

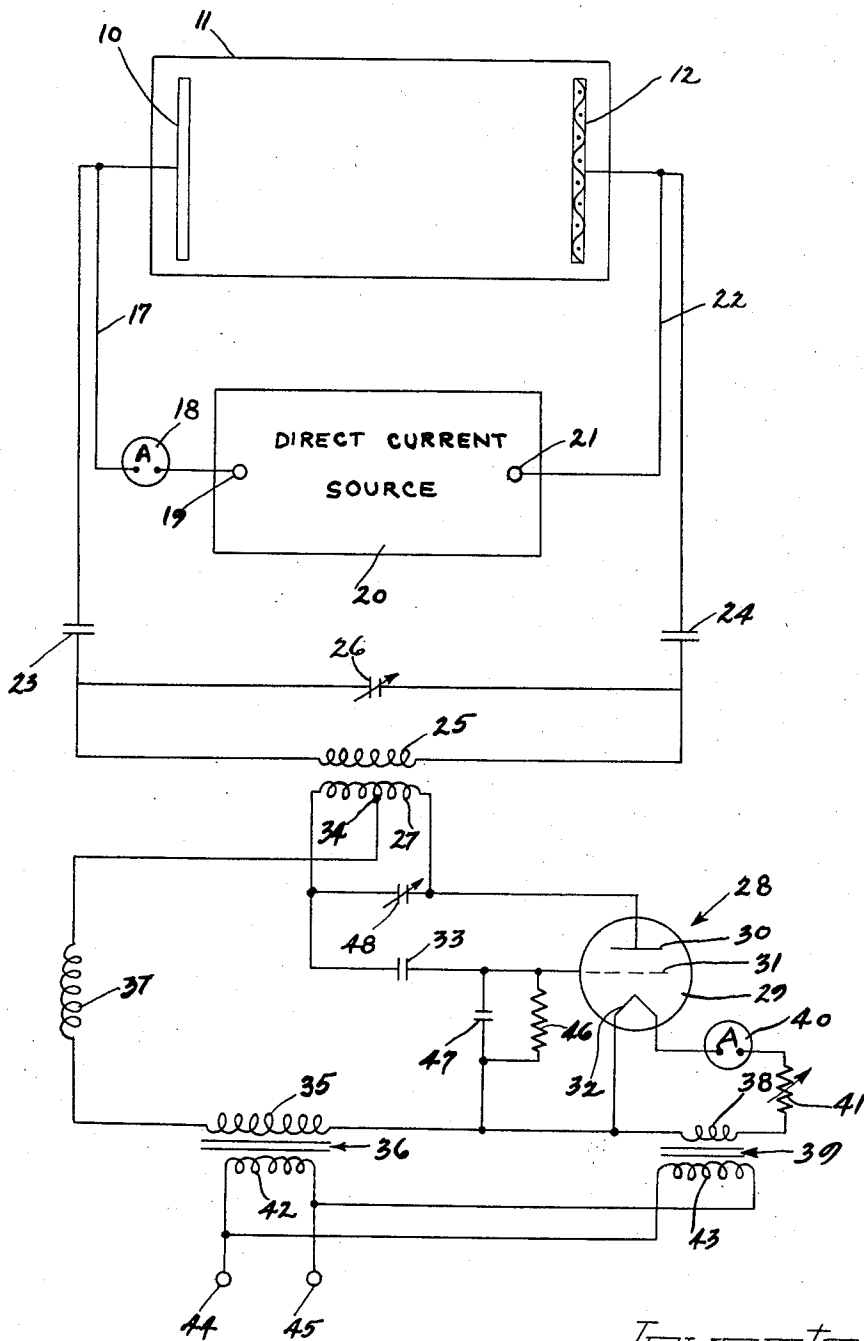
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METHOD OF ELECTRODEPOSITING CHROMIUM

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METHOD OF ELECTRODEPOSITING CHROMIUM

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3 Claims. (Cl. 204—10)

This application is a continuation in part of my co-pending application Serial No. 327,403 entitled, "Facilitating the Boiling of Liquids," filed December 22, 1952 and now abandoned.

This invention relates to facilitating the boiling of liquids, and more particularly, to an improved method for accelerating the boiling of liquids and for producing material which may be used to accelerate the boiling of liquids.

As is readily understood, the boiling of liquids is involved in a number of fields including low temperature or refrigeration fields as well as fields involving higher temperatures. In accordance with the present invention the boiling of liquids can be accelerated in order to avoid the phenomena which may be involved delaying boiling or evaporation.

