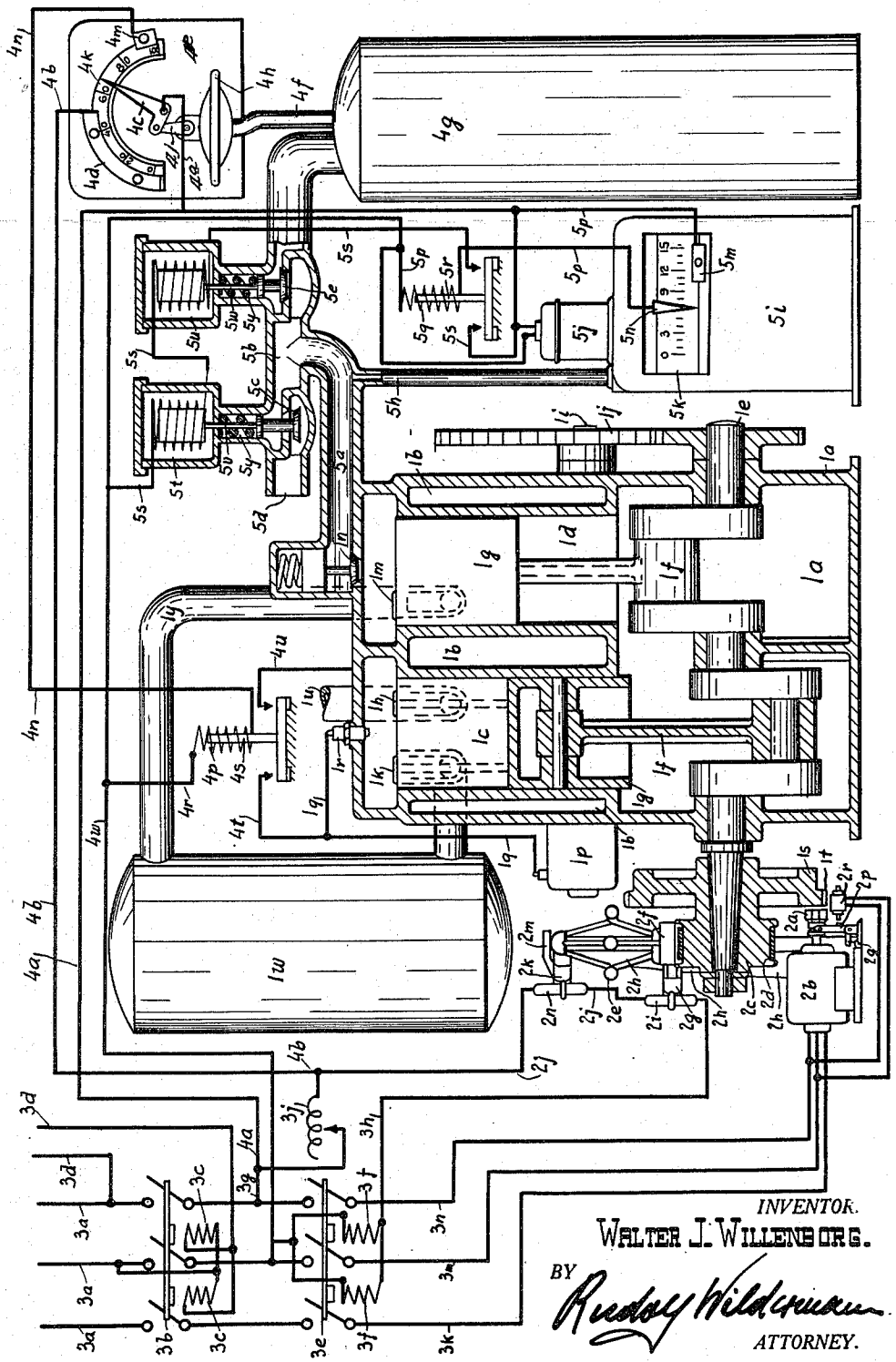
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METHOD OF PRODUCING COMBUSTION INHIBITING GAS

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METHOD OF PRODUCING COMBUSTION-INHIBITING GAS

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My invention relates to the method of controlling the production of combustion non-supporting gases. More particularly my invention relates to that method for controlling the production of combustion non-supporting gases, which was described in U. S. Patent No. 1,952,005 issued on March 20, 1934, upon a co-pending application filed by me February 19, 1929, Serial No. 341,266, for the Apparatus and method for the control for a producer for non-oxidizing gases, of which this application is a division.

