April 5, 1955 A. G. BORCK 2,705,620

METHOD AND APPARATUS FOR MIXING FLUIDS INSOLUBLE IN ONE ANOTHER

Filed June 30, 1951

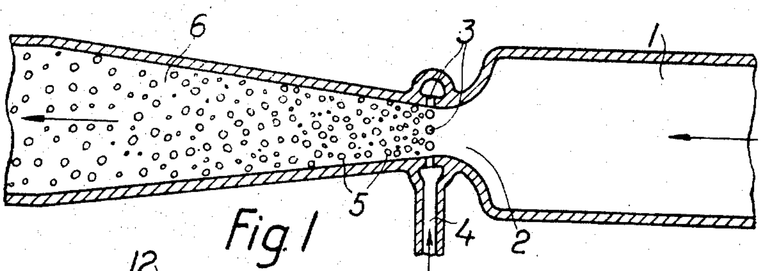

Fig. 1

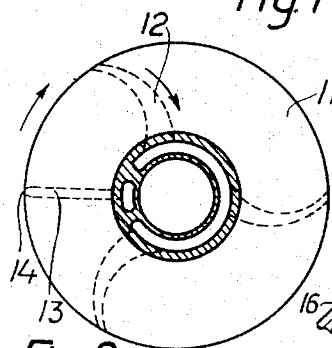

Fig. 2

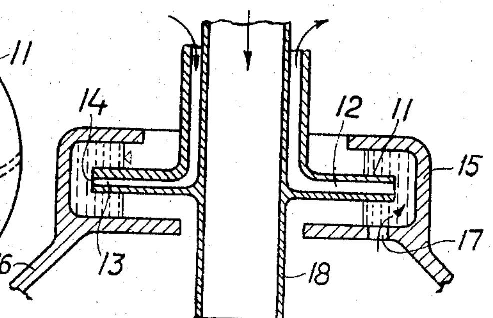

Fig. 3

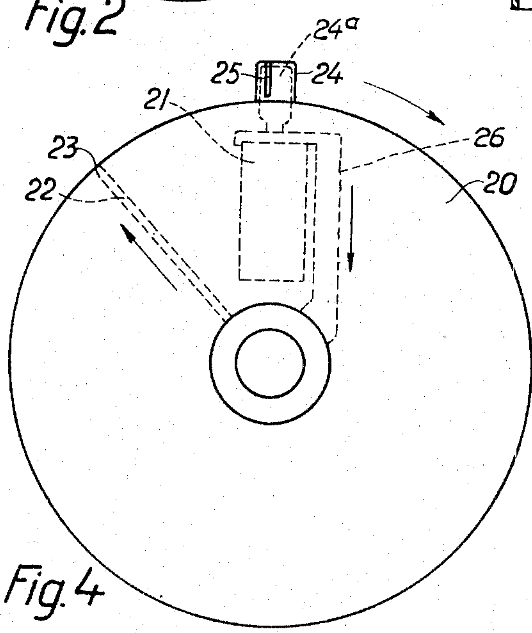

Fig. 4

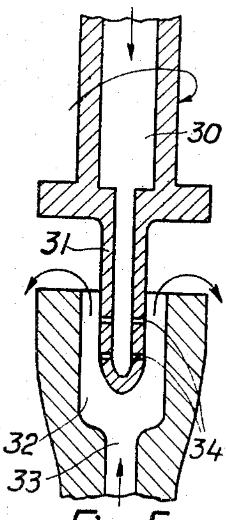

Fig. 5

INVENTOR
Alfred Gerhard Borck
BY Davis, Hoxie, Faithfull

United States Patent Office

2,705,620

Patented Apr. 5, 1955

2,705,620

METHOD AND APPARATUS FOR MIXING FLUIDS INSOLUBLE IN ONE ANOTHER

Alfred Gerhard Borck, Tullinge, Sweden, assignor to Aktiebolaget Separator, Stockholm, Sweden, a corporation of Sweden

