June 21, 1949. J. G. HOOP 2,473,525

ATMOSPHERE PRODUCTION

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Fig. 1.

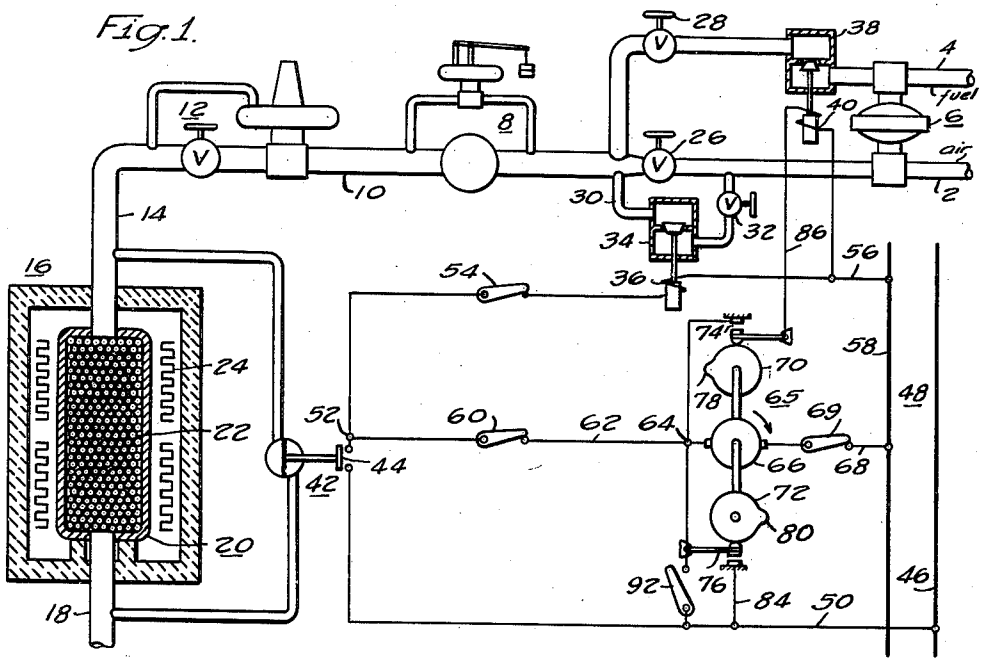
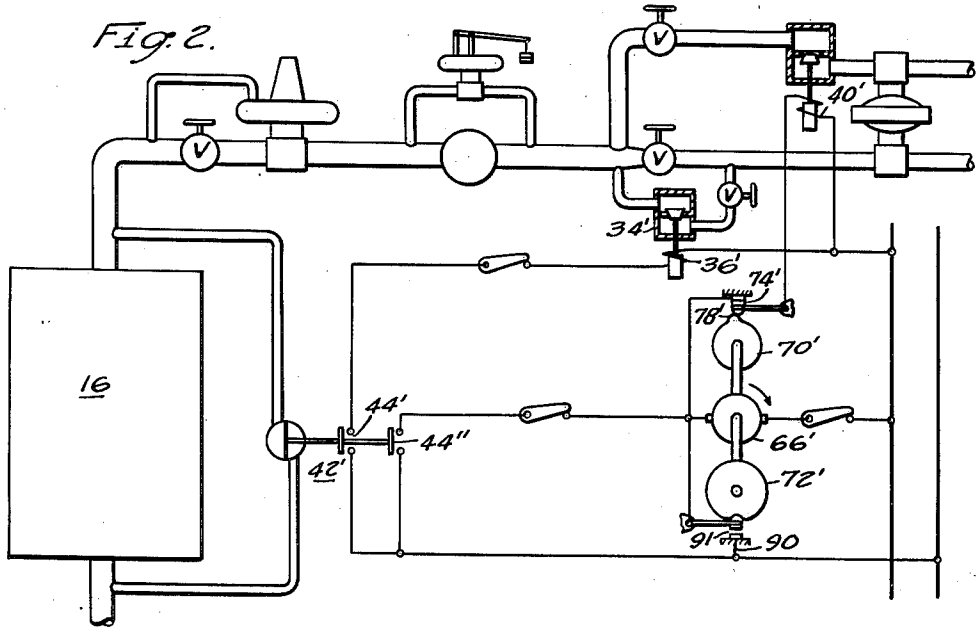


Fig. 2.



