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PROCESS OF AND APPARATUS FOR TREATING MATERIALS

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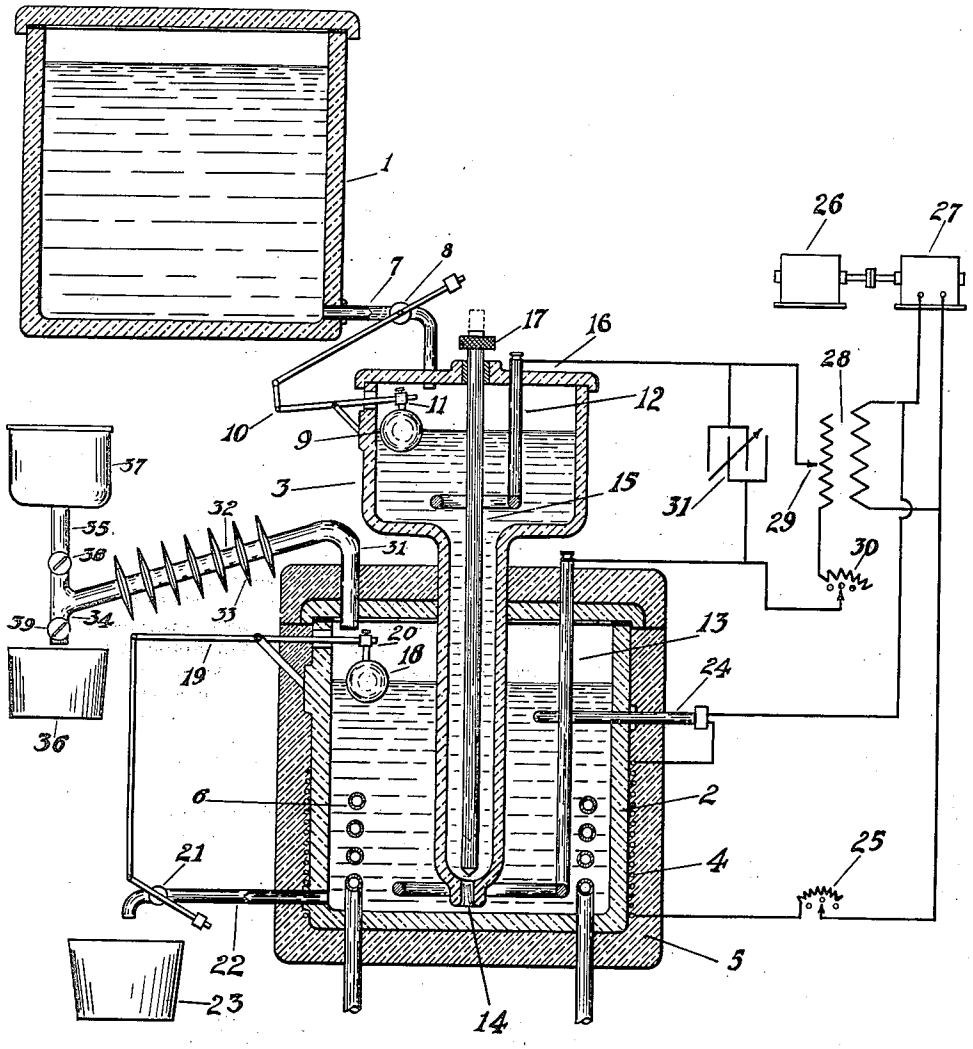


Figure 1

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PROCESS OF AND APPARATUS FOR TREATING MATERIALS

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This invention relates to processes of treating materials to cause certain changes in either their physical or chemical properties. The process may be broadly described as a method of heat application, although it is carried out by electrical means. Most of the changes to be carried out by this equipment will fall in the class of chemical changes, but the process and equipment should not be limited to chemical reactions only.

Some of the objects of my invention are to provide simple, durable, economical means and a controllable and efficient process for carrying out reactions which are now only handled with difficulty.

