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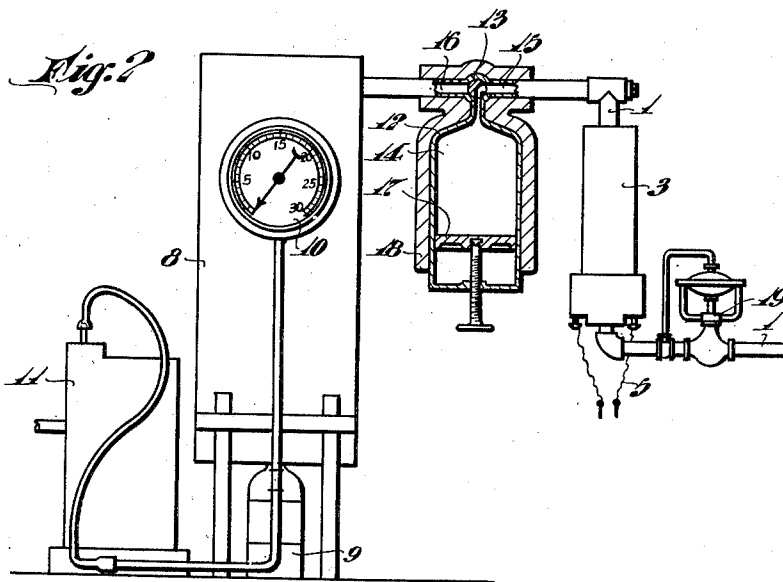
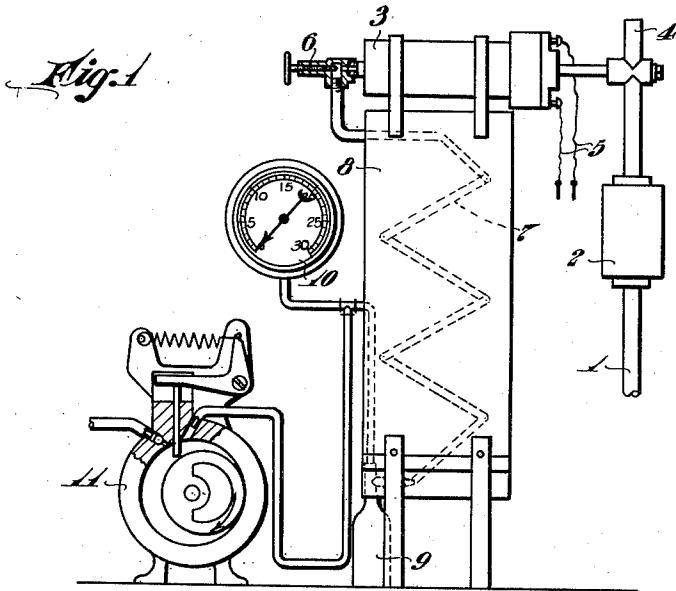
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1,953,061

