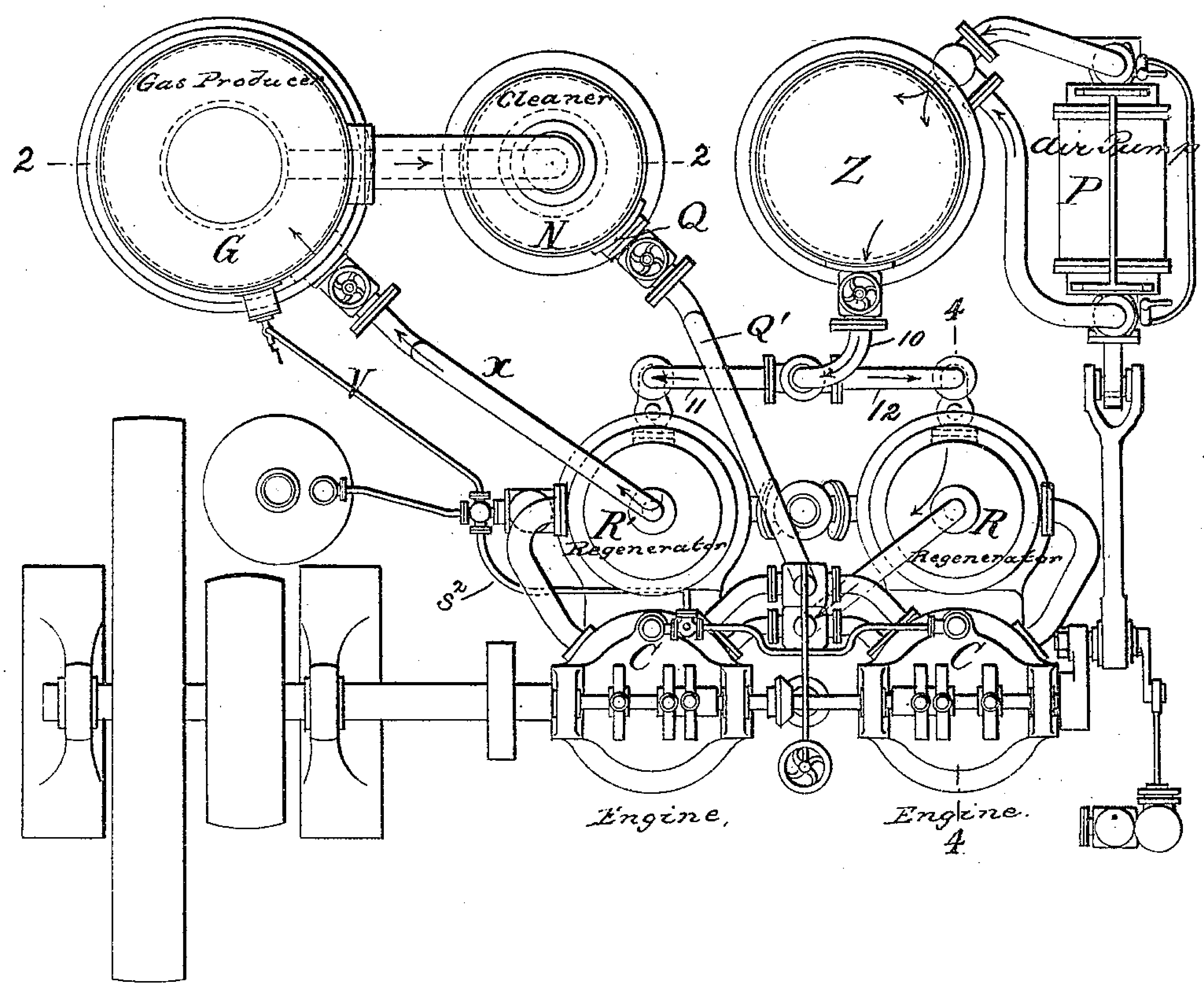
(No Model.) 5 Sheets—Sheet 1.

M. LOROIS.

GAS MOTOR.

No. 529,452. Patented Nov. 20, 1894.

Fig. 1



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(No Model.)

5 Sheets—Sheet 2.

M. LOROIS.

GAS MOTOR.

No. 529,452.

Patented Nov. 20, 1894.

Fig 2.

