lever will cause the governor wheel 121 to be pushed or pulled axially along shaft 122.

When the engine is rotating the action of centrifugal force causes radial movement of pivoted arms 123 causing the governor wheel to be moved along the shaft against the bias of spring 126. As the speed of rotation is increased the wheel is drawn nearer the engine, and as the speed of rotation decreases the wheel is pushed away from the engine by the bias of the spring. The position of the wheel along shaft 122 for any speed of rotation, may be varied by changing the setting of lock nuts 125.

The point of frictional contact between the rim of governor wheel 121 and driven wheen 118 is varied as the governor wheel is moved axially along shaft 122. The nearer the governor wheel moves towards the center of the driven wheel, the faster the driven wheel moves with respect to the governor wheel. This change of speed is transmitted through gear box 116 to fuel feeding worm gears 27 and 28.

Thus, when the engine is rotating and its speed increases, wheel 121 is pulled in towards the axis of driven wheel 118, increasing the speed of rotation of worm wheel 27 and consequently increasing the rate of fuel feed much faster than the engine speed increases. This causes a larger quantity of fuel to go to the engine, decreasing the amount of power developed per power stroke and causing the engine to slow down. The heat value of the gas produced under these conditions is increased.

When the speed of the engine decreases, the governor wheel moves towards the rim of wheel 118, causing the amount of fuel fed to the engine to decrease much faster than the engine speed decreases. The decrease in fuel increases the completeness of combustion and the power developed per power stroke, causing the engine to speed up. The heat value of the exhausted gas drops.

This action of increasing the amount of fuel fed to the engine to slow the process and decreasing the amount of fuel fed to the engine to speed up the process is the reverse of the ordinary control of internal combustion engines.

When it is desired to use the engine to produce power only and no combustible gas, the governor mechanism is reversed on the shaft 122 as shown in Fig. 3*a*. The action of the governor on the fuel feeding mechanism is then reversed and follows the usual governing action of an internal combustion engine, namely, feeding more fuel to increase the engine speed and less fuel to decrease its speed.

The manual control lever 128 may be moved so that the fingers 127 will engage the flange on the hub of wheel 121 and move the governor wheel. Manual control of the fuel feed is accomplished in this manner. If the lever is moved to push the governor wheel away from the engine, the fuel feed will decrease in spite of the governor action, the fuel feed being increased when the lever is moved in the opposite direction. The fingers 127 are spaced apart so that they are out of contact with the flange on the hub of wheel 121 when the manual control lever is in a neutral position, permitting the engine to be controlled by the governor.

The gas from the reaction chamber or cylinder 5 is discharged through exhaust ports 68 and 70 into the passageway leading to gas conduit 7. The hot gas flows through the conduit to the heat exchanger 3 where it flows through the outer heat exchange tubes 38 in the opposite direction to the flow of the mixture of fuel and gas in the inner tube. The hot gas is cooled by giving up its heat to the mixture of fuel and gas in the inner tube. The hot gas passes through gas conduit 7 to a cooling system 9 and thence through a tangential separator 130, a filter 131, conduit 132 and valve 133 into the base of an expanding flexible gas bag 134. Conduit 135 leads from the base of the gas bag to a pressure safety pop valve 136 which is adapted to release the gas pressure in the gas bag 134 if it becomes excessive for any reason. Gas conduit 137 connected with the base of the gas bag, supplies the gas used for floating the fuel particles in the mixing chamber 2. The gas is introduced into the mixing chamber through valve 36. While I have shown a flexible gas bag it is to be understood that any other suitable kind of storage tank can be used to store the combustible gas.

The gas to be used as a fuel is withdrawn from the base of the gas container through conduit 138, stop cock 139, pressure regulator 140 and conduit 141 to the place of consumption. Attached to conduit 141 is manometer 141*a* filled with mercury or a suitable liquid, so that the gas pressure may be read. Three calibrated Bunsen burners 142, 143 and 144 are connected to conduit 141 through suitable stop cocks. The Bunsen burners are adjusted to burn gas at a given pressure, which may be set with gas pressure regulator 140, with a clear blue flame when the gas has a given B. t. u. heat content. For example, the first burner is adjusted to burn with a clear blue flame with 100 B. t. u. gas; the second Bunsen burner is adjusted to burn with a clear blue flame with 150 B. t. u. gas; and the third Bunsen burner showing a clear blue flame with 200 B. t. u. gas. If the B. t. u. value of the gas is higher than that for which a given burner is adjusted, the flame will be yellow and smoky; if it is lower, the burner flame will be very short, whistle or rumble, and tend to strike back. If the gas has a B. t. u. value near the valve to which the burner is adjusted, a long clear-blue flame will result. The B. t. u. value of the gas may be easily and quickly estimated by trying the three burners in succession. Lock nuts 125 may then be adjusted to govern the fuel feed so as to secure the proper heat content gas. By-pass conduit 145 connects conduit 141 with conduit 132. If valve 133 is shut and valve 146 is opened while the engine is running the Bunsen burners may be used to determine the heat value of the gas before it mixes with the gas which may be in the gas container.

