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METHOD OF DRYING, CONCENTRATING BY EVAPORATION, OR
DISTILLING HEAT-SENSITIVE SUBSTANCES
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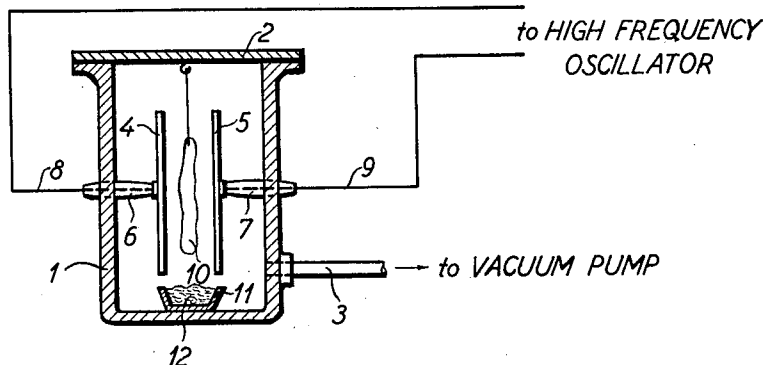
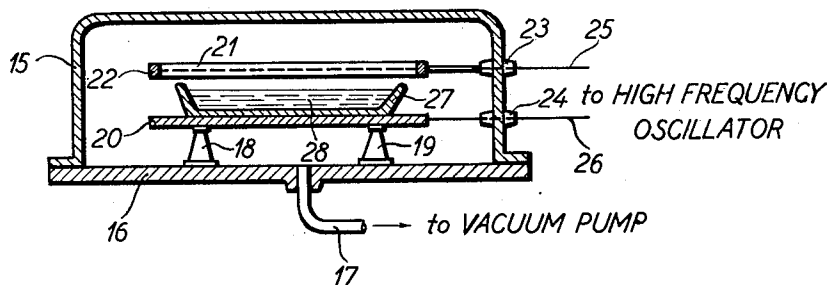


Fig. 1

Fig. 2



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METHOD OF DRYING, CONCENTRATING BY
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The present invention relates to the art of drying, concentrating by evaporation, or distilling substances which are unstable to heat. By heat-unstable substances are understood especially such substances as contain vitamins or hormones, or albumen-containing substances such as blood, sera, and plasma, or similar substances by which it is necessary to keep the temperature during the drying, concentrating or distilling process low e. g. below 40° C. and in many cases still lower, in order that during the process the substances should not be injured by such treatment whereby their vitamin or hormone contents would be destroyed or reduced, or whereby an unintentional coagulation of the albumens would arise.

The drying, concentration, or distillation of such substances therefore most often take place in vacuo. Upon rapid evaporation in vacuo the temperature of the material that is being treated drops considerably, whereby, however, the evaporation rate is reduced, so that the process of drying, concentration or distillation will proceed slowly. The large drop in temperature is caused by the fact that due to the surroundings of the material treated heat cannot be supplied to the material at a rate that can keep pace with the consumption of heat by evaporation. If the process is to be carried out in the course of a reasonable time it is therefore necessary during the process to supply an extra amount of heat to the material under treatment.

It has been attempted to supply this extra amount of heat by conduction or by radiation, but these methods both suffer from the drawback that at the points of supply, i. e. in the contact surfaces between the heat-conducting members serving for the heat supply and the material treated respectively or on the surfaces hit by the radiated heat, local superheatings arise which may cause "burns" of the heat-unstable substance or otherwise damage the latter.

A considerably better method consists in using a high frequency electrical current for the production of the necessary extra amount of heat in the material treated, the current being supplied to the material either conductively, or being produced in the latter inductively or capacitatively. The fact is that hereby a uniform and even development of heat may be achieved in all the individual parts of the material, so that the danger of local superheatings and the resultant burns should be avoided.

When the process is carried out in practice it appears, however, that in many cases there may nevertheless occur burn-like damage or more or

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less coagulation in the material, even if the extra amount of heat supplied is so small that the temperature of the material remains comparatively low.