The method herein set forth, is not only applicable to operation in connection with internal combustion engines, but as well with rotary producers of combustion non-supporting gases. It is to be understood that exhaust gases from such producers and engines are usable to produce combustion non-supporting atmospheres above and around readily burnable or explodable substance. The creation of this combustion non-supporting or inert atmosphere is made possible by the control and limitation of the oxygen content of this atmosphere. Under a given condition the oxygen content of this non-explosive atmosphere must not exceed a given percentage in order to maintain that atmosphere in non-explodable condition.

It is to the discovery of a method of so controlling the production of combustion non-supporting gases and their combination with a given atmosphere, so that this mixture will contain only such a percentage of oxygen or oxidizing agents as will result in making this atmosphere non-explosive, that the present invention most particularly relates.

To aid in the application of my method, I have provided producers of combustion non-supporting gases and a system of control combined therewith, which is in all respects substantially automatic in the performance of this method of the production of the combustion non-supporting gas and in the regulation of the quantity or percentage of that gas, which this method and means intermixes with a given atmosphere.

This automatic operation, not only extends to the means by which the percentage of combustion non-supporting gases is permitted to be mixed with a given atmosphere, but as well, to the quality of those gases, and further to the actual control automatically of the operation of the producer, and to the control of the pressure under which, if desired, combustion non-supporting gas is stored, and still further to its automatic distribution from a storage reservoir.

Some of the objects of my invention are automatically to regulate and control the operation of the gas producer, by means of a combination of electrical and mechanical devices associated therewith.

Another object is, to deliver the generated non-exploding gases from the producer to a distributing device, and likewise to control, in harmony with the producer, this distributing device.

Another object is, to effect a selective distribution of the combustion non-supporting gases produced, and to so control that selection and distribution, that gases of quality undesirable for mixture with a given atmosphere will be discharged to the air, while such gas as is desirable for mixture with a given atmosphere to produce a combustion non-supporting atmosphere, will be selected and automatically introduced into the atmosphere into which it is to be mixed.

As explained in this invention the selective distribution of the combustion non-supporting gases derived from internal combustion engines in particular, is most effectively and most conveniently brought about in accordance with the carbon dioxide contents of the gases.

Another object, is, to control the storage and distribution of the mixed non-explosive gases and atmosphere, and to retain them under any predetermined degree of pressure, and distribute them at will, automatically.

Another object is, to automatically test and analyze the gases delivered from the producer, so that a proper automatic selection of the desirable from the undesirable gases may be accomplished with certainty.

Another object of my invention is, to control the operation of a combustion non-supporting gas producer by the quantity and the pressure of gases contained in a storage means, and to prevent the admission of the gases produced by said producer to said storage means unless they are of a predetermined quality.

Another object is, to provide a system whereby the above referred to and other objects may be accomplished in the performance of my method, in such a manner that, from the initial start of the method to the conclusion of the delivery of the combustion non-supporting atmosphere to its intended use, the steps may be accomplished automatically, and produce, with certainty, both, these various steps of the operation in a given order, and, as well, the final result.

These, and other objects in the performance of my method, I may attain, by an apparatus illustrated and indicated in the accompanying drawing, which shows the various means used there-

fore in substantially diagrammatical views. It is however to be understood that the apparatus here shown is but one arbitrary embodiment of means whereby my method may be carried out, and that other means than those here illustrated might readily be devised, to fully perform the method hereinafter described and claimed.

The parts shown in the drawing may be grouped in the following classes:

1. An internal combustion engine combined with a pump.

2. A starting motor for said engine, and means for controlling said motor automatically and electrically.

3. A main power control.

4. A storage tank, and pressure control means in connection therewith.

5. Apparatus for analyzing and selecting the quality, and for controlling the delivery of the gases produced.

Parts belonging in the same one of the classes enumerated above are indicated by a corresponding numeral. Similar parts are indicated by the combination of similar numerals and letters throughout the drawing.

In order that my invention may be clearly understood, the means illustrated and utilized to perform this method and the co-operative relation of these means will now be described.