In evaporating or boiling liquids, it is known that there frequently is involved a delay in the boiling. The temperature rises above the boiling point of the liquid whereupon boiling starts suddenly with great force. In order to avoid impacts caused by such delay in boiling, a slight stream of gas may be introduced into the boiling liquid or else porous substances may be added, such as sand, carbon, pieces of blotting paper, pumice, broken pieces of China, platinum wire, etc. The action of such substances continues as long as they are capable of giving off air from their pores.

It has now been found that the delay in boiling can be eliminated not only by the development of gas within the liquid but also by the reduction of the viscosity of the liquid. In accordance with the present invention the boiling of liquids is accelerated it is believed on this latter basis; and the process involves the discovery that chromium, which has been electrodeposited under relatively high current density conditions, preferably at least 120 amperes/dm.², is added to the liquid. This metal has a smaller wetting powder for the liquid than the metallic or glass walls of the boiling vessel so that the steam bubbles form readily in the crystal surfaces of the metallic chromium, and the inner pressure of the liquid as well as the outer vapor pressure is overcome and easy substantially uniform boiling takes place.

In general, the electroplating of a metal onto a given article involves immersing the article to be plated in an electrolyte and passing an electric current through the electrolyte between the article and another electrode also immersed in the electrolyte. The electrolyte contains the metal (in this case chromium) to be plated and additional plating metal may be added to the electrolyte either by adding additional quantities of a salt of the metal to the electrolyte or, in certain cases, by employing an electrode made of the metal which will supply metal to the electrolyte solution when subjected to the electric D. C. current employed in the plating process. In the case of chrome plating the usual procedure is to add additional compounds of the metal.

The instant invention involves initially electroplating

or electrodepositing of chromium under a high current density and under the action of high frequency fields. The chromium so deposited has uniquely superior properties for accelerating the boiling of liquids, even to the extent that the apparent boiling point of such liquids is lowered.

It is, therefore, an important object of the instant invention to provide an improved process for the boiling of liquids, and an improved electroplating process for the preparation of materials which accelerate the boiling of liquids.

It is a further object of the instant invention to provide an improved process for obtaining chromium for use as an accelerator for the boiling of liquids, which comprises imposing a D. C. field of 120 to 320 amperes/dm.² current density on a plating bath of electrolyte containing chromium and superimposing on the D. C. field a high frequency field whose frequency is, expressed in wave lengths in air, of a magnitude of 1.8 to 16 meters.

Yet another object of the instant invention is to provide an improved method of boiling liquids which comprises boiling a liquid in the presence of granulated chromium prepared as herein described.

Other and further objects, features and advantages of the present invention will become apparent to those skilled in the art from the following detailed disclosure thereof and the drawing attached hereto and made a part hereof.

In the drawing, the figure is essentially a diagrammatic view showing a wiring diagram and plating tank connected thereto for use in preparing the chromium employed in the practice of the instant invention.

Although the details of the wiring diagram will be described hereinafter, it will be noted that the high frequency fields employed in the practice of the instant invention, expressed on the basis of wave lengths in air, are of a magnitude within the range of about 1.8 meters to about 16 meters, and preferably about 3.5 meters to about 6.5 meters. The wave lengths of each of a plurality of high frequency fields employed differ from one another by a magnitude of from about 2 to about 50% of their average wave length (i. e., the average wave length for the two or more high frequencies), and preferably the wave lengths differ from about 5 to 20% of their average wave length.

A hard chromium with crystal lattice structure has been found to be particularly suitable. Such chromium is produced by the electrodeposition with extremely high current densities. For certain purposes excellent activity is exhibited by chromium which has been deposited at a current density of 120 to 150 amperes/dm.². For other purposes excellent results are obtained using chromium deposited at current densities of 160 amperes/dm.² to 320 amperes/dm.²; but it is important to note that the superior acceleration of the boiling of liquids may be obtained in the practice of the instant invention using current densities within the range of 120 to 320 amperes/dm.². For this purpose, the chromium can be deposited on an iron cathode, preferably at such a high current density that the deposition takes place with the formation of nodes or blistering. It is possible, in such case, to mechanically or chemically loosen or remove the supporting material from the chromium. Narrow mesh metal grids can also be used as the cathode in which case the cathode and the applied chromium may be introduced together into the evaporating liquid. The chromium present in this form has an extremely large surface area.

Although there have been a number of theories which may possibly explain the various advantages obtained in the practice of the instant invention, certain of these

advantages may best be described on the basis of operating examples.