APPARATUS FOR MANUFACTURING WATER GAS

Filed May 28, 1931

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

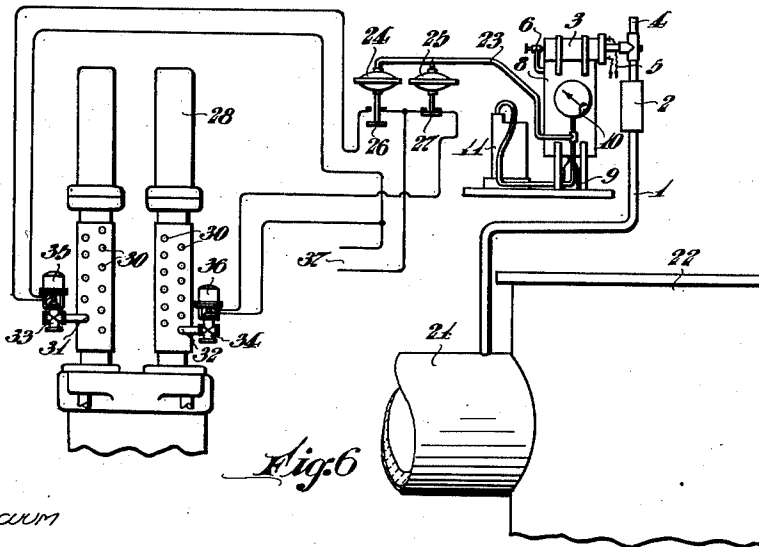


Fig. 6

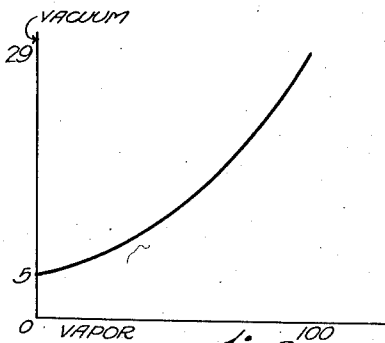


Fig. 3

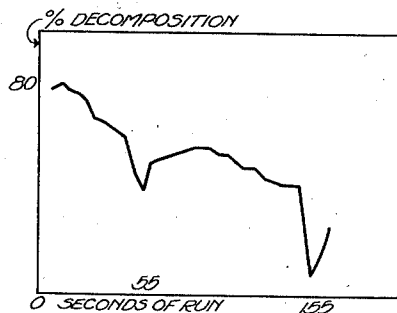


Fig. 5

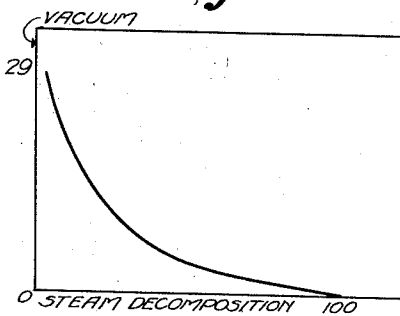


Fig. 4

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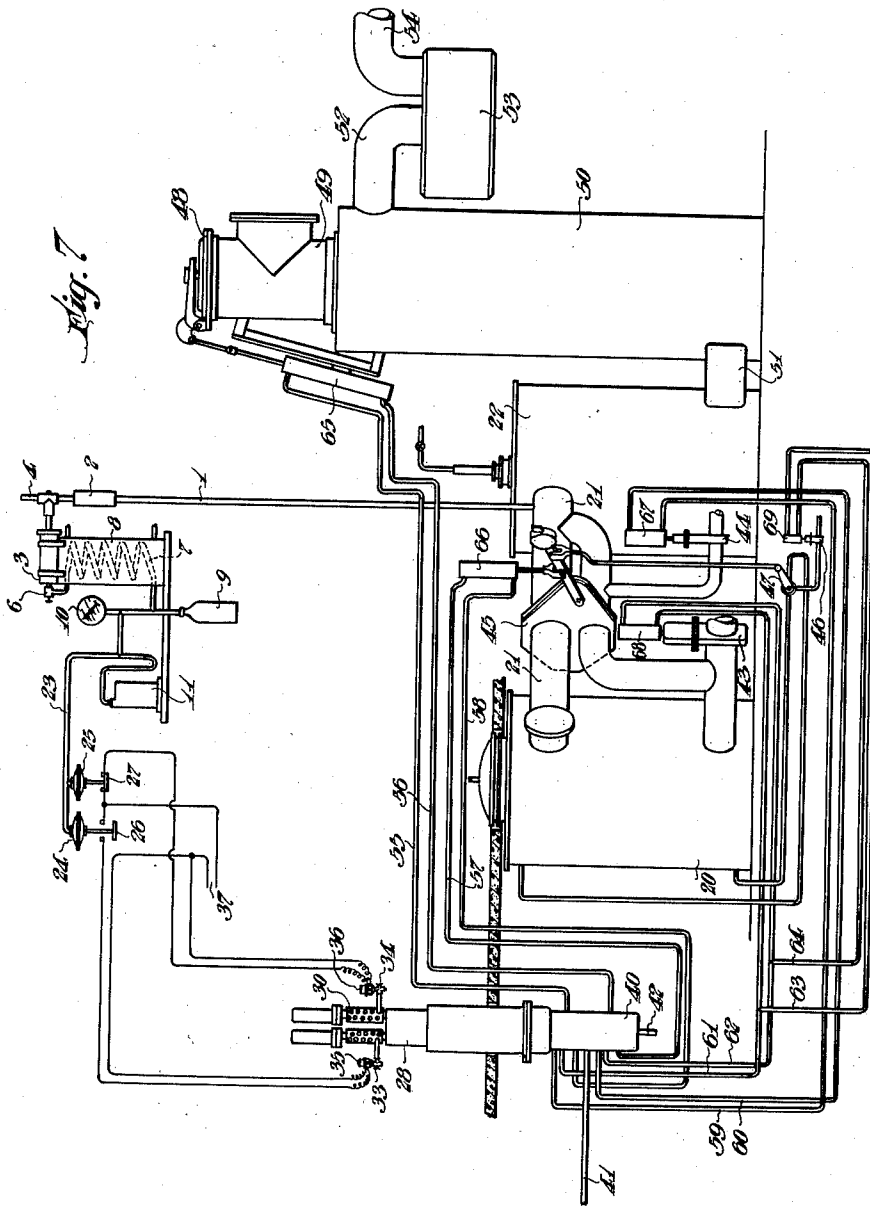
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APPARATUS FOR MANUFACTURING WATER GAS

