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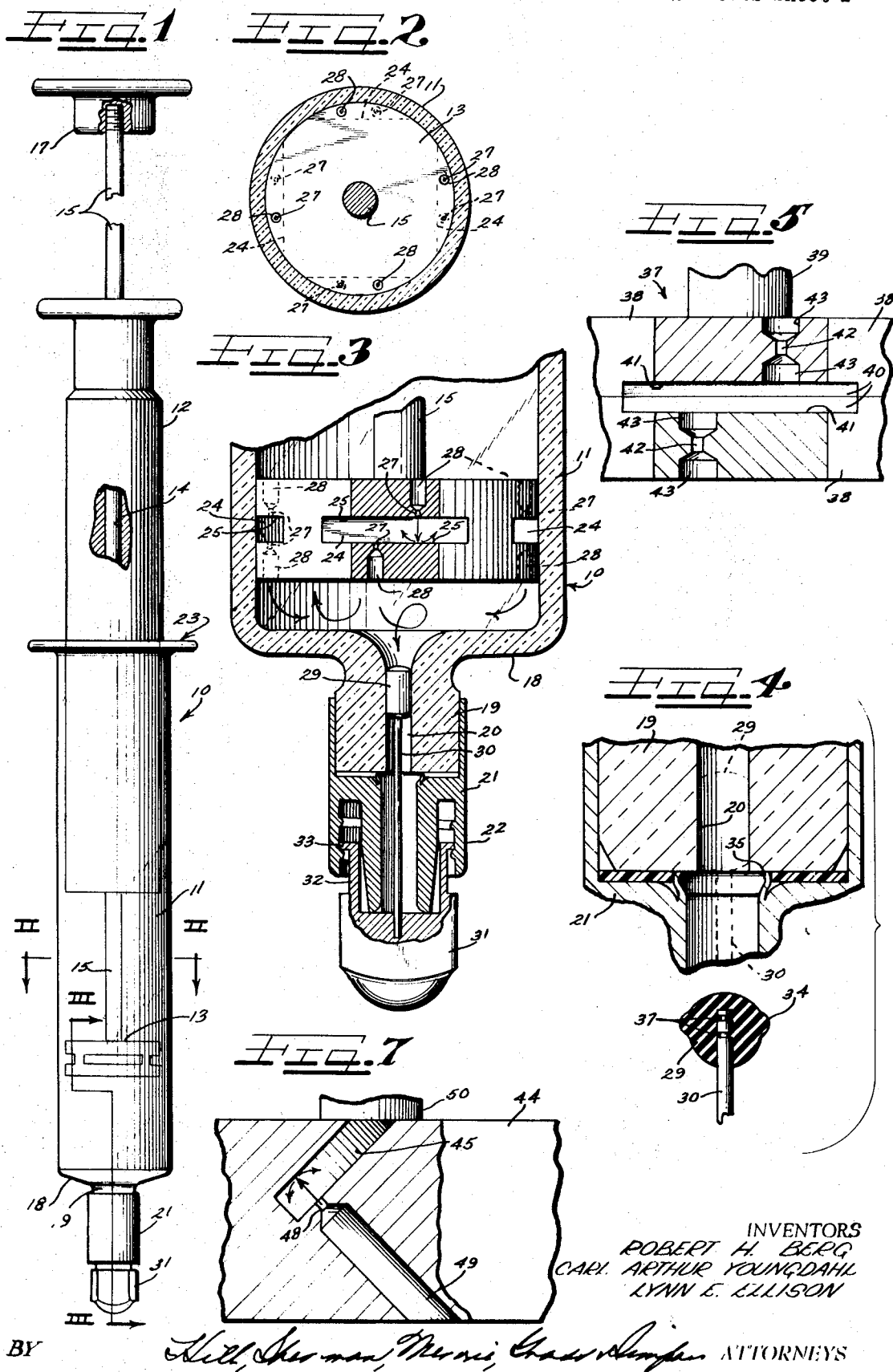
R. H. BERG ET AL

