May 18, 1937. J. R. ROSE 2,080,930

APPARATUS FOR THE TREATMENT OF HYDROCARBON FLUIDS

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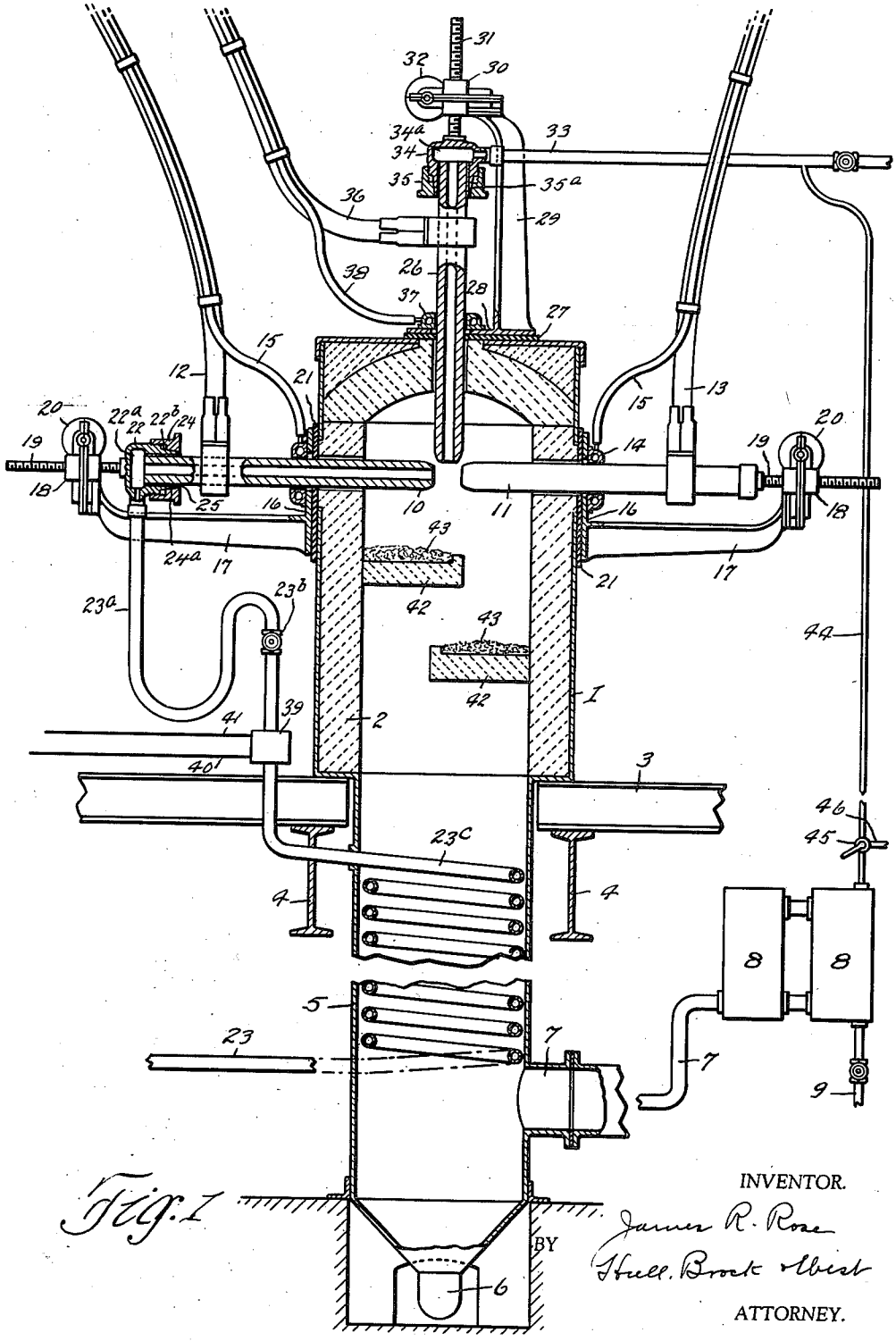


