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Stenstrom

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[54] **APPARATUS FOR ENVELOPING AND TREATING SUBSTANCES**

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[51] **Int. Cl.²** **B65B 55/02**

[58] **Field of Search** ..... 53/111 R, 127, 167, 180; 21/102

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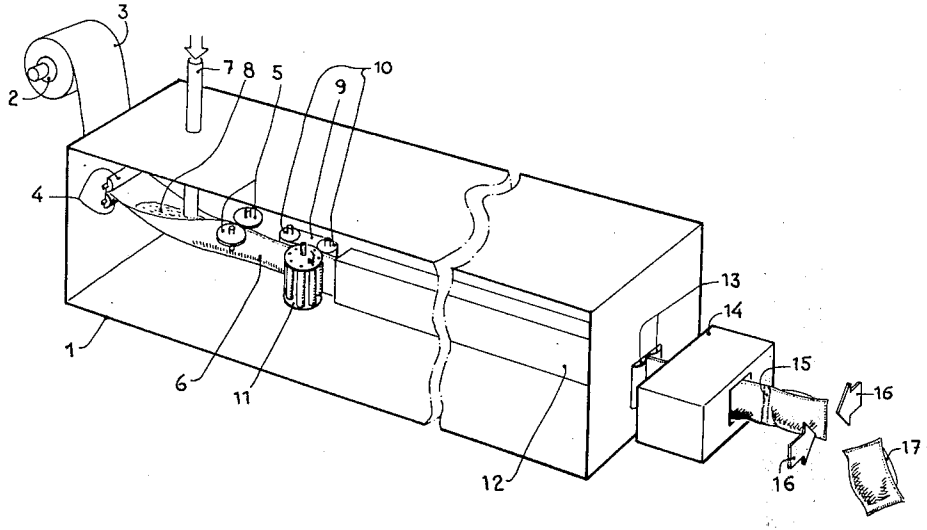
[57] **ABSTRACT**

A substance being conveyed through a treatment zone is treated substantially uniformly, while enclosed in an envelope, by an apparatus comprising means for continuously supplying to said zone a tube of flexible material which is to constitute said envelope, and means for continuously filling the tube with substance to be treated, the tube being moved through said zone.