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ATMOSPHERE PRODUCTION

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My invention relates broadly to gas-reacting systems for producing a special gaseous atmosphere such as is used for enveloping metal undergoing a heat-treating process, the production of the atmosphere involving the reaction of a combustible fuel fluid, usually gaseous, and air in the presence of a heated catalyst for providing a product-gas utilizable, directly, or after further processing, for the special atmosphere.

The characteristics of the special atmosphere to be used in a metal heat-treating process are determined, to a large extent, by the physical and chemical properties of the articles which the atmosphere is to envelop, and the nature of the heat-treating process they are to undergo. However, from the standpoint of the supplier of gas-reacting apparatus, it is desirable to provide a single apparatus which can provide a satisfactory product-gas with any of the more common fuel-gases so that it can be used with a fuel-gas that is available more cheaply in one location, or with some other fluid fuel that might be more readily available at some other location.

It is also desirable to provide a means and a method in which the nature of the product-gas can be changed when it is produced from the reaction of a single fluid fuel and air. For example, air and methane can be reacted in a ratio of about 2½ of air to 1 of methane for producing a product-gas which is admirably suited for use as a special neutral atmosphere for enveloping high carbon and alloy carbon steels for bright hardening without decarburization. By increasing this ratio to about 3½ to 1, the composition of the product-gas changes so that it is more suitable as a special neutral atmosphere in short-cycle hardening of medium carbon steels, without significant change in the carbon content of the steel.

In systems of the type described, significant amounts of carbon dioxide are generally undesirable in the enveloping atmosphere. Also practicable and economical considerations usually prevent feeding the input fuel-gas and air in a definite fixed ratio for continuously or automatically providing a product-gas of fixed composition. However, for most heat-treating processes, requiring a special atmosphere of a type described, the product-gas need not be of exactly the same composition at all times, but can vary through ranges which permit the use of a gas-generator system having a satisfactory control means. In general, a system provided with such a control means feeds a relatively rich mixture which causes free carbon to separate from the reacting

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gases and deposit in the catalyst bed. When the deposit becomes noticeable, as for example by the added restriction it interposes to gas-flow, the supply gas is made leaner for consuming carbon so as to remove the restriction. The controls are preferably such that some carbon is always left in the catalyst bed. The copending application of C. E. Peck and myself, Serial No. 447,682, filed June 16, 1942, describes an automatic system having such a control means, and is especially useful in the production of a product-gas from manufactured city gas and air; my copending application Serial No. 490,315, filed June 10, 1943, now abandoned, describes a modified form of such control means, and the instant application is a continuation-in-part and improvement thereof, which provides a device of more general application in industry.

The reaction of the fuel fluid and air, in systems of the type involved, is usually caused to take place while the supply-gas passes through a heated gas-pervious porous catalyst contained in a reaction-chamber. The exact conditions and effects of the reaction of a relatively rich gas-supply mixture which causes free carbon to separate from the gases and deposit in the pores of the catalyst or of a relatively lean gas-supply mixture which reacts with consumption of carbon, are not fully known so far as I am aware. I have determined, however, that when the gas-supply is sufficiently rich to cause carbon to be deposited, the carbon does not deposit uniformly throughout the catalyst. The deposit appears to be more dense at the entering side, with respect to the opposition it offers to gas-flow. When a pure air shot is fed, along the lines suggested in my aforesaid sole application, carbon in the pores of the catalyst is consumed, but the reaction is highly exothermic and can be permitted for a very brief time only. If an air shot is permitted to continue too long, the catalyst may be overheated and deteriorate, so that the substantially pure air shot scheme, although utilizable in some cases, is not universally satisfactory as a scheme for preventing clogging of gas-generators which are called upon to substantially continuously produce a satisfactory product-gas. On the other hand, the alternate rich and lean supply-mixture, such as disclosed in the aforesaid joint application, seems to consume the carbon primarily beyond the inlet portions of the catalyst. In some instances, it does not reduce the gas-flow restriction for intiating the control operations which change the supply-mixture. This is because the lean supply-mixture does not

appreciably react with the carbon deposit in the entrance portion of the catalyst, where the carbon is most dense and is the primary cause of the gas-flow resistance. Accordingly, there are cases where the use of either control alone will not result in satisfactory operation of the gas-generator system.