For example, the plating is carried out in a chrome plating bath (having 266.7 grams per liter CrO_3 and 2.8 grams per liter H_2SO_4 content) maintained at 135°F . with a cathode current density of 140 amperes/dm.² and an anode current density of substantially the same, using a lead anode 10 (Figure 1) at one end of the tank 11 and an iron grid (in the form of iron screen) as the cathode 12 at the opposite end of the tank 11. High frequencies of 5.2 and 6.2 meters wave length magnitude are superimposed on the D. C. field. The chromium builds up very rapidly on the screen 12 and the plating is carried out for 30 minutes.

The resulting screen has a very coarse appearance comprising granular or particulate chromium built up on the surface of the screen. The instant screen or grid may be used per se to accelerate boiling as will be demonstrated hereinafter. The procedure is also repeated and the granulated chromium affixed to the screen is removed therefrom to obtain chromium powder which may also be used to effect acceleration of boiling.

The same procedure is repeated except that the current density used is 200 amperes/dm.² and even a coarser granulated chromium layer is formed on the screen; and this procedure is also repeated, followed by removal of the granulated chromium from the screen to obtain a second sample of chromium powder.

Results compared to those obtained using 140 amperes/dm.² may also be obtained using 120, 130 and 150 amperes/dm.². At a current density of about 160 amperes/dm.² it will be noted that a distinctly more coarse chromium deposit is obtained and this may be advantageous for the purpose of giving greater porosity. Results comparable to this are obtained using current density such as 170 amperes/dm.² or 250 amperes/dm.² (up to about a practical maximum of 320 amperes/dm.²).

Although there are certain practical considerations which will be discussed hereinafter concerning the generation of the high frequency fields, it is preferable to employ high frequency fields of a magnitude of about 3.5 to 6.5 meters wave length. In this range, the best chromium deposits are ordinarily obtained using an average wave length in the lower end of this range, but the generation and control of high frequencies in this region is somewhat more difficult for practical purposes, and it is for this reason more advantageous to use wave lengths within the range of about 4.5 to 6.5 meters. Practical problems in the generation of these frequencies, such as the tendency to cause breakdown in elements such as the oscillator, may make it more desirable to use frequencies in the higher wave lengths at perhaps a slight sacrifice in time and/or quality. Actually, the benefits of the instant invention can be obtained using wave lengths as high as about 16 meters, although no appreciable improvement appears to be obtained using greater wave lengths. In general, it is desirable to use wave lengths that are as close to one another as is practical in the operation. Also wave lengths as low as about 1.8 meters may be employed to advantage in the practice of the instant invention, but below this wave length the problems of generation and control become unnecessarily difficult.

Example I

If 250 cc. water and 45 grams of chromium powder, deposited in accordance with the previously described example using 140 amperes/dm.², are placed in a glass flask, the water after heating will boil uniformly and without any delay in boiling, even if there is used completely air-free water which has been previously boiled out. While 100 cc. of water were evaporated without the chromium addition after 120 minutes, but with chromium addition, under otherwise identical conditions, 170 cc. of water evaporated during the same period of time. Furthermore, it was found that, due to the

chromium addition in accordance with the invention, a reduction of the boiling point of the water for identical barometric pressures is obtained. While the boiling point of the water, at a pressure of 740 mm. Hg is 99.2°C ., the boiling temperature, upon the addition of chromium and at the same pressure, measured with a standard thermometer, was 97.6°C . The boiling temperature of the water heated with chromium particles was, therefore, reduced by 1.6°C . Comparable results are obtained using the described chromium powder deposited at 200 amperes/dm.².

Example II

Two identical glass balloons were each filled with 100 cc. ethyl ether, whereupon the two balloons were connected to the same vacuum line in which a vacuum of about 35 mm. Hg was produced by a water jet pump. 30 grams of chromium powder produced in accordance with the previously described example using 140 amperes/dm.² were placed in the one balloon. At a room temperature of 18°C ., there starts in both balloons, after about a half a minute, a violent generation of gas which soon becomes weaker in the balloon without the chromium addition while in the balloon containing the chromium addition a strong uniform boiling took place until the end of the experiment. After 10 minutes, 43 cc. of ether had evaporated from the balloon without the chromium addition and the contents of the balloon had a temperature of -22°C . At the same time 68 cc. of ether had evaporated from the other balloon which contained the chromium addition, and the contents of the balloon had a temperature of -34°C .

A further experiment with the same arrangement with methyl alcohol showed the following results:

[Introduced into flask: 100 cc.]