3 Claims, 6 Drawing Figures



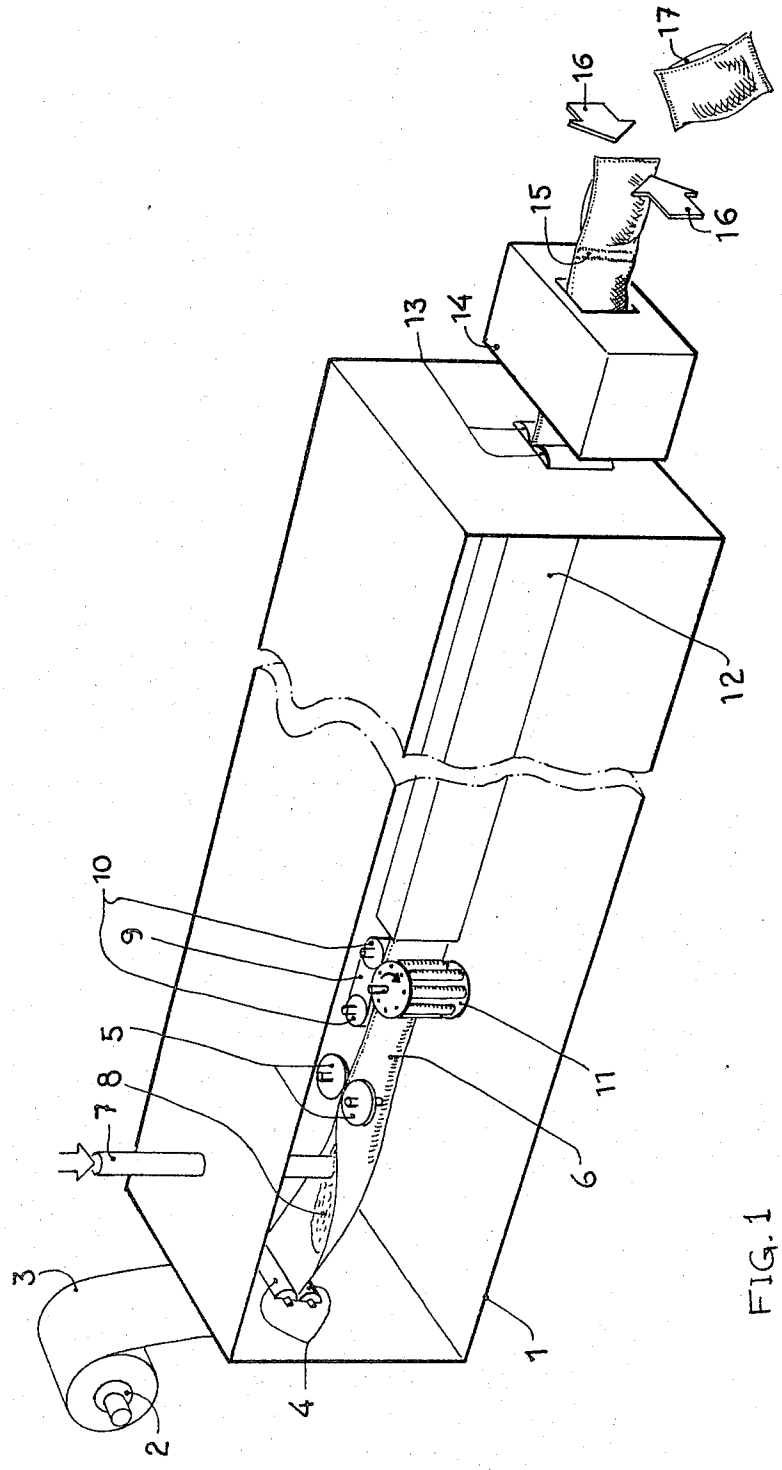


FIG. 1

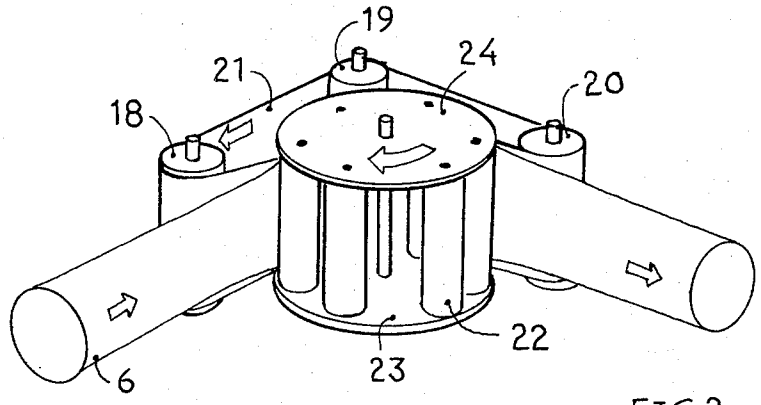


FIG.2

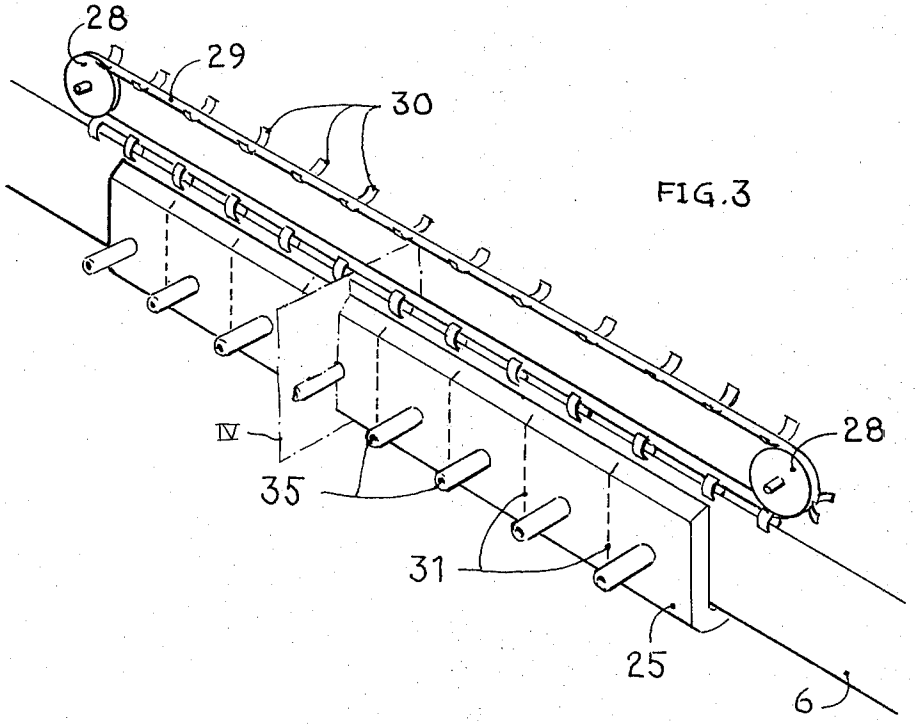


FIG.3

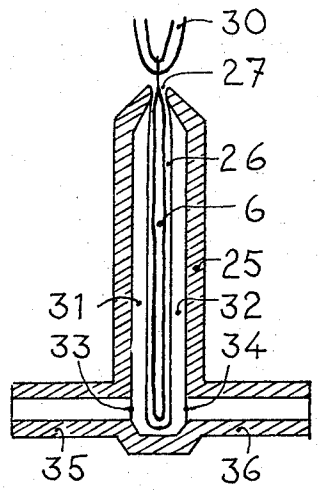
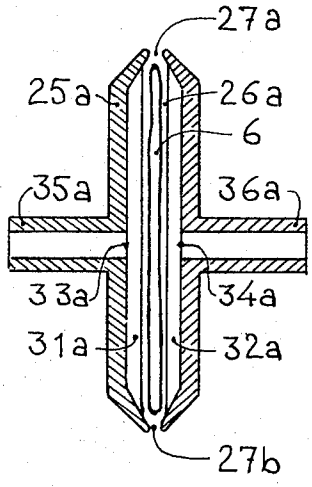


FIG. 4

FIG. 5



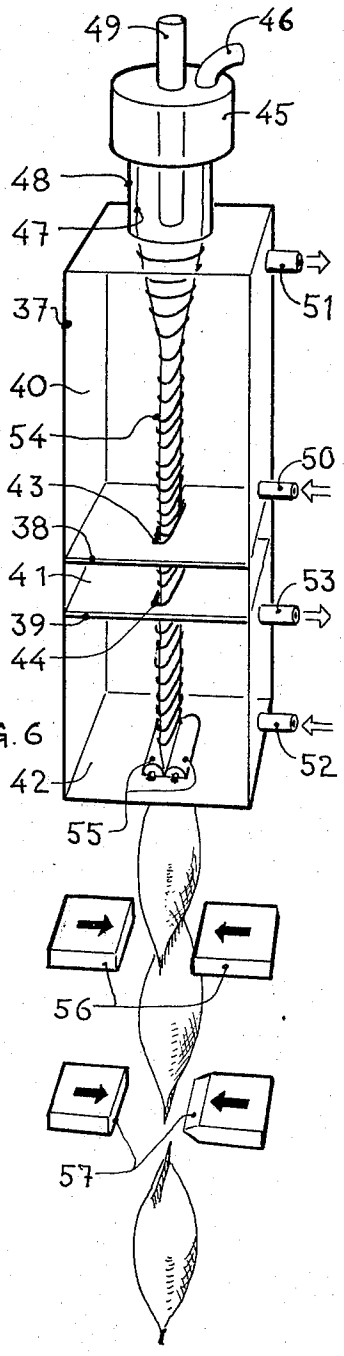


FIG. 6

APPARATUS FOR ENVELOPING AND TREATING SUBSTANCES

The present invention relates to a continuously working apparatus for treating a substance that is conveyed through a treatment zone and during this transport is surrounded by an envelope. The apparatus of the invention is intended primarily for heat treatment or irradiation of liquids, but it may also be used in other connections where it is desired to envelope a substance in connection with a treatment operation. For instance, mechanical treatment of substances is contemplated by the invention.

With most continuously working apparatuses for treating a substance, it is a problem to effect a substantially uniform treatment of the substance. The problem is accentuated if the treatment is to be performed rapidly, as in the case where a treatment zone through which the substance is to pass with a predetermined velocity has an extension along the path of movement of the substance which is small with respect to the said velocity. Irrespective of whether the treatment process is a heat treatment or a mechanical treatment of the substance, it is normally easier to obtain a uniform treatment effect in the substance if the treatment can be extended in time than if the treatment must be performed rapidly.

A rapid treatment of a product may be desired for different reasons. For instance, in connection with heat sterilization of an edible product, the heat treatment is desired to be performed rapidly for the reason that the least possible change of taste of the product should be obtained. Also, from the economic point of view it may be desired sometimes to perform a treatment rapidly, as in the case where the equipment by means of which the treatment is to be performed is expensive counted per unit of length of its extension along the path of movement of the substance to be treated. An equipment of this kind can be a microwave applicator or an ultrasound transmitter.

