PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to the Automatic Control of Temperature in Catalytic Reactions

We, SIEMENS-SCHUCKERTWERKE AKTIENGESELLSCHAFT, a German Company, of Berlin-Siemensstadt, Germany, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the production of synthetic products, such, for example, as petrol, with the use of a catalytic agent contained in a contact chamber through which the reactants to form with the aid of the catalytic agent the petrol or other product to be produced are passed at a controlled rate and temperature.

In the synthetic production of petrol according to the Fischer-Tropsch process, as this process is carried into effect in practice, the petrol is produced by first bringing coal or coke oven gases into close contact with hydrogen and steam in the presence of a catalytic agent. In the process, heat is continuously generated in the contact chamber and in consequence it is necessary to provide a cooling means to carry away continuously the heat given off. For this purpose, the contact chamber is surrounded by a cooling jacket or contains a cooling coil through which a liquid cooling medium is caused continuously to flow. The carrying off of the heat and in this way the temperature obtaining within the contact chamber may be easily regulated by permitting the cooling jacket or coil to act as an evaporative cooler and governing or keeping at a height corresponding to the required temperature, the pressure of the saturated steam formed in the jacket or coil. For this purpose, it has been the practice to insert a valve in the steam discharge pipe of the cooling jacket or coil, which valve has been operated directly by an adjustable weight-loaded piston continuously maintained under the pressure of the steam in the vapour space of the cooler.

No reason has hitherto been seen for departing from this method of controlling the temperature of the cooling medium and thereby of the interior of the contact chamber, in spite of the fact that the method has a hidden drawback which definitely militates against the economy of the whole process.

This drawback has now been perceived and the present invention provides an improved method of temperature control which avoids it.

According to the present invention, a method of controlling the contact chamber temperature in the production of synthetic products with the use of a catalytic agent in a contact chamber from which the heat of the reaction is continuously carried away through the intermediary of a fluid medium, the temperature of which as it leaves the cooling coil or the like through which it flows as it withdraws heat from the interior of the contact chamber, is governed by an automatic regulator responsive directly, or indirectly through the intermediary of the cooling medium, to temperature variations in the contact chamber, is characterised in that the regulator acts indirectly upon the regulated member of the temperature controlling means of the cooling medium and is operative in conjunction with the said regulated member to maintain a substantially constant theoretical temperature value of the cooling medium independently of the position of the regulated member.

In processes of the kind to which the improved method of temperature control which is provided according to this invention relates, the process or the catalytic agent employed generally possesses the characteristic that the chemical reaction is effected in the desired manner only at a fixed or determined temperature of the contact chamber. This temperature has to be adapted to the condition of the catalytic agent, whose properties are sustained sufficiently only for a certain period of time at a temperature which has once been fixed. After this period of time it is only possible again to obtain the required powers of conversion of the catalytic agent when the temperature in the contact chamber has been increased by a certain amount. If, by such a gradual

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increase in temperature an upper temperature limit is reached, in the sense that the catalytic agent cannot be further used at temperatures beyond this limit temperature, the catalytic agent is regenerated, after which the process is recommended at a comparatively low temperature which is then gradually increased again at certain intervals of the time until the limit temperature is again reached.

It has now been ascertained that the catalytic agent in processes of the kind referred to above has another characteristic which has to be taken into account if the most economical use of the agent is to be obtained. Thus, it has been found that after each increase in temperature, that is, in the gradual raising of the temperature of the contact chamber, beyond the fixed or predetermined temperature at which the catalytic material is operative with optimum production of the petrol or other synthetic product being produced, the catalytic agent refuses to be active at any temperature within the range of temperatures below the fixed temperatures, irrespective of whether it has previously been used within this range of temperatures or not; in other words, it is impossible, once the temperature of the contact temperature has been raised to a temperature above the fixed temperature, to reduce it again to a temperature below the fixed temperature, even if the raising of the temperature has been premature, for example, through an act of carelessness on the part of the operator working the process, with respect to the condition of the catalytic agent, that is, has been effected before it has needed to be or before the catalytic agent was really exhausted. Consequently, if the temperature is raised to the limit temperature hereinbefore referred to at once, instead of gradually and as necessary to restore the activity of the catalytic agent, the latter can only thereafter, until the next succeeding regenerating operation, be used in the range of temperature above the fixed temperature and in this way the whole of the range below the fixed temperature becomes lost, and it is necessary in the result to repeat the regenerating process sooner than it would otherwise, with consequent loss of time and also loss of effective utilisation of the catalytic agent, which suffers a loss in activity every time it is regenerated. In this connection it should be added that, as is known, the value of the catalytic agent in these conversion plants represents a substantial proportion of the total value of the plant, so that it is essential for an economical use of the plant, to avoid any improper treatment of the catalytic agent such as that referred to above, which would in effect prematurely terminate the useful life of the catalytic agent.