3,546,129

APPARATUS FOR MAKING EMULSIONS

Original Filed Feb. 2, 1962

2 Sheets-Sheet 1



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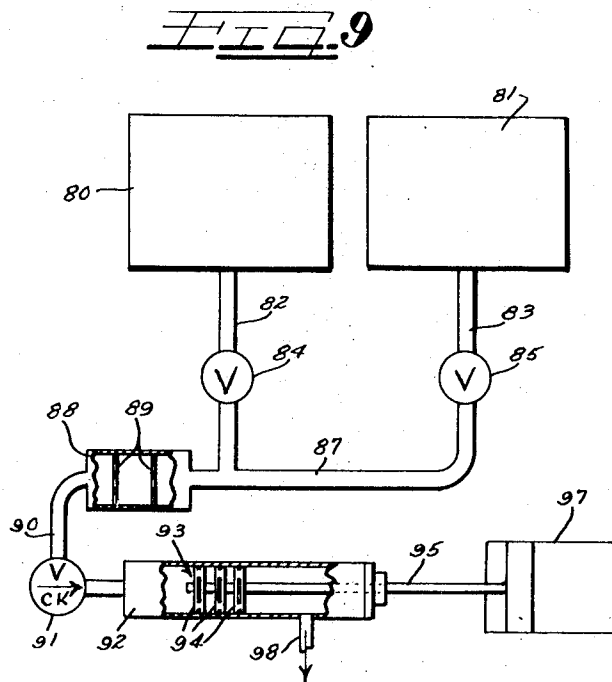
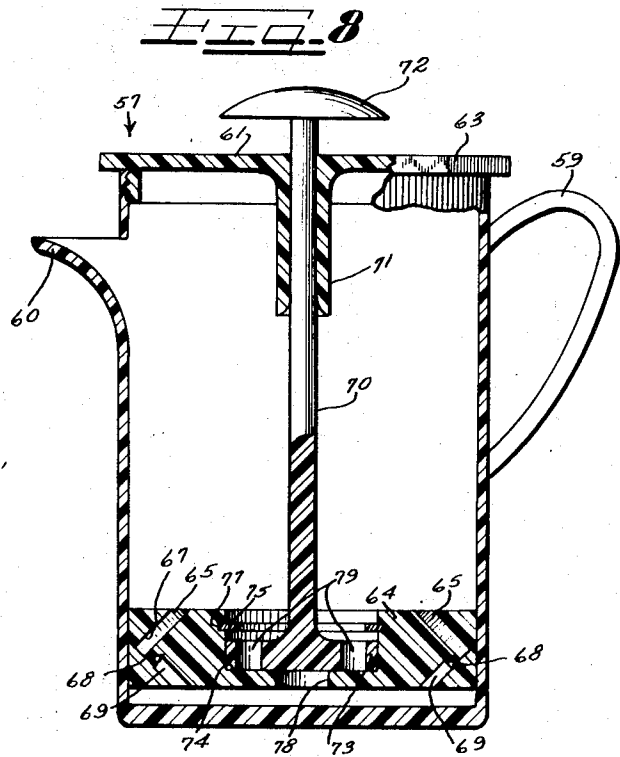
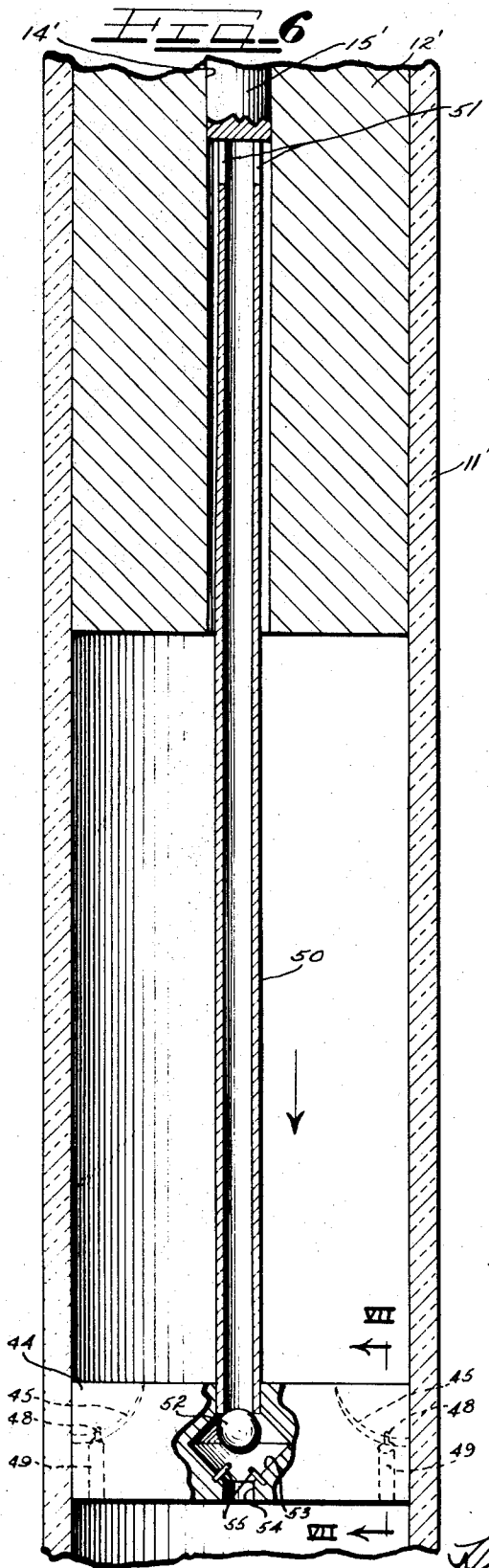
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3,546,129

APPARATUS FOR MAKING EMULSIONS

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Continuation of application Ser. No. 170,749, Feb. 2, 1962. This application Mar. 11, 1968, Ser. No. 712,305
Int. Cl. B01f 3/08, 5/08; A61m 5/00
U.S. Cl. 252—359

10 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for emulsifying in which the emulsifiable mixture is forced through an emulsifying head with opposite end faces, at least one slot in the head providing opposed spaced surfaces, an emulsifying orifice in one of the surfaces leading from one of the end faces and directed toward the other of the surfaces, and an opening from the slot through the other of the faces of the head. Means are provided for effecting movement of the emulsifiable mixture under pressure through the orifice. In a syringe the head is on a stem reciprocable through the usual reciprocable plunger in one end of the barrel. Either two-way or one-way check valved emulsifying action of the head in the barrel may be provided for. Multipass emulsification is effected through a plurality of emulsifying heads in another form.