The problem of obtaining a uniform treatment of a substance can easily be understood by consideration of a continuously working heat exchanger. For instance, in a tube heat exchanger a substance to be heated is pumped through a number of tubes which along a part of their length are contacted by a flowing heating medium. It is inevitable, when a substance flows through a tube, that the substance layer flowing close to the tube wall moves substantially slower through the tube than substance flowing in the middle of the tube. In a tube heat exchanger, certain parts of the substance to be heated will thus stay in the heating zone longer than others, so that all parts of the substance will not be uniformly heat treated.

The non-uniform heat treatment of a substance in a tube heat exchanger may result in parts of the substance being spoiled. Further, a part of the substance may burn onto the inside walls of the heat exchanging tubes, the heat transfer then being less effective so that the heat treatment must be stopped for cleaning of the tubes. These disadvantages are particularly troublesome if the substance is to be heated rapidly to a high temperature, as the heat exchanging surfaces in the heat exchanger must then be kept at a temperature which lies substantially above the average temperature to which the substance is to be heated. Another reason why deposits often are formed on the heat exchanging surfaces in a heat exchanger is that microorganisms

have particularly good growing conditions in certain parts of the heat exchanger owing to the temperature prevailing there. Cultures of microorganisms may then be formed eventually as deposits on the heat exchanging surfaces, which necessitates regular interruptions of the operation for cleaning of these surfaces.

One way of avoiding the above-described problems in connection with heating of a substance is to pack the substance in separate units in a suitable packing material, when possible, and then to perform the heat treatment. Heat treatment apparatuses are available which are arranged to continuously receive, heat treat and then deliver separately packed units of a substance. In an apparatus of this kind, the material in which the different units of the substance are packed constitutes the heat transferring element of the apparatus, and since the packing material moves through the apparatus together with the substance, the same problems cannot appear as in a tube heat exchanger.

However, another problem appears in apparatuses of this kind, in that the edges and corners of the packed units will get a more intensive heat treatment than other parts of the units. That is, the edges and corners of the units are subjected to the effect of the heating medium from different directions, and therefore these parts of the units will attain a higher temperature than the central parts of the units. In other words, the packed substance will not be uniformly treated.

In conventional heating by means of steam or hot water, the last mentioned problem might be solved if the packets were made spherical. The same solution would not be applicable, however, in connection with heating of packed units by means of microwaves. It is possible to form a microwave applicator so that a limited product unit movable along a path can be heated uniformly from all directions by this applicator, seen in the moving direction of the unit, but only if the product unit is given the form of a cylinder. However, since a product unit which is situated in a microwave field attracts field energy from all directions, it cannot be avoided that the front and rear parts of the product unit, seen in the moving direction of the product unit, will be heated more than the product unit parts situated therebetween. In other words, the product unit will not be uniformly treated.

Also, in other connections than heat exchanging, problems may arise with deposits on the surfaces of walls defining a treatment zone. In connection with crystallization, it is known to use an apparatus comprising a vertical tube through which a liquid, from which crystals are to be obtained, is caused to flow. During operation there is obtained an undesired layer of crystals on the tube wall, which eventually grow and cause changed crystallization conditions for the liquid flowing through the tube. Among other things, the crystals on the tube wall influence an often desired heat transfer through the tube wall, as well as the liquid flow in the tube. Different parts of the liquid thus will not be uniformly treated.

The present invention relates to an apparatus by means of which a substance can be subjected to substantially uniform treatment when conveyed through a treatment zone arranged for the purpose. The apparatus according to the invention is mainly characterized by means for continuously supplying to the treatment zone a tube of flexible material, which is to constitute the envelope in the treatment zone, and means for con-

tinuously filling the tube with substance to be treated, the tube being movable through the treatment zone.

By enveloping the substance in the treatment zone by an open tube of flexible material, according to the invention, the cross section of the substance flow through the treatment zone can easily be formed in the best manner with respect to the particular treatment. Further, by moving the flexible tube through the treatment zone, it is possible to control the time of duration in the treatment zone for substance which is in direct contact with the tube. Owing to this, it is possible to treat the substance substantially uniformly, which in turn enables the performing of a rapid treatment with the smallest possible risk for spoiling of parts of the substance.

In a preferred embodiment, the treatment apparatus according to the invention comprises particular means arranged to create a relative movement in the treatment zone between the substance and the envelope surrounding it, i.e., the tube of flexible material.

