

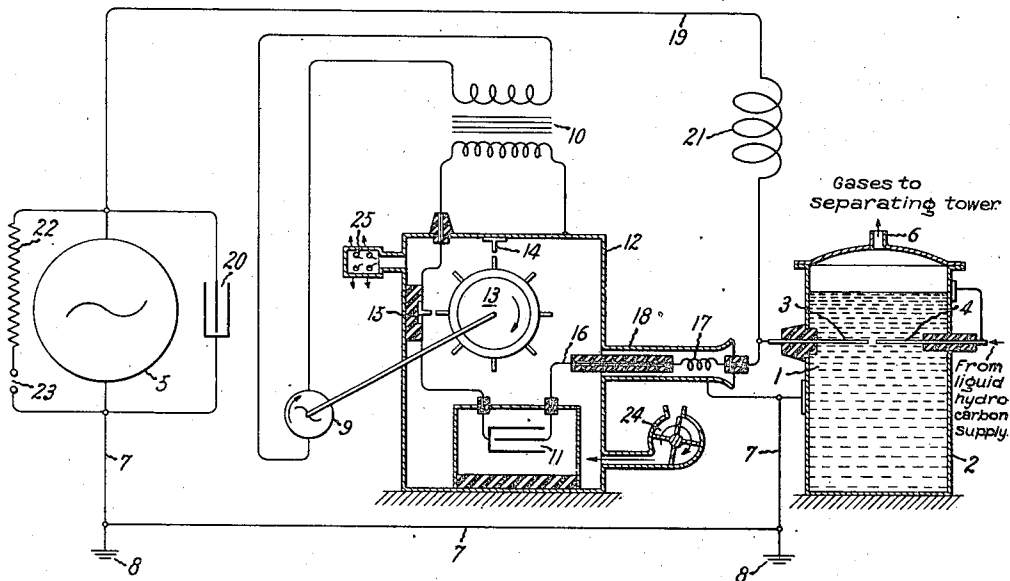
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ELECTRIC ARC APPARATUS

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ELECTRIC ARC APPARATUS

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4 Claims. (Cl. 204—327)

This invention relates broadly to the operation of an electric arc and, more particularly, to means of maintaining an arc between a plurality of electrodes situated or immersed in a medium of high dielectric strength such, for example, as liquid hydrocarbon. The present application is a division of our application Serial No. 185,498, filed January 18, 1938.

The invention is especially concerned with certain improvements and modifications in means for striking and maintaining an electric arc such as described for instance in United States Patent No. 1,930,964, issued October 18, 1933 to Joseph Bethenod.

In accordance with the Bethenod patent an electric arc is struck and maintained between two electrodes immersed in a liquid hydrocarbon by means of pilot sparks formed by a succession of high frequency discharges. The frequency of succession of these discharges is described as being of the order of magnitude of a musical frequency. Apparatus for carrying the Bethenod process into effect comprises a main source of alternating current connected to electrodes, which also are connected to an auxiliary circuit comprising a condenser; and, in addition thereto, an alternating-current generator, having a materially higher frequency than that of the main source of alternating current, for charging the condenser. A spark gap is provided which is rotated synchronously with said alternator and is arranged to discharge the condenser across said electrodes. Such apparatus has been used, for example, for producing from liquid hydrocarbon a raw gas comprising mainly acetylene and hydrogen, from which gas the acetylene subsequently may be separated. The yield of raw gas and of acetylene therefrom per unit of time heretofore has not been satisfactory. Power consumption per unit volume or weight of gas produced also has been excessive.

It is a principal object of the present invention to provide an improved apparatus for operating an electric arc in a medium of high dielectric strength, for instance, in a liquid hydrocarbon.

Another object of the invention is to materially prolong the duration of individual discharges of an auxiliary circuit comprising a condenser such as used, for example, in practicing the

Bethenod invention, so as to permit substantial increase in the voltage of an arc between electrodes in a medium to be reacted and thereby to obtain an increased yield of reaction products per unit of time.

Another object of the invention is to obtain an increased yield of gas, especially an increased yield of acetylene, from a unit of liquid hydrocarbon, than obtainable by the apparatus described in the preceding paragraph and in Bethenod Patent No. 1,930,964, with lesser power consumption per unit of gas produced by the apparatus.

Other and further objects of the invention will be apparent to those skilled in the art as a reading of this specification proceeds.

In accordance with the present invention the aforesaid ends are attained by introducing a current-limiting impedance element, for example an inductance element, of predetermined size, between a condenser of an auxiliary or so-called "pilot spark" circuit and an electrode of the main arc of the apparatus described and illustrated in the aforesaid Bethenod patent.