The housing *1a* of the engine is provided with cooling chambers *1b* adjoining the combustion chamber *1c*, as well as the pump chamber *1d*. To the crank shaft *1e*, which is rotatably mounted in the housing *1a* of the engine, the pistons *1g* are connected by the rods *1f*. These pistons are directionally opposed to each other in their operation in the two cylinders *1c* and *1d*. The crank shaft is connected by the gearing *1j* to the cam shaft *1i*. From the cam shaft, by suitable cams, the operations of the intake valve *1h* and the exhaust valve *1k*, in the internal combustion chamber *1c*, are controlled. The engine is indicated, as functioning on the principle of a four cycle combustion engine. Likewise, by the same means, the operation of the intake valve *1m* in the pump chamber *1d* is controlled, the compressed gas leaving said pump through the valve *1n*. The intake valve *1h* is supplied with the mixture of explosive gas through the pipe *1u*, which is connected to a suitable carburetor, (not shown). The exhaust valve *1k* connects through the pipe *1v*, to the "scrubber" *1w*, a tank which serves to suitably wash, clean and filter the exhaust gases, generated by the producer. The upper end of the "scrubber" connects, by means of the pipe *1y*, to the intake valve *1m* in the pump chamber. The valve *1n* is an upwardly discharging valve, a spring seated behind the valve keeping the valve normally closed. The valve *1n* opens, when the drop of pressure between the gas in the chamber *1d* and the gas in the pipe *5a* is sufficiently large to counteract the tension of the spring in the head of the valve *1n*.

The cam shaft is also coupled with a magneto *1p*, from which a high tension current is distributed through the conductor *1q* to the spark-plug *1r*, seated in the head of the piston chamber *1c*. On the crank *1e* of engine there is mounted a fly-wheel *1s* of sufficient weight to carry the engine, subsequent to an explosion cycle, through the remaining three cycles, as well as to operate the pump, in chamber *1d*, during all four of these cycles. The circumference of the fly-wheel *1s* is provided with a spur gear ring *1t*. The spur pinion *2a*, of a starting motor *2b*, meshes into the spur gear ring *1t* on the fly-wheel *1s*. The spur pinion *2a* is so mounted that it may be shifted in the direction of the axis of the motor *2b*. There are also provided automatic means effecting the disengagement of the pinion *2a* from the spur gear ring *1t*, when the engine has reached a predetermined speed. Such means have been highly developed, and are well known in the art of automotive gearing. Means for shifting the pinion *2a* are indicated by a shift lever *2p*. The free end of this lever is operatively coupled to the hub on the pinion *2a*, and the lever *2p* is normally tensioned by a spring *2q* in a counter-clockwise direction. In that position of the lever, the pinion *2a* is disengaged from the spur gear. A pole piece, mounted on said lever, faces an electromagnet *2r*, so that energization of this magnet will swing the lever to the right. Such movement of the lever slides the pinion *2a* along the shaft of the motor *2b* and into mesh with the spur gear ring *1t*.

The crank shaft *1e* of the engine carries a pulley *2c*, which, by means of a belt *2d*, drives a governor *2e*. The crank shaft and the shaft of the governor extend at right angles to each other. The belt *2d* is therefore twisted through 90 degrees, to connect the respective pulleys. Upon the belt *2d* runs an idler pulley *2f*, near the pulley *2c*. This idler pulley is mounted on the free end of the lever *2g*, which is rotatably pivoted onto a bracket *2h*. The lever *2g* carries a mercury switch *2i*, which is so mounted that, when the belt *2d* breaks and the idler pulley *2f* thereby loses its support, the lever *2g* will swing downwardly and will interrupt the electric contact made in said mercury switch, thereby opening the circuit *2j*.

Another lever *2k* is rotatively pivoted on bracket *2h;* its free end *2m* rests on top of the governor *2e*. The mercury switch *2n* is also electrically connected to the circuit *2j*. This switch is connected with the lever *2k* in such a manner that the contact in said switch, which is normally closed, is opened when the governor *2e* is driven by the pulley of the engine to such speed that the free end *2m* of the lever *2k* drops, together with the top of the governor, for a specific distance.

The three cables *3a* supply electric power from a suitable source, by means of which the control system, by which my method is made effective, is energized and actuated. These cables lead to a circuit-breaker *3b*, which has control relays *3c*, connected by wires *3d* to a remote point. From this remote point, the supply of power to the gas producing apparatus may be turned on or off.