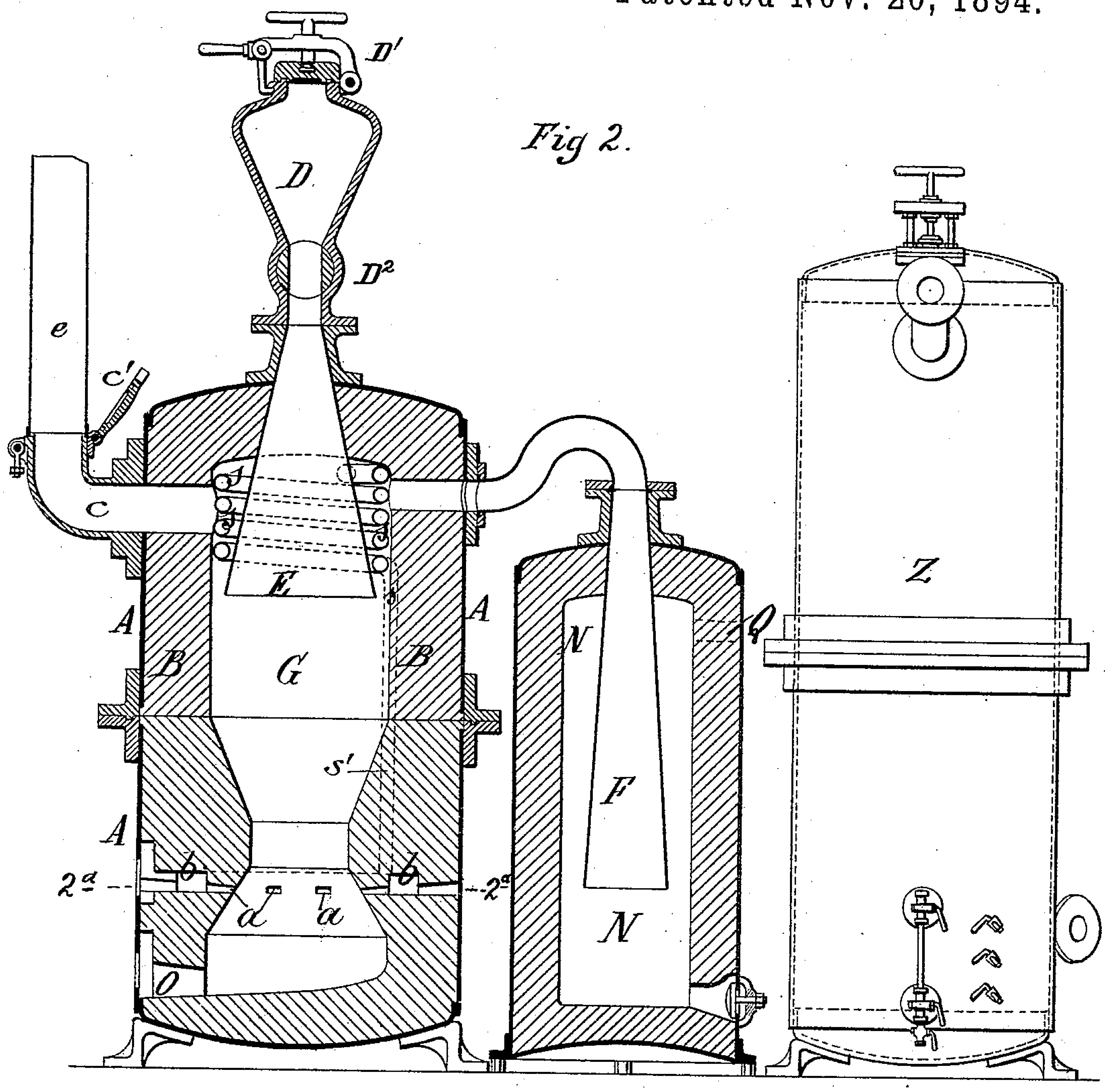
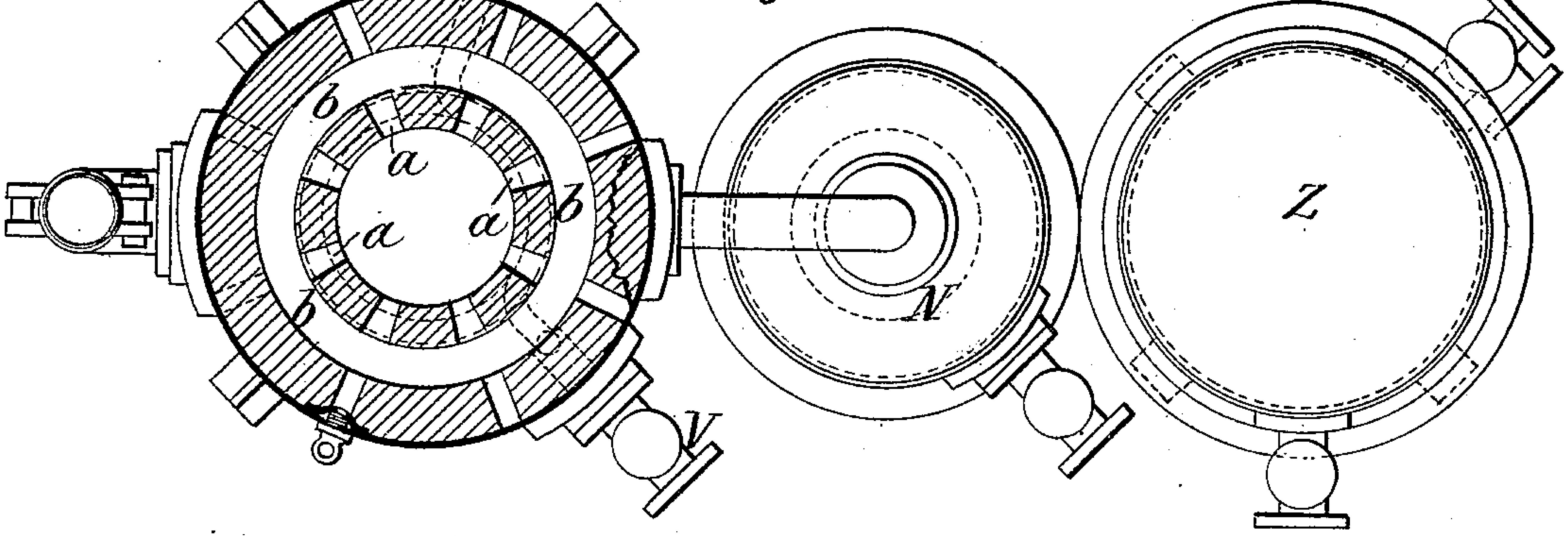


Fig. 2ª



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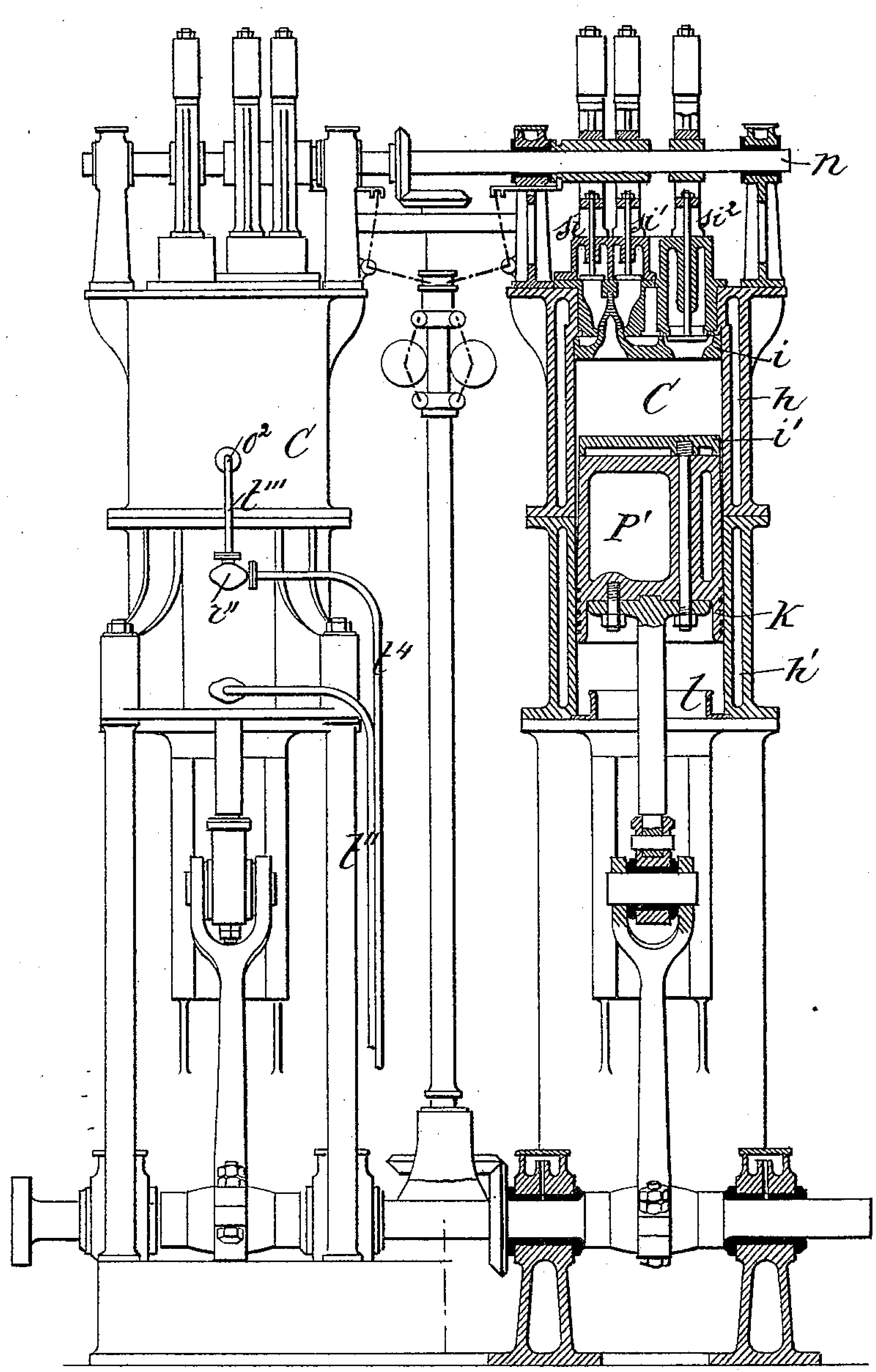
(No Model.) 5 Sheets—Sheet 3.