Flexible cable 150 is fastened to the top of bag 134. This cable passes over a pulley secured to a cross arm supported by a column 151 and then over a second pulley secured to the column. A counter weight 152 secured to the end of the cable, rises and falls as bag 134 is filled and emptied. Two triggers 153 and 154 attached to the cable, are adapted to throw weighted lever 155 pivoted to the cross arm and provided with suitable stops secured to the cross arm.

The weighted lever 155 is thrown first in one direction and then the other as triggers 153 and 154 contact it alternately on one side and then the other. Cable 156 which is attached to lever 155, is secured to a wheel on the shaft of valve 157 which is in fuel conduit 37. The shaft of valve 157 is provided with a manual control handle and is counterweighted to hold the valve open when it is not closed by the action of lever 155. Also attached to lever 155 is cable 158 which passes over another pulley secured to column 151. The other end of cable 158 is secured to the lever arm of a conventional spring loaded electric starting switch 159.

Motor-generator 13 is connected to storage battery 14 by means of electrical cables 160 and 161. A conventional time overload cut out starting switch 162 and an ordinary spring loaded switch 159 which is held shut when the weighted end of lever 155 is moved away from column 151, are interposed in cable 161 between the motor-generator and the storage battery. Load circuit 163 is attached to storage battery 14 and draws current therefrom. A branch 164 of cable 160 goes into time overload cut out starting switch 162 which is so made that when the main switch is cut out a small auxiliary switch connects branch 164 with the cable leading back to the storage battery thus lighting a small warning light 165 interposed in the cable. The warning light may be placed in any convenient location at some distance from the storage battery. A branch cable connects cable 160 with one side of a resistance wire heater located in glow plug 76 in the head of the power cylinder. The other side of the resistance wire heater is connected through another branch cable and an interposed conventional reversed current cut out, with cable 161.

When the generator is not running and gas is withdrawn from the gas container the bag contracts and drops, pulling down cable 150 until trigger 154 contacts the bottom part of lever 155 and throws it against the stop. This releases cable 156 permitting the counterweight to open fuel valve 157 in conduit 37. Simultaneously cable 158 is released allowing spring loaded switch 159 to close. Electric current then passes from the storage battery through time overload cut out switch 162 and cables 160 and 161 to the motor-generator. Simultaneously, current passes through branch cables to the resistance wire heater in plug 76 which quickly becomes red hot. The motor-generator rotates the engine and the fuel governor wheel automatically causes a suitable amount of fuel to be fed through the fuel conduit to the injector cylinder. At the proper time fuel is injected into the power cylinder where the glow plug heated by the resistance wire heater initiates combustion. If the engine starts promptly the flow of electric current through cables 160 and 161 is quickly reversed and the battery starts charging. The reverse current cut out also promptly reverses and shuts off, keeping current out of the resistance wire heater. The exhaust gas from the cylinder is rather low in heat value at first but the fuel governor wheel automatically increases the proportion of fuel to air as the engine heats up and speeds up, thus increasing the fuel value to normal. The exhaust gas gradually fills the gas bag.

If for any reason the engine does not start after a reasonable time the time overload cut out starting switch 162 trips and stops the motor-generator. The auxiliary switch in switch 162 is thrown in when switch 162 trips causing current to flow from the battery through cable 164 to light the signal light 165. This light stays on to show that the engine failed to start.

With the engine running, when the gas bag fills up, weight 152 drops causing trigger 153 to contact and throw lever 155 away from column 151. This exerts a pull on cable 156 shutting valve 157 and shutting off the flow of fuel to the injector cylinder. Simultaneously, cable 158 pulls spring loaded switch 159 open. When the fuel supply is shut off the engine promptly stops. If, for any reason, the fuel supply does not shut off the engine continues running until the pressure on the gas bag is high enough to pop the safety valve. The generator will then run idle, the governor wheel preventing over speeding with no generator load.

While I have shown and described my invention as being especially applicable to a two stroke cycle engine is to be understood that it may also be applied to a four stroke cycle engine. A four stroke cycle engine may be somewhat more expensive than the two stroke cycle engine which I have shown and described because of the valve mechanism which is necessary in a four stroke cycle engine and which is not required in a two stroke cycle engine, but it may be more desirable than the two stroke cycle engine in certain installations.