Application June 30, 1951, Serial No. 234,572

10 Claims. (Cl. 259—3)

In the washing of oils, and for other purposes, it is desired to produce emulsions which can be broken by centrifuging. But when two liquids insoluble in one another are intimately mixed for washing or other purposes, an unbreakable emulsion, or at least a relatively stable emulsion which is difficult to break, is often formed. The degree of stability is dependent upon the surface tension in the boundary between the two liquids. It also depends upon which of the two liquids forms the continuous phase of the emulsion. Vegetable or animal oils, for example, generally have a marked tendency to form with water a stable emulsion of the oil-in-water type. When two such liquids are mixed with one another without any precautionary steps having been taken, an emulsion of relatively high stability of the oil-in-water type will result. It is possible, however, to mix the identical liquids in such a way that an unstable and easy-to-separate emulsion of the water-in-oil type is formed. This may be achieved by introducing into the oil, water in the form of small drops. Also in an emulsion of this type the oil alone remains the continuous phase when the water particles are further atomized. If, with the same mixing method, water of a larger particle size is introduced into the oil, a kind of double emulsion (a primary and a secondary emulsion) will result on further atomization, whereby the water drops of the primary emulsion will contain oil drops of a smaller size. Such a water drop having a number of smaller oil drops enclosed in it makes up the secondary emulsion. It has been found difficult or impossible to break the secondary emulsion by centrifugal treatment, and it is therefore important to avoid the formation of a double emulsion and secondary emulsion. As already mentioned, this is attained by limiting the size of the water drops mixed with the oil, that is, all the water drops should be below a certain size. When this is done, the emulsion can be treated mechanically, as in a pump or other apparatus having a homogenizing effect, without a secondary emulsion thereby being formed. The treatment referred to will divide the water drops into smaller units but there will be no trace of still smaller oil drops enclosed in the water drops.

Oils have previously been washed by mixing them with water in the form of small drops. In this way an emulsion of water-in-oil was produced which could be broken without difficulty by centrifuging, for example. In spite of this, considerable losses of oil have been observed in connection with such washing, and it has been found that the stirring of the emulsion or the homogenizing of it should not be carried too far because the losses are then increased.

A comprehensive investigation into the conditions involved in such treatment of the oil has shown that, with the atomizing and stirring devices used, the water drops were of a size of about 50μ and that these water drops contained oil drops of an order of magnitude of 10μ. This constituted a secondary emulsion of oil-in-water which it has been found impossible or very difficult to break by centrifuging. This explains the reason why oil losses were incurred.

In the example chosen, the oil tends to form with the water a stable emulsion of the oil-in-water type. The properties of the two components to be mixed, that is, water and oil or other liquids insoluble in one another, may sometimes be such that they tend to form a stable emulsion of the water-in-oil type. In such cases, according to the invention, the oil is mixed with the water in the form of drops having a certain maximum size, whereby a readily breakable emulsion of the oil-in-water type is obtained. As an example of an emulsion of this type, wool grease dissolved in petroleum (kerosene) and water may be mentioned. The fatty solution has a strong tendency to form with the water an emulsion of the water-in-oil type, which cannot be separated in a centrifuge owing to its great stability. If, on the other hand, an emulsion is produced from these liquids by introducing small drops of the fatty solution into the water, the water will form the continuous phase of the emulsion and it will be found that the latter is relatively easy to break in a centrifuge owing to its low stability. This emulsion has a high surface tension in the boundary layer between the liquids so that heavier particles (usually mineral particles), contained in the water and in the fatty solution, easily fall out of the emulsion and separate therefrom. They are, therefore, separated from the fatty solution in a centrifuge, together with the water, and this affords a method of removing these impurities from wool grease without considerable loss of adhering fat or fat solvent (in the example, petroleum such as kerosene). The impurities may then be flushed out with the separated water, without the water courses into which they are discharged being contaminated by adhering fat or petroleum.

When the method referred to is not used for washing impurities from wool grease, the impurities will be retained in a sludge component which always contains a high proportion of solvent. It is therefore desirable to dissolve the dirt from the solvent by water, which may then be discharged as described above.

As mentioned, there is an upper limit for the size of the particles or drops when emulsions are formed in accordance with the invention. When sizes above this limit are used, a secondary emulsion of the reversed, undesirable type will be formed. Therefore, the particle size must be kept below this limit according to the present method.

