United States Patent

Woodham, deceased et al.

[15] **3,679,184**

[45] **July 25, 1972**

[54] MIXING DEVICES

[72] Inventors: **Cecil Halliday Woodham, deceased,** late of Tuckaway, Warren Drive, Kingswood, Surrey, England; **Lloyds Bank Limited, executor and trustee of the estate**

[22] Filed: **Jan. 12, 1970**

[21] Appl. No.: **2,169**

[30] **Foreign Application Priority Data**

Jan. 14, 1969	Great Britain	2,137/69
Feb. 17, 1969	Great Britain	8,573/69
April 3, 1969	Great Britain	17,724/69
Sept. 11, 1969	Great Britain	44,896/69
Oct. 17, 1969	Great Britain	51,216/69
Nov. 6, 1969	Great Britain	54,515/69

[52] **U.S. Cl.** **259/72,** 259/DIG. 20, 259/57

[51] **Int. Cl.** **B01f 9/02**

[58] **Field of Search** ..... 259/DIG. 20, 3, 14, 30, 72, 259/81 R, 89, 54, 57, 58; 233/25, 26

[56] **References Cited**

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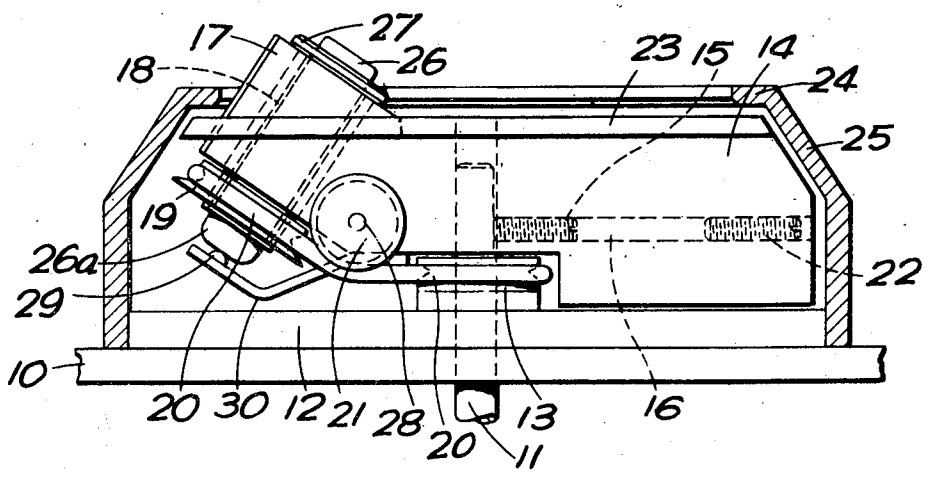
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Primary Examiner—Walter A. Scheel
Assistant Examiner—Philip R. Coe
Attorney—Wenderoth, Lind & Ponack

[57] **ABSTRACT**

A device for mixing dental cements comprises a structure mounted for rotation about a first axis, a motor for rotating the structure about that axis, a receptacle for the substance to be mixed mounted on the structure at a location spaced from the axis of rotation thereof and rotatable relative to the structure about a second axis inclined at an angle of less than 90° to the first axis, a transmission being provided to rotate the receptacle relative to the structure as the structure rotates. The receptacle receives a capsule comprising a main body having at least two compartments for the substances to be mixed, the compartments being separated by a dividing wall which is ruptured when required to permit the flow of a substance from one compartment to the other. Said one compartment also has an external rupturable wall so that the dividing wall may be ruptured by passing a piercing instrument first through the external wall and then through the dividing wall.

7 Claims, 19 Drawing Figures



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SHEET 1 OF 3

Fig. 1.

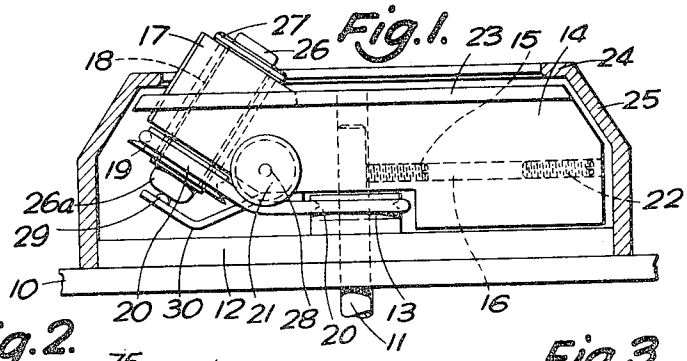


Fig. 2.

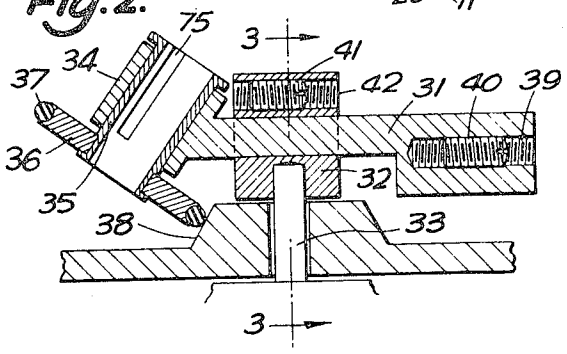


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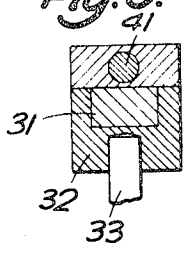


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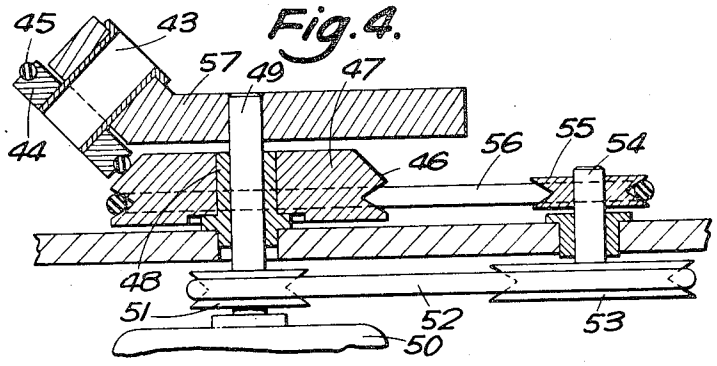
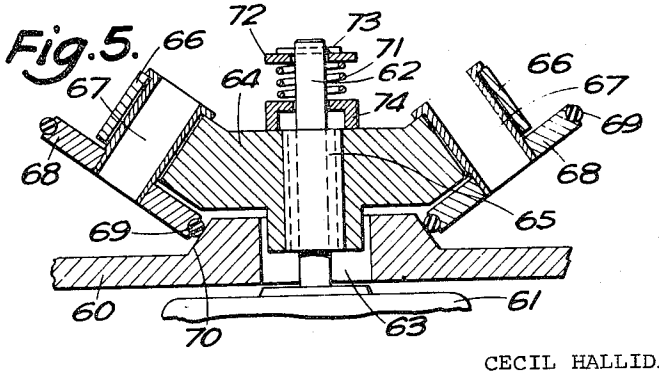


Fig. 5.