The aforementioned particular means may be of different kinds. For instance, it may comprise pressing members which are arranged along the path of the moving tube and which are arranged to compress the tube at different points of time, so that the substance therein will acquire a reciprocating movement relative to the tube in the longitudinal direction thereof. Alternatively, such means may comprise a number of rolls arranged to compress the tube while being caused to roll a distance along the same with a velocity that is greater than that of the tube. In this way, the substance may be constantly moved faster than the tube along the whole or a part of its path of movement. The relative movement between the substance and the tube may be made so great that a violent turbulence will be generated in the substance within the treatment zone, which in several treatment cases promotes a uniform treating of the substance. The achievement of a desired turbulence can be made easier by giving the flexible tube along a part of its length a through flow area that is smaller than the maximum through flow area of the tube. For instance, the through flow area of the tube may be given a form substantially like the cross sectional area of a uniformly thick ribbon.

The aforementioned particular means may be arranged to effect, by squeezing of the flexible tube, a relative movement between the substance and the surrounding tube, transverse to the direction of movement of the substance.

To obtain a relative movement between the substance and the tube surrounding it in the direction of movement of the substance, it is not always necessary to use members by means of which parts of the tube are compressed. Gravity and also centrifugal force can be used for obtaining a relative movement of this kind.

Preferably, the treatment apparatus according to the invention also comprises means situated beyond the treatment zone, seen in the direction of movement of the flexible tube, and arranged to compress and seal the tube at even intervals, so that separate units of treated substance, enclosed in flexible material, are obtained. Thus, substance supplied to the treatment apparatus may be protected from its surroundings not only during the treatment but also thereafter. If the treatment is heat sterilization of a liquid, such as milk, it is thus possible to automatically effect aseptically packaging of the sterilized liquid. In the treatment zone, not only the liquid but also the inside wall of the flexible tube surrounding the liquid during the heat sterilization are sterilized. Prior practice in connection with packing of a heat sterilized liquid normally entails the complication (i.e., if the liquid is heat sensitive) that the packing material must be sterilized separately, as by means of chemicals. That is, the sterilized liquid cannot be packed while it is at the sterilizing temperature but must be cooled to a lower temperature immediately after the heating to sterilizing temperature in order not to be spoiled. A further complication is that the packing operation must be performed in absolutely sterile surroundings. Surroundings of this kind are difficult to provide and, above all, to maintain during long periods of time.

In a treatment apparatus according to the invention, a heat sterilized liquid may be rapidly cooled before it is packed without having the packing operation performed in a sterile surrounding. Due to the fact that the liquid is situated in a tube of flexible material, the flow of sterilized liquid may easily be given a cross section which facilitates cooling of the liquid.

The form of the packets which are produced by the flexible tube after the substance has been treated in the treatment zone is independent of the cross sectional form given to the flexible tube within or before it enters the treatment zone. Thus, the finished packets may be given cylindrical, parallelepipedical or tetrahedral form, even if the flexible tube in the treatment zone has the form of a thin ribbon. The substance will then move faster than the flexible tube where the latter has the form of a thin ribbon, but the magnitude of the relative movement between the substance and the flexible tube will have been reduced to zero when the flexible tube is compressed and sealed and separate units of the treated substance are obtained.

The invention is described in more detail below with reference to the accompanying drawings in which

FIG. 1 is a perspective view of an apparatus according to the invention for treatment of a pumpable substance which is situated in a tube of flexible material;

FIG. 2 is a similar view of means for axially moving a tube of flexible material and a substance situated therein;

FIG. 3 is a perspective view of means for bringing a heat treating medium into contact with the outside of an axially movable flexible tube containing a substance to be treated;

FIG. 4 is a cross-sectional view in the plane IV in FIG. 3;

FIG. 5 is a cross-sectional view corresponding to that in FIG. 4 but showing an alternative embodiment of the means according to FIG. 3; and

FIG. 6 is a schematic view of an alternative embodiment of the apparatus according to the invention, in which the tube of flexible material and the substance situated therein move vertically downwards.

The apparatus in FIG. 1 comprises a housing 1 arranged to receive from a roll 2 a ribbon 3 of thin flexible material. The ribbon 3 is supplied into the housing 1 between two rollers 4 which are journalled in the front end wall of the housing. Within the housing 1 there are placed two discs 5 arranged to continuously join the two longitudinal edges of the ribbon 3, so that a tube 6 is formed by the ribbon. Conventional means (not shown) are arranged to give the ribbon the form necessary for the joining of its edges. A pipe 7 extends into the housing 1 and opens into a trough 8 formed by

the ribbon 3 immediately before its edges are joined. The pipe 7 constitutes an inlet for substance to be treated in the apparatus.