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

1,953,061

APPARATUS FOR MANUFACTURING
WATER GASOswald H. Blackwood and Paul G. Exline, Pitts-
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Application May 28, 1931, Serial No. 540,594

7 Claims. (Cl. 48—83)

This invention relates to the manufacture of water gas, and more particularly to the measurement of the condensible vapor or steam content of the water gas output of a water gas machine, and the control of the machine with respect to such content of the output thereof.

This application is a continuation in part of our copending application Serial No. 396,379, now Patent No. 1,880,720, dated October 4, 1932, filed September 30, 1929, Method and apparatus for measuring vapor.

It is an object of the invention to provide apparatus for the measurement of the water vapor or steam content of the water-gas output of a water-gas machine. With this object in view, definite portions of the gas being tested are subjected to a cooling action for condensing the vapor within a closed space so that the amount of vapor changed to liquid can be made evident by the degree of the ensuing vacuum.

Water-gas is made by passing steam through an incandescent fuel bed to form hydrogen and carbon monoxide and the presence of an excess of moisture in the gas leaving the fuel bed shows that the temperature of the fuel bed is too low.

It is therefore another object to provide a device for regulating the automatic control of a water gas set with regard to the water vapor or steam content of the water gas output of the generator.

Further objects are to simplify and improve the construction and operation of devices of this character, to render them inexpensive to manufacture, and efficient and convenient in use.

Other objects and features of novelty will be apparent as the following description proceeds, reference being had to the accompanying drawings, in which

Figure 1 is an elevational view partly in cross-section of the measuring apparatus as adapted to water vapor determinations;

Fig. 2 is a similar view of a modification;

Fig. 3 is a calibration curve for the apparatus as used to indicate vapor density;

Fig. 4 is a calibration curve for the apparatus as used to indicate steam decomposition;

Fig. 5 is a typical steam decomposition curve obtained by the apparatus when attached to a water-gas machine;

Fig. 6 is an elevation of the apparatus of Fig. 1 so connected to an automatic control for a water-gas machine as to control the same; and

Fig. 7 is a more or less diagrammatic elevational view of a water-gas set having an auto-

matic control provided with the regulating device of the present invention.

Referring more particularly to the drawings, a relatively large volume of the warm gas, the vapor content of which is to be determined is passed through a pipe 1, as shown in Fig. 1, and through a coarse filter 2, after which a portion is drawn into the main filter 3, and the remainder discharges through vent pipe 4 to the atmosphere. In this way, the sample drawn into the filter 3 is always drawn against a constant head. The main filter 3 is heated by electrical current from terminals 5 to prevent condensation.

The sample of gas then passes through an orifice controlled by a needle valve 6, and through a tube or coil 7 of a condenser 8. Water or other suitable cooling medium is circulated around the coil 7. Most of the vapor in the gas condenses and collects as liquid in the vessel 9 which in practice is provided with an outlet trap. A vacuum gauge 10 is connected to the coil 7. The residual gas from which vapor has been removed is drawn out of the apparatus by means of a positive displacement or constant volume output pump 11 which is operated at a uniform rate of speed.

The operation of the steam measuring apparatus is so conducted that with a given speed of the vacuum pump 11 and a given temperature of the cooling medium in the condenser 8, and with the gas to be tested entirely freed from water vapor a vacuum of preferably five inches of mercury is maintained. This is accomplished by proper adjustment of the needle valve 6 which controls the adjustable orifice.

Obviously, when the pipe 1 is then connected to the warm gas that is to be tested, if any steam is contained therein most of it will condense in the coil 7, leaving a smaller volume of non-condensable gas to be removed by the pump and the degree of vacuum will be increased. The more steam present the greater will be the degree of evacuation.

If the temperature of the condenser is not low, a certain amount of vapor will escape through the pump. This need not cause error because it may be taken care of either by calibration curves for different condenser temperatures or by different sets of dials for the gauge. The inlet pipe is made reasonably short to insure a short equilibrium period.