From the circuit-breaker *3b*, the power supply connects to a second circuit-breaker *3e*. This second circuit-breaker controls the motor *2b*, by means of the conductors *3k*, *3m*, and *3n*. In parallel with the motor, the electromagnet *2r* is connected across the two latter conductors *3m* and *3n*. The circuit-breaker *3e* is controlled by circuit closing relays *3f*, and the current required to operate these relays is tapped from one branch of the main power supply, at a point between the two circuit-breakers. The wires *3g* and *3h* form a part of said relay circuit, the wire *3h* being connected to the mercury switches *2i* and *2n*, from which the circuit is carried back by the wire *2j*. Between the wires *3g* and *2j* is coupled a quenching compensator *3j*. Wires *4a* and *4b*, connect thereto in parallel, and lead to the pointer *4c*, and to the low pressure contactor *4d* on the pressure gauge *4e*, respectively. The pressure

gauge 4e is connected by a pipe 4f to the storage tank 4g. A Bourdon chamber 4h operates the gauge 4e, so that, by a lever arrangement 4j, the pressure variations in the tank 4g are transmitted to the pointer 4c. This pointer 4c indicates on a suitable dial 4k the pressure of the storage tank. On this dial there is slidably mounted a contactor 4d, which may be set at the point of minimum pressure desired in the storage tank, and may co-operate with an electric circuit. The pointer 4c is provided, on its end, with an electric brush member which contacts with the contactor 4d when a minimum pressure is reached and the circuit 4a, 4b is closed thereby. The maximum pressure contactor 4m is similar to the contactor 4d, and it is also adjustable along the arc of the dial 4k. When the contactor brush on the end of the pointer contacts with the maximum pressure contactor 4m, electric contact is established between the circuit 4a and the conductor 4n, which leads to the solenoid 4p. The solenoid 4p is connected by the conductor 4r to 4w, one of the legs of the source of current. Excitation of the solenoid 4p will lift the contact member 4s from its position of rest, as shown, and will short circuit the magnetic circuit 1q, to which it is connected by a wire 4t, by means of a ground connection 4u to the housing 1a of the engine.

The pipe 5a, through which the gas is expelled from the pump chamber 1d, connects to a T 5b. One branch of this T pipe connects to a solenoid-operated, normally-open valve 5c, and from there, through the opening 5d, empties to the air. The other branch of the T connection 5b connects to a normally-closed, solenoid-operated valve 5e, which connects to the pressure tank 4g. Immediately below the T 5b, a pipe connection 5h leads to the CO_2 indicator or analyzer 5i, which as shown, is of the Orsat type, or any other suitable indicator or analyzer, operated on any other principle, suitable and usable by those acquainted with the art of testing flue gases may be used. The indicator or analyzer 5i is operated by a motor 5j, which is connected to the main source of power at the circuit-breaker 3b, and therefore the indicator or analyzer functions continuously, while the remote control circuit-breaker 3b is closed. A graduated scale 5k is provided on the analysis indicator by which the CO_2 content of the combustion non-supporting gases may be observed. I have shown in the drawing an exemplary indicator scale ranging from 0% to 15%. On the scale 5k is slidably mounted a contactor 5m, which may be so set as to make an electric contact with the pointer 5n, at any point on the scale. The pointer 5n is the indicating element co-operating with the scale, by means of which the CO_2 content of the gas may be observed. Suitable means for establishing a contact between said pointer and the contact 5m are provided on the end of the pointer 5n, so that when the pointer which indicates the CO_2 content of the gas, is at or above a certain percentage, the circuit 5p will be closed. The circuit 5p is supplied with power from one leg of the main circuit, and it includes a solenoid 5q, which operates a contactor 5r. When said solenoid 5q is energized, the contactor 5r closes the circuit 5s, which is supplied with power from one branch of the main circuit, and which includes the two solenoids 5t and 5u. These solenoids 5t and 5u energize and control the operation of the normally open valve 5c and of the normally closed valve 5e, respectively. The stem 5v and 5w of the two valves 5c and 5e are normally pressed downwardly by the springs 5y. And the actuation of these valves is accomplished by the flux set up in the solenoids 5t and 5u, acting counter to these springs.

The function of the producer of combustion non-supporting gases, namely the engine is well understood by those acquainted with the art of internal combustion engines in general. For that reason, the operation of the producer will be described only sufficiently to give a comprehensive understanding of my improved method.