For transportation of the formed flexible tube 6, the apparatus comprises an endless ribbon 9 extending around two rollers 10. One of the rollers 10 is arranged to be driven by suitable means (not shown). The ribbon 9 is arranged to abut against and to entrain the tube 6 in its movement. On the opposite side of the tube 6 there is situated a pressing member 11, which is arranged to press the tube 6 against the ribbon 9 and simultaneously to give it an elongated cross section.

The pressing member 11 may consist of a roller or, as in FIG. 1, it may comprise several rollers arranged in a circle and having parallel axes. A pressing member comprising several rollers may be used for pumping substance from the trough 8 through the tube 6 by being brought into rotation with a periphery velocity that is greater than the velocity of the ribbon 9, so that substance will move in the same direction as the tube 6 but at a greater velocity than the latter. The housing 1 also contains equipment for special treatment of the substance which is situated within the tube 6. This treatment equipment, which in FIG. 1 is generally designated 12, may be of any suitable kind, depending on the kind of treatment to which the substance is to be subjected.

Two additional rollers 13 are journalled in the rear end wall of the housing 1, between which rollers the flexible tube 6 (enveloping the treated substance) exits from the housing. The rollers 4 as well as the rollers 13 abut sealingly against the housing 1 as well as against the ribbon 3 and the tube 6, respectively, so that the interior of the housing may be put under pressure.

In FIG. 1, means 14 are provided for compressing and sealing the tube 6 at even intervals when the latter has left the housing 1, so that separate portions of the treated substance, enclosed by flexible material, are obtained. A compressed portion of the tube 6 is shown at 15. Arrows 16 indicate that the tube 6, compressed at intervals, is cut off at the compressed intervals so that separate units 17 are obtained, each of which consists of a portion of a substance treated in the apparatus and packed in flexible material.

Means for successively compressing and sealing at even intervals a flexible tube containing a substance, such as a powder, parboiled vegetables, or a liquid, are well known in the packing industry and need no further description here.

In FIG. 2 there is shown schematically the construction of means for moving the flexible tube 6 in its longitudinal direction at a predetermined velocity while also moving a substance situated therein, such as a liquid, in the same direction at a different velocity. Such means comprise three parallel rollers 18, 19 and 20, which are arranged in the corners of an imagined triangle. Around the rollers, one of which is connected to a driving means (not shown), there is placed an endless ribbon 21. A number of smaller rollers 22 are arranged in a ring with their axes parallel and are journalled at their ends in two circular plates 23 and 24. Each roller 22 is free to move around its own axis. The plates 23 and 24 are interconnected and connected to a driving means (not shown) which is arranged to rotate the plates around their common axis. The rollers 22 are thus forced to move in a circular path around the same axis.

As can be seen from FIG. 2, the flexible tube 6 is compressed between the ribbon 21 and some of the rollers 22. Through friction engagement between the ribbon 21 and the tube 6, the latter may be caused to move in its longitudinal direction by driving of the ribbon 21 around the rollers 18–20. Arrows show the directions of movement for the ribbon 21 and the tube 6. By rotation of the plates 23 and 24 (and thus the rollers 22) in the direction illustrated in FIG. 2, a substance may be pumped with a desired velocity through the tube 6 during the axial movement of the latter. The pumping effect is achieved by the fact that each of the rollers 22 while squeezing the tube 6 against the ribbon 21 is caused to roll along the tube 6 so that substance situated therein is pressed forward by the roller 22.

As mentioned previously, the treatment equipment 12 in FIG. 1 may be of different kinds. In FIGS. 3 and 4 are shown means for heat treatment of a substance situated within a tube of flexible material. Such means comprise an elongated body 25 defining a treatment chamber 26 (FIG. 4) extending along the entire body. Through a slot 27, the treatment chamber at the top communicates with the surroundings. As illustrated in FIG. 3, the flexible tube 6 containing substance to be treated is moved axially through the treatment chamber 26. Conveying means arranged to effect this movement comprise two wheels 28, one of which is driven by suitable means (not shown), and a chain 29 placed around the wheels and provided with grippers 30 for conveying the tube 6 along the treatment chamber 26.

By means of flanges 31 and 32, which extend from opposite walls of the treatment chamber 26 transverse to the moving direction of the tube 6, the treatment chamber is divided on each side of the tube 6 into a series of subchambers. At least some of the flanges 31 and 32 may extend to abutment against the tube 6 passing through the treatment chamber 26, so that separate treatment zones are formed in the body 25. In FIG. 4 there is shown for the sake of clearness an interspace between the flanges 31, 32 and the passing tube 6.