It is an object of my invention to overcome the disadvantages of the prior gas-generator systems.

It is another object of my invention to provide an apparatus and method by which a satisfactory product-gas can be consistently obtained from the reaction of any of the more common combustible fuel-gases with air.

It is another object of my invention to provide a gas-generator system of the type described in which the carbon deposited in the catalyst is more satisfactorily absorbed during the periods when a leaner gas-supply is supplied thereto.

Still another object of my invention is to provide a novel operating-cycle and control-system in combination with such gas-generators.

In accordance with my present invention, I change the apparatuses and processes of the prior art embodiments so that the gas-supply to the reaction-chamber is changed in some orderly manner in which it is, at times, relatively so rich as to deposit carbon in the pores of the catalyst, so lean as to react mostly with the densely deposited carbon in the entrance portion of the catalyst, and relatively lean so as to slowly consume carbon primarily from the pores of the catalyst beyond the entrance portion. In a preferred embodiment, the most lean gas-supply consists of air which is supplied for very brief periods, but sufficiently long to provide satisfactory removal of carbon of the entrance portion of the catalyst bed without producing excessive heating.

Other objects, features, methods, combinations and innovations of my invention will be discernible from the accompanying drawing diagrammatically showing several preferred embodiments thereof. In the drawing, like numerals refer to similar parts of the embodiments illustrated in the figures of which:

Figure 1 is a view of circuits and apparatus illustrating one form of my invention; and

Fig. 2 is a similar view of another form.

As shown in the drawing, two supply-pipes 2 and 4 are respectively utilized to supply or convey, under suitable pressure, air and a carbonaceous fuel-gas; a balancing regulator 6 being used for maintaining the supply uniform. The pipes feed into a constant pressure device 8 which maintains a constant pressure in a connecting pipe 10 leading to a constant flow device 12 which provides a constant flow of the supply-mixture of air and fuel-gas in an inlet pipe 14 to a gas-generator 16, so that a substantially constant output of product-gas is provided in an output pipe 18 from which the product-gas may be delivered to any place where it is needed or is to be further treated. The gas-generator comprises a reaction-chamber 20 in the form of a casing having a passage for the flowing gases, which is filled with a catalyst providing a porous catalyst bed 22. The catalyst may be nickel shot or balls of about ¼ inch diameter, or any other suitable catalyst. The casing is disposed in a heat-insulated furnace having any suitable heating means, exemplified by electrical resistor heaters 24, for heating the reaction-chamber to a degree necessary to sustain the reaction carried out in the reaction-chamber 20.

Adjustable valves 26 and 28 are provided in the supply-pipes 2 and 4, respectively, for permitting an initial adjustment of the amounts of air and fuel-gas that can pass therethrough.

Bridging the valve 26 is piping 30 having an inlet on the inlet side of the valve 26 and an outlet at the outlet side of the same valve, at a point before the feed of the gas-supply to the constant pressure device 8. This branch piping 30 includes a manually-adjustable valve 32 for determining or setting the amount of air that can pass through the branch piping when it is otherwise unobstructed. However, another automatically-operable valve 34 is provided which is normally closed but which can be moved to fully open position upon energization of an operating means comprising a solenoid 36, for removing the barrier it normally presents to gas-flow.

A normally-open automatically-operable valve 38 is provided in the fuel-gas supply-pipe 4, before the inlet side of the valve 28. This valve 38 is moved to a closing position when an operating means comprising a solenoid 40 is energized. The restriction provided by the valve 38 in closing position is adjustably settable from a fully closed position in which no fuel-gas can flow through the length of the pipe 4, to any position offering a lesser barrier. When set to operate to fully closed position, the gas-supply to the reaction-chamber will have a preponderance of oxidizing gas, consisting entirely of air, when the solenoid 40 is energized.

While any noticeable effect produced by the carbon deposited in the catalyst of the reaction-chamber 14 can be used to control the solenoids 36 and 40, I prefer to use a device responsive to the obstruction which deposited carbon introduces to the flow of gas through the reaction-chamber. To this end, a pressure-operated switch-means 42 is provided responsive to the pressure-drop across the reaction-chamber. The switch-means 42 includes contacts 44 that close when the gas-pressure drop across the reaction-chamber is over a set value indicating an excessive gas-flow restriction, and that open when it is below that value, indicating the removal of such excessive restriction.