Many types of reaction may be carried out with my process and equipment, depending of course on the method of operation and the materials used. A typical example of the method of using my process and equipment is in connection with those reactions which take place between water or water vapor and various compounds of hydrogen and carbon.

The fields of these reactions are so extensive that I do not wish to be restricted to any particular group and the description here given should be interpreted in its broadest terms, although for purposes of clearness specific reference will be made from time to time to certain definite materials.

The figure shows diagrammatically and partly in section one form of my device.

Referring to the drawing 1 indicates a storage tank or source of supply for materials to be treated. 2 indicates a reaction chamber or container within which the reaction takes place. 3 indicates a separating container through which the material from container 1 passes, during the progress of reaction. Container 2 is provided with heating means shown diagrammatically as a resistance coil 4 and insulation or supporting material 5 surrounds the chamber 2. In order to still further control the temperature within chamber 2 a coil or other device 6 is provided. This may be used to circulate cooling fluids, as for example cold water in certain cases or it may be employed to supply heat by passing steam or heating fluids either in place of resistance coil 4 or supplementing this coil. An automatic control device (not shown) may be provided to regulate the flow of material through coil 6, thus maintaining any desired temperature within chamber 2.

The material to be treated on leaving container 1 passes through duct 7 and is controlled by valve member 8 which if desired, may be operated by float member 9 through lever system 10. Float 9 therefore serves to automatically hold the level of the liquid in container 3 at a pre-determined value which may be adjusted by moving float 9 relatively to lever system 10 by means of adjusting nut 11. An electrode 12 is disposed in chamber 3 in any desired manner and serves primarily to make contact between the material in chamber 3 and the electric circuit. Another electrode 13 disposed in chamber 2 serves to complete the electric circuit. It will be noted that the current in passing through my device travels through container 3 leaving by the opening 14 shown diagrammatically in its lower portion and then through the liquid in container 2 to electrode 13. It should be understood that the current may flow in either direction or alternating current may be employed.

Control rod 15 adjustably supported in top 16 of container 3 serves by being raised or lowered to restrict opening 14 for purpose later to be described. The position of rod 15 shown in solid illustrates a position in which opening 14 is considerably restricted, whereas the dotted line above member 15 indicates the upward travel when opening 14 is well opened. Adjustable nut member 17 illustrates a diagrammatic means of adjusting and holding member 15 in place. It is desirable that, at least the lower end of member 15 be of insulating material and I find it convenient to construct the entire lower portion of member 15 of quartz or similar substance. In the same way I find it convenient to construct a portion of container 3 from quartz or other very durable insulating material capable of withstanding high temperatures and thermal shock. The portion of container 3 surrounding opening 14 should be made of a material having these properties. The remainder of container 3 may be constructed of any desired insulating material.

The level of liquid in container 2 may be automatically controlled by means of float member 18 which is adjustably supported to lever 19 by means of adjusting nut 20. The movement of float member 18 serves to actuate valve 21 in discharge duct 22 thereby controlling the rate of flow from container 2. 23 indicates a reservoir or storing means for the finished product after passing through my equipment.

A thermostat 24 may be provided to hold the temperature within container 2 at any pre-determined value by means of varying the current passing through resistance coil 4. A hand operated rheostat 25 provides further adjustment for the temperature within container 2. 26 indicates

a motor and 27 a generator which is shown diagrammatically as a source of alternating current, although direct current may be used with my equipment and in some cases is a definite advantage as will be later described. In order to make clear one circuit for my equipment I indicate a transformer 28 supplied by generator 27 and show a variable tap 29 on the secondary of transformer 28, thus making it possible to obtain varying voltages between electrodes 12 and 13. A rheostat 30 is also provided to control the current flowing between electrodes 12 and 13 and in certain cases, as for example the use of relatively high frequencies, I provide a condenser 31 which I have found in practice gives a material difference in the operation of this equipment in many cases.