Fig. 1

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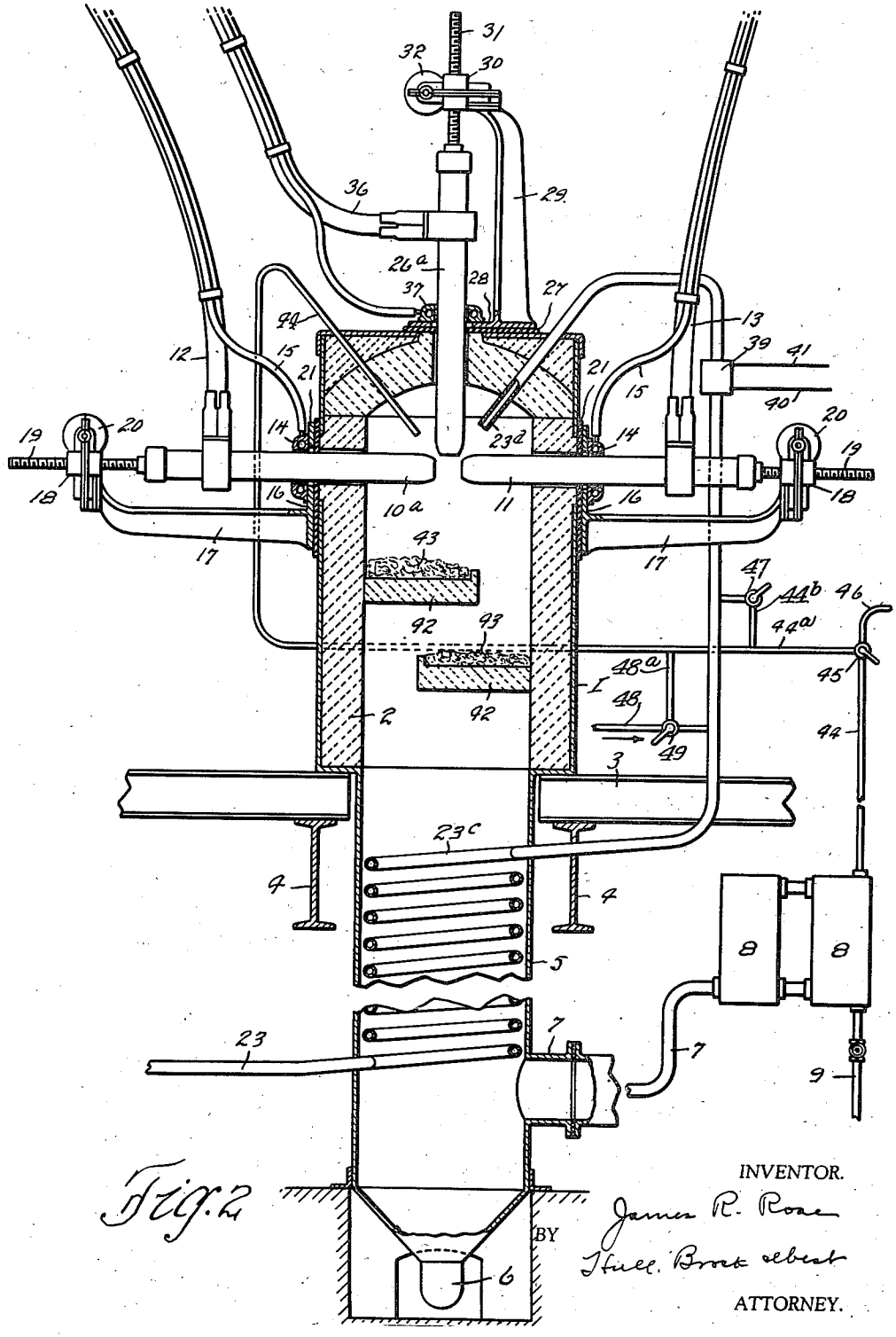


Fig. 2

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UNITED STATES PATENT OFFICE

2,080,930

APPARATUS FOR THE TREATMENT OF HYDROCARBON FLUIDS

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Application December 20, 1935, Serial No. 55,388

8 Claims. (Cl. 204—31)

This invention relates to apparatus for the treatment of hydrocarbon fluids. While the apparatus is applicable to, and has for its general object, the treatment of various gases for the purpose of recovering different and useful products therefrom, the apparatus shown herein is particularly well adapted to carry out the process of recovering benzene from hydrocarbon fluids including natural gas or methane constituting one of the limited objects of my application Serial No. 55,387, filed December 20, 1935. Further and more limited objects of the invention will appear in the specification forming a part hereof and will be set forth in the claims appended hereto.