Upon consideration of this further characteristic of the catalytic agent in contact processes of the kind referred to above, namely that the agent becomes dull or inactive even when its temperature is increased during the process, without its catalytic properties being properly or adequately utilised, and upon comparison of the working of a plant having a valve directly controlled by means of an adjustable weight-loaded piston with a plant in which the pressure is controlled by an indirectly acting regulator in accordance with the present invention, it can be proved that it is impossible with the use of a plant of the first-mentioned kind to obtain an economic use of the catalytic agent and it is only with the use of a plant of the second-mentioned kind that this can be achieved.

Consider first the application of a valve directly regulated by an adjustable weight-loaded piston. If an increase is effected in the amount of gas supplied to the contact chamber, the amount of heat given off therein will also be increased. In consequence, the cooler, that is, the cooling jacket or coil, produces an increased amount of steam, the steam accumulates and the steam pressure and in this way the temperature of the cooling liquid are increased. According to the increase in pressure, the adjustable piston will open the valve interposed in the steam discharge pipe of the cooler still further in order to permit the discharge of the increased amount of steam and so decrease the pressure. The deciding factor here is that it is not possible for the valve to reproduce exactly by means of this control device the previously prevailing pressure, since at the instant when the original pressure would act again on the adjustable piston, not only the adjustable piston, but also the valve cone or valve head would again return to the original position, by reason of these parts being rigidly connected together. This indicates that the cross-section of the opening and the pressure always have two necessarily corresponding values, so that the pressure corresponding to the enlarged cross-section of the valve opening, which enlarged cross-section is required in order to permit the discharge of the increased amount of steam, must necessarily be greater than the pressure which the regulator previously maintained. This means that, without being caused to do so by the contact mass becoming dull, the regulator, when the load on the plant is increased, increases the pressure obtaining in the

cooler and accordingly the temperature obtaining in the contact chamber and in this way a temperature range of contact is unnecessarily wasted.

This is not the case when, in accordance with the present invention, the pressure, that is, of the saturated steam in the cooler, when an evaporative cooler is employed as above described, and therefore, of the temperature of the cooling medium, is controlled by an indirectly acting regulator. Since in such a regulator the position of the regulated member is not dependent on that of the regulating member and these members are operative to maintain a substantially constant theoretical value of the temperature of the cooling medium, a permanent detrimentally acting increase of temperature of the cooling medium is eliminated when the load on the plant fluctuates, and in this way, in accordance with the relationships set out, an improved utilisation of the catalytic agent, that is, an increase in the economy of the plant, is actually ensured.

The accompanying drawing shows in combination the layout of the substantial parts of a plant for producing petrol equipped with an indirectly acting regulator of the kind referred to.

At the left hand side of the drawing, the regulator is illustrated whilst the means required for carrying into effect the contact process are indicated on the right hand side of the drawing. The detailed construction and working of the regulator is of no importance to the invention so long as an indirectly acting regulator with the properties mentioned is employed. The drawing illustrates a known contact indicator regulator by which is meant a regulator including an indicator which also makes electrical contact to complete the circuit which actuates the control and is of known construction and operation.