In the modification shown in Fig. 2, a constant volume inlet device 12 takes the place of the orifice controlled by the needle valve 6. The device 12 comprises a three-way cock or valve 13 having

a port of L-shape and which is rotated at constant speed and alternately places a chamber 14 in communication, first with the inlet 1 through a port 15 and with the condenser 8 through a port 16.

When the chamber 14 is in communication with the inlet 1 it fills with gas at inlet pressure and when the chamber is in communication with the condenser coil 7 within the condenser 8 gas passes into the coil and the pressure falls, a vacuum being created by the condensation of vapor within the coil and the action of the pump 11 on the gas and vapor that is not condensed in the coil 7.

Movement of the piston 17 adjusts the rate of passing of the gas through the inlet device 12 by altering the volume of the chamber 14. Since the through put is directly proportional to the rate of rotation of the valve 13 and to the volume of the chamber 14, the equilibrium pressure for a given vapor content of the gas may be varied by varying either the speed of rotation of the valve or the volume of the chamber.

The constant volume inlet 12 is covered with heat insulating material 18 to prevent condensation of the vapor being measured. The presence of a heating coil or an electric element as the one supplied with current by the terminals 5, is of considerable importance as it tends to keep the temperature of the gas constant.

A pressure regulating valve 19 is shown as forming part of the modification of the apparatus shown in Fig. 2. This is not necessary except in cases where there are large fluctuations in the pressure of the gas to be tested. The valve 19 takes the place of the vent pipe 4 of Fig. 1.

The operation of the constant volume inlet with its valve moving at constant speed is such that it is free from errors due to deviation in the specific gravity of the gas. That is, its operation is solely dependent on considerations of volume, pressure and temperature. The pressure difference between the inlet port 15 and the condenser port 16 is dependent on the speed of the vacuum pump 11 and the temperature of the condenser coil 7, both of which factors are kept constant.

The volume of the chamber 14 is constant except as adjusted by piston 17 and the temperature of the gas entering through port 15 should not vary. Then if the specific gravity of the gases entering through port 15 should change due to variation in the proportion of some of the constituents, exactly the same volume of gas passes through valve 13 into the condenser as before, because the action of the chamber 14 is not affected by the weight of gas entering and leaving. Moreover there is no small orifice to become altered in size or closed by particles of dust.

With the orifice in the needle valve 6 as shown in Fig. 1, the volume of gas passed is a function of the specific gravity of the gas, other conditions being equal. Consequently, new settings of the orifice or revised calibrations must be made when gas of widely different specific gravity is being tested. However, for practical test purposes the variation in gravity of gas made in any one operation is not sufficient to affect seriously the accuracy of the instrument. Other conditions being the same, the rate of effusion of the gas through an orifice such as that of Fig. 1 is inversely proportional to the square root of the density of the gas.

The calibration curve for vapor is shown in Fig. 3. The ordinates represent inches of mercury, the abscissæ, percent of vapor in the gas, and

the single curve is for a condenser temperature of 32° F.

The curve showing the calibration for steam decomposition in a water-gas generator is as shown in Fig. 4, wherein the ordinates represent inches of mercury and the abscissæ percentage of steam decomposition.

The object of the curve is that the readings will express the percentage of input steam decomposed instead of expressing the percentage of residual steam remaining in the resultant gas. However, the residual steam is the factor which produces the vacuum in the apparatus.

In theoretical water-gas consisting of 50% H₂ and 50% CO, each two volumes of gas is a result of the decomposition of one volume of steam, hence the departure of the curve from a straight line. For example, 50% undecomposed or residual steam in the resultant gas corresponds to 33 1/3% decomposition of the input steam to the bed of fuel since two volumes of gas result from one volume of steam.

If the steam blown through the fuel bed of the water-gas generator undergoes 100% decomposition, there is then no steam in the output gas. Consequently, 5 inches of mercury is shown on the gauge indicating the vacuum, because this degree has arbitrarily been selected as one of the most convenient settings for dry gas. If none of the steam being blown through the fuel bed of the water-gas generator is decomposed, then the output gas is all steam so that the maximum vacuum of 29 inches of mercury is indicated.

The steam decomposition curve in Fig. 5 shows the percentage of steam decomposition in a typical water-gas plant through the gas-making period of one cycle and ranges from 80% at the beginning down to about 15% at the end of 150 seconds. The sudden drop at the end of 55 seconds is due to the change from up-run to down-run and the sudden drop at the end of 150 seconds is due to the change from down-run to up-run.