M. LOROIS.

GAS MOTOR.

No. 529,452. Patented Nov. 20, 1894.

Fig. 3



WITNESSES:

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(No Model.)

M. LOROIS.

GAS MOTOR.

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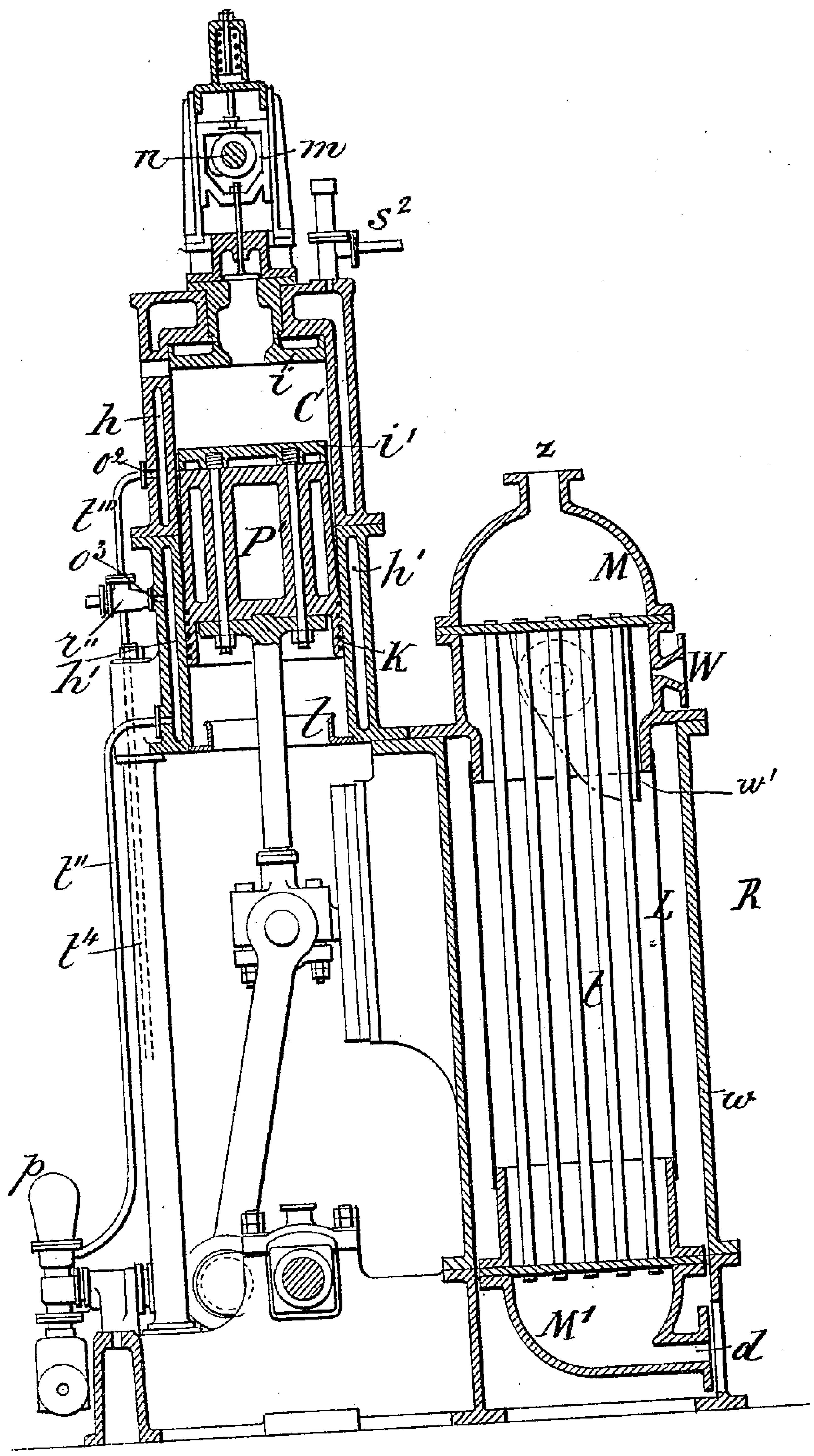
Fig. 4



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(No Model.)