The right hand side of the drawing shows the principal parts of an apparatus for carrying into practice the process of producing petrol hereinbefore referred to, which parts comprise a contact chamber 2 charged with a catalytic agent 1 which is carried upon a grid 3. A gas pipe 4 leads from beneath to the contact chamber 2, coke oven gas, for instance, being supplied to this pipe through a pipe 5 and steam through a pipe 6. The upper part of the contact chamber 2 is connected to a pipe 7 leading to a pipe 8 through which water gas is supplied. A pipe 9 leads to an apparatus in which the product obtained from the contact chamber 2 is further treated in known manner. The contact chamber 2 is mounted in a cooling tank 10 to which a cooling liquid, for instance water, is continuously supplied through a pipe 11. The steam given off by the cooling liquid is carried off through a pipe 12 in which is interposed a valve 13. The valve 13 is arranged to be opened and closed by a motor 14 which is controlled from a regulator 17 through the intermediary of relays 15, 16. Impulses are transmitted from the regulator 17, by a current carrying contact indicator 18 by which is meant the type of indicator described in the previous paragraph, of a manometer connected to the pipe 12 by a pipe 19. The contact indicator 18 may make contact against either of the two counter contact indicators 20 and 21. When steam pressure is increased in the pipe 12, the contact indicator 18 is deflected clockwise and contacts with the counter contact indicator 21 to close a circuit, resulting in the motor 14 energised through the intermediary of the relay 15 so that the valve 13 is opened. When the pressure in the pipe 12 decreases, the contact indicator 18 is deflected in the opposite direction and by contacting with the counter contact indicator 20 closes a circuit through the intermediary of the relay 16 to energise the motor 14 so that the valve 13 is closed. It will be observed from the wiring diagram, that a mofor 22 is switched on and out with the motor 14. The connection is selected so that the direction of rotation of the motor 22 is reversed simultaneously with a reversal in the direction of rotation of the motor 14. The motor 22 drives a rotary pump 23 which according to its direction of rotation draws off a liquid from the space beneath a piston movably arranged in a cylinder 24 and forces it beneath a piston located in a cylinder 25 or *vice versa*. The piston rods of the pistons, which are movable against spring pressure in the two cylinders 24 and 25, act on a beam 26 through the intermediary of connecting rods. By means of the connecting rods 27, 28, the movement of the beam 26 rotates a toothed segment 29 engaging with a pinion 30 connected to the two counter contact indicators 20, 21, which together form resilient current conductors for the regulator circuit. In order to adjust the theoretical pressure to which the regulator is to be subjected, a set screw 31 is mounted on a rotatably supported spindle 32. The spindle 32 carries a nut, not shown, which upon moving to and fro rotates a plate 33 about a pivot 34. The pivot 34 for the toothed segment 29 is carried by the plate at 35. The limits of deflection of the regulator may be adjusted by a hand screw 36 arranged to

move a member 37 operable to keep apart the two counter contact indicators 20 and 21. The closer the counter contact indicators 20, 21 are brought towards each other, the closer are the limits of deflection of the regulator and *vice versa*. The regulator is provided with two scales 38 and 39 of which one indicates the pressure in the pipe 12 and the other the temperatures of the corresponding saturatd steam. Further it is to be observed that it is possible to control the motors of the plant by hand. A push button switch 40 enables the motor 14 to be started so as to open the valve 13, whilst a push button switch 41 can be operated to close the valve 13 by the motor 14. In order automatically to switch off the motor 14 when the valve 13 has reached one or other of its end positions, two switches 42 and 43 are provided which are operated when the valve 13 has reached either end position.