The present application is a continuation of our application Ser. No. 170,749, filed Feb. 2, 1962, now abandoned.

The present invention relates to improvements in making emulsions, and more particularly concerns a new and improved apparatus for emulsifying.

Heretofore emulsification of various combinations of liquids has been a tedious, time-consuming and often uncertain process, generally effected by more or less violent, repeated mixing and agitation, beating, shaking and the like involving many cycles over extended periods of time and frequently involving complex, expensive apparatus.

For example, in the preparation of allergens for injection into humans, wherein the allergens in the discontinuous aqueous phase are emulsified in light mineral oil as the continuous phase, one practical prior method requires processing for as long as one and one-half hours to assure completeness of the emulsion. During such long processing there is appreciable loss or at least likelihood of loss of material. There is also the danger of detrimental heating.

Where, as in one prior system, movement of the material under pressure from one chamber into another through a sequence of interchanged, graduated passages to produce emulsifying turbulence has been resorted to, maintenance of sterility has been a real problem, in addition to other disadvantages already mentioned.

An important object of the present invention is to overcome the foregoing and other disadvantages of prior practices and by the provision of a new and improved means attaining greatly improved results in the art of emulsifying.

Another object of the present invention is to reduce greatly the time required to effect emulsification.

A further object of the invention is to effect emulsification at high speed but without detrimental temperature rise due to the mechanical working.

Still another object of the invention is to provide a new and improved means for emulsifying assuring complete processing of all the liquid and narrowing the chance of partially processed oversize particles in the emulsion.

Yet another object of the invention is to provide a new

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and improved means for emulsifying wherein sterility and cleanliness are effectively maintained where that is an important consideration.

A still further object of the invention is to provide an improved method of and means for emulsifying according to which loss of material is substantially avoided.

It is also an object of the invention to provide a new and improved method of and means for emulsifying which can be adapted to a large range of uses.

Other objects, features and advantages of the present invention will be readily apparent from the following description of certain exemplary embodiments thereof taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a side elevational view of a hypodermic syringe embodying features of the invention;

FIG. 2 is an enlarged fragmentary sectional detail view taken substantially on line II—II of FIG. 1;

FIG. 3 is an enlarged fragmentary sectional detail view taken substantially on the line III—III of FIG. 1;

FIG. 4 is a fragmentary assembly view of the outlet end portion of the syringe barrel and the plug provided for closing the discharge passage;

FIG. 5 is an enlarged fragmentary sectional elevational detail view showing a modified emulsifying plunger head;

FIG. 6 is a fragmentary longitudinal sectional detail view through the barrel of the syringe showing another modification;

FIG. 7 is an enlarged fragmentary sectional detail view taken substantially on the line VII—VII of FIG. 6;

FIG. 8 is a vertical sectional elevational view showing a further modification; and

FIG. 9 is a schematic, partially sectional view showing an arrangement for substantially continuous flow emulsifying.

According to the present invention, emulsification is effected rapidly and with the utmost uniformity by forming the mixture to be emulsified into jet streams and driving the jet streams at high velocity against an impingement surface with such impact as to provide great shear forces on the liquid. These shear forces instantaneously minutely subdivide the discontinuous phase component in the continuous phase component of the emulsion. This results in attaining emulsification to whatever degree desired many times faster than with prior laminar or less turbulent flow methods.

A more comprehensive understanding of the method and its numerous advantages will be had as the description proceeds with respect to certain exemplary embodiments of apparatus wherein the method is practiced. One such apparatus exemplified in FIGS. 1-4, comprises a hypodermic syringe 10 especially adapted for emulsifying and injecting various types of medication. Allergens have presented a special problem because of the necessity for extremely fine droplet sizes and uniformity of emulsification in order to attain proper results in treatment.

According to the present invention, the syringe 10 includes in addition to a barrel 11 and a close-tolerance plunger 12 as is usual, an emulsifying head 13 in the form of an auxiliary plunger and by which emulsification is effected in the barrel prior to injection of the emulsion. To this end, the plunger 12 has an axial bore 14 through which extends slidably in close tolerance a stem 15 having on its end within the barrel 11 the emulsifying head plunger 13 and on its outer end a manipulating member herein in the form of a button head 17. Through this arrangement, by manipulation of the outer head 17, the piston rod-like stem 15 is adapted to be reciprocated slidably relative to the plunger 12 for reciprocating the emulsifying head plunger 13 within a working chamber afforded between the inner end of the plunger 12 and an end closure 18 on the barrel 11. Centrally on the end closure or

base 18 is a conventional nipple projection 19 having a central discharge passage or port 20 and carrying a co-axially bored fitting 21 provided with an internally threaded skirt 22 attachably receptive of the head of a hypodermic needle. At its opposite end the barrel 11 has a finger grip flange 23.