It will be evident that by varying the speed of motor 26 and, therefore, generator 27 I can obtain various frequencies in the alternating current circuit which also gives me an additional means of controlling the reactions which take place in this equipment.

It should be understood that by varying the level of the liquid in container 3 and the level of the liquid in container 2 I can vary (or automatically hold constant) the pressure at the reaction point, which is adjacent, or within outlet 14.

I therefore provide means for controlling the pressure and temperature of the liquid at the point of reaction and by passing a current of the proper density I am able to cause an intense local heating at, or adjacent to outlet 14. When the outlet 14 is kept rather small so that the current density is high an interrupted arc occurs in and adjacent to outlet 14. The interruptions of the arc appear to be ordinarily much higher in frequency than the ordinary source of current supplied, although the frequency depends very greatly upon the pressure and temperature of the liquid, the composition of the liquid, current density, voltage and other factors.

One function of variable condenser 31 is to control in a measure the frequency with which interrupted arc occurs at or adjacent to outlet 14.

It will also be apparent that the rate of travel of the liquid to be treated from container 1 into container 2 through outlet 14 will determine the time that the liquid is exposed to the arc and, therefore, one of the important factors in connection with the reaction.

As an illustration of one application of my invention I may cite the treatment of an emulsion of a hydrocarbon such as kerosene or fuel oil with water. An emulsion may be prepared in any of the well known methods as for example by the use of a soluble soap, by means of bentonite added to water and agitated with the hydrocarbon, by means of sodium silicate and many others. I prefer to have a homogeneous uniform emulsion and preferably one which will stand a fairly high temperature range without breaking down. I may add to the emulsion certain materials which appear to act as catalytic agents such as vanadium oxide, ferric chloride, manganese chloride, cobalt chloride, etc. I do not wish to be restricted to any particular catalytic agent as obviously certain materials are more effective with some classes of compounds than others. I do not claim to have invented the use of a catalytic agent but do consider the addition of a catalytic material in the practice of my invention to represent a portion of my invention.

In practice I prefer to have the emulsion as liquid as possible from the standpoint of ready handling, but on the other hand the ratio of water to hydrocarbon should be maintained approximately in proportion to the relative quantities taking place in the chemical action. In general it will be found advisable to use a considerable excess of water or other solvent. The excessive amount of water is an objection in that it represents a diluting material which must be handled and which must be heated and cooled. It, therefore, represents a loss of heat over the theoretical operating conditions.

It is, of course, well known that certain oxidations occur when water or water vapor is heated under pressure as for example in an autoclave. Many reactions of this class are now carried on commercially and they involve considerable difficulty and expense. The available pressures by the auto-clave method are limited particularly at high temperatures. Obviously known materials will not stand simultaneously high temperatures, as for example 1000° to 2000° and high pressures as for example 1000 pounds per square inch under practical working conditions. It is, therefore, necessary to use many round-about methods to obtain commercial results with auto-claves and similar equipment. A further difficulty with the auto-clave method of heating is the inability to apply the heat economically at the desired point.

My invention, therefore, serves to provide a means for accomplishing reactions of the class now carried on in auto-claves where various materials are heated together at relatively high temperatures and pressures. My process and equipment, however, give only local high temperatures and local high pressures, thus making it possible to provide equipment which will have a long life and high efficiency without incurring a great expense.

While the temperature of the liquid in container 2 as indicated by thermostat 24 may only range from 100° to 200°, it is readily possible to obtain a temperature range from 1000° to 2000° in or adjacent to outlet 14. Since all of the emulsion or other material being treated passes through outlet 14 all of the material passing through my equipment will be successively subject to very high temperatures. The current density through outlet 14 is one of the essential factors in controlling the temperature to which the material is subjected in my process. Another factor is the rate of flow of the material through outlet 14.

It is therefore apparent that while the major portion of the equipment with which I am provided is subjected to only very moderate temperatures the material being treated may be subjected to very high temperatures.

