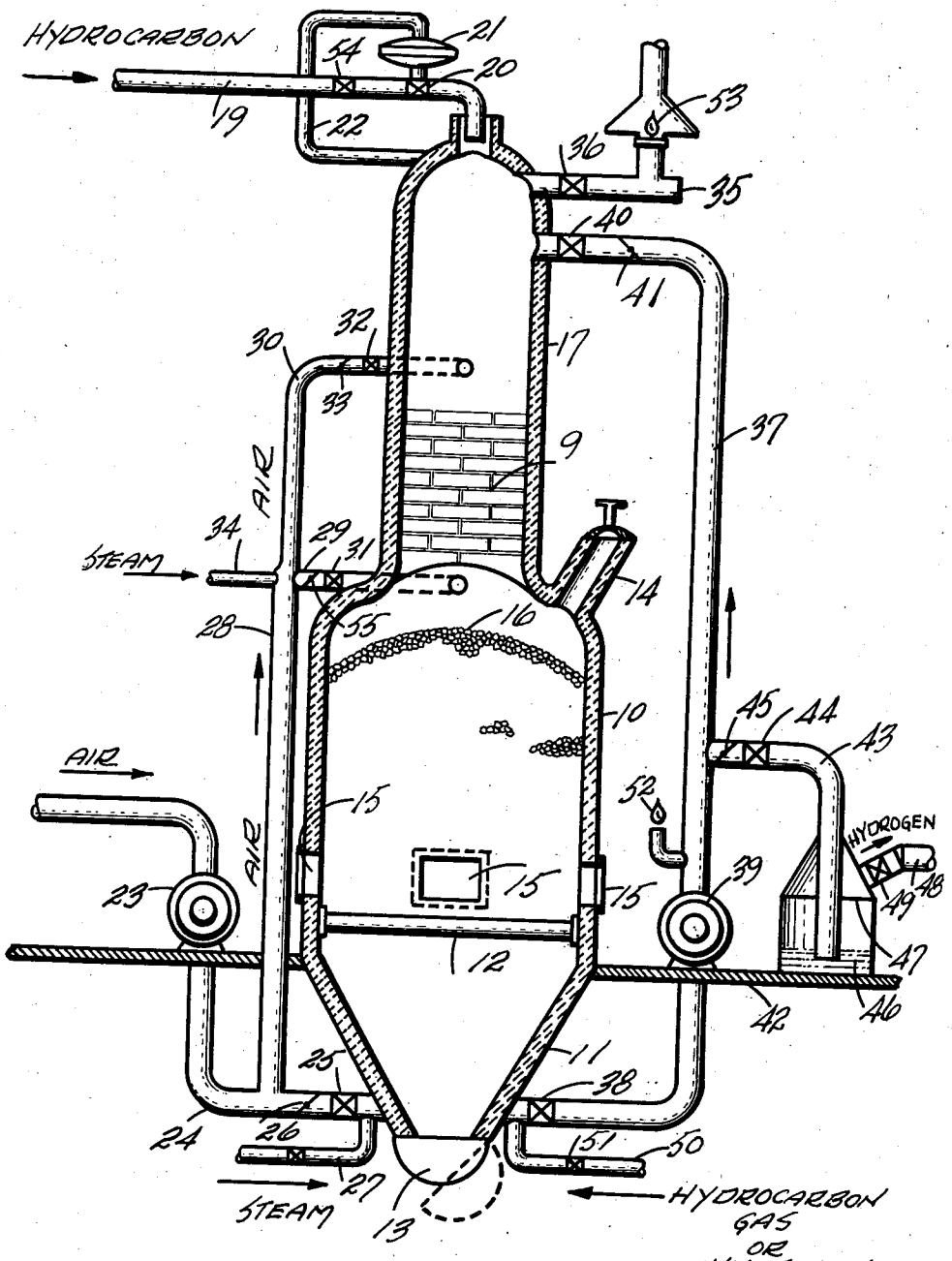
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APPARATUS FOR MAKING HYDROGEN

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APPARATUS FOR MAKING HYDROGEN

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3 Claims. (Cl. 23—212)

This application is a division of my co-pending application Serial No. 169,662, filed October 18, 1937, which has matured into Patent #2,200,607, May 14, 1940, for a method and apparatus for making pure hydrogen.

This invention relates to an apparatus for making hydrogen of exceptional purity. The object of the invention is to provide an apparatus which is exceptionally suited for carrying out the process described in the application above referred to. Other objects are to provide an apparatus of this kind which is semi-automatic in operation and from which an exceptionally pure grade of hydrogen, pure enough for the hydrogenation of oil, can be bled off continuously.

Other objects of the invention are to provide an apparatus which can be easily and thoroughly purged of air before making hydrogen and which can be built by the comparatively slight alteration of common forms of apparatus to provide a convenient automatic generator of this class which is capable of withstanding considerable internal pressures.