Desirably, the emulsifying plunger head 13 is as short as it may practically be for the intended purpose and yet withstand the pressures involved in use. It is cylindrically complementary to the inside diameter of the barrel 11, being fitted to as close a tolerance as practical so as to effectively preclude leakage thereby. In practice a tolerance of .0002 inch or better has been found desirable not only for emulsifying plunger 13, but also for the sliding fit of the plunger 12 within the barrel 11.

For its emulsifying function, the plunger 13 is provided with emulsifying passage means therethrough, desirably having jet orifice and opposed impingement barrier means. To this end, the perimeter of the plunger 13 is provided at circumferentially spaced intervals, herein shown as four, with chordal slots 24 having opposed parallel spaced flat plane surfaces 25. Opening through each of such surfaces of each of the slots 24 is a jet orifice 27 communicating with the respective opposite sides of the emulsifying plunger. As will be observed in FIG. 3, the orifices 27 are preferably and for optimum results relatively staggered or offset so that there is a substantial, solid, impingement barrier surface area of the opposing face or surface 25 directly opposite the orifice. In order to shorten the orifices and thus reduce frictional flow resistance, a substantially larger diameter lead-in bore 28 opens from each of the orifices 27 through the adjacent side face of the emulsifying plunger 13.

In the exemplary plunger 13, emulsifying action occurs in each reciprocal direction of movement. That is, as the emulsifying plunger 13 is moved toward the adjacent end of the main plunger 12, all of the liquid displaced from the chamber compartment on stem side or face of the plunger 13 must pass through the orifices 27 communicating with that side substantially as shown in FIG. 3. Similarly, upon reverse movement of the emulsifying plunger 13, that is toward the base end wall 18 of the barrel 11, all of the liquid in the chamber compartment on the free side of the plunger displaces through the orifices 27 communicating with that side or face.

The orifice to impingement plane distance is predetermined with respect to the size of orifice to effect impingement against the impingement plane by the jet stream created by the orifice while such jet stream is still as nearly as practicable a solid column and before it can flare or fan out to any appreciable extent. Excellent results have been obtained in a syringe of this type where the impingement surface spacing or distance from the jet orifice has been about three to fifteen times the diameter of the orifice. For example, in practical embodiments the orifice diameter size has been from .004 to .010 inch, and the orifice to impingement surface distance has been .030 to .060 inch. With this arrangement, under emulsifying plunger thrust pressures of such magnitude as can conveniently be applied manually, emulsifying jet streams issue from the orifices 27 to impinge the opposing surfaces 25.

As shown more or less schematically and by way of example in FIG. 3, as the high velocity small diameter jet columns issuing from the orifices 27 strike the opposing impingement barrier provided by the surface 25, the material in the column is splattered and deflected laterally in all directions along the surface 25. This effects powerful shear forces on the liquid components and causes breaking up of the components into fine droplets so that in an oil-water mixture the fine droplets of the water phase are encapsulated in the oil phase with great efficiency. In fact, it has been found that emulsification efficiency is so high that it is desirable to provide an excess of oil to water component over other emulsifying procedures in order to

assure sufficient oil coverage of the greater aqueous surface generated.

Due to the highly efficient formation of fine droplets as a result of the jet impingement action, only a relatively small number of reciprocations of the emulsifying plunger 13 are adequate to accomplish a high degree of emulsification. In practice it has been found that from 6 to 11 brisk manual strokes of the plunger will effect adequate emulsification for many purposes. Since for medical purposes it is highly desirable to eliminate as nearly as practicable all margin of error, a larger number of emulsifying strokes may be employed. Because emulsification is effected in a closed system, that is with only liquid present in the syringe chamber, and thus the occupied space is compact, it has been found that about ten strokes per minute of the emulsifying plunger can be effected conveniently and without undue manual fatigue. Hence, in from one to five minutes of stroking manipulation of the emulsifying plunger 13 results are attained which are equal to or superior to those obtained with prior commercially practical emulsifiers requiring from ten to sixty times as long in operation for emulsifying allergens. In addition, since all of the emulsifying is effected in the same chamber in the present syringe, perfect sterility can be maintained. Because the cylindrical contacting surfaces of the main plunger 12 and the barrel 11, as well as the plunger stem 15 and the bore 14 of the main plunger are of substantial length and close tolerance, leakage thereby under the emulsifying pressures developed by the emulsifying plunger 13 is precluded in a practical manner while nevertheless there is a sufficient film of liquid between such surfaces to afford adequate lubrication for relative reciprocations of the parts.