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Fig. 6.

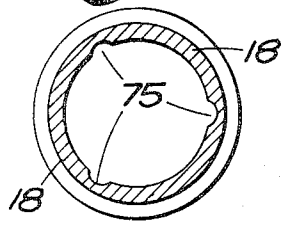


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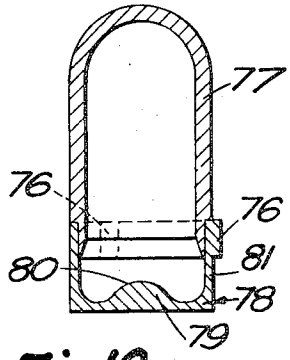


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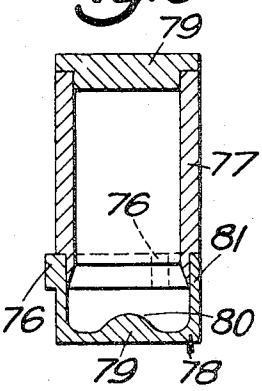


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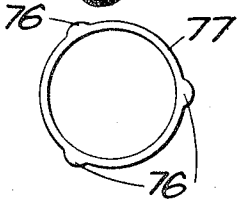


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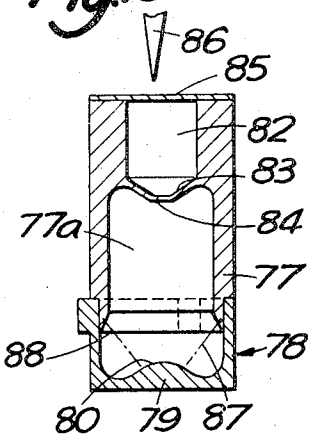


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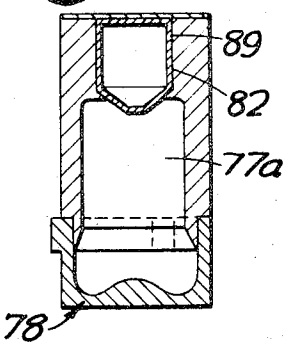


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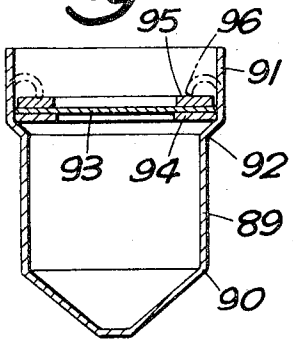


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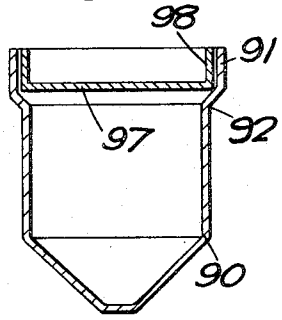
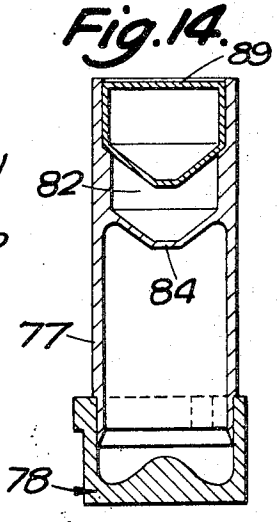


Fig. 14.



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Fig. 15.

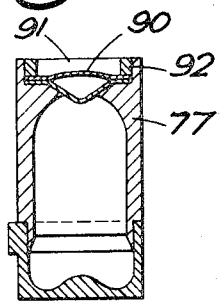


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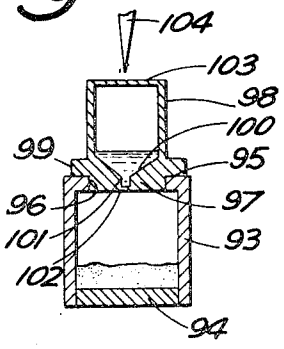


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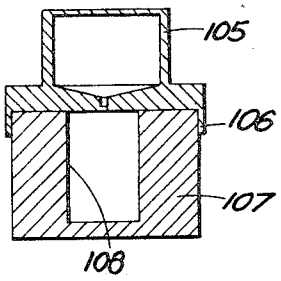


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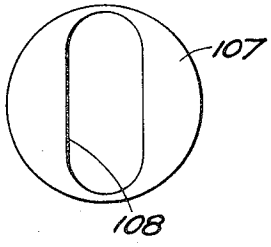
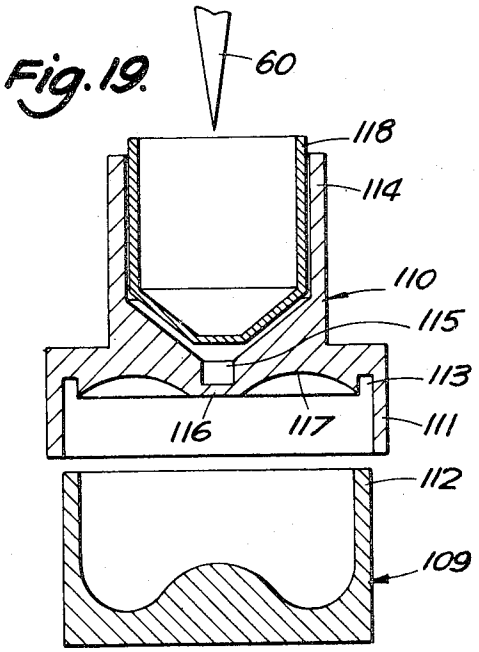


Fig. 19.



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MIXING DEVICES

The invention relates to mixing devices and is particularly, but not exclusively, applicable to devices for mixing together substances to form cements and fillings for use in dental work.

It is known to form dental cements and amalgams by introducing the materials into a chamber which is oscillated to mix the materials together. This method depends on the materials being continually thrown from side to side of the chamber by the oscillation. While this method is suitable for forming amalgams of mercury and metal powder and for mixing other materials which have little adhesiveness, it is found that it is not particularly suitable for materials which are adhesive and which tend to stick to the walls of the chamber since, at practical speeds of oscillation, such materials are not thrown across the chamber in the required manner to effect thorough mixing. The present invention provides a mixing device which is suitable for mixing such adhesive materials.