In the drawings, Fig. 1 shows in vertical section a furnace or reaction chamber constructed in accordance with my invention, the view also showing, on a reduced scale, a diagrammatic illustration of an apparatus for separating and absorbing a product (such as benzene) which is liquid at ordinary atmospheric temperatures; Fig. 2 is a view, similar to Fig. 1, showing a modification of the furnace structure illustrated in the former view.

Describing by reference characters the apparatus shown in Fig. 1, 1 denotes the outer metallic wall of the upper section of an electric furnace or reaction chamber, having therein a lining 2, preferably of carbon blocks. This upper section is shown as resting on any suitable support, as the beams 3 and 4, with a lower extension 5 having at the bottom an offtake connection 6 for the removal of carbon or other non-volatile or non-gaseous material. From the lower section 5 there extends an offtake 7 for the gaseous mixture produced within the furnace, which gaseous mixture is conveyed to separators and recovered as a liquid and from which it can be drawn off. The apparatus used for separating the carbon from the gases and for the purification of gases and the absorption of the benzene as a liquid may be any well known form of apparatus employed for this purpose, such as the separating chambers 8, 8, which may contain activated alumina, and from which the liquid benzene can be drawn off through a pipe 9.

Projecting into the furnace from opposite sides thereof is the hollow carbon electrode 10 and the solid carbon electrode 11, the former electrode being a positive electrode and the latter electrode being a negative electrode. 12 and 13 denote the electrical conductors which are connected to the said electrodes, respectively. Each electrode is provided with water cooling means comprising an annular water chamber 14 surrounding the electrode adjacent to the furnace wall, each of the said chambers being provided with a cooling water supply pipe 15. Each electrode is shown as projecting through an opening in a plate 16 secured to the furnace wall 1 and from each of which plates a bracket arm 17 extends outwardly, each bracket arm supporting at its outer end a sleeve 18 through which a threaded rod 19 extends, the said rods being each engaged by an automatic feeding device 20, such as is well known in the industry. These rods are connected to the carbons 10 and 11 and are adapted to maintain constant the distance between the inner ends thereof. Suitable insulation 21 is inserted between each plate 16 and the furnace wall.

The carbon electrode 10 and its operating rod 19 are connected through a housing 22 having at its outboard end a chamber 22^a with the flexible section 23^a of a supply pipe 23 having a valve 23^b. The inboard or furnace-facing end of this chamber is extended at 22^b to form a tapered split sleeve which may be brought into engagement with the outer end of the carbon electrode 10 by means of a nut 24 having a tapered extension wall 24^a adapted to engage the tapered surface of the sleeve. Insulating material may be inserted between the sleeve and a carbon, as indicated at 25.

Projecting into the top of the furnace is a hollow positive carbon electrode 26 which is mounted and operated in the same manner as the electrode 10, the electrode 26 extending through insulation 27 and the horizontal arm 28 of a bracket, the arm 29 of which is provided with a sleeve 30 through which extends the feeding rod 31 for the carbon 26, the said rod being driven by the automatic feeding device indicated generally at 32. The carbon 26 is supplied with gas through a pipe 33 in the same manner as the carbon 10, delivering the gas into a chamber 34^a at the outboard end of the housing 34, which is connected to the carbon 26 by means of a split tapered extension 34^b of the housing and by the nut 35, 35^a.