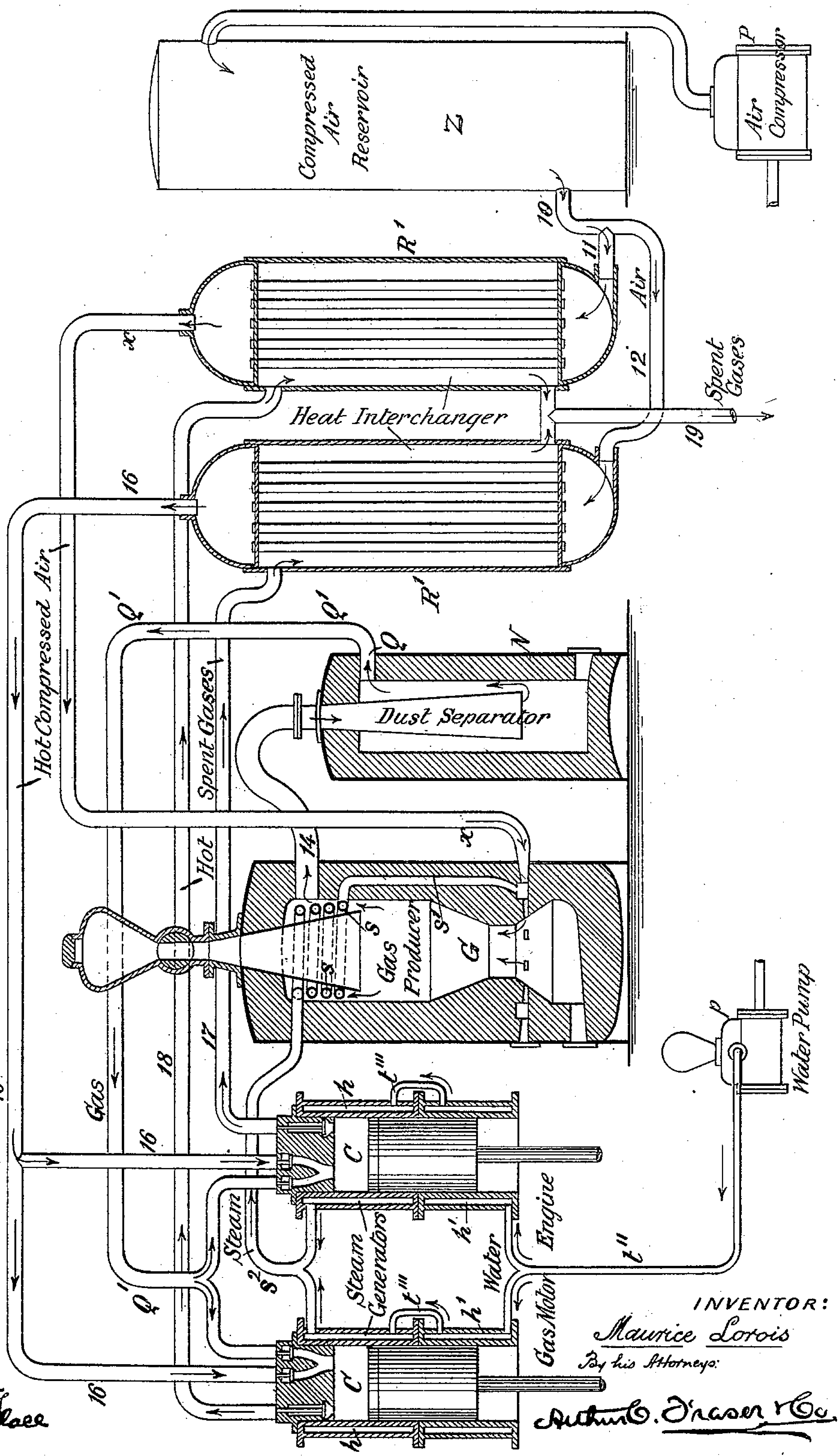
5 Sheets—Sheet 5.

M. LOROIS.

GAS MOTOR.

No. 529,452. Patented Nov. 20, 1894.

Fig. 5.



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UNITED STATES PATENT OFFICE.

MAURICE LOROIS, OF NANTES, FRANCE, ASSIGNOR TO THE SOCIÉTÉ ANONYME DES MOTEURS THERMIQUES GARDIE, OF SAME PLACE.

GAS-MOTOR.

SPECIFICATION forming part of Letters Patent No. 529,452, dated November 20, 1894.

Application filed April 25, 1893. Serial No. 471,754. (No model.) Patented in France July 30, 1892, No. 223,360; in Spain September 7, 1892, No. 13,850; in India September 9, 1892, No. 257; in England September 13, 1892, No. 16,413; in Belgium September 26, 1892, No. 101,511; in Switzerland September 26, 1892, No. 5,877; in Luxemburg September 27, 1892, No. 1,696; in Italy September 27, 1892, XXVII, 32,757; in Cape of Good Hope October 11, 1892, No. 268; in Victoria October 21, 1892, No. 10,073, and in New South Wales October 24, 1892, No. 4,066.

To all whom it may concern:

Be it known that I, MAURICE LOROIS, a citizen of the French Republic, residing in Nantes, Loire-Inférieure, France, have invented certain new and useful Improvements in Gas-Motors, of which the following is a specification.

The present invention is the subject of Letters Patent in France, No. 223,360, dated July 30, 1892; in England, No. 16,413, dated September 13, 1892; in British India, No. 257, dated September 9, 1892; in New South Wales, No. 4,066, dated October 24, 1892; in Cape of Good Hope, No. 268, dated October 11, 1892; in Victoria, No. 10,073, dated October 21, 1892; in Belgium, No. 101,511, dated September 26, 1892; in Luxemburg, No. 1,696, dated September 27, 1892; in Italy, Vol. XXVII, No. 32,757, dated September 27, 1892; in Spain, No. 13,850, dated September 7, 1892, and in Switzerland, No. 5,877, dated September 26, 1892.

This invention has for its object the combination of apparatus constituting a thermic motor of that class in which a carbonaceous fuel is used for the production of a combustible gas, and this gas is burned with air in the power cylinders of the engine to generate the requisite pressure.