A four stroke cycle engine is illustrated diagrammatically in Fig. 6. Cylinder 200 contains a cup-shaped piston 201 connected by connecting rod 202 to a crank shaft 203. Cylinder head 204 contains the fuel inlet nozzle 205. Air inlet conduit 206 and exhaust gas conduit 207 are suitably connected to the cylinder. The details of this apparatus may be the same as described and illustrated in connection with the two stroke cycle engine.

Suitable valves which may be of the poppet type, are located in each of conduits 206 and 207 and in the fuel inlet nozzle or conduit 205. These valves are indicated at 208, 209 and 210. The valves are actuated by cams 211, 212 and 213 mounted on a shaft 214 which may be connected with shaft 203, for example through a gear train so designed that shaft 214 completes one revolution for every two revolutions of crank shaft 203. The valves are actuated by the cams through any suitable mechanism such as pivoted rods 215, 216 and 217 and connections from the rods to the valves and to cam followers cooperating with the cams.

The operation of the device is as follows: Fuel is injected into the cylinder through nozzle 205 when valve 208 is opened at the end of the compression stroke. As the fuel is burned the piston moves toward the crank case end of the cylinder on the expansion stroke. At the end of that stroke valve 210 opens and gases are exhausted through conduit 207. As the piston moves toward the head end of the cylinder the exhaust continues, suitable arrangements being made to exhaust gas from the cylinder through suitable ports in the cup-shaped piston. Valve 210 closes at the end of the upstroke and valve 209 opens permitting air to be drawn into the cylinder through conduit 206 on the next down stroke of the piston. Valve 209 closes at the end of the down stroke and air in the cylinder is compressed on the upstroke or compression stroke of the piston. A new charge of fuel is injected into the cylinder at the end of the compression stroke and a new cycle is started.

While I have shown an approved form of apparatus embodying my invention it is to be understood that various modifications and substitutions can be made to different parts of the system without departing from the spirit of the invention, and that my invention is not to be limited to the specific construction illustrated herein but only by the scope of the appended claims.

I claim:

1. In a system for producing combustible gas by the partial combustion of a solid fuel of low B. t. u. content, the combination of an expansible chamber in which the partial combustion occurs, means including a pump, for forcing air and finely divided particles of fuel into the expansible chamber, means for driving said pump from a moving part of the expansible chamber, and a fuel feeding mechanism for feeding measured charges of the finely divided particles of solid fuel to the pump.

2. In a system for producing combustible gas by the partial combustion of a solid fuel in an expansible chamber device, the combination of a cylinder, a piston cooperating with said cylinder to form an expansible chamber, means for introducing charges of solid fuel and air into said expansible chamber, means for causing partial combustion of said fuel in said expansible chamber, means for varying the ratio of air to fuel for restricting said combustion to the extent that a combustible gas is exhausted from said expansible chamber, and a storage tank for said combustible gas.

3. A system for producing a combustible gas for domestic and commercial uses by the partial combustion of a solid fuel in the expansible chamber of an internal combustion engine, comprising a cylinder constituting the reaction chamber, a piston in said cylinder, a source of finely divided solid fuel, means for mixing exhaust gas from said cylinder with said finely divided solid fuel, means for injecting the mixture of fuel and gas into said cylinder, means for introducing air into said cylinder in insufficient quantities to support complete combustion of said fuel, means for causing partial combustion of said fuel in said cylinder whereby a combustible gas is produced, a storage receptacle for said combustible gas, a conduit extending from said cylinder to said storage receptacle, and a valve mechanism actuated by said piston for controlling the flow of combustible gas through said conduit.

4. In a system for producing a combustible gas for domestic or commercial uses by the partial combustion of carbonaceous fuel in an internal combustion engine, the combination of a cylinder, a piston in said cylinder, means for introducing fuel into said cylinder in equal portions at regular intervals, controllable means for introducing air into said cylinder in proportions such as to preclude complete combustion of said fuel, means for causing partial combustion of said fuel in said cylinder whereby a gas containing sufficient quantities of carbon monoxide to be combustible is obtained, a storage receptacle for said combustible gas, and a valve mechanism for controlling the flow of combustible gas from said cylinder to said storage receptacle.

5. In a system for producing a combustible gas by the partial combustion of a solid fuel in an expansible chamber, the combination of an engine including a cylinder, a piston cooperating with said cylinder to form said expansible chamber, means for conveying power from said piston to a load, a source of finely divided solid fuel, means for heating said fuel, means for introducing said heated fuel under pressure into said expansible chamber, separate means for supplying air to said chamber, means for insuring incomplete combustion of said fuel in said chamber whereby a combustible gas is formed, means for cooling said gas, and a storage tank for said gas.