The limit of the particle size depends on the liquids which are to be mixed with one another. When, for example, pressed or extracted rape seed oil (crude oil) shall be deslimed with water, the maximum size of the water particles should not exceed 20μ when the content of slimy matter of the oil is not higher than 0.5%. When the content of slimy matter is higher, the maximum size of the particles should be 10μ. When treating cocoanut oil in a similar manner, the particle size should not be larger than 5μ. Other vegetable oils used in the production of margarine, for example, have such properties that the maximum particle size should be between the values for rape seed oil and cocoanut oil.

When wool grease is refined in a crude state, the particle size should not exceed 3μ.

It is, however, generally advisable to carry the atomization beyond this limit, as a safety margin is thereby obtained with regard to the formation of a secondary emulsion. The particle size at which such an emulsion appears depends on the manner in which the emulsion is post-treated. In the case of a mild mechanical treatment, the particle size may be close to the maximum value without causing the formation of a secondary emulsion. When a violent mechanical treatment is applied, for example, powerful pumping or homogenization, a secondary emulsion will be formed at a smaller particle size. In such cases, the particle size should therefore be below the stated limit when the emulsion is formed. The lower the limit the greater the security will be that an undesirable secondary emulsion will not be formed. On the other hand, there is probably a lower limit for the particle size at which it is no longer possible to separate the components in a centrifugal separator. This limit, which seems to be connected with the so-called Brown movement of small particles, has probably not yet been ascertained and in any case seems to lie below the particle size used in emulsions for technical purposes, possibly below 0.1μ.

The present invention is based primarily on the fact that when an emulsion of liquids which tend to form stable emulsions is produced by feeding the component which tends to form the continuous phase into the other component, in the form of small drops, an emulsion will result which is relatively easy to break; whereas an emulsion of the same liquids forming reversed phases is difficult or impossible to break by means of centrifuging. (It is assumed in the above that the particle size of the drops forming the dispersed phase is in both cases identical.)

According to the invention, the component which tends to form the continuous phase on being emulgated, is fed in the form of drops or steam bubbles into the other component. These drops, or the drops resulting from condensation of the steam bubbles, are of so small a size that the formation of a double emulsion or a secondary emulsion is avoided when the material is post-treated by pumping, centrifuging or homogenizing. This feeding of one component into the other may be effected, for example, by an injector pump in which one of the components forms the main current, the pressure energy of which is converted into velocity in an injection nozzle. At the point where the velocity is at or near a maximum, the other component is fed into the nozzle, preferably in a direction at right angles to the main current. When washing oil by means of water, the amount of water is usually about 5% of the amount of oil, so that the mixture of oil and water contains a fairly low proportion of water. For the sake of simplicity, the instance chosen as an example, that is, washing oil by mixing it with water, will be followed. Experiments have shown that when the oil is forced through the mixer at a pressure of 7 kgs. and the water at the same pressure, an emulsion of the water-in-oil type is produced in which the size of the water drops is between 3 and 8μ. With an arrangement of this kind, the washing procedure can be carried out without any risk of smaller oil drops being formed in the water drops, that is, an emulsion of the oil-in-water type which cannot be broken or can be broken only with difficulty.

The injection pump is used to convert the pressure energy of the oil into energy of velocity. An important feature of the invention resides in the velocity of the oil in relation to the incoming water, as previously mentioned. This velocity relation exists in a centrifugal bowl in which the oil is discharged by a paring disc. In this bowl the oil forms a rotating body of liquid which moves in relation to the outer part of the paring disc at a considerable peripheral velocity. It is therefore possible to carry out the invention in connection with the paring disc of a centrifuge. For this purpose, a flow of water or steam is led to the periphery of the paring disc. The water then penetrates into the oil body in the form of liquid or steam and thereby forms the water-in-oil emulsion desirable for the washing. With the usual paring disc, the size of the water drops will be in the order of 3 to 8μ. A rather efficient mixing takes place in the liquid so that a fairly homogeneous emulsion of water-in-oil is discharged through the paring disc. This device may be improved by using a so-called homogenizing paring disc instead of an ordinary paring disc. This is provided with an homogenizing member built into the paring disc and also has, usually, a larger diameter than other paring discs so that the relative velocity between the rotating liquid and the stationary disc is higher. Experiments have shown that with the atomization of the water in the oil achieved with this device, the diameter of the water drops is between 1 and 2μ.