By virtue of the shearing emulsifying action as the high speed jet stream impinges the solid impingement barrier and thus causes the material to move off 90° to the axis of the stream, a relatively larger fraction of the energy of the mechanical working is converted to creating interphase surface area instead of heat. This is an important advantage because heat adversely affects the stability of many allergens.

During an emulsifying stroke of the plunger 13, the orifice created jets, of course, move in the opposite direction from the movement of the plunger. Upon striking the opposing impingement surface 25, the impinged liquid changes direction within the fairly generous area of the slot chamber 24 and creates a violent turbulence therein which assures that such chamber will be swept thoroughly clean of any particles of allergen. Simultaneously an equal quantity of the emulsified liquid passes through the offset downstream orifice 27 to the opposite, retreating side of the plunger 13, issuing from the associated bore 28, in each instance, with a highly turbulent action, as exemplified by directional arrows in FIG. 3. This maintains the liquid mass in a constant state of turbulence as the emulsifying plunger 13 retreats. Then, as the emulsifying plunger 13 is driven in a return stroke, the direction of emulsifying jet stream and displacement flow and mixing action of turbulence through the orifices and the impingement surface chambers of the emulsifying passages is reversed.

In order to reduce chances of stagnation of material in the discharge passage 20 of the syringe barrel, an elastic plug 29 is provided with means for readily inserting and removing the same. To this end, the plug 29 is carried on one end portion of a stem 30 which has its opposite end portion fixed to a multi-sided, such as hex-head, cap member 31 provided with a skirt 32 having a thread lug structure 33 on its free end engageable with the threads within the skirt 22 of the fitting 21. By having the stem 30 of proper length the optimum position of the plug 29 with its crown at approximately the narrowest diameter of the flared lead-in from the floor of the end wall 18 into the passage 20 is positively gauged when the

cap member 31 is in fully assembled relation with the fitting 21, as shown in FIG. 3.

Assurance of snug fit of the stopper or plug 29 within the passage 20 is attained by providing the plug in a slightly oversized diameter so as to compel its radial compression by the cylindrical wall defining the passage 20. In addition, the plug member 29 is shaped to afford a positive wiping action on the walls defining the passage in the fitting 21 and the passage 20 as the plug is thrust into its stopper position. For this purpose, the plug is provided with an annular rib flange 34 concentric with the stem 30 and preferably of rounded cross-sectional external shape. In order to assure that as the plug 29 is run up through the passage in the fitting 21, there will be a thorough wiping action to move all adhering liquid into the syringe chamber, the diameter of the rib flange 34 is at least as great as the diameter within a groove in sealing flange 35 on the fitting 21 about the exit from the passage 20. Thus, as the plug 29 is driven up the passage in the fitting 21 it wipes the surface thereof and drives any adhering liquid from such surfaces ahead of it, and when the plug arrives within the sealing flange 35, the rib flange 34 will expand into the groove of the sealing flange and wipe it clean and thus force any liquid into the passage 20 into which the rounded crown of the plug then leads. By having the plug 29 of a proper durometer hardness such as about 40 to 50, it has sufficient elasticity to conform by compression to the surfaces of the passages through which it is projected, taking on a substantially cylindrical conforming shape to the passage 20 as shown in dash outline in FIG. 4 and in full outline in FIG. 3.

An acceptable plastic or rubber material such as buna-N or neoprene may be utilized in molding the plug 29. Bonding of the plug onto the stem is improved by providing the plug-carrying end portion of the stem with one or more locking grooves 37.

Even though there is a shallow depression over the crown of the fully assembled plug 29 in the floor of the end wall 18, turbulence of the emulsion displaced into that portion of the syringe chamber incident to operation of the emulsifying plunger 13 is so thorough that the depression is violently swept by the liquid at each stroke cycle and stagnation therein is avoided.

After emulsification in the syringe 10 has been completed, the cap member 31 is detached and the plug 29 thereby withdrawn from the discharge passage of the syringe, and a hypodermic needle (not shown) of known construction is attached to the fitting 21. Then, with the emulsifying plunger 13 drawn up against the end of the main plunger 12 and thus serving as an auxiliary thrust or pressure surface for the main plunger, injection of the emulsion can proceed in the usual manner.

Sterilization of the syringe assembly is readily effected by withdrawing the plunger and emulsion head assembly from the barrel 11. Since the impingement surfaces 25 are exposed at the perimeter of the emulsifying plunger 13 they are fully cleanable and sterilizable and readily inspected. If desired, the plunger 13 can be removed from the plunger 12 by unscrewing the button head 17 from the stem 15, whereupon the stem 15 can be readily withdrawn from the plunger 12.

In FIG. 5 is shown a construction of an emulsifying plunger 37 comprising a pair of identical coaxially assembled disks 38 secured in lapping relation on a stem 39. On their peripheral lapping margins, or at least on selected portions of their lapping faces, the disks 38 are provided with suitable complementary opposed recesses 40 each of which is defined by an impingement surface 41 toward which an orifice 42 is directed from the opposite disk, the orifices being offset so as to provide an unbroken impingement surface area opposite the orifice. In this instance, enlarged counterbores 43 lead to each opposite end of each of the orifices 42 with the orifice in each instance inset from the impingement surface 41.