According to the invention a device for mixing together at least two substances comprises a structure mounted for rotation about a first axis, means for rotating the structure about that axis, a receptacle for the substances mounted on the structure at a location spaced from the axis of rotation thereof and adapted for rotation relative to the structure about a second axis inclined at an angle of less than 90° to the first axis, means being provided to rotate the receptacle relative to the structure as the structure rotates.

A mixer constructed according to the present invention is particularly suitable for mixing dental cements, but it may also be used for mixing together other materials. For example by constructing the mixer on a larger scale it is possible to mix together calcium or potassium alginate with water to provide a material suitable for taking dental impressions. Plasters and artificial stones may also be mixed by this method.

The second axis is preferably in the same plane as the first axis and is inclined at between 35° and 45° thereto. For example it may be inclined at about 37½° to the first axis.

The means for rotating the receptacle may comprise a driving transmission operated by rotation of the structure whereby the receptacle is rotated in synchronism with the structure.

The driving transmission may be a pulley system comprising an endless band encircling a pulley wheel rotating with the receptacle about said second axis and also encircling a fixed further pulley wheel co-axial with said first axis. Alternatively the endless band may encircle a further pulley wheel co-axial with said first axis, means being provided to rotate said further pulley wheel relative to the structure. The speed of rotation of the receptacle relative to the structure may thus be adjusted by adjusting the speed of rotation of the further pulley wheel.

At least one of said pulley wheels may be slightly eccentric so that the rotational speed of the receptacle fluctuates as the structure rotates.

The endless band may pass over idler pulley wheels rotatable mounted on the structure.

In an alternative arrangement the driving transmission comprises a wheel rotating with the receptacle about said second axis, the periphery of which wheel frictionally engages a fixed track co-axial with said first axis so that the wheel and receptacle are rotated as the structure rotates. Alternatively the wheel may engage a track on a member co-axial with the first axis, means being provided to rotate said member relative to the structure. In either arrangement the track may be slightly eccentric with respect to said first axis.

In any of the above arrangements the receptacle is preferably adapted to receive a capsule containing the materials to be mixed.

The receptacle may comprise a circular cross-section socket the outer surface of which is rotatable in a bearing on said structure. The lower end of the socket may be open so that the lower end of a capsule located in the socket may protrude into the air, means being provided to locate the capsule axially and rotationally in the socket.

Since the build up of a static electrical charge may effect the quality of mixing certain parts of the device are preferably

formed from material of a kind which does not build up a static electrical charge when subjected to friction. Similarly where certain parts of the device are formed from metal those parts are preferably earthed to dissipate any static electrical charge built up during operation of the device.

One form of capsule for use in the device comprises a main body having at least two compartments for the substances to be mixed, the compartments being separated by a dividing wall adapted to be ruptured when required to permit the flow of a substance from one compartment to the other, said one compartment also having an external rupturable wall so that the dividing wall may be ruptured by passing a piercing instrument first through the external wall and then through the dividing wall.

Said other compartment may be formed partially by a cup-shaped element which is detachable from the main body of the capsule and into which the substances pass when said dividing wall is ruptured. For example the main body of the capsule may be generally tubular and the rim of the cup-shaped element may be in tight frictional engagement with the rim of the main body.

Preferably the internal surface of the bottom wall of the cup-shaped element has a central projection.

Preferably the portion of said other compartment which is in said main body of the capsule is of sufficient volume to accommodate the whole of the substance in said compartment, whereby the capsule may be filled by placing the substance in said portion and then applying the cup-shaped element thereto.

The dimensions of the cup-shaped element are preferably such that the whole of the exposed inner surface of the element is swept by the substance during mixing.

The cup-shaped element may be formed from metal to facilitate the earthing of any static charge built up during mixing.

In any of the forms of capsule referred to said one compartment may comprise a thin metal container located in a cavity in the main body of the capsule, the metal of the container being sufficiently thin to be readily ruptured by a piercing instrument. For example the container may be a sachet formed from metal foil.

Alternatively the container may be a canister, that wall of the canister which constitutes the aforesaid rupturable dividing wall being substantially conical to assist the flow of the material from the canister when said wall has been ruptured.

The external surface of the capsule may be integrally formed with projections to locate the capsule in the socket of the mixing device.

For the reasons mentioned above at least a portion of the capsule is preferably formed from material of a kind which does not build up a static electrical charge when subjected to friction.

The following is a more detailed description of various embodiments of the invention reference being made to the accompanying drawings in which:

FIG. 1 is a vertical section through a mixing device;

FIG. 2 is a similar view through an alternative form of mixing device;

FIG. 3 is a section along the line 3—3 of FIG. 2;

FIGS. 4 and 5 are vertical sections through further forms of mixing device;

FIG. 6 is a cross-section through the socket of the apparatus of FIG. 1 and for holding a mixing capsule;

FIGS. 7 and 8 are vertical sections through alternative forms of capsule for use in the apparatus of FIG. 1;

FIG. 9 is a section through the lower cap part of the capsule shown in FIGS. 7 and 8;

FIGS. 10 and 11 are vertical sections through alternative forms of capsule;

FIGS. 12 and 13 show alternative forms of the metal canister used in the capsule of FIG. 11;

FIGS. 14, 15, 16 and 17 are vertical sections through further forms of capsule;

FIG. 18 is a horizontal section through the lower part of the capsule shown in FIG. 17; and

FIG. 19 is a vertical section through a further form of capsule.

The mixing device shown in FIG. 1 comprises a base plate 10 which constitutes the upper wall of a casing for an electric motor (not shown). The output shaft 11 of the electric motor passes through the base plate 10, through a disc 12 mounted on the base plate and through a fixed pulley wheel 13 secured to the disc 12. A rotatable structure 14 is secured to the shaft 11 by a grub screw 15 located in a threaded hole 16.

At one end of the structure 14 is a bearing portion 17 within which is rotatable a tubular socket 18 which is of such a size as to receive and locate a capsule for the materials to be mixed. The axis of rotation of the socket 18 is inclined at an angle of about 37½° to the vertical.

A pulley wheel 19 is mounted on the lower end of the socket 18. An endless band 20 passes around the pulley wheel 19 and the fixed pulley wheel 13 and each stretch of the band between those two pulley wheels passes across an idler wheel 21, two idler wheels being freely rotatable on opposite sides of the structure 14. The lower flange of the pulley wheel 19 is of greater diameter than the upper flange to prevent the endless band balooning downwardly under centrifugal force.

The idler pulleys preferably have shaped peripheries, in known manner, to locate the stretch of the endless band passing over them. Also since the pulley wheel 19 on the lower end of the socket is of different diameter to the other pulley wheel 13 encircled by the endless band it may be desirable to incline the shafts carrying the idler wheels so that the peripheries of the wheels are correctly aligned with the endless band. A further grub screw 22 within the threaded hole 16 acts as an adjustable counter-balancing weight.