5 The purpose of the present invention is to remedy this difficulty, and the invention is based on the comprehension that the damage occurring in most cases is due to the fact that in the air remaining in the treatment chamber around the substance treated there occur ion currents which are able to "burn" the substance or give rise to coagulation. It has not formerly been comprehended that the said damages are due to ion currents, for these are not injurious in all cases. 10 It may often be observed that ionization with ion currents deriving therefrom prevail in the treatment chamber without the material treated being damaged. The applicant has, however, observed that the said damage occurs when the ion currents get the opportunity of influencing the material with too great a strength. As the probability of an ionization arising at a given temperature in the air around the substance will first and foremost depend on the electric field strength and the air pressure in the treatment chamber, the method in accordance with the invention consists therein that these quantities are so adapted in relation to each other that ion currents will not be produced of a strength that may damage the substance that is being treated. 20 25 30

Distinct values or limits for these quantities cannot be determined in general as the values which these quantities must have in order that injurious ion currents may be avoided vary widely from one case to another in accordance with the conditions under which the process of drying, concentration, or distillation is carried out. This is due to the fact that the electric field strength and the air pressure besides being interdependent are also dependent on other conditions, especially on the temperature at which the process is to be carried out, the shape and mounting of the electrodes, and the electrical conductivity or dielectrical properties of the substance treated. The frequency of the high frequency electric energy employed also plays a part in this connection. The adaptation of the said values in accordance with the invention must therefore be effected in accordance with concrete conditions, but in practice the adaptation gives no difficulties, a few experimental tests being sufficient for fixing the values required in a given case. An exceedingly simple way of effecting the adaptation in practice consists in so regulating the air pressure and the electric field strength 35 40 45 50 55

that in the treatment chamber there will not occur luminous zones of such an extent that they touch or extend to the direct vicinity of the substance that is being treated, as it appears that if this condition is fulfilled no damage due to ion currents will occur.

The present invention is of greatest importance in cases where a capacitive supply of the high frequency electric energy is used, the possibility of detrimental ion currents occurring being greatest in such cases, whereas by an inductive or conductive supply of energy the electric field strength will only very seldom obtain such a value that detrimental ion currents can be formed in the air present around the substance. Nevertheless the invention is not without importance in the latter cases, as by inductive supply so-called "electrodeless discharges" may happen, and by conductive supply non-conductive zones may arise when the substance has become sufficiently dry, and in these zones the conditions will then be exactly similar to those by capacitive supply of energy.

Although as it appears no distinct limit may be given in general, it may, however, be stated about the order of magnitude of the pressure permitted in the treatment chamber with a capacitive supply of energy that in most cases it will be below 1.5 mm. of mercury.

As mentioned above the shape and mounting of the electrodes also play a part besides the electric field strength and air pressure, and by a suitable supporting and guiding of the substance treated in relation to the electrodes it is possible to attain a reduction of the possibilities of ionization and thereby of the production of injurious ion currents. Hereby it has proved that especially the following conditions are of importance. During the evaporation that takes place, vapours from the substance treated will enter the space between the latter and the electrodes. The evaporation will usually be the greatest from the surfaces of the substance facing the electrodes presumably because molecules with a dipolar momentum will under the influence of the high-frequency field oscillate in accordance with the direction of the field and therefore to a special degree be detached from the surfaces facing the electrodes. If the vapours formed are not able to escape sufficiently easily and quickly, a local increase in the pressure may arise and thereby the possibility of ionization. Furthermore the vapours formed will often carry with them very small drops or other particles, around which electric fields will arise of a rather considerable strength, and if electric fields are formed around many such particles, extending from the substance towards the electrodes, the possibility of ionization will be strongly increased.

In accordance with the invention the substance is placed or led at such a distance from the electrodes that the vapours developed from the substance have room for escaping without giving rise to any perceptible increase in pressure. It may be advantageous to use perforated or net-shaped electrodes, so that the vapours can escape through the electrodes. Furthermore it is expedient in the vicinity of the substance that is being treated, e. g. in or in the vicinity of the space between the substance and the electrodes, to place means which can adsorb, absorb, or condense the vapours formed. The vapours are thus quickly removed from these spaces. In cases where water vapour is formed, concentrated sulphuric acid or silica gel may be used as absorb-

ing means, and cooled surfaces may be used on which condensation takes place outside the active field.