For assistance in understanding the invention, the process to be carried out in the apparatus is also here described.

Briefly stated, my process comprises forcing a crackable aliphatic hydro-carbon for example, methane, ethane, propane, butane or high grade natural gas through a primary cracking zone of heated checkerbrick then through a deep bed of solid carbonaceous fuel maintained at least partially at incandescence and withdrawing the cracked gas from the lower end of the fuel bed, and then recycling the free hydrogen-rich gas thus obtained again through the checker work and the fuel bed until the desired degree of purity has been obtained. The product may then be stored while another cycle is run or the entire yield may be recycled. It is, of course, necessary to reheat the checker work and the fuel bed at intervals by blasting with air and the apparatus must be purged of air after such blowing, so as to avoid nitrogen compounds and CO in the hydrogen, which are objectionable.

Referring to the drawing, the figure is an elevation of the apparatus partly in longitudinal section.

10 is a generator, refractory lined, having a conical bottom 11, a grate 12, a bottom discharge 13 and a side charging chute 14. Suitable clinkering doors 15 are provided. A bed of fuel 16 preferably of coke, is carried within the retort and should be of at least four feet in depth, but a depth of about ten feet is preferable. There is no upper limit as to depth. Extending vertically above the generator there is a dome 17, the interior of which is refractory lined and communicates with the interior of the generator. The lower part of the dome, say from one-third to one half of its height, is filled with refractory brick checkwork, 1, which comprises about 50% of voids.

At the top of dome 17, there is a pipe 19 for the admission of the hydro-carbon to be cracked. The process and apparatus will be described as for handling butane, but any skilled chemical engineer in possession of this disclosure can regulate conditions to use the others named, or even commercial gasoline, kerosene, gas oil or distillate, pipe 19 therefore handles liquid butane which may be shut off in the pipe or allowed to flow by the action of a snap valve 20 controlled by a diaphragm 21, which is in turn controlled by a pressure existing within a dome 17, but which is so communicated to the diaphragm through a small pipe 22. Air is supplied to the generator by means of a horizontal pipe 24 in which there is both a conventional shut off valve 25 and a butterfly valve 26. A steam supply pipe 27 enters air pipe 24 in advance of the shut off valve 25. Behind butterfly valve 26 there is a riser pipe 28 for the delivery of secondary and tertiary air to the dome. The purpose of the secondary air is to burn the producer gas made by blasting the fuel bed and also the carbon from the checker work during the heating operations. This combustion creates considerable carbon monoxide which is subsequently burned to the dioxide with the tertiary air. Pipe 29 is therefore arranged to enter just below the checker-work to deliver secondary air and pipe 30 just above the checkerwork to deliver the tertiary air. Pipe 29 contains shut off valve 31 and pipe 30 contains a shut off valve 32 and a butterfly valve 33 just behind it. Steam may be supplied to pipe 29 through a pipe 34 which enters riser pipe 28 opposite pipe 29. In pipe 29 there is a butterfly valve 55 in addition to a shut off valve.

The exit of waste gases from the dome 17 may occur through a flue pipe or stack 35 in which there is a shut off valve 36, or gases may be recycled from the conical bottom 11 to the dome 17 through second riser pipe 37 in which there is a shut off valve 38 in the lower portion near the generator, an exhauster 39 and a shut off valve 40 and butterfly valve 41 near the dome. A convenient arrangement for the entire apparatus is to have the operating floor of the build-

ing at the approximate level of the top of the conical portion of the generator and below the grate therein. Such floor, 42, in the drawing will be adapted to support the blower 23 and exhauster 39 at a convenient height.

At a point above exhauster 39 a delivery pipe 43 containing a shut off valve 44 and a butterfly valve 45 taps riser pipe 37 and leads to below the liquid level 46 of wash box 47 which rests upon the operating floor. This box has an outlet pipe 45 in which there is a shut off valve 49.

For purging the apparatus there is a bottom inlet pipe 50 having a shut off valve 51 which enters riser pipe 37 between valve 38 and the generator. A test flame 52 is provided in the pipe 37 between the exhauster and the pipe 43. By means of this flame or analyzing apparatus, the kind and approximate purity of hydrogen gas may be estimated by qualified engineers. Or, this purity may be followed by continuously weighing a container of known weight and volume through which the gas continuously flows.

The cycle of operations is as follows:

The generator having been filled with maintenance fuel (i. e., that fuel which is charged into the generator for the purpose of providing a bed of hot carbon) and valves 25, 26 and 36 being open and all the rest closed, the fuel is ignited and blown with air from the blower 23 until the fuel bed is at approximate incandescence. Valve 31 is opened and secondary air admitted through pipe 29 to allow producer gas to burn and heat the checker work. Tertiary air is admitted also through pipe 30 by opening valves 32 and 33. The amounts of secondary and tertiary air are regulated by means of butterfly 33 and no more is admitted than is necessary to burn the carbon monoxide below and above the checkerwork, to carbon dioxide. Both air inlets are so arranged that the stream of air is directed substantially tangentially to the shell of the generator.