When the contacts 44 close, a circuit is completed from a conductor 46 of power line 48, through a conductor 50, through the closed contacts 44 to a junction point 52, from which two circuits branch.

A first of these circuits controls the air-flow through the branch piping 30 and comprises a normally-closed manually-operable switch 54, the solenoid 36, and a return conductor 56 which is connected to the other conductor 58 of the power line 48.

The other branch circuit which branches from the junction point 52 controls the flow of fuel-gas through the supply-pipe 4, and comprises a normally-closed manually-operable switch 60 and a conductor 62 which leads to a junction point 64. From this junction point 64, a circuit is connected to a timer apparatus, indicated in its entirety by the reference numeral 65, and shown schematically as comprising an electrical timer motor 66 having one energizing terminal connected to the junction point 64 and its other energizing terminal to a conductor 68 connected to the power conductor 58 through a normally-closed manually-operable switch 69.

The timer motor 66 is preferably one which runs at a constant but adjustable speed, and drives a pair of cams 70 and 72 which control normally-open switches 74 and 76, through a

detent 78 on the cam 70, and a detent 80 on the cam 72, respectively. The angular length of the detents can be adjustable.

Assume that the motor is rotating in the direction of the arrow shown. The cam 72 is so arranged that the detent 80 will close the switch 76 for completing a temporary locking circuit for the motor 66, through conductors 50 and 84, the switch 76, and conductor 68. This locking circuit remains closed until the detent passes the cooperating lug of the switch 76.

The switch 74 is in an obvious circuit-branch from the junction point 64, this circuit including the conductor 86 and the solenoid 40 for the valve 38. If the motor 66 rotates sufficiently, the detent 78 will close the switch 74, completing this circuit-branch so that the solenoid 40 will become energized if the motor holding circuit, including the conductor 84, is completed through the switch 76 to the junction point 64, or if the contacts 44 are closed, thereby completing a circuit path from conductor 50 to the junction point 64.

It is desirable to have the rotation of the detent 80 time-related to the operation of the switch 74 by the detent 78 so as to have the switch 76 closed during the time that the switch 74 is closed, in order to prevent surge conditions, arising out of changes in the gas-flow, from interfering with smooth operation of the timer.

In the operation of the system shown in Fig. 1, it may be initially assumed that the gas-supply to the gas-generator is slightly over-rich, the pores of the catalyst in the reaction-chamber are being slowly filled with free carbon, the fuel-gas valve 38 open but adjusted so as to be operable to fully closed position, and the air valve 34 in the branch 30 closed. When the accumulation of carbon in the catalyst, under such an operating condition of the system, is sufficiently great to cause the pressure-actuated switch-means 42 to close its contacts 44, the solenoid 36 is closed, opening the valve 34 and permitting additional air to flow to the constant pressure device 8, through the branch pipe 30, for changing to another operating condition of the system in which the ratio of the air to gas in the gas-supply is increased, depending on the position of switch 74. With the switch 74 open, so that the fuel-gas valve is open, the gas-supply should be slightly too lean, with sufficient oxidizing power to slowly consume deposited carbon in the hot catalyst. Assuming that the contacts 44 remain closed until the detent 78 of the cam 70 reaches and closes the switch 74, the solenoid 40 thereupon is energized for closing the fuel-gas valve 38, and again altering the operating condition of the system. The supply of fuel-gas is shut down and a preponderance of oxidizing gas, in this case in the form of substantially pure air, flows into the reaction-chamber for a time-period determined by the time the solenoid 40 remains energized.

The air-control solenoid 36 energizes immediately upon closure of the contacts 44 by the pressure-actuated switch-means 42 and remains energized when these contacts are closed. Energization of the air-control solenoid 36 without energization of the fuel-gas-control solenoid 40 permits a relatively lean oxidizing mixture to flow through the reaction-chamber 20 for slowly consuming carbon, primarily in the part of the reaction-chamber appreciably beyond the inlet end. When the solenoid 40 is subsequently

energized, the preponderance of the oxidizing power of the gas is greatly increased and carbon in the inlet portion of the catalyst is consumed more rapidly than elsewhere.

When the consumption of carbon has progressed to a suitable degree, the pressure-actuated switch-means 42 restores to a position opening contacts 44.