Regarding the other factor of pressure which is of course more or less definitely connected with temperature, it will be evident that a pressure gauge if placed in the liquid of container 2, adjacent to outlet 14 might show only a very moderate pressure, as for example that resultant from the height of the liquid above outlet 14. In actual practice this head may range from one foot to many feet, depending on the materials treated and the desired product. On the other hand, in passing through outlet 14 the liquid from container 3 is subjected to extremely

high temperatures as previously discussed, which in turn forms instantaneous portions of vapor at very high pressures ranging ordinarily many pounds or even hundreds of pounds per square inch. This pressure is, of course, not maintained continuously except in the outlet 14 and in constructing my device I prefer to make the length of outlet 14 quite appreciable as illustrated diagrammatically in the drawing. Momentarily, therefore, portions of the material being treated are simultaneously subjected to very high temperatures and pressures. One factor which controls the maximum temperature to which the vapors are subject is the high lag of the liquid material in moving away from the small highly heated bubbles caused by the current. In other words, when dealing with relatively high frequencies in connection with the formation of the arcs and therefore the bubbles and portions of materials heated to high temperatures the liquid behaves in the manner of a very viscous solid. This makes it possible, therefore, for momentary pressures of extremely large amounts to occur.

The temperature of the liquid in and adjacent to outlet 14 appears to control the size and speed with which the bubbles of vapor are produced. As a theory for explaining this action, I am of the opinion that when the liquid in and adjacent to outlet 14 is close to the boiling point it flashes into vapor very readily and is slower to condense. On the other hand if the liquid in container 2 and in and adjacent to outlet 14 is relatively far below its vapor point a greater interval results before a given amount of electrical energy can convert the liquid into vapor. Bubbles of vapor are, therefore, slower in forming under these conditions and somewhat quicker in condensing. In general I obtain the most satisfactory results in forming oxidation products of hydrocarbons by using a relatively low temperature, as for example 40° or 50° F. in containers 2 and 3. Where, however, the materials to be treated react with considerable ease and require relatively low temperatures and pressures, I am able to get a greater volume of product treated at a higher efficiency by carrying a relatively high temperature in containers 2 and 3, as for example 150° to 200° F.

Obviously these are points which vary with the materials treated and the desired product to be produced and I do not wish to be restricted to any set of conditions in the process of my invention.

While I have previously referred to the reactions taking place between hydrocarbons and water vapor it will be apparent that I may treat any liquids or liquid emulsions in this manner. In place of water I may use water solutions of various materials or such liquids as sulphuric acid, acetic acid, carbon tetrachloride, alcohol, etc. I may also use a wide range of materials in place of the hydrocarbon and I do not wish to be restricted to any particular series of hydrocarbons as the various so-called aromatic series, paraffin series, etc., are equally applicable to my process.

While my process is well adapted to the formation of oxidation or addition compounds, it may also be used in the proportion of chlorinated, sulphonated and other hydrocarbons.

It will be apparent that my process consists largely of a thermal and pressure treatment, although in certain cases particularly where direct current is used there appears to be an additional effect due possibly to the electrolytic decomposition of the solution. In most cases this is materially less important than the pressure and thermal effects.

I have found that a wide range of materials or emulsions may be treated by my process. When applying a low voltage with a relatively large current, it is desirable to have the conductivity of the liquid treated relatively good, as otherwise too great an amount of heating will occur in containers 2 and 3 and not enough heating in outlet 14. It is possible, however, to produce decided results with my invention when using materials whose insulating value corresponds to that of oil having small amounts of water dissolved in it or mixture of distilled water or emulsions such as paraffin, asphalt, etc. In cases of this kind it is necessary, of course, to apply higher voltages between terminals 12 and 13, to use smaller total currents and therefore a materially smaller opening in outlet 14. It will be apparent from a consideration of these factors that it is impractical to confine this invention to any specific set of currents, voltages or frequencies as these must be adjusted in each case to conform to the materials being treated and the products desired.