Each of the subchambers formed within the body 25 in the above-described manner has an inlet and an outlet for a heat treating medium. In FIG. 4 there are shown two inlets 33 and 34 to two subchambers formed on opposite sides of the tube 6. The slot 27 situated at the top forms an outlet from all of the subchambers on both sides of the tube 6.

Through conduits 35 and 36, heat treating medium with a desired temperature and a desired pressure may be supplied to the inlets 33 and 34, respectively. By choosing different temperatures of the heat treating medium for the various subchambers, any desired heat treatment program may be realized for the substance passing through the treatment chamber 26. Thus, the treatment chamber may comprise a heating zone, a zone wherein the substance is to be kept at an unchanged temperature, and finally a cooling zone.

Owing to the fact that the slot 27 in the body 25 is relatively narrow, which means that the outlets from the subchambers are throttled, an overpressure may be created in all or a part of the treatment chamber 26 by means of the heat treating medium. An overpressure of this kind may be required for counteracting an overpressure arising within the flexible tube 6 due to the heat treatment.

Also for another purpose it may be desired to create an overpressure in the different subchambers. By creat-

ing overpressure in two subchambers situated opposite to each other, the flexible tube 6 may be locally compressed entirely or partly. This may be used for pumping substance through the tube 6 with a desired velocity. Then subsequent subchambers are successively subjected to overpressure, so that a compressing of the tube 6 propagates forward along the tube like a wave. Overpressure used for pumping is maintained only during short periods of time in each subchamber. Between these periods of time the flexible tube is allowed to expand and again be filled with substance from the inlet end of the tube. Pumping means working in this manner, of course, may be used exclusively for pumping substances through the flexible tube 6. The pressure medium used for the pumping thus need not be used also as heat treatment medium.

An arrangement of the above-described kind may also be used for other purposes than those mentioned above. Thus, desired turbulence may be generated in the substance within the flexible tube 6 by means of an arrangement of this kind before or during a particular treatment of the substance. The particular treatment may be microwave treatment or ultrasonic treatment. By means of the latter treatment it is possible, for instance, to homogenize a liquid or to disperse one or more substances in a liquid without addition of particular surface-active substances. The arrangement in FIGS. 3 and 4 may also be used for mechanical treatment of the substance in the flexible tube.

By using a liquid as a pressure or heat treatment medium in the treatment chamber 26, the friction between the flexible tube 6 and the flanges 31 and 32 may be reduced to a minimum.

The modification shown in FIG. 5 comprises a body 25*a*, a treatment chamber 26*a* and, in the latter, flanges 31*a* and 32*a* which define several subchambers. The body 25*a* in this embodiment has longitudinal slots 27*a*, 27*b* both above and below the treatment chamber 26*a*, the inlet to each of the subchambers being situated halfway between these two slots. Two inlets 33*a*, 34*a* and two inlet conduits 35*a*, 36*a* are shown in FIG. 5.

In FIG. 6 there is shown an alternative embodiment of a treatment apparatus according to the invention. A housing 37 forms a chamber which, by means of partitions 38 and 39, is divided into three treatment chambers 40, 41 and 42. Substance to be treated moves from above and downwards through the treatment chambers 40, 41 and 42 in the said order, enclosed by a tube of flexible material moving in the same direction. For the passage between the different chambers, the partitions 38 and 39 have slots 43 and 44, respectively.

The reference 45 in FIG. 6 designates a conventional extruder for continuous production of a tube of flexible material, which tube is supplied to the uppermost treatment chamber 40. The extruder 45 at the top has an inlet pipe 46 for liquid material, and at the bottom is an annular slot (not shown) through which the liquid material is extruded as a tube. Reference 47 designates a tube of flexible material produced in this manner. Below the extruder 45 is a cylindrical pipe 48, which is arranged to receive the finished tube 47 of flexible material from the extruder 45 and to direct it further into the treatment chamber 40.

Through the extruder 45, and into the part of the finished flexible tube 47 situated within the pipe 48, there extends an inlet conduit 49 for substance to be treated within the housing 37. Preferably, substance is supplied through the conduit 49 in an amount per unit of time such that a free liquid surface is maintained in the flexible tube 47 situated in the cylindrical pipe 48. The position of the liquid surface may be controlled in any suitable manner, as by means of a siphon arrangement.