Unless the switch 76 happens to be closed, opening of the contacts 44 causes the solenoid 36 and timer 65 to become deenergized, the air valve 34 to restore to its initial closed condition, the timer motor to stop in whatever position it is in, and the original rich supply-mixture to be restored.

If the switch 76 happens to be closed when contacts 44 open, in the embodiment disclosed in which the switches 74 and 76 operate substantially together, the solenoid 40 will be energized, cutting off the supply of fuel-gas, but only so long as the locking circuit switch 76 is closed while the switch 74 is closed. If the contacts 44 open before the detent 78 has reached the switch 74, the timer motor will stop at a particular place, awaiting the next closure of the pressure-actuated switch-means 42. Accordingly, it requires an integrated closure time of the contacts 44 of the switch-means 42, before the solenoid 40 is actuated. This may require several operations of the switch-means 42. To have a single operation of the switch 74 during one revolution of the cam 70, only a single detent equivalent to 78 is provided on the cam 70, in which case the integrated closure time is substantially that of a complete revolution of the cam 70 by the timer motor. Accordingly, for each revolution of the cam 70, gas-supply consisting of an air shot will be provided, either before the relatively lean gas-supply if the switch 74 is closed substantially simultaneously with the contacts 44, or superseding it for a time if the switch 74 is closed later.

In Fig. 2, however, a holding circuit 90 is provided for causing the timer motor 66′ to go through one or more complete revolutions whenever the pressure-actuated switch-means 42′ is actuated for simultaneously closing the contacts 44′ and 44″. This holding circuit includes a switch 91 which is normally open when the motor 66′ is stationary in a predetermined position, but completes a motor-energizing circuit in all other positions of the motor, in any well-known manner. One revolution will be made when the switch-means 42′ closes the contacts 44″ for a period less than the time of a revolution of the cams 70′ and 72′. If the contacts 44′ and 44″ remain closed after the timer motor 66′ has completed a single revolution, the timer will continue upon a second complete revolution and so on, stopping only after it completes the particular revolution in which the pressure-actuated switch-means 42′ releases or opens its contacts.

Fig. 2 differs from Fig. 1 also in the fact that the solenoid 36′ is actuated only during closure of the contacts of the pressure-actuated switch-means 42′, while the solenoid 40′ is actuated at least once for each closure of these contacts.

In Fig. 2, the cam 70′ has a detent 78′ which is adjusted to maintain the switch 74′ in normally closed position when the timer motor 65′ stops so that the air shot for the reaction-chamber occurs immediately upon the closure of the pressure-actuated contacts 44′ and 44″. Any other adjustment can obviously be provided. After the detent 78′ has passed the cooperating lug of

the switch 74', the latter opens and the solenoid 40' deenergizes, restoring the flow of fuel-gas through the fuel-gas supply-pipe. In the meantime, if the pressure drop or differential across the reaction-chamber has not been decreased to the proper extent, the solenoid 36' remains energized through contacts 44', allowing the relatively leaner mixture of fuel-gas and air to flow to the reaction-chamber immediately after the air shot stops.

Apparatus in accordance with the foregoing is also useful for controlling the "carbon pressure or potential" of the gas, since numerous adjustments are possible.

If a high "carbon pressure" product-gas is desired at all times, the air shots may be made independent of the gas-pressure control system. Specifically, referring to Fig. 1, they can be made independent of the pressure-actuated switch-means 42 by opening the normally-closed switch 60 and closing a manually-operable normally-open switch 92 paralleling the locking circuit switch 76. Under these connections, the timer motor 66 is continuously energized and, therefore, continuously rotates so as to periodically supply an air shot to the reaction-chamber while the supply of relatively leaner mixture remains under control of the pressure-actuated switch-means 42. Independently timed air shots can be used where the carbon deposits quite densely at the inlet end, as it usually will with a gas-supply to the gas-generator which is entirely or mostly extremely rich. By opening the switch 54 also, the time-controlled air shots alone will be supplied at regular intervals.

If a medium or low value of "carbon pressure" is desired, as it might be for some heat-treating processes, air shots would not only be unnecessary but undesirable since the relatively rich gas-supply would not be sufficiently rich to cause appreciable carbon deposits even over extended periods of time. By leaving switches 60, 69, and 92 open, air shots are prevented.

With switches 60, 69 and 92 open, and switch 54 closed, the system becomes substantially that shown in the aforesaid joint application of Peck and myself, insofar as the general sequence of control operations is concerned.