In Figs. 6 and 7 the apparatus is shown applied to a water-gas set to aid in the control of the same. The inlet or sampling pipe 1 is connected to the gas offtake pipe 21 leading from a water gas generator 20 to a carburetter 22.

The connection leading from the coil 7 of the condenser 8 of the decomposition apparatus to the pump 11 is provided with a branch pipe 23 which leads to two diaphragms 24 and 25 that in turn operate switches 26 and 27.

In Figs. 6 and 7 there is shown a water-gas set equipped with an automatic hydraulic control illustrated and described at length in the patent to Stone No. 1,671,093, May 22, 1928, and more particularly in the patent to Stone et al. No. 1,670,911 of May 22, 1928. The timing portion of the automatic control is shown at 28 and this part of the mechanism regulates the speed of the automatic hydraulic control through a plurality of small valves 30 during the various portions of the cycle of operations of the water-gas machine.

As set forth and described in the aforesaid patents to Stone and as illustrated in Fig. 7, the automatic control is provided with a master cylinder 40 which is functionally similar to a nest of four-way valves. Hydraulic fluid is supplied under pressure through a conduit 41 to the cylinder 40 which is provided with a drain 42.

The pressure differential between the conduits 41 and 42 is employed to govern the operation of the operating valves of the water gas set, such, for example, as a primary air blast 43, a secondary air blast 44, a reversing valve 45, an off-and-on

steam valve 46, a steam reversing valve 47, and a stack valve 48, the latter being employed to control the flow of gas from a stack 49 of the superheater 50 connected to the carburetter 22 through a connection 51. The superheater 50 is also provided with a water gas outlet 52 leading to a wash box 53 having an outlet 54.

Control of the various aforesaid valves 43 to 48 inclusive is accomplished by means of a suitable plurality of hydraulic pressure and relief conduits 55 to 64 inclusive, pairs of which lead to hydraulic operating cylinders 65 to 69 inclusive.

By means of the timing mechanism 28, a piston (not shown) traveling within the master cylinder 40, is caused to deliver pressure impulses to the various operating cylinders 65 to 69 in order to effect operation of the various valves 43 to 48 in predetermined time sequence.

Two of these regulating valves are removed at locations 31 and 32, these being valves that determine the speed of the automatic control during the first uprun and during the downrun respectively. In their stead are substituted valves 33 and 34 which normally remain closed and bring the automatic control to a stop at such times as it comes under the control of either of these two valves. The valves are opened by solenoids 35 and 36 respectively that are in turn connected to the switches 26 and 27, the power being derived from a source 37.

After either of the valves 33 or 34 has brought the automatic control to a standstill, the water-gas set continues in that particular portion of its cycle until such time as there is a change in the percentage of steam decomposition of the gas passing through the offtake pipe 21, and this change is detected by the decomposition apparatus through the sample being led off by inlet pipe 1 whereupon through the action of either diaphragm 24 or 25 the energizing of solenoids 35 or 36 opens valve 33 or 34 and allows the automatic control to continue the cycle of the water-gas set.

The operation of the decomposition apparatus as applied to an automatically controlled water-gas set as shown in Figs. 6 and 7 is as follows: The water-gas set operates on a definite cycle that includes an air blasting period in which air passes upwardly through the fuel bed, a first uprun period during which steam is passed upwardly through the fuel bed, a downrun period in which steam is passed downwardly through the fuel bed, and a second steam uprun period.

During the first uprun and during the downrun it is only necessary to make sufficient alterations in the automatic control to bring it to a standstill during these two periods. Then it is necessary to install a restarting arrangement under the control of the decomposition apparatus so arranged that when the steam decomposition falls to a certain percentage during the first uprun or the downrun the automatic control will be again started.

In the example illustrated the automatic control is a hydraulic one, and a simple way of stopping this type of automatic control is to insert valves, such as 33 and 34, in the speed regulating portion of the automatic control. These valves can readily be opened by solenoids 35 and 36 that are energized by current passing through switches 26 and 27 that are closed by diaphragms 24 and 25, subject to the vacuum of the condenser coil 7 of the condenser 8 of the decomposition apparatus.