It is well known that in the ordinary generation of power from fuel by means of the boiler furnace and steam engine, there is a great waste of fuel, only a very small percentage of the latent power contained in the fuel being realized, the remaining energy being lost by the unconsumed fuel in the form of smoke and gases discharged from the chimney, by the heat which is given out from the furnace other than that absorbed in heating the water, by the residual heat discharged in the exhaust steam, by frictional and other mechanical losses in the steam engine, &c. The known higher efficiency of gas engines as compared with steam engines, has led to efforts to economize in the production of power from fuel by first converting the fuel into combustible gas, and then employing this gas for driving a motor engine. Such engines, however, if operated on the explosive principle taking cold gas and cold air into the cylinder, have an efficiency which falls far short of the theoretical, and by reason of the abrupt increase of pressure due to the explosion, are subject to serious shocks which are injurious to the mechanism; by reason of the necessity for keeping the cylinders of such engines reasonably cool to enable them to be lubricated and to prevent premature explosions, the cylinder and piston are necessarily at a much lower temperature than that of the burning gas, so that the heat is rapidly abstracted from the latter, with the effect of reducing its pressure, the loss of pressure and heat resulting in a proportionate waste of energy. Attempts have, however, been made to attain the desirable economy by providing a gas producer or generator connected directly with a motor engine in order that the gas may pass directly from the producer to the power cylinders, being utilized in the cylinders as fast as it is generated in the producer. Such a system has the advantages that the entire apparatus is self-contained and easily made portable, since no gasometer is required; and by providing suitable heat regenerators or interchangers for utilizing the heat of the spent gases exhausted from the power cylinders to heat the air or air and gas supplied to the cylinders, a considerable economy of energy may be effected. All such apparatus, however, as heretofore constructed, have encountered the fatal difficulty that the gas made by passing air and steam through the incandescent fuel in the gas producer, has invariably contained impurities in the nature of ammoniacal and tarry matters, the effect of which upon the valves and cylinders of the engine have been excessively deleterious, the ammoniacal substances exerting a corrosive action upon the metal surfaces, and the tarry or carbonaceous impurities serving to choke the valves and produce carbonized incrustations within the valve chests and cylinders. In the apparatus disclosed in the United States patent of Gardie, No. 412,882, dated October 15, 1889, which is of this character, the gas coming from the producer is first cooled by utilizing its heat in a boiler and superheater, and is then passed through a washer, where it is showered with water and forced through a mass of water in order to remove the ammoniacal substances and precipitate any tarry matters or heavy hydrocarbons that the gas may contain, after which the gas is compressed and then reheated by passing it through a heat regenerator. Air is compressed and passed through a heat regenerator, and the hot compressed air and gas are introduced together into the power cylinders, wherein they are commingled and ignited, burning without explosion, and by their expansion generating power, the hot gaseous products of combustion exhausted from these cylinders being passed through the heat regenerators or interchangers to heat the air and gas. It is on this last described system that my present invention is most directly an improvement. As compared with the said Gardie motor, my present invention provides such means for generating the gas as to wholly avoid the formation of impurities in the gas which would be injurious to the engine, such as ammoniacal and tarry or carbonaceous matter, whereby I am able to wholly dispense with the washing or scrubbing of the gas, and consequently am able to avoid the disadvantage of first cooling the gas as it comes from the gas producer, and subsequently reheating it before introducing it to the power cylinders.

According to my present invention the air and steam from which the gas is made, instead of being drawn through the gas producer by suction as has heretofore almost invariably been proposed, are forced through the gas producer under a considerable pressure, and furthermore are superheated or preheated before being introduced to the gas producer. Thus the production of the gas is effected under pressure and at an exceedingly high temperature, with the effect of generating a gas of such purity that no washing or scrubbing is necessary, since no ammoniacal substances, and no tarry or sedimentary matters are contained in it, so that the gas is adapted for immediate introduction to the power cylinders of the engine, a result which has never heretofore been produced. At the same time the calorific power of the gas is greatly increased, with a proportionate further gain of economy, and the heat contained in the generated gas is economized by passing it directly to the power cylinders with the minimum loss of heat. The excessive heat given out in the power cylinders is economized by utilizing it for generating the steam necessary to supply the requisite amount of hydrogen for the gas, and this steam is superheated by passing it through a superheater which absorbs the excessive heat from the newly generated gas, so that the steam is brought to an exceedingly high temperature before being introduced into the gas producer. All the hot gaseous products from the power cylinders are utilized by passing them through heat interchangers or regenerators for heating on the one hand the compressed air which is introduced to the gas producer, and on the other hand the compressed air which is introduced to the power cylinders to complete the combustion of the gas. These several economies of heat are practically so perfect that the total waste in the spent gases which are finally discharged to the chimney is but twelve and one-half per cent. of the total number of calories latent in the generated gas as it comes from the producer. Thus by the combination of apparatus provided by my invention, power is generated with such economy as to effect a saving of over sixty six per cent. in the cost of fuel, as compared with the most economical generation of power by means of steam boilers and engines.

I will now proceed to describe my improved apparatus in detail with reference to the accompanying drawings, wherein—

Figure 1 is a general plan. Fig. 2 is a section on a larger scale in the plane of the line 2—2 in Fig. 1, and showing the gas producer and dust separator in vertical section, and the compressed air reservoir Z in elevation. Fig. 2^a is a plan partly in horizontal section cut through the gas producer in the plane of the line 2^a—2^a in Fig. 2. Fig. 3 is a front view of the engine partly in vertical mid-section showing the working cylinders of the engine. Fig. 4 is a vertical transvere section taken through one of the power cylinders of the engine and one of the heat interchangers in the plane of the line 4—4 in Fig. 1. Fig. 5 is a diagrammatic view showing the entire apparatus and all the connections between the members thereof.

I will first describe the general operation before describing the apparatus in detail.

An air pump or compressor P (see Figs. 1 and 5) compresses atmospheric air to a pressure of three kilograms and upward per square centimeter (say forty-three pounds per square inch) into an air reservoir Z, where the water is separated from the compressed air. The compressed air passes from this reservoir through a pipe 10 and branch pipes 11 and 12 into two heat interchangers or regenerators R R′, in which it is heated by the spent gases of combustion exhausted from the power cylinders C C of the engine. The heated compressed air passes from the interchanger R′ by a pipe x to the gas producer G constructed as a cupola furnace. At the same time superheated steam is introduced to this producer as will be hereinafter explained, and commingling with the air flows through a mass of incandescent fuel in the producer, whereby is generated the combustible gas. This gas being produced under the same pressure as that initially given by the pump P, passes out from the producer by a pipe 14, and enters a dust separator N, which disengages any dust or ashes from the gas and then flows through the pipe Q′ to the inlet ports of the power cylinders C C. The compressed air which is heated in the interchanger R passes therefrom by a pipe 16 which has branches leading to the air inlet ports of the power cylinders.