After incandescence to the extent of about 2600° F. has been attained in the fuel bed and the checker brick in the dome has attained about 2000° F., the operation of purging may then begin.

Blower 23 is then shut down and valves 25, 31 and 32 are closed. Sufficient steam is now admitted through pipe 27 to purge air from the base below the grate only. Butane gas is then admitted through pipe 50 so as to crack to hydrogen within the fuel bed, and this hydrogen rises and purges all blast products through the open stack 35. After pure hydrogen only is passing up stack 35 as indicated by the test flame 23, stack valve 36 is closed and liquid butane is allowed to flow into pipe 19. Valves 38 and 40 are now opened simultaneously, butterfly 41 being partly open. Exhauster 39 is started which recycles hydro-carbon purge gas to the top of the dome to be adjusted on passage through the hot checkerwork. Valve 44 is then opened and butterfly 45 cracked to allow hydrogen to pass into the wash box 47, the butterfly valve 45 in pipe 43 being used to control the pressure in the retort. It is set to exceed the back pressure of the wash box. Due to the fact that there is a thermal expansion of the butane gas after it is fed in, and later undergoes secondary expansion due to the "swell" in volume caused by cracking, it is desirable that the apparatus be built to be able to withstand high pressure. A predetermined amount of butane is admitted per cycle to reach the maximum pressure desired, to accommodate the expansion in volume described. The setting of butterfly 45 should be high enough to hold this pressure. The setting of butterflies 45 and 41 are controlled in accordance with the indications of the test flame 52 or suitable mechanical or chemical testing devices. If this shows that pure hydrogen is not being produced the butterflies are opened further to recycle more gas. Fluid hydro-carbon material is now admitted through the top of the dome in quantities governed by the diaphragm regulator 21 which allows sufficient liquid butane to enter the retort to replace the butane lost by the exit of hydrogen from the previous cycle through pipe 48 to a gas holder (not shown).

Operation is now continued until the drop in the temperature of the fuel bed requires excessive recycling through the pipe 37 by reason of the fuel bed not being hot enough to crack the hydrocarbon completely to occur. When this condition occurs the butane supply is shut off by a valve 54 and valves 40 and 38 are closed. Exhauster 39 is shut down. Purging steam is admitted through pipe 27 sufficient to purge only the hydrogen from below the grate. Blower 23 is now operated, then stack valve 36 and likewise butterfly 26 and secondary and tertiary air admitted by means of valves 31 and 32 as desired. When this blasting or reheating step is complete, the hydrogen-making cycle is again restarted. Very little maintenance fuel will be required because almost all of the fuel consumed in the process will be carbon which has been deposited in the interstices of the fuel bed by the cracking of the butane.

I claim as my invention:

1. An apparatus for producing pure hydrogen comprising a generator adapted to contain a deep bed of incandescent fuel, a dome above said generator, means for supplying air and steam to said generator, means for supplying hydrocarbons to said dome to a point adjacent the upper part of said checkerwork, means for voiding purged gases from said generator and piping from the lower portion of said generator directly to the upper part of said dome adapted to recycle said gas after passage through said fuel bed directly to said dome, an exhauster connected in said piping to so move said gas and an exit pipe connected to said recycling piping for voiding hydrogen.

2. An apparatus for making pure hydrogen which comprises a generator, a grate in the lower portion thereof, a dome above said generator and connection interiorly therewith, brick checkerwork in said dome, a blower and piping adapted to deliver air selectively below said grate, just below said checkerwork and just above said checkerwork, a vent pipe at the top of said dome, a pipe adapted to deliver hydrocarbon to be cracked to the top of said dome, means for admitting steam at the bottom of the generator and just below the checkerwork, means for admitting purging gas at the bottom of said generator, means including piping and an exhauster for recycling gas from the bottom of the generator to substantially the top of the dome and means for voiding gas during the recycling operation.

3. An apparatus for producing pure hydrogen comprising a generator adapted to contain a deep bed of incandescent fuel, a dome above said generator, refractory checkerwork in said dome, means for supplying primary and secondary air selectively to said generator and secondary and tertiary air selectively to said dome, a vent pipe at the top of said dome, a pipe adapted to de-

liver liquid hydrocarbon to be cracked, to the top of said dome, a pressure responsive valve in said pipe, a pressure transmitting pipe connecting said valve and the interior of said dome whereby the supply of liquid hydrocarbon is cut off when the pressure rises to a predetermined level within said dome, means for admitting steam at the bottom of said generator and also just below said dome, means for admitting purging gas at the bottom of said generator, gas-recycling means including piping and an exhauster, an outlet pipe and a wash box for voiding gas during the recycling operation and means for blasting the said fuel bed with air.

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