6. The method of generating a combustible gas by the partial combustion of a solid fuel in an internal combustion engine, which comprises mixing a finely divided solid fuel with a gaseous medium containing insufficient oxygen for complete combustion of said fuel, heating the mixture, compressing the heated mixture, introducing the compressed heated mixture into the cylinder of said internal combustion engine, introducing compressed air into said cylinder in amounts insufficient to produce complete combustion of said fuel, causing partial combustion of said fuel in said cylinder, exhausting the gaseous products of said partial combustion from said cylinder, utilizing said gaseous products to heat said mixture of finely divided solid fuel and the gaseous medium, storing said gaseous products, and utilizing the mechanical power generated by said internal combustion engine.

7. An internal combustion engine gas producing system comprising a cylinder, a piston having a tubular portion fitting snugly within said cylinder, a cylinder head extending into said cylinder and spaced therefrom to form a tubular chamber just large enough to accommodate the tubular portion of said piston, a source of finely divided solid fuel, means for heating said fuel, a conduit for conveying said heated fuel under pressure to said cylinder through said cylinder head, said conduit terminating adjacent said tubular chamber, means for insuring incomplete combustion of said fuel in said chamber, a port in said cylinder adjacent the inner end of said cylinder head for withdrawing the gases of said incomplete combustion, and a storage tank for said gases.

8. A system for producing combustible gas by the partial combustion of a solid fuel in an internal combustion engine, comprising a cylinder having a piston therein, means for introducing measured quantities of air and solid fuel divided into small particles into said cylinder, means controlling the proportions of fuel and air introduced into said cylinder whereby incomplete combustion of said fuel and the production of a combustible gas having the desired B. t. u. content is insured, a valve system constituted in part by said piston for controlling the exhaust of said combustible gas from said cylinder, a storage tank for said gas, and means associated with said storage tank for indicating the B. t. u. content of said gas.

9. A system for the production and storage of a combustible gas for domestic and commercial

uses, comprising a source of solid fuel, a reaction chamber, means for introducing equal charges of said solid fuel into said reaction chamber at regular intervals, means for introducing air into said reaction chamber in insufficient quantities to support complete combustion of said fuel, means for causing partial combustion of said fuel in said reaction chamber whereby a combustible gas is produced, a storage receptacle for said combustible gas, a conduit extending from said reaction chamber to said receptacle, and a valve mechanism for controlling the flow of gas through said conduit.

10. In a gas generator adapted to generate a combustible gas by the incomplete combustion of fuel in the presence of air, the combination of means for applying a pressure materially higher than atmospheric pressure to said fuel, means for applying a pressure materially higher than atmospheric pressure to said air, a reaction chamber, means for introducing the fuel and the air separately into said chamber at their respective high pressures in such proportions as to insure incomplete combustion of said fuel, means for exhausting from said reaction chamber at a high pressure the combustible gas resulting from said incomplete combustion, and a storage receptacle for said combustible gas.

11. A system for producing combustible gas for domestic and commercial uses, comprising a reaction chamber, means for introducing a solid fuel into said chamber, separate means for introducing air into said chamber, means for insuring a reaction in said chamber whereby said fuel is converted into both carbon dioxide and carbon monoxide, means for introducing a combustible fluid into said reaction chamber to raise the B. t. u. content of the gas formed by said reaction, a storage receptacle, and means for exhausting the gas from said reaction chamber into said storage receptacle.

12. The method of producing a combustible gas from a solid fuel in a system including a pre-heater, a fuel injector and an internal combustion engine, comprising the steps of (1) drying said solid fuel and producing some oxidation thereof by applying controlled heat to the fuel in said pre-heater, (2) producing further and an accelerated oxidation of said fuel by applying pressure thereto in said injector, (3) producing still further oxidation and gasification of said fuel by causing the partial combustion thereof in said internal combustion engine, and (4) exhausting the gaseous products of combustion from said engine.

13. The method of producing a combustible gas from a finely divided solid fuel in a system including a pre-heater, a fuel injector and a combustion device operating on the Diesel cycle, comprising the steps of (1) drying said fuel and producing partial oxidation thereof by applying heat to said fuel in said pre-heater, (2) producing further and an accelerated oxidation of said fuel by combining said fuel with a gaseous medium and increasing the pressure thereof in said injector, (3) producing still further oxidation and gasification of said fuel by causing auto-ignition and partial combustion thereof in said combustion device operating on the Diesel cycle.