An explosive mixture is fed into the engine or producer from a suitable carburetor, by means of the pipe 1u through the valve 1h. The power created by the explosion of this mixture in the chamber 1c of the producer, is transmitted from the piston 1g, by means of a connecting rod 1f, to the crank shaft 1e. Ignition of the explosive mixture is caused in the usual and well understood way, by the spark plug 1r, which, at suitably timed intervals, receives a high frequency current from the magneto 1p. The burned gases resulting from the explosion are driven through the exhaust valve 1k, from the cylinder 1c, by the upward stroke of the piston 1g, following the down stroke resultant from the explosion. These gases pass through the pipe 1v into the tank 1w, where they are cleaned, filtered and washed. From the tank 1w, the cleaned gases are drawn through the pipe 1y and through the valve 1m into the pump cylinder 1d, by the suction resulting from the downward stroke of the piston 1g, which is operatively connected to the crank shaft 1e. These gases then leave the pump cylinder upon the upward stroke of the piston, and pass through the valve 1n, when they are compressed in the cylinder to a pressure sufficient to overcome the combined pressure of the spring restrained valve 1n, and of the back pressure of the gases contained in the pipe 5a and the parts connected thereto.

Prior to the invention of the apparatus which is the subject of the co-pending application herein above referred to, and which is illustrated in the drawing of this application, devices of a type which have the valve 1n as substantially the only control means regulating the operation of combustion non-supporting gas producers, represented the only type of mechanism and the only method known in this art.

This type of mechanism and this method of control presented serious defects to their efficient and satisfactory operation. These defects arose through inability to properly control the distribution system by which the gas was conducted to the point of use, in such a manner that it would be maintained at and delivered at a desired, constant and suitable pressure. It was found that when a sufficient pressure had been built up in the pipe line by means of which the gas was handled after it came from the pump, particularly in the pipe 5a and the parts connected thereto, that the exhaust gas ceased to operate the valve 1n; that is to say, the exhaust gas was not of sufficient pressure to overcome the pressure of the spring acting upon the valve 1n and the back pressure of the gases in the pipe 5a. Eventually, the gases which would otherwise exhaust were retained in the engine and in the tank 1w, and prevented the entrance upon the explosion chamber of additional unburned gases. The result of this was that the gas in the cylinder head failed to ignite and that the engine eventually came to a stop. The consequence of this was that unburned gases would mix with

exhaust gases, and thereby reduce the non-oxidizing quality of the gas leaving the explosion chamber. Still another consequence was that, it caused choking and collection of carbon whereby the efficient operation of the engine was greatly impeded.

Although in the performance of my method, and in the device by which that method is performed, I operate with and have therein a valve *1n*, such as is to be found in devices for like purposes in the prior art; and although, as the result of the utilization of such a valve in the performance of my method, the engine would be eventually stopped when a high pressure had been built up on the exhaust end; yet by reason of the provision of additional means in my system, and by reason of novel features peculiarly characteristic to the performance of my method, I overcome the undesirable result hereinbefore referred to, namely, the stoppage of the engine or producer by back pressure. In my method the stoppage of the engine in my apparatus is not accomplished by the reaction of exhaust gases, as the result of the high back pressure thereof; but by automatic means which form a part of my apparatus and which co-operate to make possible the performance of my method, said means being the electrical system connected to and controlling the engine or producer and the means which control that electrical system and co-operate therewith.

This stoppage of the engine, by these last referred to means, automatically occurs when the exhaust gases, which have been delivered into the storage tank *4g*, have reached the predetermined and intended maximum pressure, under which they are to be retained and delivered therefrom. One of the means by which this interruption or stoppage of the producer of the combustion non-supporting gases is accomplished, and by which also their creation and flow is brought about, and by which the control of these two steps of my method is maintained, is the pressure gauge *4e*. On this gauge there is a contactor *4m* set upon the dial *4k* so that its radially disposed side indicates on the scale the maximum predetermined desired pressure which is to be maintained in the tank and under which the non-oxidizing gases are to be delivered therefrom. This scale is graduated in any desired graduation, and any suitable pressure may be automatically maintained. These graduations are shown in the drawing accompanying this application and are, as illustrated, arbitrary markings and are merely in this drawing shown on the dial *4k* as illustrative.