By leaving switches 54 and 92 open and switches 60 and 69 closed, the operation of the system becomes practically like that of my aforesaid sole application, except usually for the timing of the air shots and the adjustments of the proportions of air and gas in the gas-supply during the different settings of the gas-flow determining or controlling devices.

Because of the variations in the kind of fuel-gas used in practice, and in its pressure, composition, and other variables, it is difficult to set forth exact conditions of operation for all applications. Generally, in the aggregate, for the more common uses of the apparatus, the rich carbon-depositing mixture is on from periods of three minutes to three hours and more, and the lean carbon-consuming mixture from three minutes to one hour, approximately. Air shots persist for about fifteen seconds to as much as two minutes or more, every ten minutes to two hours, approximately. A specific example of a system utilizing this invention with a reaction-chamber slightly more than three feet long, having a capacity of one thousand cubic feet of product-gas per minute, used a fuel-gas comprising a mixture of 60% coal gas and 40% water gas, the former having a composition in percentages of 2.9 CO_2, 2.9 illuminants, .6 O_2, 14.4 CO, 25.1 CO_2, 49.4 H_2 and the balance N_2; and the latter 4.5 CO_2, 9.7 illuminants, .6 O_2, 31.1 CO, 15.7 CH_4, 32.4 H_2, and the balance N_2. Air and fuel-gas were reacted in volume ratios of 1 of air to 3 of fuel-gas for from fifteen to eighteen minutes and shifted to a ratio of 1:1 for about fifteen to twenty-two minutes in repeating cycles. Approximately one minute air shots were supplied every totalized fifteen minutes of relatively lean mixture flow. When the gas-supply ratio was 1:3, the product-gas had a dew point of 3° F. and a composition in percentages of 25.8 CO, .3 CO_2, 1.4 CH_4, 51.7 H_2, balance N_2; and in a ratio of 1:1, the product-gas had a dew point several degrees higher and a composition in percentages of 28.2 CO, .2 CO_2, .8 CH_4, 34.7 H_2, balance N_2. For this operation, a fifteen-second air shot was required about every fifteen minutes of lean-mixture flow.

I have found, by tests, that the effect of substantially pure air is to react quickly with carbon, even in the entering section of the porous catalyst 9. This is probably true because the reaction between air and carbon is exothermic, resulting in sufficient heating to carry on the reaction even in the absence of preheating of the air. In fact, the time during which the passage of air is permitted must be carefully limited to a short time-interval, so as to reduce the localized, excessive temperatures which may otherwise become sufficiently high to be injurious to the equipment, if the rapid oxidation of the carbon were permitted to continue for any extended length of time.

The product-gas, during this period of air-operation, will consist essentially of a mixture of nitrogen and carbon monoxide, without any hydrogen. This is another reason why the period of operation, with air only, should be short, so as not to greatly change the nature of the product-gas which is accumulated in the container (not shown) which is fed by the outlet-pipe 18 of the gas-generator. It will be understood, of course, that this outlet-gas can be diverted to the atmosphere or to another container, if it should not be dseirable or permissible to mix it with the regular product-gas of the apparatus.

While I have described my invention in forms which are now preferred, it is obvious that many modifications can be made therein and equivalent parts substituted for those symbolically and schematically shown. Thus, for example, although the devices 42 and 42' have been described as "pressure responsive devices," the term, pressure responsive device, and similar expressions, include a device actuable otherwise than directly by pressure so long as it is responsive to, or reflects, pressure.

I claim as my invention:

1. A method of manipulating a gas-generating apparatus; said apparatus comprising a porous catalyst bed having some carbon deposited within its pores, a gas-supply means for forcing a mixture of two gases through said catalyst, richness-regulating means for varying the proportions of the gases in said mixture, and means for adding heat to said mixture while it is undergoing a reaction within the pores of said catalyst; said method comprising periodically forcing, through said catalyst, in a predetermined direction, a mixture of a carbonaceous fuel-gas and air in an amount less than necessary to oxidize, to carbon-monoxide, the carbon content of the mixture so that additional free carbon will be slowly deposit-

ing within the pores of the catalyst; and before the deposited carbon clogs the apparatus, forcing through said catalyst in said direction, instead of the first-mentioned mixture, another mixture of said gases having a relatively greater amount of air than said first mixture for partially oxidizing the carbon-deposit within the pores of the catalyst; and periodically, for brief intervals, forcing through the catalyst in said direction, a gas-supply composed substantially entirely of air for consuming carbon deposited at the gas-entrance end of the catalyst.