14. In a device for producing a combustible gas from a solid fuel of low B. t. u. content, the combination of means for drying said fuel and producing some oxidation thereof by applying controlled heat thereto, means for producing a further and accelerated oxidation of said fuel by applying pressure to a mixture of said fuel and a gaseous medium, means for producing still further oxidation and gasification of said fuel by causing auto-ignition and partial combustion thereof, and means for storing the gaseous products of said partial combustion.

15. The method of producing a combustible gas from a finely divided solid fuel of low B. t. u. content in a system including an internal combustion engine adapted to operate on the Diesel cycle, comprising the steps of (1) mixing the particles of said solid fuel with a gaseous medium, (2) producing partial oxidation of said fuel by applying pressure to said mixture of fuel and gaseous medium in an inclosure other than the combustion chamber of said internal combustion engine, (3) producing still further oxidation and gasification of said fuel by causing auto-ignition and partial combustion thereof in said internal combustion engine, and (4) exhausting the gaseous products of combustion from said engine.

16. The method of producing combustible gas comprising combining finely divided particles of a low B. t. u. content solid fuel with insufficient oxygen for the complete combustion of the fuel, causing partial combustion of said fuel in the combustion chamber of an internal combustion engine, utilizing the power developed by said partial combustion for operating said internal combustion engine and the fuel feeding mechanism, utilizing heat from said partial combustion to pre-heat said fuel, and exhausting the gas produced by said partial combustion from said internal combustion engine into a storage tank.

17. The method of producing a combustible gas from a finely divided solid fuel of low B. t. u. content in the combustion chamber of an internal combustion engine which comprises, introducing charges of equal amounts of said solid fuel into said combustion chamber at regular intervals, introducing air into said combustion chamber in insufficient amounts to permit complete combustion of said solid fuel, whereby a combustible gas is produced, and varying the proportion of air to fuel to control the richness of said combustible gas.

18. A system for utilizing a normally waste product consisting of a low grade fuel for the purposes of developing power and producing a combustible gas comprising a charge-forming device capable of treating said low grade fuel to produce an explosive mixture, an internal combustion engine capable of operating on said explosive mixture in a manner whereby a considerable part of said fuel is not consumed but is converted into a combustible gas, and purifying and storing means for said combustible gas.

19. A gas producer system comprising an engine including an expansible chamber, a piston operating in said chamber, a power generator operated from said piston, means for storing power generated by said generator, a source of finely divided solid fuel, a fuel feeding mechanism, a governor for controlling said mechanism, means for mixing a gaseous medium containing oxygen with said solid fuel, means for heating said mixture, means for supplying said heated mixture under pressure to said chamber, means for supplying additional oxygen to said chamber, means for varying the ratio of fuel to oxygen in said chamber for insuring incomplete combustion of the fuel in said chamber whereby usable combustible gases are formed, means for cooling said gases, a storage tank for said gases, and means for automatically starting and stopping operation

of said engine to simultaneously produce gas and generate power under predetermined conditions.

20. The method of producing a combustible gas from a finely divided solid fuel of low B. t. u. content in the combustion chamber of an internal combustion engine which comprises introducing charges of said finely divided solid fuel into said combustion chamber, introducing air into said combustion chamber in insufficient amounts to permit complete combustion of said solid fuel, causing partial combustion of said solid fuel to occur whereby a combustible gas is produced, and introducing steam into said combustion chamber.

21. A system for producing combustible gas by the partial combustion of solid fuel comprising an expansible chamber, means for introducing said solid fuel into said chamber, means for introducing steam into said chamber, means for introducing only sufficient air into said chamber for partial combustion of said solid fuel and means for causing partial combustion of said solid fuel in said chamber.

22. A gas producer comprising a reaction chamber, a mechanism for supplying a carbonaceous material to said reaction chamber, and a device responsive to the rate of operation of said reaction chamber, for increasing the amount of carbonaceous material supplied to said reaction chamber when the rate of operation of said reaction chamber increases.

23. A combustible gas producing system comprising an expansible chamber device having a movable part, means for feeding a carbonaceous material to said expansible chamber, a shaft rotated from said movable part, and a speed responsive device driven from said shaft and operating to increase the rate at which said carbonaceous material is fed to said expansible chamber device as the speed of rotation of said shaft increases.

24. A gas producer comprising an internal combustion engine, means for feeding fuel to said engine, means for insuring incomplete combustion of said fuel in said engine, a speed responsive device operated from said engine, and means actuated by said speed responsive device for increasing the rate at which fuel is fed to said engine as the speed of the engine increases, until a predetermined engine speed is reached whereupon the fuel feeding means is stopped.

KENNETH M. URQUHART.