The novel features which are characteristic of our invention are set forth in the appended claims. The invention itself, however, will be understood most readily from the following description when considered in connection with the accompanying drawing in which the single figure is a diagrammatic view which illustrates by way of example one embodiment of the invention.

Referring to the drawing:

Immersed in a medium 1 of high dielectric strength, for example liquid hydrocarbon, such, for example, as gas oil contained in a suitable metal reservoir or arc chamber 2, are electrodes 3 and 4, which are supplied with direct or alternating electrical current. Additional electrodes may be provided as desired, or as conditions may require. The current supplied to arc-supporting electrodes 3 and 4 is shown by way of example in the drawing as being obtained from an alternating-current generator or alternator 5 of low or industrial frequency and of suitable generated voltage. These electrodes may be tubular in form, consisting, for example, of carbon tubes with thick walls, in which form they may serve both as electrodes between which an arc is struck and maintained and as means for

introducing liquid hydrocarbon into arc chamber 2. Carbon electrodes of this general type are described, for example, in Soularly Patent No. 1,964,832. In the drawing the liquid hydrocarbon is indicated by an arrow as being introduced into the arc chamber through the electrode 4, but of course it will be understood that either or both of the electrodes, when in tubular form, thus may be employed.

The arc chamber 2 is provided with an outlet 6 through which vapors or gases formed as a result of decomposition of the liquid hydrocarbon by the heat of the arc are conducted to a suitable separating tower (not shown). Liquid condensate from the tower may be mixed with fresh charging stock and returned through the electrode 4 to the arc chamber 2.

The gases from the separating tower may be used as such, if desired, or they may be separated further into their components, or a desired component, for example acetylene, may be freed of impurities with which it may be contaminated.

The electrode 4 is grounded to the arc chamber 2, the supply circuit being completed by the conductor 7 which is grounded at 8. A pilot high frequency alternator 9, having a musical or audible frequency of, for example, 500 to 1000 periods per second, constitutes an auxiliary generator which supplies current to the primary conductor of a transformer 10. In practicing the present invention a pilot high frequency alternator 9 with a frequency of 1000 periods per second advantageously may be used in combination with a relatively greater powered low frequency alternator 5 with a frequency of 60 periods per second.

The secondary leads of the transformer 10 are connected to one of the terminals of a condenser 11 and to the body of a metal box or case 12, which forms a screen for a spark gap. This spark gap is shown by way of illustration as a rotary spark gap, the rotor 13 of which operates or rotates synchronously with that of the pilot alternator 9. Known means (not shown) are provided suitably to regulate the angular position at which a spark passes to the teeth of the rotor 13 with respect to the poles of the rotor of the alternator 9.

The metal box 12 is connected with the conductor 7 and with the ground at 8. The electrode 14 also is grounded, while the insulated electrode 15 is connected to one pole of the transformer 10, which pole also is connected to one of the terminals of the condenser 11. The other terminal of the condenser 11 is connected by means of conductor 16 to the electrode 3. An impedance shown by way of example as an inductance coil 17 is electrically interposed in the conductor 16 between the condenser 11 and the electrode 3. The coil 17 is adapted to increase the duration of the individual discharges of the condenser 11 to a period permitting a substantial increase in the length of the arc path between the electrodes 3 and 4 without increasing the voltage available from alternator 5. Such increase in the length of arc path is accompanied by an increased arc voltage and an increased yield of gaseous reaction product. The conductor 16 and the inductance coil 17 may be surrounded as shown by a metal tube or shield 18 which constitutes the connection between the metal box 12 and the grounding cable 7. Such shield over said conductor and coil may be

omitted, if desired, or it may be positioned about the one or the other.

The condenser 11 is charged periodically by the high frequency alternator 9, the charging circuit being completed by the principal supply conductor 19, the alternator 5 in parallel with the condenser 20, and the ground mains 7 and 8. A current-limiting impedance element shown by way of example as an inductance coil 21 is electrically interposed in the conductor 19 and protects the alternator 5 against the passage of high frequency discharge currents. The condenser 20, which is connected to the terminals of the alternator 5, and an ohmic resistance 22 in series with a spark gap 23, constitute a convenient means for ensuring that the alternator 5 will not be subjected to dangerously excessive voltages. A fan or blower 24 driven by any suitable means may be connected, as desired or as may be required, to the metal box 12, and serves to renew the atmosphere within said box. The vitiated air passes outwardly to the atmosphere through the opening 25 in box 12.