The paring disc with its paring chamber may be replaced by a rapidly rotating hollow body, preferably tube-shaped, provided with one or more lateral openings and enclosed by a container in which the oil flows past the lateral openings.

The method may be further improved by using steam instead of water. A certain quantity by weight of water occupies in the form of steam a volume which is many times larger than when it is in the form of a liquid, for example, 1000 times at the steam pressure used in the present case. If, therefore, the water is fed into the oil in the form of steam bubbles or particles, the size of which is between 1 and 3μ, the water drops formed on condensation of the steam will be between 0.1 and 0.3μ. With this very considerable atomization, it is assured that an emulsion of oil-in-water will not be formed, and the contact surface between the water and the oil will be very large, which insures a very efficient and rapid washing of the oil. At the beginning, when the water is still in the form of steam bubbles, the contact surface is further enlarged considerably. The steam bubble must be regarded as bounded by a layer of water in contact with the enclosing oil, and it is of material importance for the washing that this contact surface is as large as possible. Before a considerable condensation has taken place, the mixture of steam vapour and oil has substantially the character of froth in which the oil forms relatively thin walls between the steam bubbles, which contributes strongly to making the washing rapid and efficient.

The use of steam instead of water has also the practical advantage that steam of a sufficient pressure is usually available, whereas the pressure of the water requires a pump. When using steam in combination with a paring disc, a device is thus obtained which is entirely independent of pumps.

Another important advantage attained when using steam instead of water is that heating of the oil, which is usually necessary in connection with the washing, is obtained without extra measures.

The accompanying drawing shows some devices for washing of oil in accordance with the invention. Fig. 1 is a longitudinal sectional view of an injection pump arranged for this purpose;

Figs. 2 and 3 are horizontal and vertical sectional views, respectively, of a paring device with paring discs for feeding wash water into the oil;

Fig. 4 is a plan view of a so-called homogenizing paring disc; and

Fig. 5 is a vertical sectional view of another device for the same purpose.

According to Fig. 1, the oil is fed under pressure (for example, 7 kgs. per cm.^{2}) through a pipe **1** into a nozzle **2** in which the pressure energy is converted into velocity energy. At the smallest cross-section of the nozzle is at least one lateral opening **3** through which the water or the steam flows from a pipe **4** and is mixed with the oil current in the form of small drops **5**. The mixture of oil and water proceeds through the expanding pipe **6** into a centrifuge (not shown), for example, in which the water is separated. Experiments have shown that with this device the water is atomized into drops of the order of 3 to 8μ at a pressure of 7 kg./cm.^{2}.

According to Figs. 2 and 3, the stationary paring disc **11** is provided with a number of ordinary discharge channels **12** and also with one or more channels **13** for the supply of water or steam for washing of the oil. One such channel **13** ends at the edge **14** of the paring disc in the rotating body of liquid in the hollow rotor **15**, which forms the paring chamber. The water or the steam is atomized in the same way as in the Fig. 1 device and is mixed with oil. The emulsion thus formed is caught by the channels **12** and discharged therethrough. The paring device may advantageously be built into a centrifugal bowl **16**, from which the paring chamber **15** receives the oil through passage **17**. The oil may be fed into the bowl **16** through an axial tube **18** supporting the paring disc.

The paring disc **20** shown in Fig. 4 differs from that illustrated in Fig. 2 mainly in that it is provided with an homogenizing device or is shaped to form such a device. The disc **20** may be provided with any desired number of such devices, but as shown in Fig. 4 it has only one homogenizing device **21**. The washing agent is fed outward through a channel **22** to a point **23** at the periphery of the paring disc, where the water or the steam is mixed with the rotating body of oil in the same way as in Fig. 2. The emulgation thus formed is caught by a projection **24** of the paring disc, comprising a cylindrical chamber **24***a* forming a cyclone and provided with a tangential inlet **25**. From this chamber, the oil flows in the form of a jet into the homogenizing device or zone **21**, which may be a whirl chamber, for example, and then discharges from the periphery of chamber **21** through an outlet **26**. A paring disc of this type may advantageously be built into a centrifugal bowl, as shown in Fig. 3. Examples of paring discs embodying homogenizing devices are disclosed in my copending application Serial No. 225,291, filed May 9, 1951, now Patent No. 2,612,356 dated September 30, 1952.