Each of the plurality of valves 30 in Fig. 6

regulates the speed of the automatic control during a different portion of the cycle of the set. Valve 33 when inserted at 31 stops the automatic control during the downrun period. Solenoid 35, switch 26 and diaphragm 24 restart the automatic control. Valve 34 located at point 32 stops the automatic control during the downrun period.

The instrument can be used in a similar manner to control the cycle of any type of water-gas set other than that shown in Fig. 7, using any other type of automatic control or any variation of the water-gas set.

In a similar manner it can be used to regulate the rate of supply of steam to the generator so as to decrease the rate of steam as the decomposition tends to decrease. In this way the percentage of decomposition can be maintained practically constant throughout the steaming period.

The measuring apparatus has the advantage of a short time lag or a short equilibrium period. That is, the interval of time from the start of a change of moisture content of the gas being sampled until the new reading is indicated on the vacuum gauge is very short, due to the small volumetric capacity of the condenser coil.

The invention can be used to determine moisture content of gas at room temperature through the use of liquid carbon dioxide or other low temperature refrigerant. Also the percentage of vapors having much higher condensation points than steam can be determined by the use of suitable refrigerants.

Other modifications of the measuring apparatus itself are possible. It has been found that a pressure pump may be placed at the inlet to the condenser and the orifice placed to serve as the outlet for the condenser.

It will be obvious to those skilled in the art that while I have described my invention with respect to water gas set controlling mechanism of a particular type, namely, the so-called "hydraulic" control, my invention may be utilized to the same advantage and may be adapted, without requiring anything other than mechanical skill, to water gas installations in which the operation of the set is controlled by means of other types of automatic controls, for example, mechanical and electrical controls.

While embodiments of the invention have been illustrated and described in such detail as to enable anyone skilled in the art to practice the invention, it is to be understood that the invention is not to be limited to the details disclosed, other than as necessitated by the development of the prior art. Instead it will be appreciated that the invention embraces such embodiments of the broad idea as fall within the appended claims.

We claim as our invention:

1. In combination, a water gas machine adapted to contain a bed of carbonaceous fuel, an automatic control mechanism adapted to operate said machine through a series of air-blasting and steaming periods, and means responsive to the extent of steam decomposition effected by said machine in said steaming periods for regulating said automatic control mechanism.

2. In combination, a water gas generating set having valves for admitting air and steam there- to, an automatic control mechanism for operating said valves in a predetermined sequence of air-blasting and steaming periods, and an automatic device for controlling the progress of said control mechanism through said steaming periods

in accordance with the extent of steam decomposition in said periods.

3. In combination, a water gas generating set adapted to contain a bed of carbonaceous fuel, and having valves for admitting air and steam thereto, an automatic control mechanism for operating said valves in a predetermined sequence of air-blasting and steaming periods, means for arresting the progress of said automatic control mechanism during one of said periods, and means responsive to the extent of steam decomposition effected by the fuel bed in the steaming periods adapted to release said automatic control mechanism.

4. In combination, a water gas generating set adapted to contain a bed of carbonaceous fuel, and having valves for admitting air and steam thereto, an automatic control mechanism for operating said valves in a predetermined sequence of air-blasting and steaming periods, means for arresting the progress of said automatic control mechanism during said steaming periods, and automatic means adapted to release said mechanism when the extent of steam decomposition effected by the fuel bed reaches a predetermined point.

5. In combination, a water gas generating set having valves for admitting air and steam thereto, an automatic control mechanism for operating said valves in a predetermined sequence of air-blasting and steaming periods, means for arresting the progress of said automatic control mechanism during one of said periods, means for

sampling the gas output of said set, means for condensing the steam content of said sample, and means responsive to pressure change due to said condensation for releasing said automatic control mechanism.

6. In combination, a water gas generator adapted to contain a bed of carbonaceous fuel and having valves for passing air and steam thereto, an automatic hydraulic control mechanism for operating said valves in a predetermined sequence of air-blasting and steaming periods, a normally closed valve adapted to interrupt the progress of said mechanism during one of said steaming periods, and means responsive to the amount of undecomposed steam in the gas leaving said generator and adapted to open said valve when said amount falls to a predetermined value.

7. In combination, a water gas generator adapted to contain a bed of carbonaceous fuel, valved means for passing air and steam there-through, a gas outlet from said generator, a sampling conduit in communication therewith, a pump located in said conduit for evacuating gas from said outlet, a condenser located in said conduit between the gas outlet from the generator and the pump, and means adapted to regulate admission of steam to said generator and responsive to the pressure change effected by said condenser.

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