	Without Chromium Addition, degrees	With Chromium Addition, degrees
Initial Temperature.....	+11	+13
after 1 minute.....	+5	-3
after 2 minutes.....	-5	-7.5
after 3 minutes.....	-8	-10.0
after 4 minutes.....	-9	-11.0
after 5 minutes.....	-10.0	-11.5
after 6 minutes.....	-10.0	-12.0
after 7 minutes.....	-10.2	-12.2
after 8 minutes.....	-10.5	-12.2
after 9 minutes.....	-10.8	-12.5
after 10 minutes.....	-11.0	-12.5

After 10 minutes, the test was stopped, the liquid which remained was then measured. In the flask without the chromium addition there was found a quantity of 89 cc. liquid while in the flask with the chromium addition there was found an amount of 71.2 cc. methyl alcohol.

Example III

Into each of two identical evaporators of a compression refrigerator machine there were introduced 100 cc. methyl alcohol and one of the evaporators was charged with 40 grams of a chromium powder prepared in accordance with the previously described example using 140 amperes/dm.². The two evaporators were now connected to the compressor and the compressor placed in operation. While a temperature of 0°C . was reached in the first evaporator which contained only methyl alcohol after 11 minutes and 45 seconds, a temperature of 0°C . was obtained in the other evaporator, containing the addition of chromium, already after 5 minutes, 25 seconds.

Example IV

The procedures of Examples II and III are repeated using the chromium powder deposited at 200 amperes per dm.² and it is found that evaporation is still more noticeably accelerated.

It is thus evident that the boiling accelerators, in ac-

cordance with the invention, are susceptible of numerous applications. They can advantageously be used in all processes in which liquids are evaporated, for instance in industry, in the distillation of the most different kinds of liquids or liquid systems, and also, however, in particular, in the refrigerating industry in connection with compression and absorption refrigerators.

To apply the D. C. field to the plating bath, the anode 10 is connected through a conductor 17 and an ammeter 18 to one terminal 19 of a direct current source 20 having a second terminal 21 connected through a conductor 22 to the cathode 12. The source 20 may be any source of steady or pulsating current. Batteries may be used or where standard 25, 50 or 60 cycle alternating current is available, it will ordinarily be preferable to provide rectifiers to convert the alternating current to direct current.

To apply a high frequency field to the plating bath, certain points of the conductors 17 and 22 are respectively connected through coupling capacitors 23 and 24 to the terminals of a coil 25 which may have a variable tuning capacitor 26 connected in parallel therewith. The coil 25 is inductively coupled to a tank coil 27 of an oscillator generally designated by reference numeral 28, which comprises a triode vacuum tube 29 having a plate or anode 30, a control grid 31 and a directly fed "Hartley" type with the plate 30 being connected to one end of the tank coil 27, with the grid 31 being connected to the other end of the tank coil 27 through a D. C. blocking capacitor 33 and with a plate supply voltage being connected between a tap 34 on the coil 27 and the filament 32.

A source of direct current may be used for the plate supply but preferably, to eliminate the need for rectifiers, an alternating current supply is used. In particular, the filament 32 is connected to one terminal of a high voltage secondary winding 35 of a transformer 36 and the tap 34 is connected through a choke coil 37 to the other terminal of the winding 35.

To heat the filament 32, one side thereof is connected to one side of a secondary winding 38 of a transformer 39, the other side of the filament being connected through an ammeter 40 and a rheostat 41 to the other side of the winding 38. The transformers 36 and 39 have primaries 42 and 43 connected in parallel to terminals 44 and 45 which may be connected to a suitable A. C. source, such as a source of 60 cycle, 220 volt current.

Grid-leak bias is preferably used for the oscillator 28 to insure self-starting, the grid 31 being connected through the parallel combination of a resistor 46 and a capacitor 47 to the filament 32.

With the coil 25 being tuned by the capacitor 26, it is not necessary to tune the coil 27. However, it may in some circumstances be desirable to connect a variable capacitor 48 across the coil 27.

It will be appreciated that with the oscillator circuit as thus far described, a high frequency field of one frequency may be readily applied to the plating bath. To apply a high frequency field of a different frequency, a separate oscillator may be used. According to an important feature of this invention, however, the oscillator 28 is used to simultaneously apply two different frequencies to the plating bath, to thus eliminate the need for two separate oscillators.