As mentioned previously, the interior of the housing 37 is divided into three different treatment chambers 40, 41 and 42. The chamber 40 is a heating chamber and has an inlet 50 and an outlet 51 for a heating medium. The chamber 41 constitutes a dwell chamber in which the substance within the flexible tube 47 is to be maintained at substantially the temperature to which it has been heated in the chamber 40. If desired, the chamber 41 may have an inlet and an outlet (not shown) for a heat treating medium. The chamber 42 is a cooling chamber and has an inlet 52 and an outlet 53 for a cooling medium. Within each of the chambers 40, 41 and 42 are supporting members 54 for the flexible tube 47 during its passage therethrough. These supporting members may consist of rigid wires, such as a net of such wires, which are formed so that they provide a passage for the flexible tube 47 through the chamber. The cross section of the passage, which can be chosen as desired, will determine the cross section of the flexible tube 47 when the latter passes through the treatment chambers. In FIG. 6, the cross section of the passage is elongated, which enables a rapid heat treatment of the substance present within the tube 47.

The bottom of the housing 37 has an opening where two rollers 55 are journalled in the bottom of the housing. Between these rollers 55, the flexible tube 47 and the heat treated substance present therein are adapted to pass from the housing 37. The rollers abut sealingly against the housing 37 as well as against the flexible tube 47. Outside the housing 37 are members for compressing and sealing the flexible tube 47, so that separate portions of the treated substance are defined, and members for cutting off the tube 47 at the places where it has been compressed. These members are shown only schematically in FIG. 6 and are designated 56 and 57, respectively. The members 56 and 57 are arranged to move downwards when pressed together around the tube 47, so that the latter is moved downwards with a desired velocity. Due to the compression of the tube at the bottom, the weight of the tube and the substance situated therein may be utilized for moving of the tube downwards.

In the apparatus in FIG. 6, the substance present in the flexible tube 47 moves downwards through the treatment chambers 40, 41 and 42 by gravity. By controlling the velocity at which the flexible tube 47 moves through the treatment chambers 40, 41 and 42, in relation to the velocity at which the substance flows downwards through the flexible tube, the desired volume can be obtained for the finished portions defined and separated at 56 and 57, respectively. When the flexible tube 47 has left the housing 37, it can be allowed to expand to its original circular form, or to some other form that can be determined by means of supporting members, for instance, of the same kind as the supporting members 54 in the treatment chambers 40–42. If desired, different means may be used for forcing the substance to move faster through the flexible tube 47 than only gravity will effect. FIGS. 1–5 show examples of means of this kind. A further possibility is to maintain an overpressure in the substance at its entrance into the flexible tube 47 within the cylindrical pipe 48. A corre-

sponding pumping effect on the substance to be treated is obtained in the apparatus according to FIG. **1**, if the interior of the housing **1** is connected to a pressure source.

In the apparatus according to FIG. **6**, the extruder **45** may be replaced by means of the kind shown in FIG. **1** for continuous supply of a tube of flexible material to the treatment part of the apparatus.

As will be apparent from the foregoing, an apparatus according to the invention provides a large relative movement between the liquid substance and the ribbon-formed tube. This promotes heat transfer between the liquid and the tube, causes turbulence which promotes temperature equalization in the liquid, and promotes contact of the liquid with a large heat transferring surface (despite the short treatment time) which contributes to a uniform heat treatment of the liquid. Also, the ribbon-like form of the tube makes it easy to apply micro-waves for the heat treatment, if desired.

I claim:

1. Apparatus for heat treatment and packing of a liquid, which comprises means forming a heat treatment zone, means for continuously supplying a tube of flexible material for passage through said zone, a device for continuously filling the tube with liquid, said zone including a portion adapted to give a thin ribbon-like form to the tube passing therethrough, means for passing the liquid-filled tube through the heat treatment zone at a predetermined velocity while moving the liquid through said zone and within the tube at a velocity greater than said tube velocity, thereby providing rapid and uniform heat treatment of the liquid, and means acting on the liquid-filled tube passing from the heat treatment zone for closing and sealing the tube at spaced intervals.

2. The apparatus of claim **1**, wherein said tube and liquid moving means include a plurality of members which engage the tube in sequence to compress the tube during its movement, said members being movable relative to the tube during said engagement and thereby moving the liquid within the tube at said greater velocity.

3. The apparatus of claim **2**, wherein said tube and liquid moving means also include a plurality of rollers and an endless ribbon driven around said rollers, said ribbon engaging the tube opposite said members to move the tube relative to said zone, said members acting to compress the tube against said ribbon.

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