In the following some examples will be given of carrying the method into practice.

EXAMPLE 1

Meat drying

The meat is cut to a thickness of 0.3 cm. and placed on a plane horizontal electrode. Above and parallel to the latter another electrode is mounted at a distance of 4 cm. The treatment chamber is evacuated by pumping, until the pressure has been reduced to 0.3 mm. Hg, after which the electrodes are connected with a generator which produces a high-frequency electric current of a frequency of 20 megacycles per second and sustains a difference of potential between the electrodes of 400 volts. The temperature in the treatment chamber is thereby held at about -30° C. Silica gel is placed around the lower electrode for keeping a suitably low pressure of the vapours. After about 1 hour the meat is dried out. The meat dried in this way will easily absorb water and has after this exactly the same taste as in its original state.

If the pressure is higher than the value stated, luminous zones will occur extending from the parts of the meat from which the evaporation is most rapid. By the reduction of the pressure to the value stated, these zones will vanish, and instead the space between the electrodes is filled with a faint lilac light. There is, however, at a distance of 0.5 cm. from the electrodes and from the meat a non-luminous zone.

It will be seen that the relationship between electrical field and air pressure in the foregoing can be mathematically expressed per centimeter of distance between the electrodes by the following equation:

$$F = 333\frac{1}{3} \cdot p$$

wherein F is the field strength in volts per centimeter and p is the air pressure in millimeters of mercury.

EXAMPLE 2

Meat drying

The meat is cut in the same way as in Example 1, but instead of being placed direct on one electrode it is suspended between the electrodes or led in between the latter on a band of an insulating material of a low dielectric loss factor.

The drying otherwise occurs as in Example 1.

EXAMPLE 3

Concentration by evaporation and drying of serum

The serum is placed in a thin layer either directly on the lower electrode or in a quartz cup placed on the latter.

The treatment being otherwise as stated in Example 1, the serum freezes and rather quickly gives off its water content. The remainder is an easily soluble powder consisting of small flakes of dry serum.

The accompanying sheet of drawings sets forth illustrative embodiments of apparatus for carrying out the process of the invention. Of the illustrated figures,

Fig. 1 is a sectional view through one form of apparatus, and

Fig. 2 is a sectional view through a second form of apparatus.

In Fig. 1 a container 1 is closed by a lid 2 to form an airtight treatment chamber which may be evacuated through a pipe 3 leading to a suitable vacuum pump. In the container are placed two parallel plate shaped electrodes 4 and 5 secured to the container 1 by means of insulators 6 and 7 extending through the wall of the container. By means of leads 8 and 9 passing through the insulators 6 and 7 the electrodes are connected to a suitable high frequency oscillator. The substance to be treated, for example a piece of meat 10 is suspended from the lid 2 in the space between the electrodes 4 and 5.

When the lid 2 with the substance 10 to be treated is placed on the container 1 the high frequency oscillator and the vacuum pump are switched on, and by regulating the voltage of the oscillator and the efficiency of the vacuum pump the electric field strength and the air pressure in the treatment chamber are so adjusted that no ion current reaches into close vicinity of the substance 10 to be treated.

In order to facilitate the escape of vapour from the substance 10 during the treatment a container 11 containing a vapour absorbing means 12 such as silica gel may be placed close to the space between the electrodes.

In Fig. 2 a treatment chamber is formed by a cover 15 resting, in airtight relationship, upon a bottom plate 16 through which passes a pipe 17 leading to a vacuum pump by means of which the chamber may be evacuated. Resting on insulators 18 and 19 is a metal plate 20 which forms a lower electrode. The upper electrode consists of a network 21 of metallic wire secured in a metal frame 22. The electrodes are connected to a high frequency generator by means of leads 25 and 26 passing through insulators 23 and 24 in the cover 15. On the lower electrode 20 is placed a cup 27 of quartz or other material with low dielectric loss containing the liquid 28 to be concentrated or dried. As the upper electrode 21 consists of a network the vapours from the liquid 28 have no difficulty in escaping. If necessary there may also in this case be placed vapour condensing, absorbing or adsorbing means around the lower electrode to assist in drawing the vapours away from the space between the electrodes.