The operation of the plant is as follows:—

As long as the balanced working of the whole plant is maintained, the pipe 12 has a certain balancing pressure which is determined by the opening position of the valve 13. The contact indicator 18, the two counter contact indicators 20 and 21 and the beam 26 assume the position indicated in the drawing and the motors 14 and 22 are at rest. When the load on the plant is increased, that is, more gas is supplied to the container 2 through the pipe 4, a greater amount of heat is given off and more cooling liquid is vaporised in the cooling chamber 10. The pressure in the pipe 12 is increased and the indicator 18 of the manometer is deflected clockwise and contacts with the counter contact indicator 21 to close the circuit of the relay 15 whereby the motor 14 is energised and rotates to open the valve 13. The motor 22 is simultaneously started and drives the rotary oil pump 23. The pump 23 draws oil from the cylinder 24 and forces it into the cylinder 25 so as to cause the piston in the cylinder 24 to move downwardly whilst the piston in the cylinder 25 moves upwardly. The beam 26 is moved and rotates the toothed segment 29 in an anti-clockwise direction and the pinion 30 to which are fixed the counter contact indicators 20 and 21 in a clockwise direction. At the same time the circuit, which had been closed by the indicator 18 contacting with the counter contact indicator 21, is again opened so that the two motors 14 and 22 come to rest. The movement of the counter contact indicator 21 is now reversed so that it follows the contact indicator 18 which moves towards its initial position by reason of the fact that the valve 13 is further opened and the pressure in the pipe 12 is decreased. The return movement of the counter contact indicator 21 is effected by the oil which was pumped beneath the piston in the cylinder 25 being forced by the action of a spring disposed above the piston, through a return flow conduit into the cylinder 24. In this manner, the pistons located in the two cylinders 24, 25 return to their mean or original position and in this way move the beam 26 back to its original position. The toothed segment 29 is thus rotated in a clockwise direction and the pinion 30 in an anti-clockwise direction so that the counter contact indicator 21 secured on the pinion 30 actually effects the said return movement. If the control impulse is sufficient, by the further opening of the valve 13, the pressure in the pipe 12 is again lowered to its original value and a further regulating action does not take place since the indicator 21 cannot reach again the indicator 18. Otherwise, another contact is effected between the indicators 18 and 21 as a result of which the motor 14 opens further the valve 13. If the control means are still not balanced, the operation described is repeated until finally the counter contact indicator 21, which every time moves towards the original position, does not strike against the indicator 18.

Upon comparison in this connection of the contact manometer indicator 18 as an impulse control member with the adjustable piston of the known control means hereinbefore described, the substantial difference of the two control methods is particularly clear. As has been shown above, in the known regulator any position of the controlled valve always automatically corresponds to a determined position of the adjusting piston. In the present case, there is not any such dependence of adjustment. At the end of the regulating action the indicator 18 returns to its original position independent of the final position of the valve 13.

The invention is not limited to the case where the contact chamber is cooled by an evaporative cooler and the cooling is regulated by a pressure control. On the contrary, it is applicable to any method which makes use of a flowing cooling medium as the means of controlling the reaction temperature in the contact chamber, the temperature of which cooling medium is governed by an automatic regulator responsive to temperature variations in the contact chamber. For example, as already indicated, the regulator may if desired be responsive directly to the temperature variations in the contact chamber instead of indirectly through the

intermediary of the cooling medium, as in the above specific embodiment of the invention; or in this event of the regulator being responsive indirectly through the cooling medium the arrangement could be one in which the regulated member under the control of the regulator is a valve controlling the rate of supply of the cooling medium to the cooler.

The invention is further not limited in its application to processes for the production of petrol, but is applicable broadly in this respect to all cases where similar working conditions prevail.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A method of controlling the reaction in the production synthetic products with the use of a catalytic agent in a contact chamber from which the heat of the reaction is continuously carried away through the intermediary of a fluid cooling medium, the temperature of which, as it leaves the coling jacket, cooling coil or the like through which it flows as it withdraws heat from the interior of the contact chamber, is governed by an automatic regulator responsive directly, or indirectly through the intermediary of the cooling medium, to temperature variations in the contact chamber; characterised by the use of a regulator which acts indirectly upon the regulated member of the temperature controlling means of the cooling medium and is operative in conjunction with the said regulated member to maintain a substantially constant theoretical temperature value of the cooling medium independently of the position of the regulated member.

2. A method as claimed in Claim 1, wherein the cooling jacket or coil is employed as an evaporative cooler and the regulated member is a valve in the steam discharge outlet of the cooler.

3. A method of controlling the reaction temperature in the production of synthetic products with the use of a catalytic agent, substantially as hereinbefore described with reference to the accompanying drawings.

4. Automatic reaction temperature regulating means for use in processes for the production of synthetic products with the use of a catalytic agent, constructed, arranged and adapted to operate substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 5th day of April, 1937.

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Agents for the Applicants.