36 denotes the conductor for supplying electric current to the carbon electrode 26, the said electrode being a positive electrode. The electrode 26 is provided with cooling means similar to those employed with the electrodes 10 and 11 and consisting of an annular circulating chamber 37 and a water supply pipe 38.

Hydrocarbon fluid supplied through the pipe 23 enters the lower extension of the furnace

where the pipe is formed into a coil 23c, preferably located adjacent to the furnace wall. The upper or delivery end of the coil extends through the furnace wall and to the casing of the valve 23b. 39 denotes any conventional high-frequency apparatus applied to a suitable portion of the pipe 13 and capable of subjecting the gas in this portion of the pipe to the disruptive action of the arc, the said device being provided with the conductors 40 and 41. The high-frequency apparatus may be one of the type manufactured by the General Electric Company and the Westinghouse Electric & Mfg. Company, comprising a chamber through which the gas is conveyed, said chamber containing non-sparking high-frequency coils, whereby an initial dissociation of the gas is instituted, which dissociation is completed by the arc formed between the electrodes. Frequencies of 12,000,000 cycles per second are conventional and may be employed herein. Below the electrodes, shelves 42 project into the furnace from the lining, said shelves containing a catalyst 43, such as platinum black, finely divided nickel, or iron ore, which will increase the yield of benzene.

With the parts constructed and arranged as described, the operation will be as follows:—

Hydrocarbon fluid will be supplied through the pipe 23 to the bottom of the coil 23c, whereby the gas is raised to such a temperature as to materially reduce the electric current required for its dissociation within the furnace. In its passage from the coil to the electrode 10, it is subjected to the disruptive action of the high frequency current whereby a partial dissociation of the fluid is produced. When delivered into the interior of the arc formed between the electrodes 10 and 11 or into the region of the arc, further dissociation takes place. When the hydrocarbon fluid is methane or natural gas, it is dissociated in accordance with the reaction:

$$6(CH_4) = C_6H_6 + 18H.$$

As pointed out in my copending application for the process of treating gases filed December 20, 1935, Serial No. 55,387, it is necessary, for the use of my apparatus for certain specific purposes, to introduce into the arc another fluid, such as hydrogen, or a gas consisting essentially of hydrogen. This additional gas is supplied through the pipe 33, which may be connected to any source of hydrogen supply or which may receive a portion of the surplus gas (consisting essentially of hydrogen) resulting from the separation of the benzene in the apparatus 8, 8. In the latter event, the surplus gas is conducted from the separating and absorbing apparatus 8, 8 by the pipe 44. As much of this surplus gas as may be desirable will be delivered to the electrode 26, the amount of gas so delivered being controlled by a three-way valve 45, the remainder of the gas being conducted elsewhere through the pipe 46.

My apparatus shown in Fig. 2 differs from that shown in Fig. 1 mainly in that solid carbon positive electrodes are employed in place of the hollow carbon electrodes 10 and 26, with the result that the fluid to be treated is delivered through a pipe entering the top of the furnace and into the arc formed between the three electrodes. For convenience of description, the parts which are identical with those appearing on Fig. 1 will be designated by the same numerals, and detailed description of such parts are here unnecessary. The parts of Fig. 1 which are duplicated in Fig. 2 are numerals 1—9 inclusive, 11—21 inclusive, 27—32 inclusive, and 36—46 inclusive.

The electric conductor 12 is connected to a solid carbon electrode 10a, which is substituted for the hollow carbon electrode 10 of Fig. 1 and which therefore does not require the fluid-supplying means shown in connection with said hollow electrode.

The solid electrode 26a is substituted for the hollow carbon electrode 26 of Fig. 1, with the elimination of the gas supply means shown in connection with said hollow electrode. Each of the electrodes 10a, 26a and 11 is provided with the automatic feeding devices and the cooling devices shown in connection with the electrodes of Fig. 1.