It will be seen that as the structure 14 is rotated by the electric motor the socket 18 will also be rotated, about its axis, by the pulley system.

To protect the rotating structure 14 and to prevent clothing, for example, being caught in it, a disc 23 is mounted on the top of the structure. The disc may be integrally moulded with the structure 14 or separately formed and screwed to it. The disc 23 rotates beneath a circular aperture 24 in an inverted cup-shaped cover 25 the lower periphery of which is a press fit on the disc 12.

In the simplest method of operation the materials to be mixed are introduced into a capsule 26 which is then inserted in the socket 18. As mentioned earlier the device is particularly suitable for the mixing of dental cements which are normally mixed from a powder and a liquid, some times with the addition of a catalyst.

As the arm 14 is rotated it will be appreciated that the material within the capsule will be thrown away from the axis of rotation by centrifugal force so that it will gather in the part of the capsule furthest from the axis of rotation. However as the capsule 26 is itself rotating about its central axis, the material will move towards the axis of rotation of the arm 14 by being carried around to a certain extent by adhering to the walls of the capsule. At a certain point however the centrifugal force due to rotation of the arm 14 as a whole will overcome the adhesion of the material to the walls of the capsule and will throw the material outwardly again to the outermost side of the capsule. This process will be continually repeated and results in rapid and thorough mixing of the liquid and powder to form the cement.

Preferably the relative rates of rotation of the arm 14 and the socket 18 are so selected that the material loses its adhesion to the walls of the capsule only when the capsule has been rotated through 180° from the position shown in FIG. 1. Thus the material will be constantly thrown radially outwards by centrifugal force across the width of the capsule. It will be appreciated that if the rate of rotation of the arm 14 is too great in relation to the speed of rotation of the capsule the material will not be carried round to any great extent by the rotation of the capsule and will remain substantially at the outermost side of the capsule. On the other hand if the rate of rotation of the capsule is too great in relation to the rate of rotation of the arm 14 the material will adhere to the walls of the capsule throughout its complete rotation and will not be thrown across the container by centrifugal force due to rotation of the arm 14.

Excessive centrifugal force may also have the effect of tending to maintain the powder and liquid separate within the container the device acting somewhat in the manner of a centrifugal separator.

In the arrangement shown the axis of rotation of the socket 18 is arranged at about 37 ½ to the vertical but it will be appreciated that the axis may be arranged at other angles. The smaller the angle of the axis of rotation to the vertical the easier it is for the materials to move across the container since the bottom wall of the container will be less "steep."

As mentioned above the materials may be placed in the capsule 26 before it is placed in the socket 18. However it will be appreciated that if the capsule is open-topped the materials may be introduced into the capsule whilst it is in position in the socket, or the socket 18 itself may have a closed bottom and may constitute the capsule into which the materials are introduced. By using a dispenser which rotates with the arm 14, the materials may also be introduced into the capsule whilst the arm is rotating. The dispenser (not shown) may comprise a feeding duct extending radially outwards from the axis of rotation of the arm 14 to the open upper end of the capsule. Predetermined quantities of the materials are introduced into the duct from a measuring dispenser on the axis of rotation of the arm 14 and are then thrown outwardly along the duct by centrifugal force and ejected into the capsule.

Alternatively and preferably, however, predetermined quantities of the materials to be mixed may be provided in prepacked capsules which are placed in the socket 18. Various forms of such capsules will be described below.

In the particular example described the socket in which the capsule is to be located may have a radius of nine thirty-seconds of an inch and its axis may be at a radial distance of 2 11/16 of an inch from the center of rotation of the rotating arm of the device. As described above the capsule is rotated at such a speed in relation to the rotation of the arm as a whole that the material in the capsule is constantly thrown across the diameter of the capsule. It is found that suitable speeds for the dimensions given may be of the order of 2,000 r.p.m. for the arm and 1,250 r.p.m. for the capsule relatively to the arm. Thus as the arm rotates through 360° the capsule rotates through 225° relatively to the arm.

The rotating arm 14 carrying the capsule may be mounted beneath a transparent domed cover (not shown) which provides protection but which enables the capsule to be seen when mixing has been completed. The shaft 11 on which the arm 14 rotates may project upwardly through the domed cover and may be provided with a knob by means of which the arm may be brought manually to a halt and rotated to a position opposite a hatch in the dome so that the capsule may be removed from the arm. The hatch may have the operating switch of the motor associated with it in such a manner that shutting of the hatch closes the switch. The arm cannot therefore rotate until the hatch has been closed.

The switch controlling the motor may be a time switch to control automatically the length of time during which mixing takes place. At low temperatures the viscosity of the liquids used increases making effective mixing less rapid. The time switch may therefore be graduated on a temperature scale.

It is found that in a mixing device of the kind described there may be a tendency for the ease and quality of mixing to deteriorate under certain conditions. Although it is not known for certain, it is believed that one reason for this might be the generation of static electricity in the mixing device. It may therefore be desirable to reduce or eliminate the generation and/or effect of static electricity.

It is believed that static electricity can be generated in two ways: It may be generated as a result of friction between the

moving parts of the mixer, and also by friction of the material being mixed against the walls of the containing capsule as well as friction between elements of the material itself.

In the arrangement shown in FIG. 1 the arm 14 might be formed from plastics bearing material, such as molybdenum-disulphide filled nylon, to provide a self-lubricating bearing for the sock 18 which would be formed from metal. However rotation of the metal socket in the bearing material may built up a charge of static electricity which may be dangerous and may interfere with the ease and quality of mixing.

It will be seen from FIG. 1 that the socket 18 is formed at its upper end with a peripheral flange 27. To earth any static electricity generated a metal spring (not shown) may be connected by the clamping screw 15 to the shaft 11 and the opposite end of the spring arranged to bear against the flange 27. Since the shaft 11 of the motor will be earthed the spring will earth the socket 18 as it rotates so dissipating any static electricity which is generated. The arrangement of the spring may be such that centrifugal force tends to urge the end of the spring into good electrical contact with the flange 27 as the socket rotates.

The opposite end of the spring to the end which contacts the flange 27 may be deformed, the deformed part being received in a depression in the upper surface of the arm 14 to prevent displacement of the spring on the arm. However it will be appreciated that there are many other ways in which the spring may be mounted and connected to the shaft 11.

In some cases the shaft 11 itself may not be adequately earthed and if this is the case then a further earthed spring may be mounted on the motor casing at its lower end to bear against a projecting extension of the motor shaft to ensure adequate earthing of the shaft. This further spring may be a simple leaf spring bearing against the end of the shaft or may be a spring loaded collar encircling the extension of the shaft.