That which occurs in the operation of the engine is as follows: On the opening of the inlet valves the heated compressed air and hot compressed gas which until now have been separate, and which are both at the initial pressure given them by the pump P, flow in suitably regulated proportions into the cylinder, entering it at the commencement of the stroke of the piston, and being ignited by contact with the walls of the cylinder and piston, which thus serve as the igniter. The gas and air being mixed in the proportion necessary to complete combustion, burn in the cylinder. The gases continue to enter while the piston moves through a portion of its stroke and up to the instant when the inlet valves are closed. Up to this time the pressure continues the same as the initial pressure given by the compressor, and which is maintained in the gas producer and all the apparatus. From this moment the expansion of the gases commences, and as the piston recedes the pressure falls, while in acting against the piston the gases develop mechanical energy, and in consequence undergo a considerable reduction in temperature. At the end of the working stroke of the piston the exhaust valve is opened, and during the return stroke the products of combustion are expelled from the cylinder and ultimately escape into the atmosphere. The pistons of the two cylinders work alternately, each developing power on its working stroke, and being driven by the other on its return stroke. The hot spent gases of combustion expelled from the respective cylinders are conducted through pipes 17 and 18 respectively to the two heat interchangers R and R′, through which they flow giving up their heat to the compressed air which is flowing oppositely through these interchangers, and the spent gases being finally discharged through a pipe 19 into the atmosphere, producing neither noise nor smoke, and having given up nearly all of their heat. At the same time water is forced by a pump p through a pipe t'', which divides into two branches, conducting the water into jackets h' surrounding the lower portions of the power cylinders, from which jackets the water passes by pipes t''' into jackets h surrounding the upper portions of the cylinders, these upper jackets constituting steam generators wherein by the heat disengaged in the cylinders the water first heated in the lower jackets is converted into steam, and the steam flows through a pipe s^2 to the gas producer, wherein this pipe is formed into a coil or superheater s exposed to the intense heat of the newly generated gas, whereby the steam is highly superheated, after which it is conducted through a passage s' down through the heated brickwork or lining of the producer, and commingled at the lower part thereof with the heated compressed air introduced through the pipe x.

The operation, and the course of the heated air, steam, gas, and spent gases being now understood, I will proceed to describe more fully the construction and operation of the gas producer and other features characteristic of my improved apparatus.

The gas producer G is constructed to resist a pressure of three kilograms and upward, to which end it has (see Fig. 2) a strong outer casing or jacket A of sheet steel, within which is built a firebrick lining B. To permit the coal or fuel to be introduced while maintaining this pressure, the gas producer is provided with a feeding hopper D on top having a tight closing lid D′ and a delivery valve D^2. By closing the valve D^2 and opening the lid, the hopper can be filled with fuel, whereupon by tightly closing the lid and opening the valve D^2 this fuel falls into the producer. A steel cone or reversed funnel E controls the height of the fuel in the producer, storing it as in a magazine when the said height is exceeded, thereby maintaining the top of the fuel at a constant level. The generated gas escapes laterally outside the lower edge of the reversed funnel, and the superheating coil s is arranged in the top of the producer chamber around this funnel. In the lower portion of the gas producer the lining is thickened so as to contract the producer chamber, and beneath this contraction orifices or tuyeres a a into the chamber, all communicating with a circular channel b formed in the lining. The heated compressed air from the interchanger R′ enters by the pipe x into this channel b. The superheated steam from the superheating coil s descends through the passage s' in the heated firebrick lining, and is discharged into this same channel b, so that the hot air and steam are commingled in this channel, and their mixture flows through the tuyeres a a into the producer chamber.

To provide for starting the apparatus, the producer is formed with a flue c having a tightly closing cap c', and provided with a detachable chimney or stack e. While kindling the fire the chimney e is connected as shown in Fig. 2 to carry off the smoke from the fuel, but after a sufficient bed of fuel has become incandescent the chimney e is disconnected and the cap c' is closed to resist the internal pressure which will be subsequently maintained.

The operation of the gas producer under pressure in connection with the pre-heating of the air, the superheating of the steam, and the retention of the heat in the gas producer by reason of the thick lining of refractory and non-conducting material B, enables a much higher temperature to be maintained in the gas producer than has ever been possible heretofore. The result is to furnish a gas which is rich in combustible principles, of a uniform combustion, having a high calorific power, and completely free from tar and ammonia. The chemical action which takes place when the air and steam are passed in contact with the incandescent carbonaceous fuel consists in the conversion of the oxygen of the air into carbon monoxide, while by the decomposition of the steam hydrogen is produced which passes through unchanged, and the oxygen produced is converted first into carbon dioxide and afterward into carbon monoxide, all well understood phenomena. The generation of the gas under a combined high temperature and pressure such as has never heretofore been availed of, assists the dissociative action which takes place in the reduction or decomposition of complex bodies (such as condensible hydrocarbons, of high equivalence tarry substances, ammoniacal compounds and the like which ordinarily tend to form) to their elementary states, whereby such bodies are reduced in presence of the excess of carbon to the state of carbon monoxide and hydrogen and noncondensible hydrocarbons of low equivalence. It will be understood that a partial combustion occurs in the gas producer which is sufficient to maintain it at the high interior temperature required, notwithstanding the different conversions effected. The gas produced being free from all impurities which would necessitate the use of condensers and purifiers, permits complete suppression of such purifying apparatus with their attendant necessity of cooling the gas. These results are completely attained only when the pressure of three kilograms is reached, and this or a higher pressure should be constantly maintained.

My improved apparatus has the further advantage that the rate of production of the gas by the gas producer can be varied from time to time in accordance with the varying requirements of the engine, so as to allow of the complete suppression of a gasometer between the gas producer and the engine.

As the fuel in the gas producer is consumed it settles to the bottom, and the resulting ashes or slags may be removed from time to time through an orifice O (Fig. 2) by opening a tightly closing lid or door.

The dust separator N has a strong outer shell which is protected by a refractory nonconducting lining as shown. The gas enters through a conical tube or reversed funnel F, which facilitates the deposit of the dust. The gas, freed from dust, passes out from the top of the separator by an orifice Q (Fig. 2).

The heat interchangers R R′ are both of the same construction. Each (see Fig. 4) is constructed with an upright cylinder of sheet metal L, having at top and bottom two cast domes M M′, between which are extended numerous tubes t t fixed at their ends in two metallic tube sheets. The whole construction is surrounded by an independent cast jacket w. In order to allow of a free expansion and to avoid leakage, the chamber M is fixed on the jacket w, while the chamber M′ is inclosed in the jacket, so that it can move up or down with the ends of the tubes. As an extra precaution the tubes t are protected against burning by the high temperature (about 800° centigrade) of the spent gases from the working cylinder, by means of a shield or plate w' placed between them and the orifice W.

The compressed air enters the hood of each interchanger at the bottom opening d, and rises through the tubes t, passing out finally by the upper opening z. The hot spent gases from the working cylinders enter at the opening W and circulate around the tubes t, flowing from top to bottom and escaping by a bottom orifice.

The compressor P has been designed to avoid dead spaces, to provide for cooling the air during the compression, and for obtaining the greatest useful effect. The reservoir C for the compressed air serves to separate the water which has served to cool the air during its compression.