As an example of the operation of this part of the performance of my method, by reference to the means for the performance of this method as illustrated, it will be seen that the contactor *4m*, has thus been set to register with the 90 lb. pressure graduation on the scale. At that setting the pointer of this apparatus will contact with the contactor *4m* when it registers 90 lbs., and a circuit will thus be closed, and a current set up by the above pressure. The circuit thus set in operation consists of *4a*, *4n*, *4r* and *4w*. As the result of the energizing of this circuit, the relay *4p* therein is excited and the contactor *4s* will be caused to close the circuit *4t*, *4u*. The closing of the circuit *4t*, *4u* effects a short circuit of the circuit *1q*, which serves to supply current from the magneto *1p* to the spark plug *1r*, and the action of the ignition apparatus is thus interrupted. The result of this interruption of the ignition causes the instantaneous stopping of the internal combustion engine or generator of the combustion non-supporting gases. The instantaneous stopping of the generator is made possible, not only by this performance, but by reason of the fact that the weight of the fly-wheel *1s* is predetermined to be just sufficient to carry the operation of this generator or engine through one complete cycle as above explained. The circuit controlling the performance of this step and the operation of this ignition means will be short circuited so long as the pressure in the tank *4g* remains at or above the predetermined set figure of 90 lbs. when, and in the event, that the pressure in the storage reservoir drops below 90 lbs. indicated by the pressure gauge, the circuit *1q* is no longer short circuited. The circuit *4a*, *4n*, *4r*, *4w* are then opened as the contact between the pointer *4c* and the contactor *4m* is interrupted. But it will be understood that the ignition operation will not take place again until the engine or producer is started and that result will only follow upon the starting of the motor *2b*.

It will be seen that I not only automatically control the functioning and operation of the respective elements and the device illustrated and the performance of the respective steps which comprise my method, but that I likewise automatically control the operation of the entire process as well as the apparatus which performs it. This initial control of the entire apparatus and of the performance of the entire process is effected by the circuit-breaker *3b*. This circuit breaker *3b* however, is controlled by the relay circuit *3d*. This latter circuit includes the relays *3c* which control the closing of the circuit-breaker *3d*. The relay circuit *3d* leads to a remote point at which there is a suitable switch included in that circuit, and by which switch the operation of the engine or combustion non-supporting gas producer is to be controlled and stopped and started. The motor *2b* is controlled by the circuit-breaker *3e*, the feed of current is controlled by the circuit-breaker *3b*. The circuit-breaker *3e* is in turn automatically controlled by the relays *3f*. The motor *2b* will however only be started by the closing of the switch *3b* when the switch *3e* is closed. The closing of the switch *3e* on the other hand depends upon whether the circuit which includes the relays *3f* is closed. The circuit of the relays *3f* includes three switches. These switches are the mercury switch *2i*, the mercury switch *2n* and the low pressure contacting means on the pressure gauge *4e*. The mercury switch *2i* is one which is maintained normally closed when the twisted belt *2d* extends between the driving pulleys *2c* at the end of the crank shaft and the governor *2e*. This switch opens only when the belt *2d* is not in operative relation to the means which it normally co-operates with. Such a non-co-operative relation will arise when said belt does not support the idler pulley *2f*.

The mercury switch *2n* will be understood to be closed when the engine or generator is not in operation, when the engine or generator attains a certain predetermined speed, the rotation of the governor permits the lever *2m*, which rests on top of said governor, to drop and the contact in the mercury switch *2n* to be interrupted. When the engine or generator is operated at its normal speed, the circuit of the relays *3f* will therefore be open at the mercury switch *2n*. When the engine or generator is not in operation, the circuit of the relays *3f* is closed at the mer-

cury switches. Under this condition the relays will be energized when the main switch 3*b* is closed and when the pointer 4*c* connects with the contactor 4*d* on the pressure gauge 4*e*.

As an example, after the contactor 4*d* has been set on the dial 4*k* of the pressure gauge, so that the pointer contacts with the contactor when any pressure below 50 lbs. is registered, then whenever there is a pressure of more than 50 lbs. in the storage tank 4*g*, the starting motor of the engine or generator cannot be energized. But the starting motor 2*b* may be operated, when the engine or generator is not in operation, when the pressure in the storage tank 4*g* is at any point below the predetermined said pressure of 50 lbs. above referred to.

It is understood that the relay 2*r* is energized when the switch 3*e* is closed; under this condition the pinion 2*a* is in engagement with the gear 1*t* whenever the starting motor 2*b* is in operation. After the starting motor has started the operation of the engine or generator, so that said engine or generator operates as a prime mover, the mercury switch 2*n* is caused to open by the governor. The switch 3*e* thereby opens and the starting motor comes to a stop, and the driving pinion 2*a* is withdrawn from engagement with the gear 1*p*.

It will be seen from the above example, that by my method and the means by which it is performed, that the pressure of the combustion non-supporting gases stored in the tank 4*g* is automatically maintained between 50 and 90 lbs., and that there results a corresponding amount of storage of non-oxidizing gases under these conditions in the tank 4*g*. The means by which this automatic control is initially effected, is the contactors which form parts of the operating circuits of this control. This effect and result, it will be understood, can be accomplished only in case the main switch 3*b* is closed.