The device illustrated in Fig. 5 consists mainly of a rapidly rotating tube **30** provided with a hollow pointed or reduced end **31** projecting into a stationary container **32** which is provided with a supply channel **33**. The pointed end **31** is provided with a number of lateral openings **34** inside the container **32**. In operation, the oil is suplied through the channel **33** and discharges over the top edge of the container **32**. A washing agent in the form of water or steam is added through pipe **30** and enters the container **32** through openings **34**. During operation, the pipe **30** rotates at very high speed, for example, at 20,000 R. P. M. The liquid or steam leaving the openings **34** will then meet the oil enclosing the pointed end **31** at a relative velocity approximately the same as or higher than in the arrangements according to Figs. 2–4. As in the previously described arrangements, the water or steam will thus be mixed with the oil in very fine form.

In the following claims, the terms "water" and "drops" are used in their broad sense to include, respectively, steam and steam bubbles or particles which, after condensation, form drops.

I claim:

1. A method of inhibiting the formation of a stable emulsion when mixing two mutually immiscible fluid components, one of which normally forms the continuous phase upon emulgation of the components, comprising feeding into a body of the other component drops of said one component which are of smaller size than that necessary to form an emulsion of said other component in said drops of the one component as a continuous phase when the mixture is post-treated by strong mechanical action.

2. A method according to claim 1, for mixing water with a fatty substance normally forming with the water a stable emulsion of the water-in-oil type, in which the fatty substance is fed into the water in the form of drops of said smaller size, to form an unstable emulsion in which the water is the continuous phase.

3. A method according to claim 1, for mixing with water an oil normally forming with the water a stable emulsion of the oil-in-water type, in which the water is fed into the oil in the form of drops of said smaller size, to form an unstable emulsion in which the oil is the continuous phase.

4. A method according to claim 1, in which said drops are of a size less than about 20 μ.

5. A method according to claim 1, in which said other component is passed into a nozzle, prior to said feeding of the drops, to convert pressure energy of said other component into velocity energy, said drops being fed laterally into the stream of said other component during passage thereof through the nozzle.

6. A method according to claim 1, in which said other component is rotated in the form of an annular body

during said feeding of the drops, the drops being fed into the rotating body generally radially thereof.

7. A method according to claim 1, in which said other component is rotated in the form of an annular body during said feeding of the drops, the drops being fed into the rotating body generally radially thereof, the mixture then being passed through an homogenizing zone adjacent said body.

8. A method according to claim 1, in which said component normally forming the continuous phase in the stable emulsion is rotated rapidly during feeding of the drops thereof into said other component, said drops being fed laterally into a surrounding stream of said other component.

9. A method according to claim 1, in which said drops are of a size less than about 20 μ and greater than about .1 μ.

10. Apparatus for mixing mutually insoluble fluid components tending to form stable emulsions, such as oils with water, which comprises a hollow rotor forming a paring chamber, said chamber having an inlet for the component tending to form the dispersed phase upon emulgation of the components, said last component forming a rotating annulus in said chamber, a stationary paring disc extending into the rotor and having a channel positioned to project into said annulus to discharge material from said annulus, the disc also having a small passage positioned to extend into said annulus, means for feeding the other component through the disc to said small passage, whereby said other component is delivered in drops to said annulus, and an homogenizing device in the disc and forming part of said discharge channel.

References Cited in the file of this patent

UNITED STATES PATENTS

2,125,453	Lindgren	Aug. 2, 1938
2,230,210	Brecour et al.	Jan. 28, 1941
2,298,016	Lincoln	Oct. 6, 1942
2,401,431	Lewis	June 4, 1946
2,477,269	Sandler	July 26, 1949
2,527,689	Suthard et al.	Oct. 31, 1950

FOREIGN PATENTS

203,794	Great Britain	Sept. 17, 1923
485,656	Great Britain	May 23, 1938