Static electricity may also be generated by rotation of the idler wheels 21 and the metal shaft 28 on which they run is also therefore preferably earthed. To achieve this the spring referred to above may be integrally formed with arms which are bent down on opposite sides of the arm 14 and have at their ends parts which embrace the shaft 28 so as to earth that shaft.

Instead of the whole arm 14 being formed from a bearing material, however, it is preferably formed from a suitable metal, such as an aluminium alloy, and the socket 27 may then rotate in a bearing nylon bush in the portion 17 of the arm. In this case it will be appreciated that the spring referred to could simply be connected to the body of the arm 14 itself and need not be connected directly to the shaft 11. In this case the shaft 28 of the idler pulley will then automatically be earthed.

Instead of the metal socket 27 rotating in a bearing nylon mesh in the portion 17 of the arm 14, it may be coated on the outside with a plastics bearing material, such as "Nylatron" and may be rotatable in a steel bush in the portion 17.

In an alternative and preferred arrangement shown in FIG. 1, however, the arm 14 is formed from a suitable metal such as an aluminium alloy and is bushed with a steel bearing, the socket 18 in this case being formed from a bearing nylon such as "Nylatron G.S.." In this case the static electricity due to friction in the bearing is automatically earthed, but it is also desirable to earth the capsule itself. In the arrangement shown in FIG. 1 this is achieved by making the capsule 26, or at least the lower part 26*a* in which the materials are actually mixed, from metal such as stainless steel or aluminium. The lower metal end of the receptacle bears against a metal projection 29 on a metal bracket 30 which is secured to the metal arm 14. The capsule itself is thus always connected to earth. The projection 29 is arranged to be the sole support for the capsule, in the axial direction, so that centrifugal force ensures good contact between the projection and the capsule.

As mentioned earlier, static electricity generated in the capsule itself may be generated by friction between the materials being mixed and the interior walls of the capsule. It follows therefore that the problem might also be reduced by using for the capsule a material which does not tend to generate a static charge. For example Bakelite may be a suitable material for this purpose. In this case if little or no static charge is generated there may be no necessity for the capsule itself to be connected to earth. A similar type of material is also preferably used for the pulley wheels 13 and 19 since static electricity may be generated by the endless belt rubbing against the pulleys.

To reduce the likelihood of capsules building up a static charge during storage and transport it is preferable for the capsules to be stored in an earthed metal storage rack so that any static charge built during storage and handling is dissipated before the capsules are used.

If the capsule 26 or the cup part 26*a* are formed from aluminum it may be anodized.

It will be seen that in the arrangement of FIG. 1 the part 26*a* of the capsule in which the materials are actually mixed projects below the pulley wheel 19 into the open air. This assists in keeping the capsule and materials cool during mixing and reduces conduction of heat to the mixing cup from the bearing for the socket 18.

It will be appreciated that there are many different ways in which the socket 18 may be arranged to rotate in synchronism with the arm 14.

For example the pulley system 13, 19, 20, 21 may be replaced by a gear transmission or the socket may carry a star wheel which is struck around by one or more fixed pins as the arm 14 rotates. Alternatively the socket 18 may carry a gear wheel in mesh with a fixed roothed rack encircling the device, or could be rotated by a miniature electric motor mounted on the arm 14. The socket 18 may also carry a friction wheel arranged to run on a fixed track as shown in FIG. 2. In this case the bearing part 17 could be mounted to pivot so that centrifugal force urges the friction wheel into engagement with the fixed track.

In a further modified version of the arrangement shown in FIG. 1, the pulley wheel 19 is mounted about halfway along the socket 18 instead of at the lower end as shown. In this case the portion 17 of the arm 14 will be suitably slotted to accommodate the pulley and the positions of the pulley 13 and idler wheels 21 will require to be repositioned accordingly. Such an arrangement will serve to distribute the bearing lead more evenly along the length of the bearing for the socket 18.

In the alternative arrangement shown in FIGS. 2 and 3 the rotating structure 31 is slidable in a bearing member 32 secured to the upper end of the motor shaft 33.

The structure 31 is formed at one end with a bearing part 34 in which is rotatable a socket 35. A wheel 36 having a rubber tire 37 is secured to the lower end of the rotatable socket 35. The rubber tire 37 bears against a conical surface 38 surrounding the shaft 33. The end of the structure 31 opposite to the socket 35 has a threaded hole 39 which receives a grub screw 40 which acts as a balance weight. The grub screw 40 is located in a position such that centrifugal force biases the structure in a direction to urge the periphery of the wheel 36 into engagement with the surface 38 so that the socket 35 is rotated as the structure 31 rotates. Since this biassing of the structure 31 throws the assembly out of balance, the balance is restored by an adjustable grub screw 41 in a threaded hole 42 in the bearing member 32. As will be seen from FIG. 3 the bearing member 32 is formed in two parts the lower of which is formed with a groove to receive the structure 31 in a slidable manner.

In the case of some materials to be mixed it may be desirable that the speed of rotation of the capsule should be somewhat less than can readily be achieved by suitably selecting the sizes of the wheel 36 and conical surface 38 and FIG. 4 shows an arrangement by which a slower speed of rotation of the capsule may be achieved for a given speed of rotation of the structure.

In the arrangement of FIG. 4 the socket 43 for the capsule carries a wheel 44 encircled by a rubber ring 45 which bears against a conical surface 46 on a pulley wheel 47. The pulley

wheel 47 is rotatable on a tubular bush 48 through which the shaft 47 of the motor 50 passes. A pulley wheel 51 is secured to the shaft 49 and drives, via an endless band 52, a pulley wheel 53 mounted on a stub shaft 54 parallel to and spaced from the shaft 49. The stub shaft 54 carries a further pulley wheel 55 which drives the pulley wheel 47 via and endless band 56.

It will be seen that due to this arrangement the pulley wheel 47 is rotated in the same direction as the shaft 49 and structure 57, but at a slower speed. This means that the socket 43 rotates at a slower speed than it would if the track 46 were stationary as in the arrangement shown in FIGS. 2 and 3.

In a modification of the arrangement of FIG. 4 the pulley wheel 44 does not bear on a conical track on the pulley wheel 46 but is driven from an endless band encircling a further pulley wheel rotatable with the pulley wheel 46. The endless band passes around idler wheels corresponding, for example, to the idler wheels 21 in the arrangement of FIG. 1.

FIG. 5 shows a modified device according to the invention. The device comprises a casing 60 in which is mounted an electric motor 61. The shaft 62 of the electric motor passes through an aperture 63 in the upper wall of the casing. A rotor 64 is mounted on splines 65 on the shaft 62 so that it is capable of limited degree of up and down sliding movement on the shaft. The rotor comprises diametrically opposed bearing parts 66 in each of which is rotatable a socket 67 adapted ro receive a mixing capsule containing a cement materials. The sockets rotate about axes inclined to the vertical axis of the shaft 62.