In order to perform the selection of the choice of desirable and undesirable gases which are discharged from the engine or generator, these gases must be led to the analyzing device 5*i*. As the gases come from the generator, a portion thereof is directed to this analyzer or tester 5*i* through the pipe 5*b* which leads from the pipe 5*a*. The CO_2 analyzer shown, or whatever indicator is used is in continuous operation. The operating motor 5*j* which forms a part thereof is supplied with current through the main switch or circuit-breaker 3*b*. Various methods well known to the art and various devices likewise known, may be employed to analyze the gases discharged from the generator so that the quality may be indicated automatically.

I provide a scale which forms a part of the analyzing and indicating means. This scale indicates the CO_2 content of the gas being analyzed, and is graduated from 0 to 15%. There is also shown a pointer 5*n* which indicates, exemplarily, the percentage of CO_2 contained in the gas to be 6%. The contactor 5*m* is set so as to cause a contact between the pointer 5*n* and said contactor 5*m* at approximately 10% of CO_2 content. When the indicator 5*n* is in the position shown or registers any other percentage of CO_2 content below 10%, the circuit 5*p* is open. The solenoid 5*c* is then not energized, and the circuit 5*s* is open. Then the solenoid operated valve 5*c* is open and the solenoid operated valve 5*e* is closed, as shown in the drawing.

Therefore when the non-oxidizing gases being delivered from the generator contain less than 10% of CO_2, then, because of the position of these valves under that condition, the gas of that quality will pass through the valve 5*c*, and be discharged into the air. This discharge will continue until the CO_2 content reaches the predetermined percentage of 10%. When this percentage of CO_2 is reached, contact is made by the pointer 5*n* of the analyzer with the contactor 5*m*. This causes the solenoid circuit 5*p* to close and the contactor 5*r* to close. The circuit 5*e* is thereby closed and the two solenoids 5*t* and 5*u* operate the respective valves and change their positions. Then the valve 5*c* will be closed and the discharge of the gas to the air is thereby interrupted, and the valve 5*e* is opened, and the combustion non-supporting gases, having now a predetermined CO_2 content, will be delivered to the storage tank 4*g*.

This delivery of these gases of this predetermined CO_2 content will automatically be maintained until by disturbance of the operation of the generator, the character of the discharge gases varies to such an extent, that they will not test to that predetermined desired analytical quality. If for instance the CO_2 content of the combustion non-supporting gases should drop below the predetermined percentage of 10%—which is that at which the contactor 5*m* is illustrated as set on the scale of the analyzer and indicator—the valves 5*c*, and 5*e* will again return to the position shown in the drawing and will, because of that position, prevent the delivery of gases into the storage reservoir and will cause their discharge into the atmosphere. This return of the valves 5*c* and 5*e* to the original position indicated in the drawing is effected by the tension of the springs 5*y*, after the solenoids 5*t* and 5*u* have been deenergized.

Because of this operation of the solenoidal valves and by the performance of this step in my method, no gas of a quality, inferior in percentage to the predetermined value at which the analyzer 5*i* is set, is permitted to be fed to the storage tank or reservoir, and the quality of the gas stored in and possible to be discharged from said reservoir is maintained at a fixed grade and kept at any desired standard. This grade and standard may be varied to any desired degree, and thus a gas of any predetermined quality of inertness or CO_2 content may be delivered or stored, by setting the contactor 5*m* on the scale 5*k* so as to contact with the indicator 5*n* at and above the point on the percentage scale which indicates the minimum inertness or CO_2 content which is sought for in the delivered or stored gases. When any gas of a quality of inertness below that to which the contactor is set on the scale issues from the combustion non-supporting gas producer, such gas will be by-passed and delivered to the air, because the indicator 5*n* is not contacting with the contactor 5*m*, as long as gas of such inferior quality is sampled through the pipe 5*h*, and because the solenoid valves are automatically positioned to produce this effect.

From the foregoing explanation of the apparatus and the manner in which the parts thereof co-operatively function and are co-related, it will be observed that my method comprises a series of well defined operations and steps, which have definite relations to each other, and are so ordered and performed and controlled in their performance or non-performance, that they constitute a purely mechanical method by which non-oxidizing gases, having certain qualities of inertness because they contain a predetermined percentage of

certain gases, may be selected and stored for use and discharged to be used, with precise certainty as to the quality of the gas and the pressure under which it is stored and may be delivered.

It is further to be observed that this method, and the control of the performance of every step thereof, and as well of the entire complete method, is accomplished entirely mechanically and fully automatically.