In operation, the periodic discharge through the gap between the electrodes 3 and 4 is ensured by the passage of the teeth of the rotor 13 in front of the electrodes 14 and 15. Each passage determines two sparks jumping simultaneously between each of these electrodes and the corresponding tooth of the rotor 13, thus producing a periodical short circuiting of the secondary of the transformer 10. At each short circuit, the voltage of the terminals of the condenser 11 is suddenly transferred between the electrodes 3 and 4, between which it is discharged if the voltage is sufficiently high. The number of discharges per second of the condenser 11 depends upon the number of teeth of the rotor 13 and generally will be either equal to or double the frequency of the alternator 9. By arranging the rotor 13 in the metal box 12 and by surrounding the conductor 16 with a metal tube 18 in the manner shown in the drawing, electromagnetic radiations are suppressed, and interference with radio communication is thus avoided. As an additional precautionary measure to obviate interference with radio receivers, the high tension terminal supporting the electrode 3 may be surrounded, if desired, by a metal hood.

We have found that the duration of the individual discharges of the condenser 11, when the gaps between the teeth of the rotor 13 and the electrodes 14 and 15 break down, is determined by the capacity of this condenser and the distributed capacity and inductance of the leads (for example, 16, 12, 3, etc.) to the arc gap formed between the electrodes 3 and 4. We have further found that the voltage from the alternator 5 that is obtainable across the electrodes 3 and 4 i. e. the width of gap that may be obtained with a given current from the alternator 5, and the quantity of gas produced by the heat of the arc, depends on the duration of the electric current in one direction from the condenser 11 through the gap between the electrodes 3 and 4. In an oscillatory circuit such as herein described, there will be additional half waves of electric current alternating in direction and of successively smaller magnitude. The duration of each of these half waves is one-half the reciprocal of the calculated resonant frequency of the discharge circuit; that is, it is the approximate time required for one discharge of the condenser from zero current to zero current through one-

half cycle. If the duration of an individual condenser discharge that is oscillatory is increased, there is a decrease in the natural frequency of the high frequency discharge circuit; that is, a decrease in the rate at which the condenser in such circuit discharges. For purpose of brevity, current durations as above described are referred to herein as "duration of individual condenser discharges."

By increasing the duration of the individual discharges of the condenser 11 in the manner hereinbefore described, we are able to maintain the main arc across a substantially wider gap with a larger arc voltage and to increase substantially the yield of gas produced in a given time, with given electrical energy (kilowatt-hour) consumption. In other words, by practicing the present invention there is obtained an increased yield of gas per unit of electrical energy used per unit of time in a process of producing gas by subjecting a liquid hydrocarbon to the action of an electric arc. For example, with 150 amperes current in a 60 cycle circuit from the alternator 5 and with a duration of individual condenser discharges of 1 micro-second, the quantity of raw gas produced per hour was of the order of 500 cubic feet. By increasing the duration of individual condenser discharges to, for example, 7.2 micro-seconds, by means of an inductance coil placed in the circuit between the condenser 11 and the electrode 3, approximately 1500 cubic feet per hour of raw gas were produced.

The development of the discharge in a device of this kind takes place in the following order. Initially, electrons originating at the cathode traverse the space to the anode under the influence of the high gradients imposed by the inter-electrode voltage. These high velocity electrons make very few collisions with the gas molecules so that in general they may lose their energy only by ionization. In the case of the spark discharge which has a duration of micro-seconds, the process described above is complete in that period of time.

In the case of a persistent discharge, the subsequent development proceeds along the following lines. The energy which the electrons take from the field is transmitted to the electrodes, and to the gas molecules by processes involving the absorption of radiation. As the number of the ionizing collisions per unit of time increases, the electron energies decrease and the gas energy and temperature are raised, leading to a thermal equilibrium between all components of the discharge. The establishment of this equilibrium is synonymous with the formation of an arc discharge characterized by low potential gradient and high conductivity in the arc column. It is at this point that sufficient conductivity develops to allow power current to flow in the arc. The time required to develop this steady state high conductivity arc is of the order of 100 micro-seconds for the case in hand, which involves a train of half waves for each oscillatory discharge. The thermal equilibrium results from the cumulative effect of successive half waves of the oscillatory discharge. The flow of power current thus depends upon the development of this thermal equilibrium which is characterized by temperatures of the order of 6000° K., high electron density and high electric conductivity.

In the table are presented data taken while operating apparatus such as described in the aforesaid Bethenod patent, with and without an inductance coil in the auxiliary circuit.