Each socket 67 has mounted at its lower end a wheel 68 having a rubber tire 69. The rubber tires 69 bear against a conical surface 70 integrally formed, or secured to, the upper wall of the casing 60 and surrounding the shaft 62. The arrangement is such that, as in the arrangement of FIGS. 2 and 3, as the rotor 64 is rotated by the motor 61 the sockets 67 are also rotated due to the engagement of the tires 69 with the track 70. As described above this effects thorough mixing of the materials. The arrangement now described, however, has the advantage that two batches of cement may be mixed simultaneously and the rotor is automatically balanced since it is symmetrical.

In order that the tires 69 bear in frictional engagement against the track 70 a helical compression spring 71 encircles the shaft 62 above the rotor 64 and is compressed between a washer 72 engaging a fixed abutment 73 on the shaft and a washer 74 bears against the upper surface of the rotor 64. The spring serves therefore to urge the rotor downwardly into engagement with the surface 70. This biassing arrangement could also be used in the arrangements of FIGS. 2, 3 and 4 in which only a single socket is provided with a wheel bearing against a track.

Although the arrangement described incorporates two diametrically opposed sockets it will be appreciated that almost any number of sockets may be provided in the rotor 64, the sockets being equally spaced around the central axis of rotation of the rotor. For example three sockets may be provided. In the case where a number of sockets are provided the rotor 64 preferably mounted on the splines 65 with sufficient play to enable the tires 69 to seat themselves automatically on the conical surface 70.

Where two or more sockets are used a number of capsules can be mixed in one operation. However if it is required to mix a number of capsules less than the total number of sockets the free sockets are preferably balanced by placing in them a blank of the same weight as a capsule.

In a modified form of the arrangements described above, and indeed in any arrangement where the sockets have wheels which run against a fixed track, the rotor itself may be rigidly fixed to the motor shaft and the track itself may be biassed upwardly by a spring to engage the wheels carried by the sockets.

In all the above arrangements the rotor is in each case mounted directly on the shaft of the electric motor. In some cases this may not be desirable since it may not give a suitable layout to the components of the device or because it may be necessary to gear the drive to the shaft up or down. In this case it will be appreciated that any suitable transmission may be provided to dive the shaft carrying the rotor. For example the shaft carrying the rotor may be driven through a pulley and endless belt transmission or through toothed gearing.

In the arrangement of FIG. 4 the shaft 49 is directly driven by the motor 50. It will be appreciated however that the drive could be transmitted to the rotor by arranging for the motor 50 to drive the shaft 54. This also applies to the modified version referred to in which the wheel 44 does not bear on a conical track on the pulley wheel 46 but is driven from an endless band encircling a further pulley wheel rotatable with the pulley wheel 46.

In the case of some materials to be mixed it may be found that the relative rotational speeds between the socket and the whole rotatable structure are fairly critical to obtain satisfactory mixing. This relationship may be made less critical by causing the speed of rotation of the socket to fluctuate. In the arrangement shown in FIG. 1 this may be achieved by arranging for the fixed pulley 13 to be slightly eccentric with respect to the shaft 11. The endless band 20 is resilient, being formed from rubber like material, and thus as the arm 14 rotates the eccentricity of the pulley wheel 13 causes fluctuations in the speed of rotation of the socket 18. It will be appreciated that a similar effect might be obtained by arranging for the pulley wheel 19 to be eccentric with respect to the socket 18 or, indeed, both pulley wheels 13 and 19 could be eccentrically arranged. In any of these arrangements the stretches of the endless band 20 passing over the idler wheels 21 may tend to move laterally as the rotor rotates. The idler wheels 21 are therefore preferably slidable on the shaft 28 on which they are mounted to permit this side to side movement.

In the arrangements shown in FIGS. 2 and 4 the conical surfaces 38 and 46 may also be eccentric with respect to the shafts 33 and 49 respectively to give fluctuating speeds of rotation to the sockets as described above with respect to the arrangement of FIG. 1.

In any of the arrangements described above it is preferable that the motor driving the apparatus is such as to give an immediately high rotational speed from rest. It is found that if the machine gathers speed relatively slowly the mixing tends to be less satisfactory than if rotational speed is reached rapidly.

It is not essential for the sockets for the capsules to rotate continuously and the transmission in any of the above arrangements may be such as to rotate the socket intermittently or to oscillate it back and forth through 180° as the arm which carries it rotates. Similarly it is not essential for the arm itself to rotate continuously but this also could provide centrifugal force by simply oscillating back and forth.

The capsule for containing the materials to be mixed may be of various forms and a number of examples will now be described with reference to FIGS. 6 to 19.

Referring to FIGS. 6: the internal bore of the socket 18 of the mixing device is preferably formed with three axially extending semi-circular grooves 75 which extend partially down the socket from the upper end thereof. Any capsule for use in the machine, such as capsules of the kind shown in FIGS. 7 and 8, may be formed with projections 76 which co-operate with the grooves 75. These projections prevent the capsule rotating in the socket 18 and also, since the grooves 75 do not extend completely through the socket 18, the projections can serve to locate the capsule axially in the socket if the support arrangement 29, 30 on the device (see FIG. 1) is omitted. Also since the capsule is located by the grooves it need not be a particularly tight fit in the socket and this permits air to circulate around the capsule for the purposes of mixing. It will be appreciated that the projections 76 and grooves 75 may be of many different forms and arrangements to locate the capsule in the socket 18.

There will be described below capsules which contain both liquid and powder in separate compartments the compartment containing the liquid being ruptured to permit the materials to

mix when required. This is desirable when the materials need to be used in precisely predetermined quantities. However if the relative quantities of the materials are not so critical it is possible to use a capsule of the kind shown in FIGS. 7 and 8 into which materials are measured as required, from a dispenser. Alternatively this form of capsule may be pre-packed with the powder only.

Each capsule may be formed from a suitable plastics and comprises a main body portion 77 and a cap portion 78 on which the projections 76 are formed. The capsule shown in FIG. 7 has a domed main body portion 77. In the case where the capsule is pre-packed with a predetermined quantity of powder only, the capsule is inverted so that the cap 78 is uppermost and is then tapped against a hard surface so that powder is thrown out of the cap into the domed main body portion 77. The cap 78 is then removed and from a dropper bottle or other measuring dispenser the required amount of liquid is deposited into the now empty cap. The cap is then replaced on the main body portion taking care not to spill the contents of either. The capsule is then ready to be placed in the device for mixing.

The alternative form of capsule shown in FIG. 8 has a removable stopper 79 so that liquid may be added by removing the stopper. A tear-off enclosure such as adhesive paper may be used instead of the stopper.