The pipe 23 is shown as extending through the top of the furnace, at 23d, having its delivery end in proximity to and adapted to discharge into the arc produced between the electrodes the fluid preheated in the coil 23c and subjected to the high frequency current from the apparatus 39. Hydrogen (which may be part of the excess hydrogen resulting from the operation of the apparatus) may be delivered into the pipe 23 through the pipe 44a, branch pipe 44b and valve 47, and the mixture thus formed be subjected to the high frequency current before it is discharged into the furnace, hydrogen may also be delivered into the pipe 23 from a separate source of hydrogen supply, as through a pipe 48 having therein a three-way valve 49; and it may also be delivered into the furnace in the vicinity of the arc through the pipes 44 and 44a; also through the pipes 48, 48a and 44a.

In both forms of my apparatus, the fluid to be treated is delivered between the inner ends of the electrodes and into the region of the arc formed between the electrodes and, assuming that the fluid thus treated is methane or natural gas, it will be dissociated in accordance with the reaction $6(CH_4) = C_6H_6 + 18H$.

The purpose of introducing hydrogen in addition to the hydrocarbon fluid is, as pointed out in my process application aforesaid, to insure not only the production of the heavy hydrocarbon which is the principal product which I desire to produce and recover, but also to prevent or limit the liberation of carbon. This result can be accomplished with the operation of either form of my apparatus shown and described herein.

The separating and absorbing apparatus 8, 8, as stated hereinbefore, may be of any standard type, one such apparatus being that known to the trade as "Lectrodryer" employing therein activated alumina.

Having thus described my invention, what I claim is:

1. An apparatus for the treatment of hydrocarbon fluids comprising, in combination, a reaction chamber having an outlet, electrodes in said chamber, a conduit for delivering hydrocarbon fluid between the inner ends of said electrodes and into the region of the arc formed therebetween, and means interposed between the arc and the outlet for subjecting the gaseous products produced by the action of the arc to a catalytic agent.

2. An apparatus for the treatment of hydrocarbon fluids comprising, in combination, a reaction chamber having an outlet, three electrodes in said chamber and having their inner ends in close proximity to one another, of a conduit for delivering hydrocarbon fluid between the inner ends of said electrodes and into the region of the arc formed therebetween, a conduit for deliver-

ing an additional aeriform fluid into the region of the arc formed between said electrodes, and means interposed between the arc and the outlet for subjecting the gaseous products produced by the action of the arc to a catalytic agent.

3. An apparatus for the treatment of hydrocarbon fluids comprising, in combination, a reaction chamber having an outlet, electrodes in said chamber, means for supporting a catalyst in said chamber between the electrodes and the outlet, a conduit for supplying a hydrocarbon fluid to the arc produced between said electrodes, said conduit having a portion thereof located within said chamber between the electrodes and the outlet.

4. In the combination claimed in claim 1, a high frequency apparatus applied to a portion of said conduit located outside of said reaction chamber.

5. In the combination claimed in claim 3, a high frequency apparatus applied to a portion of said conduit located outside of said reaction chamber.

6. In the combination claimed in claim 2, a high frequency apparatus applied to a portion of said conduit located outside of said reaction chamber.

7. An apparatus for the treatment of hydrocarbon fluids comprising, in combination, a reaction chamber, electrodes in said chamber, means for delivering a hydrocarbon fluid to the arc formed between said electrodes, an offtake flue for the gaseous products produced in said chamber, means for supporting a catalyst in said chamber between the said electrodes and the said outlet flue, separating and absorbing apparatus with which said flue communicates, and a pipe for delivering more or less of the excess gas from said separating and absorbing apparatus between the inner ends of said electrodes and into the region of the arc formed therebetween.

8. An apparatus for the treatment of hydrocarbon fluids comprising, in combination, a reaction chamber, two hollow electrodes and a solid electrode in said chamber and having their inner ends in proximity to one another, means for delivering a hydrocarbon fluid through one of said hollow electrodes into the arc produced between said electrodes, an offtake flue for the gaseous products produced in said chamber, means for supporting a catalyst in said chamber between the said electrodes and the said outlet flue, separating and absorbing apparatus with which said flue communicates, and a pipe for delivering more or less of the excess gas from said separating and absorbing apparatus into and through the other hollow electrode and into the arc produced between said electrodes.

JAMES R. ROSE.