United States Patent Office

3,071,454

Patented Jan. 1, 1963

3,071,454

APPARATUS FOR REFORMING GASES

Charles R. Kuzell, Phoenix, Morris G. Fowler, Douglas, Leonard Klein, Scottsdale, and John H. Davis, Jr., Douglas, Ariz., assignors to Phelps Dodge Corporation, New York, N.Y., a corporation of New York

Filed Aug. 4, 1960, Ser. No. 47,444

5 Claims. (Cl. 48—196)

This invention relates to gas reforming and more particularly to apparatus for reforming natural gas to produce a gas having gaseous components different from those initially present in the natural gas.

When gases such as natural gas, or other combustible hydrocarbon gases of similar nature, are burned under certain conditions with insufficient air to carry the combustion to completion the gas is reformed and the hydrocarbon components may be caused to be reformed to produce a reformed gas containing substantial amounts of other gaseous components such as hydrogen, and carbon monoxide. The reformed gases containing hydrogen (H_2) and carbon monoxide (CO) are known to be more suitable for carrying out certain desired reducing reactions than the natural gas itself or the other hydrocarbon gases of similar nature in their initial or "raw" (unreformed) state. Consequently, it is often desired to produce such reformed reducing gases when a subsequent gaseous reduction reaction is to be carried out. This is particularly true in the metallurgical and metal refining arts, although the reformed gas may be effectively used in other industrial arts and processes.

This invention provides a method and apparatus admirably suited to produce reformed gas containing desired, substantial amounts of CO and H_2 from hydrocarbon gases, such as natural gas, in which these very reactive reducing gases are not initially present in the raw gas.

For convenience of description, the invention will be described in connection with reforming natural gas, but it will be understood that the invention is not confined to the treatment of natural gas, since the apparatus may be useful in reforming other hydrocarbon gases of similar kind. Also, the natural gas which is charged to the apparatus for reforming is, for convenience of description, referred to herein as "raw" gas, although it may have been subjected to previous treatment such, for example, as chemical or other treatment for the purpose of removing sulfur or other constituents which may be considered as impurities or, at least, not wanted in the final reformed gas product.

According to the invention there is provided a reaction chamber containing a suitable catalyst, and a carburetor of particular design and construction for mixing cold or preheated raw hydrocarbon gas with a predetermined and controlled quantity of cold or preheated air and for introducing the air-gas mixture into the reaction chamber wherein is brought about a desired but incomplete combustion of the hydrocarbon components of the raw gas so that the carbon content is reformed to free CO which becomes a component in the final reformed gas product and the hydrogen content of the raw hydrocarbon gas in combined form is reformed to free H_2 which is also a component of the final product. The nitrogen of the air, being inert, remains as such in the final product.

The carburetor is of novel construction and is connected to the reaction chamber and arranged in such manner that backfiring, which was a drawback in prior known burners or mixers, is eliminated. Furthermore, the arrangement of the reaction chamber, its contained catalyst and the carburetor is such that unwanted carbon formation in the catalyst chamber is eliminated, this unwanted carbon formation having always been a serious drawback in prior art practice.

Although the novel features which are believed to be characteristic of the invention are pointed out in the annexed claims, the invention itself as to its objects and advantages and the manner in which it may be carried out may be better understood by reference to the following description taken in connection with the accompanying drawings, forming a part hereof, in which

FIG. 1 is a view in elevation and partly diagrammatic of apparatus embodying our invention;

FIG. 2 is a view in section and to larger scale of the furnace or catalytic chamber and the carburetor connected thereto;

FIG. 3 is a view on line 3—3 of FIG. 2;

FIG. 4 is a view on line 4—4 of FIG. 2;

FIG. 5 is a view on line 5—5 of FIG. 2;

FIG. 6 is a view in elevation of the carburetor on line 6—6 of FIG. 1; and

FIG. 7 is a view in section on line 7—7 of FIG. 6.

Referring now to the drawings, in which like reference characters throughout the several views indicate like parts, the apparatus, as shown, comprises a carburetor 12 into which the air and raw gas are intermixed and a reaction furnace 13 providing a reaction chamber 20 containing catalyst 21 into which the air and hydrocarbon gas mixture is passed and in which the hydrocarbon gas is reformed.

Air is delivered to the carburetor 12 through an air inlet conduit 15 and raw natural gas is delivered to the carburetor through a gas inlet conduit 16. An air preheater 10 (shown conventionally) of known construction and of a kind which will heat atmospheric air passed therethrough to a temperature up to 1600° F. or higher, may be used to improve reformed gas composition. Likewise the preheater 11 (shown conventionally) of known construction and of a kind which will preheat the natural gas to a temperature up to 1000° F., or higher, may be used to improve reformed gas composition and elevate its temperature. It will be understood that the air is drawn from the atmosphere and the natural gas is supplied from a suitable source.

The carburetor 12 may be made of any suitable material but preferably and, as shown, is stainless steel. It comprises a cyclone type of air inlet chamber 22. The air chamber 22 is bounded by a cylindrical wall 23 closed at its upper end by a dome-shaped cap portion 24 having an access hole 25 closed during reforming operation. Extending downwardly from the cylindrical sidewall portion 23 is a tapered portion 26 in the form of a truncated cone. Extending downwardly from the lower, and smaller, end of the truncated cone portion 26 is a cylindrical air-gas mixing chamber portion 27 of a diameter smaller than the diameter of the air inlet chamber 22. The lower end of the mixing chamber portion 27 is secured, as by welding, in a suitable aperture 28 in the center of a carburetor mounting flange 29. An air-gas mixture conduit comprising a pipe nipple 30, threaded at its upper end, is screwed into a female threaded bore in the carburetor mounting flange. This air-gas conduit provides communication between the air-gas mixture chamber 31 provided by the cylindrical portion 27 and delivers the air-gas mixture into the reaction chamber. The air-gas delivery conduit 30, as described in further detail hereinafter, extends into the catalyst mass in the reaction chamber 20.

The air inlet conduit 15, which communicates with air chamber 22, is secured to the side wall 23 and is placed in tangent position so that air forced through conduit 15 will be given a swirling or cyclone motion as it passes through chamber 22 into the air-gas mixing chamber 31. Air inlet conduit 15 is provided with a flange 32 for connection to the air conduit 33 from the air source.

The raw gas inlet 16 communicates with an annular