The advantage of having capsules which are pre-packed with powder only is that the shelf life of the capsules is increased. The shelf life of capsules, described below, containing both liquid and powder may be limited by the tendency of liquid to be lost due to evaporation through the walls of the capsule or by interaction with the material of the capsule. Various other methods of reducing this problem will be described below.

If the capsules are not to be pre-packed, the upper end of the body portion may be open and funnel-shaped for ease of filling.

It will be seen from FIGS. 7 and 8 that the central portion of the bottom wall 79 of each capsule is formed with a smooth dome 80 and the junction between the peripheral wall 81 of the cap and the base 79 is smoothly curved. The reason for this is that it is found that if the cap is formed with a flat floor there is a tendency, as the capsule is rotated, for unmixed grains of material to remain in the central area of the cap, thus spoiling the mix. This is more noticeable in thick mixes than in mixes of materials of thinner consistencies which are most easily removed. The higher central portion of the base ensures that particles in the mix do not tend to remain in the middle of the cap.

FIG. 10 shows a modified form of capsule which is pre-packed with measured quantities of both liquid and powder. In the capsule of FIG. 10 the upper part 77 is integrally formed with a compartment 82 for the liquid the compartment having a conically shaped lower portion 83 and being closed at its lower end by a tin wall 84. The junction between the peripheral wall of the part 77 and the thin wall 84 is rounded as shown so that particles of material cannot be trapped there during mixing. The upper part of the compartment is closed by a further thin wall 85 which may, for example, be of thin plastics bonded to the capsule or may be of aluminum foil. The measured quantity of powder is located in the cap 78.

The liquid and powder are normally kept separate in the capsule but when it is required to form a cement the walls 85 and 84 of the capsule are ruptured for example by a tapered steel pin indicated at 86. For example the capsule may be placed in a suitable press as described below. When the walls 85 and 84 are ruptured the liquid flows downwardly into the cap 78 and the capsule is placed in the socket 18 on the mixing apparatus. The arm 14 of the apparatus is then rotated and the liquid and powder are mixed in the manner described above. It will be appreciated that the effect of centrifugal force is to ensure that all the liquid id completely ejected from the compartment 82 into the cap 78.

When mixing has been completed, the capsule is removed from the device and the upper part 77 removed from the cap 78 and discarded. The mixed cement may then readily be removed from the cap 78.

The dimensions of the cap 78 are so chosen in relation to the quantities of material in the capsule that when the materials are being mixed the mix sweeps over substantially the whole of the exposed interior surface of the cap 78.

The surface of the mix, during mixing, is indicated by the dotted line 87 and it will be seen that besides sweeping over the entire internal surface of the cap 78 the mix also sweeps over the lower end edge 88 of the upper part 77 thus when mixing has been completed any unmixed particles will be confined to the interior of the part 77, which is discarded and the mix in the cap 78 will not be contaminated by such unmixed particles.

The lower edge of the part 77 is a tight fit in the upper edge of the cap 78 so that particles cannot find their way between the two parts of the capsule. In a modified arrangement, not shown, the mating parts of the two portions of the capsule are tapered so as to provide a tight wedging fit. Although the capsules are described as being of circular cross-section, they may also be of any other convenient cross-sectional shape, for example the interior compartment may be of oval or other elongated cross-section. The space 77*a* within the part 77 and below the wall 84 may be as large or small as convenient without effecting the mixing action, provided of course that it is of sufficient capacity, with the cap 78, initially to accommodate the charge of powder.

As mentioned above the two materials contained within the capsule may be brought into contact with one another by rupturing the wall 84 by a metal spike. A convenient device for effecting this comprises a hollow circular cross-section tube of a size to accommodate the capsule. One end of the tube is closed and a metal spike extends axially into the tube from the end wall. To operate the device the capsule is introduced into the tube with the wall 85 facing towards the spike and the capsule and tube are then pressed together so that the spike passes axially through both walls 85 and 84. The capsule is then withdrawn from the tube and placed in the mixing device.

It is found that in some cases (for example when the liquid contained in the capsule is phosphoric acid) polythene and similar plastics from which the capsule may be conveniently formed may be slightly permeable to the liquids contained in them. Such permeability can shorten the shelf life of the capsule especially under high temperature conditions. The capsule shown in FIG. 11 is designed to overcome this problem. In this form of capsule the liquid is contained within a canister 89 formed from thin aluminum and located within the chamber 82. In this case the thin wall 84 is not necessary although it may be present if required to give further support to the canister 89. The canister 89 has walls of about ten thousandths of an inch in thickness and the bottom wall of the canister is conically shaped.

Since the aluminum canister 89 is impermeable to liquid there is no tendency for the liquid to be lost by permeation and thus the shelf life of the capsule is increased. When it is required to form a mix the upper and lower walls of the canister 89 are pierced by a steel pin in a similar manner to that described above in relation to the capsule of FIG. 10.

It will be seen that in the capsules of FIGS. 10 and 11 the point where the liquid emerges from the compartment 82 or canister 89 is disposed below the surrounding upper wall of the chamber 77*a*. It is found that if this is not done there is a tendency for droplets emerging from the aperture formed by the pin 86 to be thrown radially outwards in contact with the upper wall of the chamber 77*a* (due to their surface tension) rather than being thrown into the mix by centrifugal force. The arrangement shown in FIGS. 10 and 11 ensures that liquid emerging from the compartment or canister is thrown outwardly by centrifugal force clear of the upper wall of the chamber 77*a* and into the mix. Also due to the curving of the upper wall of the chamber 77*a* there is little tendency for

grains of the powder material to adhere to the corners of the chamber 77*a* and thus not become fully mixed.

The canister 89 may be formed in two parts and FIGS. 12 and 13 show examples of methods of closing the canister. In FIG. 12 the canister 89 has a bottom part 90 which has an enlarged diameter upper portion 91 so as to form a shoulder 92. A soft metal diaphragm 93 rests on the shoulder 92 between two washers 94 and 95. The upper end of the portion 91 is then folded inwardly (as indicated in dotted lines at 96) to secure the washers and diaphragm firmly against the shoulder 92 and thus seal the canister. In the alternative arrangement shown in FIG. 13 the canister is closed by a thin metal disc 97 having a peripheral upstanding wall 98. The wall 98 may be welded to the surrounding portion 91 or the two parts 91 and 98 may be secured together by folding or rolling them inwardly or outwardly. It will be appreciated that many other methods may be used for sealing the canister.