The method comprises a series of distinct steps. There is first a generation of the combustion non-supporting gas by ignition of a suitable substance in the explosion chamber of an internal combustion engine or like apparatus. The next step consists in automatically delivering the generated gas to a scrubber for purification. Following this, the purified gas is also automatically delivered to a pump chamber, from which it then is automatically ejected by the action of the pump into a delivery pipe. Then, automatically, the gas is directed to an analyzer or testing apparatus which has been set to indicate whether that gas contains a greater or lesser percentage of certain ingredients which qualify it for a sought for use. The testing apparatus is in continuous operation so long as the gas is being generated. When the test is made the control system co-operating with the analyzer automatically operates to effect the further course of delivery of the tested gases. If the gas tested is of an inferior quality, for instance, below a certain predetermined percentage of CO_2 content, the re-action of the control system is such, that gas of that character is automatically directed through a passage which opens directly into the air, and is thereby discarded from use. If the gas tested is of such a percentage of CO_2 content as has been predetermined to be desirable for use, the control system co-operating with the analyzer mechanism automatically prevents the discharge of that gas to the air, and directs it to a storage reservoir into which it is forced by the operation of pressure, generated by the pump chamber, from which it was previously discharged. It is to be observed that at this stage of operation of my method, the mechanical selection for use, or for discharge as unusable, of the combustion non-supporting gas takes place automatically. The gas stored for use in the storage reservoir, may be maintained therein under a predetermined, substantially constant pressure, or there may be an inflow and discharge of the gas directed into and from the storage reservoir, and the pressure maintained during the inflow and discharge at a constant predetermined pressure point. It is to be observed that this maintenance of the pressure as well as the regulation of the control of that pressure, is fully automatically accomplished in my method by means which have heretofore been described. Not only will it be observed that the selected gas may be stored in and discharged from the reservoir at a substantially constant and predetermined pressure, but that when the pressure in the reservoir and, consequently, the quantity of gas in the reservoir rises to a point beyond the maximum desired to be maintained, the operation of the generator is automatically stopped.

When the generator is thus automatically stopped, the generation of the gas is of course likewise stopped; the discharge of gas from the reservoir may however continue until the pressure in the reservoir is reduced to a predetermined pressure point. When the pressure has returned to this predetermined pressure point, the operation of the generator may automatically be caused to re-occur.

It will be observed therefore, that so long as the main control switch is closed to energize the main power circuits of the system, the operation of the generator will continue and the gas will be generated and analyzed and either discarded to the atmosphere or stored in the reservoir and maintained under a predetermined pressure and distributed for use from the reservoir. All of these steps of the method are automatically caused to take place in their proper sequence and automatically controlled and automatically stopped. It is in the devising of a method of mechanical generation, selection, storage and delivery to use by and under a continuous automatic control, that my invention consists.

Although the prior art may show a means and a method by which non-oxidizing gases may be generated and stored under pressure and delivered under pressure, yet I believe it to be new to combine with those steps, the heretofore unknown step of automatically analyzing and selecting a predetermined quality of gas from the generated gas for such storage under pressure, and for such use, and to have an automatic control of quality and quantity.

Although I have illustrated in detail the means by which my method is performed and have described in detail the manner in which my method may be practiced, yet I do not wish to be limited to the specific means nor to the specific steps, nor order of steps which constitute my invention, except as the state of the art and the appended claims may require, for it is obvious that various modifications and changes may be made in the performance of my method without departing from the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent is:

1. The method of controlling the production of combustion non-supporting gases having a substantial CO_2 content, comprising the initial generation of said gases by the controlled combustion of a fuel, the controlled circulation of said gases under a predetermined pressure, analyzing the CO_2 content of said gases, discharging to the atmosphere for disuse such of said gases as analyze to show a CO_2 content less than the desired predetermined amount, storing for use under said predetermined pressure gases having the desired CO_2 content, and controlling said initial generation of said gases by the reaction of the pressure of the selected stored gases.

2. The method of controlling the quality of combustion non-supporting gases have a substantial CO_2 content, comprising the initial generation of said gases as exhaust gases of an internal combustion engine, continuously analyzing said gases for their CO_2 content, directing for use such of said analyzed gases as have a desired predetermined CO_2 content, discharging to the atmosphere such of said analyzed gases as have a CO_2 content less than the desired predetermined amount, storing such of said gases as were directed for use, and controlling the initial generation of said gases by the reaction of the pressure of the stored gases.

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