The present invention is of a considerable importance in the so-called short distance distillation, by which the molecules detached by the evaporation move from a warmer to a colder surface placed at a mutual distance corresponding to the mean free path of the molecules. By the oscillations of the molecules in the field direction which occur on account of their dipolar momentum under influence of the high-frequency field, the amplitude of these oscillations will be directly dependent on the molecular weight, and hereby it becomes possible to attain an excellent separation by short distance distillation.

I claim:

1. In a method of drying, concentrating by evaporation or distilling a heat-unstable substance of the character of blood, sera, plasma, hormone preparations and the like at a low temperature in vacuo, the requisite heat being produced in the said substance by means of high-frequency electrical energy, said substance being placed between the electrodes, the step of adjusting the electric field strength and the air pressure in the treating zone constituting the space between the electrodes so that the said

field strength F does not exceed a value measured in volts per centimeter of the distance between the electrodes which is determined by the equation $F=333\frac{1}{2}\cdot p$ volts per centimeter, p denoting the air pressure in millimeters of mercury, this mutual relationship between field strength and air pressure being such as to establish only ion currents of a strength and extent such that the resultant luminous zones are remote from the substance being treated, whereby undesired overheating of the latter is avoided.

2. In a method of drying, concentrating by evaporation or distilling a heat-unstable substance of the character of blood, sera, plasma, hormone preparations and the like at a low temperature in vacuo, the requisite heat being produced in the said substance by means of high-frequency electrical oscillations generated between spaced electrodes, intermediate which the said substance is positioned, the steps of maintaining the said substance at such a distance from the electrodes that the vapors developed from the substance may escape without producing any perceptible rise in pressure in the space between the substance and the electrodes, and adjusting the electric field strength and the air pressure in the treating zone constituting the space between the electrodes so that the said field strength F does not exceed a value measured in volts per centimeter of the distance between the electrodes which is determined by the equation $F=333\frac{1}{2}\cdot p$ volts per centimeter, p denoting the air pressure in millimeters of mercury, this mutual relationship between field strength and air pressure being such as to establish only ion currents of a strength and extent such that the resultant luminous zones are remote from the substance being treated, whereby undesired overheating of the latter is avoided.

3. In a method of drying, concentrating by evaporation or distilling a heat-unstable substance of the character of blood, sera, plasma, hormone preparations and the like at a low temperature in vacuo, the requisite heat being produced in the said substance by means of high-frequency electrical oscillations generated between spaced electrodes, intermediate which the said substance is positioned, the steps of maintaining the said substance at such a distance from the electrodes that the vapors developed from the substance may escape without producing any perceptible rise in pressure in the space between the substance and the electrodes, adjusting the electric field strength and the air pressure in the treating zone constituting the space between the electrodes so that the said field strength F does not exceed a value measured in volts per centimeter of the distance between the electrodes which is determined by the equation $F=333\frac{1}{2}\cdot p$ volts per centimeter, p denoting the air pressure in millimeters of mercury, this mutual relationship between field strength and air pressure being such as to establish only ion currents of a strength and extent such that the resultant luminous zones are remote from the substance being treated, whereby undesired overheating of the latter is avoided, and collecting the vapours developed from the said substance with the aid of an adsorbent.

4. In a method of drying, concentrating by evaporation or distilling a heat-unstable substance of the character of blood, sera, plasma, hormone preparations and the like at a low temperature in vacuo, the requisite heat being pro-

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duced in the said substance by means of high-frequency electrical oscillations generated between spaced electrodes, intermediate which the said substance is positioned, the steps of maintaining the said substance at such a distance from the electrodes that the vapors developed from the substance may escape without producing any perceptible rise in pressure in the space between the substance and the electrodes, adjusting the electric field strength and the air pressure in the treating zone constituting the space between the electrodes so that the said field strength F does not exceed a value measured in volts per centimeter of the distance between the electrodes which is determined by the equation $F=333\frac{1}{2} \cdot p$ volts per centimeter, p denoting the air pressure in millimeters of mercury, this mutual relationship between field strength and air pressure being such as to establish only ion currents of a strength and extent such that the resultant luminous zones are remote from the substance being treated, whereby undesired overheating of the latter is avoided, and collecting

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the vapours developed from the said substance with the aid of an absorbent.

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