The two power cylinders C are alike, each being single-acting, and are so constructed as to withstand a very high temperature in their upper portions. Each cylinder is divided into two parts, the upper or hotter section being made larger than the piston or plunger P′, while the lower or cooler section is made to fit with the piston. The upper section is provided with a non-conducting substance, and with a plate i of a suitable heat-retaining metal adapted to maintain a sufficiently high temperature for automatically igniting the gases. The piston is of considerable height, its lower part which never leaves the cooled lower section of the cylinder being provided with packing rings K. For lubricating the cylinder, oil is contained in a collar l, into which the lower flange of the piston dips. The lubrication of the piston is made possible since the temperature of the lower portion of the cylinder does not reach 60° centigrade. The lower section of the cylinder is cooled by the circulation of cold water in the jacket h'. This water goes directly from the pump p through the pipe t'', and is either discharged through a cock r'' and pipe t^4, or is passed through r'' and pipe t''' into the jacket h of the upper cylinder section. It is in this upper jacket h, which is exposed to the heat of the combustion, that the steam is generated which passes out by pipe s^2. The top of the piston P′ is also provided with a plate i' of a suitable heat-retaining metal insulated by asbestos. Nickel is a suitable metal for the plates i and i'. As the plates i and i' are always red hot, the combustible gas and heated air introduced through the gas and air inlet ports mixing in the cylinder in contact with these plates, is ignited and burns without explosion while being introduced, remaining at the initial pressure of three kilograms or upward (this pressure once determined upon remaining constant) so long as the inlet valves are open, but as soon as the latter are closed the pressure will fall by reason of the expansion that takes place according to the work to be performed. Contrary to what occurs in ordinary gas engines no explosion takes place, nor will the pressure be increased, but its volume will be considerably enlarged.

The valves are alike for both cylinders and symmetrical. Each cylinder is provided (see Fig. 3) with three valves, one *si* for the compressed air, another *si'* for the compressed gas from the gas producer, and a third si^2 for exhausting the products of combustion. Each of these valves has its stem fixed to a vertical sliding metallic frame *m* (Fig. 4) within which revolves a horizontal spindle *n*, which carries cams acting on the frames to lift them and open the respective valves. These cams are adapted to be shifted by a governor, or by hand when no governor is provided, thereby allowing the duration and area of valve opening to be varied at will. It is evident that when the usual reversing gear is provided, the apparatus will work in either direction as desired.

I am aware that it has been proposed in a patent to generate a combustible gas in a gas producer under pressure (amount not stated) by forcing compressed air (not heated) along with steam (not superheated) through a mass of incandescent fuel in a gas producer, the gas to be thus produced being conducted to the inlet valves of the power cylinders of an engine, to which also is simultaneously introduced unheated compressed air to form a combustible mixture with the gas, which upon being ignited exerts power to drive the piston, and on the return stroke the burned gases escape through a heat interchanger, serving to heat the water from which the steam employed is generated. For generating steam the gas producer was proposed to be water-jacketed, a construction by which the heat would unavoidably be so rapidly abstracted from the gaseous matter within the gas producer as to prevent the attaining of that high temperature which alone will suffice for preventing the formation of ammoniacal and tarry impurities in the gas. Furthermore, the steam being introduced as wet steam and not superheated, and the compressed air being introduced cool, would prevent the attaining of the high temperature which is necessary to the production of a rich combustible gas pure enough for immediate use. The produced gas would necessarily leave the gas producer at a low temperature compared with that produced in my apparatus, and being commingled in the power cylinders with cool compressed air, no such high temperature can result, and no such perfect combustion can take place, while no adequate means is provided for economizing the waste heat of the spent gases discharged from the cylinders. No such motive power apparatus as disclosed in said patent has ever been operated, as I am informed, and if operated would be found, notwithstanding the advantages which might be expected to result from the generating of the gas under pressure, to lack the essential requisites for the production of a gas free from impurities and residual matter, and incapable of immediate introduction to the working cylinders of an engine, and furthermore would be found uneconomical in its utilization of the generated heat.

It must not be inferred from the particularity of detail with which I have described the preferred construction of apparatus illustrated in the accompanying drawings that my invention is by any means limited to the exact construction shown and described, since in fact my invention is susceptible of considerable variation without departing from its essential features. For example the two heat interchangers R R' should be considered as essentially one interchanger which is subdivided into two solely for convenience of construction and arrangement.

I make no claim in my present application for patent to the hereinbefore described process for manufacturing combustible gas, as I have made this process the subject of a separate application for patent filed May 23, 1894, Serial No. 512,219, and I hereby reserve to myself the right to claim the same in the patent to be granted on that application. I also make no claim in my present application to the construction of the gas producer when used solely for the manufacture of a combustible gas as distinguished from the immediate utilization of the gas in a gas motor engine for generating power, such gas producing apparatus being made the subject of my application for patent filed February 23, 1894, Serial No. 501,166, and the same being hereby reserved by me to be claimed in the patent to be granted on said last named application.

I claim as my invention the following-defined novel features, substantially as hereinbefore specified, namely:

1. The combination of a gas motor engine, a gas producer for containing carbonaceous fuel, constructed with thick walls of refractory non-conducting material to enable it to retain a high degree of heat, an air compressor, a steam generator, and connecting pipes leading from said air compressor to said gas producer and from said steam generator to said gas producer, whereby gas is made in the latter under pressure and at high temperature so that the resulting gas is so pure as to be adapted for immediate use, a pipe leading from the gas producer to the engine to conduct hot gas thereto, and a pipe leading from a source of compressed air to the engine, whereby the latter is fed simultaneously with hot compressed combustible gas and compressed air.

2. The combination of a gas motor engine, a gas producer for containing carbonaceous fuel, constructed with thick walls of refractory non-conducting material to enable it to

retain a high degree of heat, an air compressor, an air heater for heating the compressed air, a steam generator, and connecting pipes leading from said air compressor to said air heater and thence to said gas producer, and from said steam generator to said gas producer, whereby gas is made under pressure and at high temperature so that the resulting gas is so pure as to be adapted for immediate use, a pipe leading from the gas producer to the engine to conduct hot gas thereto, and a pipe leading from a source of compressed air to the engine, whereby the latter is fed simultaneously with hot, compressed, combustible gas and compressed air.

3. The combination of a gas motor engine, a gas producer for containing carbonaceous fuel, an air compressor, a steam generator, and a heat-interchanger receiving the hot gases from said engine, with connecting pipes leading from said air compressor to said heat interchanger to heat the compressed air and thence to said gas producer to conduct hot, compressed air to the latter, and from said steam generator to said gas producer to conduct steam to the latter, whereby gas is made under pressure and at high temperature so that the resulting gas is so pure as to be adapted for immediate use, a pipe leading from the gas producer to the engine to conduct the hot gas thereto, and a pipe leading from a source of compressed air to the engine, whereby the latter is fed simultaneously with hot, compressed combustible gas and compressed air.