2. A method for continuously producing a product-gas utilizable for a special atmosphere in a heat-treating furnace, by the reaction of air and a fuel-gas comprising hydrogen and carbon, which method comprises a plurality of steps operating under a pre-arranged control, said steps comprising passing a gas-supply of the fuel-gas and air into a gas-porous heated catalyst in a predetermined direction, the fuel-gas and air being in amounts such that free carbon will be deposited in said catalyst, and product-gas produced, with the deposit being more dense at a gas-inlet point in the catalyst than at other places therein, passing a leaner gas-supply of the fuel-gas and air into the catalyst, in said direction, for providing product-gas and for consuming deposited carbon in the catalyst beyond said gas-inlet point, and passing, for a brief interval, a still leaner gas-supply into the catalyst for reacting more strongly with said dense carbon deposit.

3. A method for continuously producing a product-gas of a type described, utilizable for a special atmosphere in a heat-treating furnace, by the reaction of air and a combustible fuel gas comprising hydrogen and carbon, which method comprises passing, in a predetermined direction, a mixture of a fuel gas and air through a gas pervious heated catalyst bed in amounts such that free carbon will be deposited in said catalyst bed and product-gas produced, the deposited carbon restricting the flow of the gas mixture through the catalyst bed, repeatedly interrupting the flow of the gas mixture, and during some interruptions supplying air to said catalyst bed, the last said interruptions being for brief periods for consuming deposited carbon at the gas-entrance end of the catalyst bed, and during remaining interruptions supplying a mixture of fuel gas and air, the last said mixture being more oxidizing than the first said mixture for consuming carbon in the catalyst bed, and continually withdrawing said product-gas from said catalyst bed.

4. A gas-generator comprising, in combination, an oxidizing-gas supply-means including an oxidizing-gas conduit for supplying an oxidizing gas, a fuel-gas supply-means including a fuel-gas conduit for supplying a carbonaceous fuel-gas, a valve in said fuel-gas conduit, means for mixing the gases from said conduits, a reaction-chamber having a porous catalyst filling, an inlet-conduit for supplying said mixture to said reaction-chamber, an outlet-conduit for said reaction-chamber, means for heating said reaction-chamber, means for maintaining a substantially constant rate of gas-flow through said reaction-chamber, a pressure-responsive means, including a conduit-connection to said inlet-conduit, for responding to changes in the resistance to gas-flow through said reaction-chamber, and means operatively connected and responsive to said pressure-responsive means for operating said valve in the fuel-gas conduit.

5. A gas-generator comprising, in combination, an oxidizing-gas supply-means including an oxidizing-gas conduit for supplying an oxidizing gas, a fuel-gas supply-means including a fuel-gas conduit for supplying a carbonaceous fuel-gas, means for mixing the gases from said conduits, a reaction-chamber having a porous catalytic filling, an inlet-conduit for supplying said mixture to said reaction-chamber, an outlet-conduit for said reaction-chamber, means for heating said reaction-chamber, means for maintaining a substantially constant rate of gas-flow through said reaction-chamber, a pressure-responsive means, including a conduit-connection to said inlet-conduit, for responding to changes in the resistance to gas-flow through said reaction-chamber, and means operatively connected and responsive to said pressure-responsive means, for substantially shutting off the flow of gas through said fuel-gas conduit.

6. The invention as defined in claim 4, in combination with timer-means, responsive to said predetermined pressure-response, for thereafter maintaining said valve-operation for a predetermined fixed period of time.

7. The invention as defined in claim 5, in combination with timer-means, responsive to said predetermined pressure-response, for thereafter keeping the flow of gas through the fuel-gas conduit shut off for a predetermined short fixed period of time.

8. The invention as defined in claim 4, in combination with means associated with the oxidizing-gas and fuel-gas conduits for varying the relative proportions of the oxidizing gas and the fuel-gas delivered therefrom.

9. The invention as defined in claim 5, in combination with means associated with the oxidizing-gas and fuel-gas conduits for varying the relative proportions of the oxidizing gas and the fuel-gas delivered therefrom.