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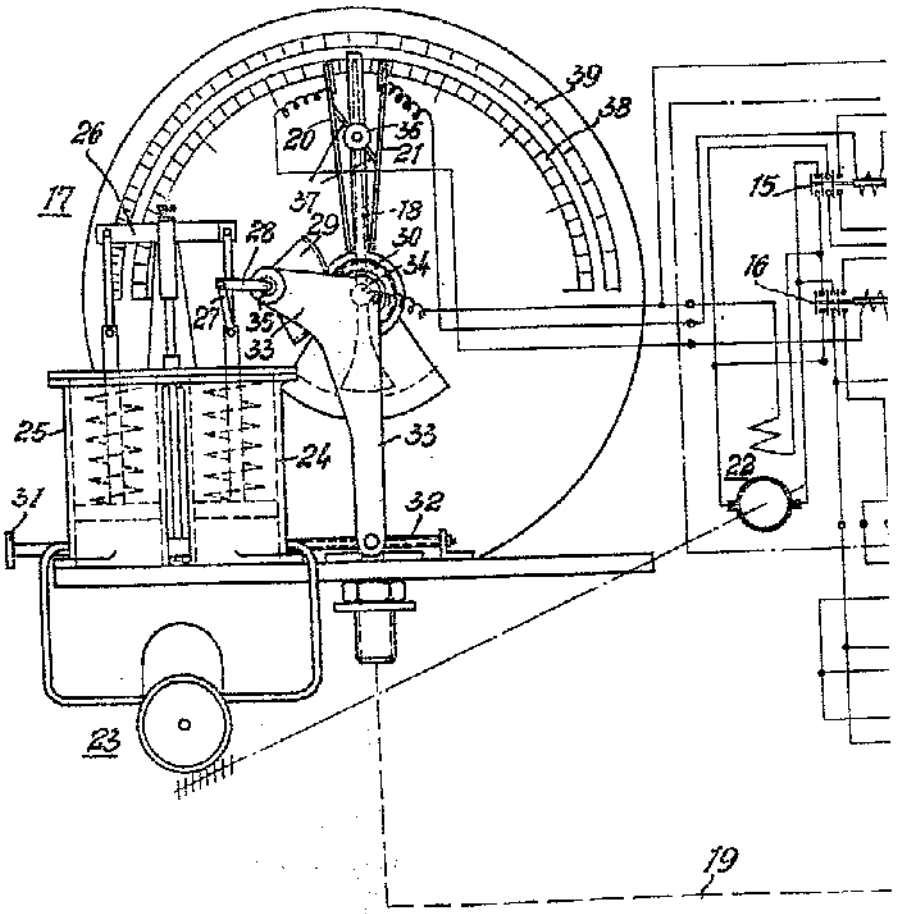