Thereby, the total width of the slot or chamber 40 can be minimized for thereby minimizing the overall thickness of the plunger 37, since the orifice to impingement surface distance includes the counterbore 43 at the inner end of each of the orifices, and the inner end counterbores 43 serve as supplements to the total capacity of the chamber 40. Functioning of the emulsifying plunger 37 is the same as described for the emulsifying plunger 13.

For certain purposes it may be desirable to effect the emulsifying impingement only during plunger stroke in one direction. For this purpose a syringe structure 10' (FIGS. 6 and 7) in general respects similar to the syringe 10 may be provided having a similar barrel 11' and main plunger 12' but provided with a modified emulsifying plunger 44. In this modified arrangement the construction is such that jet impingement emulsification is effected on the inward stroke of the plunger 44 as indicated by directional arrows in FIG. 6, while on the return or outward stroke of the piston free but turbulent displacement of the liquid occurs.

For one directional jet impingement emulsification, the plunger 44 has in its outer face, that is the upper face as shown in FIGS. 6 and 7, a plurality of slots 45 of predetermined width providing adequate respective impingement surfaces 47 toward which are directed respective orifices 48 opening through the opposite face defining the chamber slot 45 and having leading thereto from the opposite or inner face of the plunger an enlarged counterbore 49. In order to facilitate machining, and subsequent cleanliness inspection in use, the slots 45 are cut as by milling at an angle into the rim and outer face of the plunger so that the counterbore 49 and the orifice 48 in each instance can be drilled in from the opposite face to intersect the slot 45 at right angles. Through this arrangement, liquid in the chamber provided by the barrel 11' can pass freely through the counterbore 49 of the several orifices 48 and emerge as jet streams from the downstream ends of the orifices 48 to impinge against the impingement surface 47 opposite to the respective orifice to effect emulsification and then issue turbulently from the mouths of the respective slot chambers 45. Since the slot chambers 45 are disposed angularly in the same direction, the liquid displaced under pressure from the mouths of the chambers 45 will cause a swirling turbulence in the barrel chamber between the emulsifying plunger 44 and the adjacent end of the main plunger 12'.

Actuation of the emulsifying plunger 44 is effected similarly as in the case of the emulsifying plunger 13 by means of a stem 15' which is reciprocally slidably engaged through an axial bore 14' in the plunger 12'. In this instance, however, the plunger 15' has means coactive with the plunger 44 for displacement of the liquid to the inner side of the emulsifying plunger during each return stroke following an emulsifying stroke. For this purpose, the stem 15' has a tubular inner end section 50 attached at its inner terminus to the plunger 44 and of a smaller outside diameter than the bore 14' so that liquid can under some turbulence-creating pressure pass through the passage in the space between the stem portion 50 and the bore 14' and through inlet slots 51 adjacent juncture with the full diameter portion of the plunger 15' to the interior of the tubular plunger section 50 and past a check valve 52 within a valve chamber 53 interiorly of the plunger 44 to discharge through a port 54 into the barrel chamber at the inner side of the emulsifying plunger. During an emulsifying stroke, the check valve 52 is forced off of spacer supports 55 to seat sealingly in the discharge end of the tubular stem section 50, as shown in FIG. 6. Through this arrangement, emulsification occurs on a pressure stroke inwardly by which the emulsifying plunger 44 is motivated by the stem 15' while on the return stroke of the plunger 44 which is adapted to be effected with much less effort, relatively free but turbulent return displacement of the emulsified fluid is effected. In other

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respects, construction and operation of the syringe 10' will be understood to be substantially the same as the syringe 10, and to that extent the description of the syringe 10 will be understood to be equally applicable to the syringe 10'.

In FIG. 8 is shown an adaptation of the emulsifying plunger construction to a utensil 57 adapted for emulsifying components under possibly less critical conditions than for medicinal purposes. For example, the utensil 57 may be adapted for kitchen utility as for example to prepare salad dressings and the like where oil and vinegar, spices, as well as other salad dressing ingredients are desirably emulsified. For this purpose, the utensil 57 comprises a generally cup-shaped container 58 having a handle 59 on one side and a discharge spout 60 adjacent its upper normally open end.

A closure cap 61 is adapted to be removably secured to the open end of the container 58 as for example by screwing a threaded flange 62 on the cap into the upper internally threaded end portion of the container 58, an angularly flattened lateral flange 63 being provided on the cap for a ready manipulation.

For emulsifying a batch of liquid ingredients in the container 58, an emulsifying plunger 64 is provided for reciprocation vertically in slidable engagement with the internal wall defining the container. In this instance, the emulsifying plunger 64 is of the one-way emulsifying type similarly as the plunger 44 of FIG. 7, having a plurality of angular slots 65 formed in its upper face and providing impingement faces 67 toward which are directed at right angles emulsifying jet orifices 68 to which lead respective enlarged counterbores 69 opening through the lower face of the plunger.