10. A gas-generator comprising, in combination, an oxidizing-gas supply-means including an oxidizing-gas conduit comprising a valve therein, for supplying an oxidizing gas, a fuel-gas supply-means including a fuel-gas conduit for supplying a carbonaceous fuel-gas, a valve in said fuel-gas conduit, means for mixing the gases from said conduits, a reaction-chamber having a porous catalytic filling, an inlet-conduit for supplying said mixture to said reaction-chamber, an outlet-conduit for said reaction-chamber, means for heating said reaction-chamber, a device responsive to pressure of gas in said inlet-conduit, means operated by said device for operating said oxidizing-gas valve, an electrical mechanism energizable for operating said fuel gas valve, a timer, a circuit including said electrical mechanism and a switch, and operable means for opening and closing said switch, the last said means being operated by said timer.

11. A system for supplying a protective atmosphere to heat-treating furnaces, comprising a reaction-chamber adapted to contain a catalyst promoting the oxidation of a fuel gas, an outlet conduit from said reaction chamber, an inlet conduit to said reaction-chamber, a first branched conduit thereto for the supply of fuel gas, a second branched conduit thereto for the supply of oxygen to mix with said fuel gas in said inlet conduit, a first valve means in said second branched conduit, a supply line for air connected to said inlet conduit between said first valve means and said reaction chamber, an automatically operated valve in said supply line, means connected to said inlet conduit and responsive to

changes in pressure in said inlet conduit for operating said valve, an automatically operated valve in said fuel gas branch conduit, means arranged to close said fuel gas valve momentarily likewise actuated by said means responsive to changes in pressure, and effective during an extended period of opening of said first valve.

12. A gas-generator comprising, in combination, an oxidizing-gas supply-means including an oxidizing-gas conduit for supplying an oxidizing gas, a fuel-gas supply means including a fuel-gas conduit for supplying a carbonaceous fuel gas, a valve in said fuel-gas conduit, means for mixing the gases from said conduits, a reaction chamber having a porous catalyst filling, an inlet-conduit for supplying said mixture to said reaction-chamber, an outlet-conduit for said reaction-chamber, means for heating said reaction-chamber, a pressure-responsive means, including a conduit-connection to said inlet-conduit, for responding to changes in the resistance to gas-flow through said reaction-chamber, and means operatively connected and responsive to said pressure-responsive means for operating said valve in the fuel-gas conduit.

13. A gas-generator comprising, in combination, an oxidizing-gas supply-means including an oxidizing-gas conduit for supplying an oxidizing gas, a fuel-gas supply-means including a fuel-gas conduit for supplying a carbonaceous fuel-gas, means for mixing the gases from said conduits, a reaction-chamber having a porous catalytic filling, an inlet-conduit for supplying said mixture to said reaction-chamber, an outlet-conduit for said reaction-chamber, means for heating said reaction-chamber, a pressure-responsive means, including a conduit-connection to said inlet-conduit, for responding to changes in the resistance to gas-flow through said reaction-chamber, and means operatively connected and responsive to said pressure-responsive means, for substantially shutting off the flow of gas through said fuel-gas conduit.

14. The invention as defined in claim 12, in combination with timer-means, responsive to said predetermined pressure-response, for thereafter maintaining said valve-operation for a predetermined fixed period of time.

15. The invention as defined in claim 13, in combination with timer-means, responsive to said predetermined pressure-response, for thereafter keeping the flow of gas through the fuel-gas conduit shut off for a predetermined short fixed period of time.

16. A system for supplying a protective atmosphere to heat-treating furnaces, comprising a reaction-chamber adapted to contain a catalyst promoting the oxidation of a fuel-gas, an outlet conduit from said reaction chamber, an inlet conduit to said reaction-chamber, a first branched conduit thereto for the supply of fuel gas, a second branched conduit thereto for the supply of oxygen to mix with said fuel gas in said inlet conduit, a first valve means in said second branched conduit, a supply line for air connected to said inlet conduit between said first valve means and said reaction chamber, an automatically operated valve in said supply line, means connected to said inlet conduit and responsive to changes in pressure in said inlet conduit for operating said valve, and a timer means arranged to actuate said automatically operated valve in the fuel gas branch conduit to close same for a predetermined short fixed period of time.

JOHN G. HOOP.

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2,301,812	Rentschler et al.	Nov. 10, 1942