In certain cases some of the materials resulting from the heat treatment in this process become either gases or vapors which must be treated as such. In order to take care of this condition I may provide an outlet duct 31 connecting to a condenser 32, which is shown diagrammatically with cooling fins 33. Condenser 32 connects to pipes 34 and 35. 35 shows diagrammatically a means of delivering condensed liquids to storage container 36, while pipe or duct 35 shows means of conducting the permanent gases to storage container 37. Valve members 38 and 39 control the flow of material from the condenser to the storage for gas or liquid respectively. It will be noted that pipe members 34 and 35 together with the associated equipment serve as a separating device for removing liquids from gases or vapors and conducting each to their desired storage point.

This invention does not include any specific form of condenser, gas separator or storage vessels. It should be understood, therefore, that any practical equipment for this purpose may be substituted without departing from the scope of my invention.

It should also be understood that in referring to emulsions or mixtures I do not exclude the use of solutions as there are many instances in which sufficient water may be dissolved in the material being treated to sustain the necessary reaction.

During the operation of my equipment I have noted as specified above, that a series of small arcs or high temperature zones, which frequently give off light as well as heat, are produced in outlet 14 and adjacent thereto. It appears that these arcs are caused partly by an interruption of the current flow due to the formation of a series of small bubbles or spacers, which become relatively poor insulators and which serve to interrupt the flow of liquid from container 3 through outlet 14.

There appear to be a certain set of voltage and current conditions which give the most effective treatment. It is obviously desired to subject all of the liquid to the same treatment. A long interval between heating periods (arcs) usually results in a definite amount of material passing through outlet 14 without being subjected to the pressure and temperature conditions. I have found that the amount of material thus escaping

treatment or the amount of material being subjected to a diminished treatment is ordinarily reduced when the frequency of the current supplied is increased the frequency of the production of arcs is increased. In general an increase in the applied voltage and the volume of current will also produce a more uniform product. There are limits, however, to this statement as when using extremely high voltages with too large an opening in outlet 14 proper treating conditions are not obtained. In general it may be stated that the desired results are obtained when the heat produced by the current passing through outlet 14 is sufficient to supply the necessary heat units to raise the liquid to the desired temperature within the desired time.

It should be understood therefore that one phase of my invention includes a definite control of the temperature and pressure to which the liquid is subjected and simultaneously controlling the time interval, and rate of flow.

Certain materials and certain reactions require closer control than others. The exact condition depends so largely on the nature of the materials being treated that it is impractical to specify a given set of conditions. In general it may be stated that the higher hydrocarbons, as for example, paraffin or related materials will permit a greater range of temperature and pressure conditions than will the simpler hydrocarbons such as ethylene, etc. The following equations illustrate types of reactions which may take place in carrying out my invention.

$$C_xH_y+nH_2O=C_xH_yO_n+H_{2n}$$
$$C_xH_y+nH_2O=C_xH_y(OH)_n+H_n$$
$$C_xH_y+nH_2O=C_{x-n}H_y+nCO$$

It should be understood, however, that while I have shown in these equations only reactions between hydrocarbons and water that the reactions may take place between any group of chemical compounds.

Having now fully described my invention what I claim as new and wish to secure by Letters Patent in the United States is as follows:

1. The process of oxidizing hydrocarbons in an electrolytically conductive aqueous emulsion, by subjecting consecutive portions of said liquid successively to instantaneously controlled high temperature and high pressure, resulting from an electric arc immersed in said liquid.

2. The process of treating materials containing a hydrocarbon suspended in an electrolytically conductive aqueous solution, by subjecting portions of the liquid to instantaneous high temperatures and pressures for a controlled time interval, by passing an electric current through said liquid while in a confined space, said current density being sufficient to create a localized arc within said restricted passageway having said conducting liquid at the ends of said passageway for arc terminals.