For motivating the emulsifying plunger 64, a plunger operating stem 70 is provided which is reciprocably guided in a combination hollow depending integral stop flange and boss 71 on the inner side of the cap 61. On its outer end the plunger actuating stem 71 has a manipulating button or knob 72. On its inner end the stem 70 has a combination coupling and valve flange 73 which fits reciprocably into an upwardly opening recess 74 in the central portion of the plunger 64 and is retained therein for a limited range of relative vertical movement with respect to the plunger by means such as a snap ring 75 set within a suitable groove 77 formed in the vertical wall defining the recess 74. During each emulsifying stroke of the stem and plunger assembly, the flange 73 operates as a check valve with respect to a return port 78 of substantial diameter opening centrally from the recess 74 under the flange 73. Thereby, the liquid under the emulsifying plunger 64 is forced during an emulsifying stroke to displace through the emulsifying orifices 68.

During return stroke movement of the plunger 64 the operating stem flange 73 displaces upwardly a limited distance away from the floor or bottom of the recess 74 until the margin of the flange 73 engages against the overhanging retainer ring flange 75 whereby the plunger 64 is drawn upwardly in the return stroke. As a result, a plurality of free passage ports 79 through the flange 73 offset from the port 78 are opened for relatively free displacement of homogenized fluid from above the plunger 64 downwardly through the ports 79 and the port 78 in more or less turbulent fashion into the chamber below the plunger 64. Such upward movement of the plunger 64 is limited to a range below the spout 60 by the lower end of the bearing boss 71 acting as a stop.

After the last emulsifying stroke of the plunger 64, and while it is on the bottom of the container 58, the emulsified contents can be poured from the container through the spout 60.

Instead of batch emulsification, more or less continuous flow emulsification can be practiced by the present invention. An exemplary system for this purpose is illustrated in FIG. 9 wherein the liquid components to be emulsified are derived from suitable sources such as re-

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spective storage containers 80 and 81 from which lead respective conduits 82 and 83 equipped with control or metering valves 84 and 85 respectively. Desired proportions of the liquids from the source containers or vessels 80 and 81 are commingled in a manifold 87 which leads to a mixing chamber 88 of any preferred type, such as one having a series of agitating baffles 89, herein shown as of the perforated type. From the mixing chamber 88 the mixture is conducted through a conduit 90, having therein a check valve 91, to an emulsifying barrel cylinder 92. Within the cylinder 92 is reciprocably operable a combination emulsifying plunger and pumping piston 93 comprising one or more, herein shown as three emulsifying plunger members 94 in the form of suitably spaced plunger disks which may be of any preferred construction comprising the emulsifying structures of any of the emulsifying plungers 13, 37, 44, 64, or combination or modification thereof and characterized by the jet impingement principle according to the present invention.

For actuating the emulsifying piston 93, a piston rod 95 is provided which projects from the opposite end of the cylinder 92 from that through which the conduit 90 delivers the mixture to be emulsified. Actuation of the piston rod 95 and thereby the piston 93 reciprocably is effected in any suitable manner as for example by means of a reciprocating differential motor 97. The exemplary arrangement is such that during each inward stroke of the emulsifying piston, that is toward the delivery end of the cylinder 92, toward the left as shown in FIG. 9, the check valve 91 closes and prevents return flow of the mixture in the cylinder 92 between its supply inlet end and the emulsifying piston 93 so that such mixture must displace through the emulsifying heads or disks 94 of the plunger 93. Thus, as the mixture is displaced through the successive spaced emulsifying members 94 it is progressively emulsified into a thorough, stable emulsion in a single pass.

During the emulsifying stroke of the piston 93, a certain amount of the emulsified liquid is displaced by the piston rod 95 through an outlet and discharge duct or conduit 98 leading from the cylinder 92 to a point of use, a storage container, or the like. On return stroke of the piston 93, it acts to drive emulsified liquid into and through the discharge duct 98 and simultaneously draw a charge of mixture into the cylinder to replenish the emulsified liquid driven off during the return stroke. Thus, there is a substantially continuous though probably pulsating flow of emulsified liquid through the discharge passage duct 98 during the continuous cyclical pumping and emulsifying actions of the piston 93.

From the foregoing, it will be readily apparent that the present invention affords an advanced technique for emulsifying adaptable to a large variety of practical applications among which in the medical field, on-the-spot hypodermic syringe emulsification affords an important advance. Although the emulsifying of allergens has been especially referred to, any other emulsifying of medicaments such as effective spore dispersions in extracts and numerous other emulsions can be effected. In the culinary arts the emulsifying of salad dressings, gravies and sauces, and the like are examples. In the industrial arts, numerous adaptabilities of the invention will readily suggest themselves, including homogenizing, preparation of colloidal dispersions, and the like.