It has been found that this highly advantageous result is achieved by using a relatively high degree of coupling between the coils 25 and 27. It is believed that a high degree of coupling results in the generation of two frequencies because of the fact that when two resonant circuits are coupled together with a coefficient of coupling greater than a certain amount, two resonant peaks will exist at frequencies respectively above and below the frequency to which the circuits are tuned (which hereinbefore is referred to as the "average" frequency). The oscillator circuit may thus have the greatest degree

of amplification at two different frequencies and can operate simultaneously at both frequencies.

If the oscillator output is viewed on an oscilloscope, for example, the wave will have the same general form as is produced by the addition of two sine waves. As is well known, "beat" frequencies may be produced from waves of two different frequencies and such beat frequencies are produced by the oscillator of the system of this invention.

It should be noted that the greater the degree of coupling, the more prominent are the pair of resonant peaks and the greater is the spacing or frequency difference therebetween. Thus, the relation of the two frequencies can be adjusted by adjusting the coupling between the coils 25 and 27.

In practice, the coupling is generally adjusted until optimum performance is achieved. In any case, the coupling should be such that the mutual inductance in henries is substantially greater than

$$\frac{\sqrt{R_1 R_2}}{w}$$

where R_1 is the resistance of the coil in ohms, R_2 is the resistance of the other coil in ohms and $w=2\pi f$, f being the frequency to which tuned, in cycles per second. A coupling such that

$$M = \sqrt{\frac{R_1 R_2}{w}}$$

is generally termed "critical coupling" and hence the coupling should be substantially greater than critical coupling.

By way of illustrative example and not by way of limitation, the capacitors 23 and 24 may each have a capacitance of 2000 micro-microfarads; the capacitor 26 may have a maximum capacitance of 125 micro-microfarads; the capacitor 33 may be constituted by two vacuum capacitors each having a capacitance of 250 micro-microfarads; the capacitance 47 may have a capacitance of 100 micro-microfarads; the resistor 46 may have a value of 10,000 ohms; the voltage developed across the secondary 35 may be 5000 volts R. M. S.; and the tube 29 may be an air-cooled high vacuum type with 2000 watts maximum power output. As above indicated, the capacitor 48 is not necessary.

It will be noted that the high frequency source is connected in parallel relation to the direct current source. A series coupling could be used but such would necessitate that the D. C. source have a very low internal impedance to the high frequency currents to obtain efficient operation. This is difficult to achieve, particularly with the relatively long conductors usually used to connect the D. C. source to the electrodes.

With a parallel coupling such as shown, the impedance of the high frequency current path through the plating bath should be much less than the impedance of the path through the D. C. source. With conductors of substantial length as are usually used to connect the D. C. source to the plating bath, this is achieved to a certain extent by merely connecting the high frequency source to points on the conductors 17, 22 close to the anode 10 and cathode 12. If desired, in addition, choke coils may be provided between the terminals of the D. C. source and the points to which the high frequency source is connected.

A further specific feature is in the adjustment of a position of connection of the high frequency source to the conductors 17—22 to obtain optimum coupling to the bath. With frequencies in the ranges previously specified, the conductors, 17, 22 can form a transmission line of substantial length as compared to one wave length, and by moving the points of connections to the conductors 17, 22, resonant and anti-resonant points (or nodes and anti-nodes) may be found and by using the

resonant points, optimum coupling can be achieved. In many cases, points can be found at which the high frequency current path through the bath is resonant with the high frequency path through the D. C. source being anti-resonant so that the ideal coupling can be obtained. 5

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim as my invention:

1. A process for obtaining chromium for use as an accelerator for the boiling of liquids, which comprises imposing a D. C. field of 120 to 320 amperes/dm.² current density on a plating bath of electrolyte containing chromium and superimposing on the D. C. field a high frequency field whose frequency is, expressed in wave lengths in air, of a magnitude of 1.8 to 16 meters. 10

2. A process for obtaining chromium for use as an accelerator for the boiling of liquids, which comprises imposing a D. C. field of 120 to 320 amperes/dm.² current density on a plating bath of electrolyte containing chromium and superimposing on the D. C. field a plurality of high frequency fields whose frequencies are, expressed in wave lengths in air, of a magnitude of 1.8 to 16 meters. 20

3. A process for obtaining chromium for use as an accelerator for the boiling of liquids, which comprises imposing a D. C. field of 120 to 320 amperes/dm.² current density on a plating bath of electrolyte containing 25

chromium and superimposing on the D. C. field a plurality of high frequency fields whose frequencies are, expressed in wave lengths in air, of a magnitude of 1.8 to 16 meters and which differ from one another by a magnitude of 2 to 50% of their average wave length.

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