4. The combination of a gas motor engine, a gas producer lined with non-conducting refractory material for containing carbonaceous fuel, an air compressor, a steam generator, and a heat interchanger receiving the hot gases from said engine, with connecting pipes leading from said air compressor to said heat interchanger to heat the compressed air, thence to said gas producer to conduct hot compressed air to the latter, from said steam generator to said gas producer to conduct steam to the latter, whereby gas is made under pressure and at high temperature, so that the resulting gas is so pure as to be adapted for immediate use, a pipe leading from the gas producer to the engine to conduct the hot gases thereto, and a pipe leading from a source of compressed air to the engine, whereby the latter is fed simultaneously with hot compressed combustible gas and compressed air.

5. The combination of a gas motor engine, a gas producer lined with non-conducting refractory material for containing carbonaceous fuel, an air compressor, a steam generator, and a heat interchanger receiving the hot gases from said engine, with connecting pipes leading from said air compressor to said heat interchanger to heat the compressed air, pipes leading thence to said gas producer and to the engine to conduct hot compressed air thereto respectively, a pipe leading from the steam generator to said gas producer to conduct steam to the latter, whereby in the latter gas is made from heated compressed air and steam under pressure and at high temperature, and a pipe leading from the gas producer to the engine to conduct the hot gas thereto, whereby the engine is fed simultaneously with heated compressed air and hot compressed combustible gas.

6. The combination of a gas motor engine, a gas producer lined with non-conducting refractory material for containing carbonaceous fuel, an air compressor, a steam generator, and a heat interchanger receiving the hot gases from said engine, with connecting pipes leading from said air compressor to said heat interchanger to heat the compressed air, pipes leading thence to said gas producer and to the engine to conduct hot compressed air thereto respectively, a pipe leading from the steam generator to said gas producer to conduct steam to the latter, a superheater arranged to superheat the steam before it is liberated in the gas producer, whereby in the latter gas is made from heated compressed air and superheated steam under pressure and at high temperature, the resulting gas being so pure as to be adapted for immediate use, and a pipe leading from the gas producer to the engine, whereby the engine is fed simultaneously with heated compressed air and hot compressed combustible gas.

7. The combination of a gas motor engine, a gas producer lined with non-conducting refractory material, a steam superheater arranged to be heated by the hot gases generated in said producer, a steam generator, an air compressor, and a heat interchanger receiving the hot gases from said engine, with connecting pipes leading from said air compressor to said heat interchanger to heat the compressed air, pipes leading thence to said gas producer and to the engine to conduct hot compressed air thereto respectively, a pipe leading from said steam generator through said superheater and discharging superheated steam therefrom into the gas producer, whereby in the latter gas is made from heated compressed air and superheated steam under pressure and at high temperature, the resulting gas being so pure as to be adapted for immediate use, and a pipe leading from the gas producer to the engine to conduct the hot gas thereto, whereby the latter is fed simultaneously with hot combustible gas under pressure and heated compressed air.

8. The combination of a gas motor engine having its working cylinders formed with water jackets to constitute a steam generator, a gas producer lined with non-conducting refractory material, an air compressor, a water pump, and a heat interchanger receiving the hot gases from said engine, with connecting pipes leading from said air compressor to said heat interchanger to heat the compressed air, pipes leading thence to said gas producer and to the engine to conduct hot compressed air thereto respectively, a pipe leading from said

water pump to said steam generating water jackets for circulating water therethrough, a pipe leading from the latter to said gas producer to conduct steam thereto, whereby in the gas producer gas is made from steam and heated compressed air under pressure and at high temperature, the resulting gas being so pure as to be adapted for immediate use, and a pipe leading from the gas producer to the engine to conduct the hot gas thereto, whereby the engine is fed simultaneously with hot combustible gas under pressure and heated compressed air.

9. The combination of a gas motor engine, a gas producer lined with non-conducting refractory material, a steam generator, and an air compressor, said compressor and generator adapted to supply compressed air and steam at a pressure of three kilograms and upward per square centimeter, a heat interchanger receiving the hot gases from said engine, with connecting pipes leading from said compressor to said heat interchanger to heat the compressed air, pipes leading thence to said gas producer and to the engine to conduct hot compressed air thereto respectively, a pipe leading from said steam generator to said gas producer to conduct steam to the latter so that the heated air and steam are supplied to said producer at a pressure of three kilograms or upward, and a pipe leading from the gas producer to the engine to conduct the hot gas thereto, whereby combustible gas is generated and fed to the engine with heated compressed air under an equal pressure of three kilograms or upward.

10. The combination of a gas motor engine having its power cylinders formed with water jackets constituting steam generators, a gas producer lined with non-conducting refractory material, a superheating coil in said gas producer to receive heat from the newly generated gas, a dust separator for freeing the gas from dust or ashes, a heat interchanger receiving the hot gases from said engine, an air compressor, and a water pump with connecting pipes leading from said compressor to said heat interchanger, thence to said gas producer and to the engine to conduct hot compressed air thereto respectively, a pipe leading from said water pump to said steam generating water jackets, a pipe leading from the steam space of the latter to said superheating coil and thence into the gas producer, and a pipe leading from the gas producer to the dust separator and thence to the engine, whereby the latter is fed simultaneously with hot combustible gas under pressure and with heated compressed air.

11. The combination of a gas motor engine having power cylinders provided with heat-retaining plates for igniting the combustible mixture as it enters, a gas producer wherein gas is generated under pressure, a source of heated compressed air, and pipes leading from said gas producer and said source of heated compressed air to the power cylinders of said engine.

12. A gas motor engine having power cylinders provided with heat-retaining plates for igniting the combustible mixture as it enters, and constructed in two sections, the lower and cooler section being of smaller internal diameter than the upper section within which the combustion occurs, elongated pistons working in said cylinders fitting loosely in and guided by the lower sections and formed with packing rings rubbing against the cooled surfaces thereof, combined with a gas producer wherein gas is generated under pressure, a pipe leading therefrom to conduct the hot gas therefrom directly to the engine, a heat interchanger receiving the hot gases exhausted from the engine, an air compressor arranged to force compressed air into said heat interchanger, and a pipe for conducting the heated compressed air therefrom to the engine, whereby heated compressed air and hot combustible gas under pressure are fed simultaneously to the cylinders of the engine and are ignited therein by contact with said heat-retaining plates.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

M. LOROIS.

Witnesses:
E. RATHANIE,
F. NARFUE.