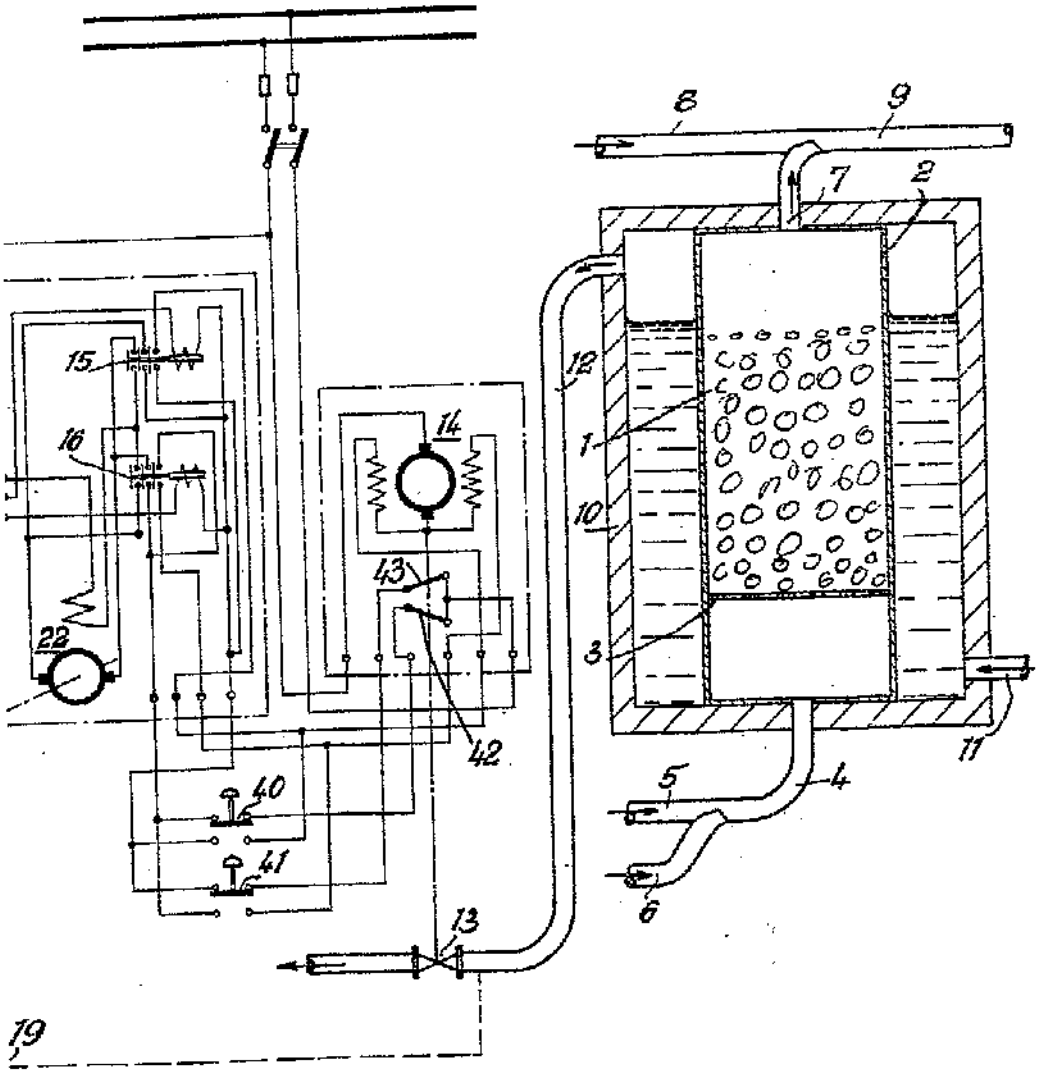

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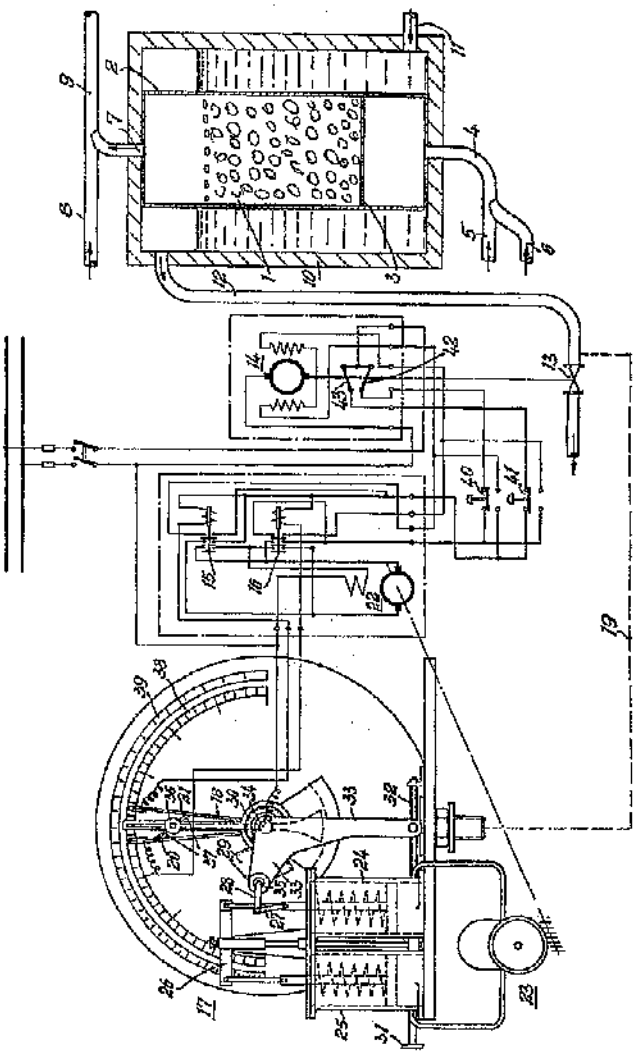

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