Table

	Without inductance coil in the auxiliary circuit	With inductance coil in the auxiliary circuit
Open circuit volts.....	1,300	1,270
Power to motor of main generator, kw.....	62	145
Power factor.....	Low	0.7-0.85
Power to motor of pilot spark, kw.....	7	5
Cycles, power supply.....	60	60
Arc gap, mm.....	1	4 to 5
Oil circulation, gallons per minute.....	30	60
Temperature of oil, deg. C.....	35 to 99	90
Yield of raw gas in cubic feet per hour.....	460	1,600
Per cent by volume of acetylene in raw gas.....	33	30
Yield of acetylene in pounds per hour.....	10	34.5
Kwh. per pound of acetylene produced.....	6.9	4.4

It is to be noted that by using an inductance coil in the auxiliary circuit of the apparatus, the yields of raw gas and of acetylene are more than tripled, with approximately two-thirds of the power consumption per pound of acetylene produced. In other words, by the practice of our invention the efficiency of gas production per unit of power is materially increased as compared with operation of apparatus having no inductance coil in the auxiliary circuit.

In practicing our invention we adjust the duration of individual discharges of the condenser 11 in such manner as to permit greater separation of the electrodes 3 and 4 for a given terminal voltage. The optimum condenser discharge rate may depend, for example, upon the composition, shape and area of the electrodes 3 and 4, upon the composition and dimensions of the arc chamber generally, and upon other variations in mechanical and electrical elements of the apparatus. In no case, however, is the duration of individual condenser discharges increased to the point at which a substantial portion of the energy stored in the condenser passes around the inductance coil 21, the condenser 20 and through the conductor 7 to the ground at 8, since such action would decrease the effectiveness of the condenser discharge in igniting the arc at the 60 cycle current zero.

In practicing the present invention a polyphase arc between more than two electrodes may be employed. However, for purpose of illustrating how this invention may be carried into effect, a system employing only two electrodes has been shown and described.

The invention may be carried out in various other modes of procedure than that herein specifically described. The scope of the invention is not limited to the medium in which the arc is maintained or to the purpose for which it is employed. For example, the medium may be water and the arc may be used to weld articles immersed therein, or the medium may be a compressed gas, for example air, hydrogen, nitrogen, methane, ethane or the like, under such high pressure, above atmospheric pressure that an arc therein otherwise would become unstable.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An apparatus for operating an electric arc between electrodes situated in a liquid of high dielectric strength which comprises a primary circuit including a main source of cyclically varying electrical current connected to said electrodes, an auxiliary circuit connected in parallel with said primary circuit to said electrodes and comprising a condenser, means for charging the said condenser, and means for repeatedly dis-

charging said condenser across the said electrodes, to initiate discharges between said electrodes during the cyclic variations of said main source, said auxiliary circuit including an impedance device connected in series with said condenser whereby the duration of the individual discharges of said condenser is increased.

2. An apparatus for maintaining an electric arc between electrodes situated in a liquid of high dielectric strength which comprises a primary circuit including a main source of alternating current connected to said electrodes, an auxiliary circuit connected in parallel with said primary circuit to said electrodes and comprising a condenser, an auxiliary alternator for charging the said condenser, a discharge circuit including a spark gap device which is operable in synchronism with said auxiliary alternator and which is connected to discharge said condenser across the said electrodes, and an inductance coil in said auxiliary circuit for increasing the duration of the individual discharges of said condenser.

3. An apparatus for generating gas by operating an electric arc between electrodes situated in a liquid hydrocarbon which comprises a primary circuit including a main source of alternating current connected to said electrodes, an auxiliary circuit connected in parallel with said primary circuit to said electrodes and comprising a condenser and an auxiliary source of alternating current having a materially higher frequency than the said main source of electrical current

for charging the said condenser, said auxiliary circuit including a rotary gap device which is operable in synchronism with said auxiliary source for periodically discharging said condenser across the gap between said electrodes, and an inductance element in the discharge circuit of said condenser, said element having a sufficiently high inductive value to materially increase the efficiency of gas production.

4. An apparatus for generating gas by an electric arc between electrodes situated in a liquid hydrocarbon, which comprises a primary circuit including a main source of alternating current of low frequency connected to said electrodes, an auxiliary circuit connected in parallel with said primary circuit to said electrodes and comprising a condenser and an auxiliary alternator of an audible frequency which is connected to charge the said condenser, a discharge circuit including a synchronous spark gap for discharging the said condenser across the said electrodes, and an inductance coil connected in the discharge circuit between said condenser and said electrodes, said inductance coil having sufficient inductive value to cause the individual discharges of the said condenser to persist during a period of sufficient length to cause the energy consumption and the gas generation by said electric arc to be more than twice as high than would be the case in the absence of said inductance coil.

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