3. The process of partially oxidizing hydrocarbons while suspended in an electrolyte which consists in passing said liquid at a controlled rate consecutively through a restricted passage, causing an alternating electric current of relatively high density to produce an arc in said liquid material in a coherent liquid phase, while in said passage, thereby strongly heating said liquid and having a portion of said electrically conducting liquid for terminals and finally removing said treated material at a controlled rate, thus determining the product formed.

4. An apparatus for treating hydrocarbons suspended in an electrolyte, consisting of a treating duct of relatively long length and small section with an enlargement near each end, means for maintaining a constant normal pressure head on the material in said treating duct, means for producing a controlled temperature in said treating duct, said means comprising two electrodes immersed in said conducting liquid located in said enlargements adjacent the ends of said treating duct and means for removing said material after treatment, said electrodes being arranged to create an electric arc in said treating duct.

5. An apparatus for treating hydrocarbons suspended in an electrolyte consisting of a treating duct formed from insulating material, means for maintaining a constant normal pressure head on the material in said treating duct, electrical means for heating said liquid to a controlled temperature while in said treating duct, said means comprising two electrodes located adjacent the terminals of said treating duct and connected to a source of electric potentials and means for removing said material after treatment, said treating duct and electrodes being arranged so as to create an arc within said treating duct.

6. An equipment for treating materials suspended in an electrolyte, comprising a treating duct of electrically insulating materials, means for maintaining a normal pressure head on the material in said duct, means for controlling the rate of flow of said material through said treating duct and means for producing high temperatures and pressures in said treating duct comprising a pair of electrodes immersed in said liquid, one of said electrodes being located adjacent to each end of said treating ducts, said electrodes serving to cause an arc in said treating duct.

7. The process of heat treating materials containing carbon compounds and an electrolyte, which consists in passing said materials through a treating duct at a controlled rate, maintaining a controlled normal pressure on said materials in said treating duct momentarily and subjecting successive portions of said material while in the liquid phase and in said treating duct to the direct flow therethrough of an electrical current of high density, thus causing an electric arc within said liquid and thereby strongly heating said liquid, said treating duct being subjected to an intermittent arc.

8. An equipment for heat treating an aqueous mixture of hydrocarbons and electrolyte, consisting of a treating duct of electrically insulating material, a reservoir supplying said mixture of said treating duct, control means for regulating the rate of flow of said mixture through said treating duct and electrical means for applying heat to said material while in said treating duct, said electrical means consisting of a pair of electrodes immersed in said electrolyte and serving to create an electric arc in said treating duct.

9. In a device for treating materials in an electrolytically conducting liquid and in the coherent liquid phase, a restricted passage, electrodes contacting with said liquid at the opposite ends of said restricted passage thus electrically heating said material while in said passage by means of an electric arc formed by said electrodes and variable means for controlling the effective cross section of said passage between said electrodes, thus varying the current density in said passage and thereby controlling the product formed by said treatment.

10. In a device for electrically heat treating material containing a hydrocarbon suspended in an electrolyte, a treating duct, variable means for restricting the cross section of said treating duct, thereby causing localized arc heating, said arc being located within the restricted section of said duct having the liquid at the ends of the duct as terminals for said arc, a reservoir supplying said material to said treating duct, electrodes adjacent the ends of said duct, and means for controlling the rate of flow of material through said treating duct.

11. The process of heat treating materials containing a hydrocarbon suspended in an electrolyte which consists in passing said materials in a coherent liquid phase through a restricted passage under controlled conditions subjecting successive portions of said material while in said passage to an arc caused by electrical current of high density thereby heating said successive portions of liquid and collecting, cooling and condensing the resultant material.

12. The process of heat treating materials containing a hydrocarbon mixed with an electrolyte containing catalytic materials, which consists in passing successive portions of said materials, in coherent liquid phase, through a restricted passage under controlled conditions, forming an electric arc in said material by the direct flow of electric current in said passage, and removing and collecting the resultant material.

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