Although for brevity the term "emulsion" and derivatives of this term have been used in describing and claiming the method and apparatus of this invention, this terminology should be understood to mean an intimate combination of materials, that is a mixture, one of which is a liquid and the remainder comprising liquids and/or particulate solids.

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

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We claim as our invention:

1. In apparatus for emulsifying:

a barrel defining a chamber to be filled with an emulsifiable mixture;

a plunger extending reciprocally into one end of said barrel and across said chamber;

an emulsifying head; said head being separate from said plunger and being capable of movement relative to said plunger and located in and extending across said chamber and providing an impingement barrier spaced in adjacent relation to the downstream end of an orifice through which the mixture under pressure is forced to form a jet stream trained against the impingement barrier and thereby emulsify the mixture; and

means for effecting relative movement between the plunger and the head and the barrel to pressurize the mixture in the chamber and force it through said orifice of the head.

2. Apparatus according to claim 1, said emulsifying head having opposite faces, at least one slot in said head providing opposed spaced surfaces, one of which provides said barrier, said orifice opening through the other of said surfaces and leading from one of said faces to direct a jet stream against said barrier, and an opening from said slot through the other of said faces.

3. In a hypodermic syringe including a barrel having a discharge end and an opposite end through which a main plunger extends into the chamber defined by the barrel:

an auxiliary plunger providing an emulsifying head disposed in said chamber between said main plunger and said discharge end and having emulsifying passage means therethrough; and means operative to effect stroking movement of the head;

whereby an emulsifiable mixture in said chamber between said main plunger and said discharge end is emulsified during such stroking movement.

4. In apparatus according to claim 3, means for plugging said discharge end, said main plunger having a longitudinal bore and said auxiliary plunger having a stem extending through said bore and operable manually from the outer end of the main plunger; said emulsifying passage means in said auxiliary plunger comprising an impingement barrier and an orifice having its downstream end adjacent to said barrier and through which an emulsifiable mixture in said chamber is adapted to be forced by manual operation of said auxiliary plunger by means of said stem to form a jet stream trained against the impingement barrier to splatter against the impingement barrier and thereby emulsify the mixture.

5. In apparatus according to claim 4, said plugging means comprising an elastic plug carried on a stem attached to a closure cap for said discharge end and serving together with said closure cap stem to gauge the disposition of the plug in said discharge end.

6. In apparatus for emulsifying, having means defining a chamber:

means for effecting emulsifying pressure upon an emulsifiable mixture within said chamber;

and emulsifying means providing an impingement barrier spaced in adjacent relation to the downstream end of an orifice through which the mixture under pressure is forced to form a jet stream trained against the impingement barrier to splatter against the impingement barrier and thereby emulsify the mixture;

said pressure effecting means comprising a plunger in said chamber including a check valve arrangement permitting relatively free displacement of emulsifying mixture through the plunger during movement of the plunger in one direction;

said plunger having a passage therethrough including said orifice and said impingement barrier oriented

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for displacement of emulsifying mixture through said passage for emulsification upon movement of the plunger in the opposite direction.

7. In apparatus according to claim 6, said plunger having an actuating stem provided with a hollow end portion attached to the plunger with an inlet opening spaced from the plunger, said check valve arrangement comprising a check valve carried by the plunger permitting said free displacement of emulsifiable mixture through said inlet opening and said hollow end portion during movement of the plunger in said one direction and closing said hollow end portion during movement of the plunger in said opposite direction.

8. An apparatus according to claim 6, said check valve arrangement comprising a port through the plunger and an operating stem for the plunger having a valve flange having a limited range of movement reciprocally relative to the plunger and operative to open said port during movement of the plunger in said one direction, and operative to close the port during movement of the plunger in said opposite direction.

9. In apparatus for emulsifying, having means defining a chamber:

means for effecting emulsifying pressure upon an emulsifiable mixture within said chamber;

and emulsifying means providing an impingement barrier spaced in adjacent relation to the downstream end of an orifice through which the mixture under pressure is forced to form a jet stream trained against the impingement barrier to splatter against the impingement barrier and thereby emulsify the mixture; said chamber comprising a cylinder having an inlet attached to a mixture supply;

check valve means enabling passage of mixture into the cylinder but preventing reverse flow through the inlet;

said pressure creating means comprising a piston reciprocable in said cylinder;

a piston rod extending from said piston through the opposite end of the cylinder;

means for driving said piston rod to reciprocate the piston in the cylinder;

said piston having said orifice and impingement barrier means operative during strokes of the piston toward said inlet end to emulsify the mixture;

an outlet from the cylinder adjacent to said opposite end;

said piston being operative during movements toward said opposite end to pump emulsified mixture from the cylinder through said outlet and to draw mixture to be emulsified through said inlet into the cylinder.

10. In apparatus according to claim 9, said piston comprising a plurality of coactive plungers each of which has emulsifying orifice and impingement barrier means whereby to afford multi-stage emulsification during each emulsifying stroke of the piston.

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