As mentioned earlier capsules may be employed for mixing together more than two materials. Where two or more different liquids are to be used the upper part of the capsule may include two or more canisters, each having a different liquid and placed one above the other so that the canisters can all be pierced at the same time by the pin 86. If more than one canister is used in this manner then the canisters may be a loose fit in the compartment n the in 77 to allow liquid from an upper canister to flow downwardly around a lower canister. In this case the upper part of a lower canister may be formed with a raised dome to prevent liquid from an upper canister being trapped on top of the lower canister. It will be seen that the canister will then be domed in a similar manner at each end. An advantage of having the canister similarly shaped at opposite ends is that it is then immaterial how the canister is inserted in the compartment 82 and this facilitates assembly of the capsule during manufacture. A projection formed on the lower conical part of the canister or on the mating conical part of the body portion 77 will prevent these two surfaces bedding together and thus allow for the passage of the liquid around the lower canister from an upper canister. Alternatively a washer with a central hole and a serrated or star shaped edge placed below the lowermost canister will serve this purpose. It will be appreciated that there are many shapes of canister which will allow the free passage of liquid between the canister and the surrounding wall and will also prevent the lower canister sealing off the hole in the body portion 77.

Alternatively the lower part of an upper canister may be conically formed and may fit within a conical depression in the upper part of the canister beneath it so that when the canisters have been pierced the liquid from the upper canister runs downwardly through the lower canister before passing into the chamber 77*a*.

FIG. 14 shows an alternative form of capsule where two liquids are to be mixed with a third powdered material. As in the arrangements described above the body portion 77 of the capsule is formed from an easily pierceable material such as polythene and the compartment 82 accommodates one liquid. In this case the canister 89 contains a second liquid and is spaced above the bottom wall 84 of the compartment 82. It will be seen that the canister 89 then serves as a stopper to contain the liquid in the compartment 82. The two liquids may be released and delivered into the mixing cap 78 by passing a single piercing instrument through the canister 89 and the wall 84. It will be seen that in the arrangement of FIG. 14 the upper thin wall 85 to the capsule has been dispensed with.

In the mixing apparatus described earlier the socket in which the capsule is mounted is inclined at about 37½° to the vertical. In the capsules shown in FIGS. 10, 11 and 14 the bottom walls of the compartments for containing liquids are conical. It is preferable for the conical angle to be such that when the capsule is placed in the inclined socket 18 centrifugal force tends to force the liquid down to the apex of the cone at all points around the conical surface. it will be appreciated that if the conical angle is too shallow there may be a tendency for liquid on parts of the surface furthest away from the center of rotation of the arm 14 to be thrown upwardly. This may not be serious since it will only happen around a small portion of the conical surface but it is preferable to avoid this if possible.

As mentioned earlier the lower part of the capsule may be formed from metal such as stainless steel or aluminum so that it may be earthed to dissipate any static electricity generated. Thus in the capsules described the lower cap part 78 of the capsule may be formed from metal. Alternatively the whole capsule may be made from a material which does not generate static electricity, such as Bakelite (Registered Trade Mark).

FIG. 15 shows an alternative form of capsule somewhat similar to that shown in FIG. 11 but in which the liquid is contained within a sachet 90, of metal foil, mounted within a suitably shaped recess 91 in the upper part of the capsule portion 77. The sachet consists of two circular discs welded or otherwise bonded together around their periphery. A locating ring 92 is wedged in the recess 91 to locate the sachet 90 in position and the ring 92 prevents the sachet 90 being withdrawn from the capsule body as the pin which has been used to puncture the sachet is withdrawn.

There are already known various forms of capsule for containing cement-forming materials in predetermined quantities. Such capsules have hitherto been used in mixing apparatus which simply oscillates the capsule to effect mixing. However such a known form of capsule may also be employed in a mixing apparatus according to the present invention. One such capsule comprises an elongated body part domed at one end and closed at the other end by a removable cap. The main body part of the capsule contains the powder material and the cap contains the liquid. The liquid is normally either contained in a metal foil sachet, similar to the sachet 90 of FIG. 15, or is retained within the cap by sealing discs and rings. The arrangement is such that when the cap and main body portion of the capsule are squeezed together the sealing disc or sachet is ruptured so that the liquid passes into the main body of the capsule containing the powder. Although such a capsule may be used in the mixing device described earlier it is preferably modified by replacing the domed end of the main portion of the capsule by a removable cap similar to the cap 78 in the arrangements described above, and also by forming the capsule with external projections to engage the projections in the socket of the device.

The capsules described above are all suitable for use in the device shown in FIG. 1. There will now be described certain further forms of capsule which have features not found in the capsules described above. Since the capsules to be described below are of different shape and proportions to those so far described it will be appreciated that the socket 18 of the device of FIG. 1 would require to be suitable modified to accommodate them.

The capsule shown in FIG. 16 is formed from plastics material and comprises a lower mixing chamber 93 of circular cross-section one end of which is closed in liquid-tight manner by a piston 94. The upper end of the chamber 93 is formed with an inwardly projecting annular flange 95 encircling a central aperture 96. The chamber 93 contains the powder component for forming the cement. The lower end 97 of a hollow cover 98 is a tight fit in the aperture 96 and a flange 99 on the cover 98 overlies the flange 95. The cavity in the cover 98 contains the liquid component of the materials for forming the cements.

The lower part of the cavity within the cover is conically formed as indicated at 100 the lower apex of the cone leading to an outlet aperture 101. The outlet aperture 101 and the upper end of the cover are closed by thin walls 102 and 103 respectively. The walls 102 and 103 may be of thin plastics bonded to the remainder of the cover or one of them may be formed during the moulding process. Alternatively one or both of them may be formed from any rupturable materials such as aluminum foil. As in the case of the capsules previously described the liquid may be mixed with the powder by rupturing the walls 102 and 103 by a steel pin 104 before the capsule is placed in the mixing device.

When mixing has been completed the capsule is removed from the apparatus and the cover **98** discarded. The mixing chamber **93** is then placed over a suitably shaped spigot and pressed downwardly so that the piston **94** is forced upwards to meet the flange **95**. This brings the mixed cement to the top of the chamber where it may be readily removed.

Any unmixed particles of powder present in the chamber **93** after mixing will be adhering to the walls of the chamber and thus will be trapped below the flange **95** when the piston **94** is raised so that these unmixed particles of powder will not contaminate the cement. It will be appreciated however that if the depth of the chamber **93** is small enough the material will extend up the whole height of the wall of the chamber when the material is thrown to its outermost position in the inclined capsule during mixing. Thus as the chamber rotates the materials will sweep over the whole of the internal walls and thus there should not be any unmixed particles of powder remaining. Thus in some instances the flange **94** may not be necessary.

FIGS. **17** and **18** show an alternative form of capsule. The cover **105** of the capsule is similar to the cover **98** of FIG. **16** except that it is formed with a peripheral skirt **106** which tightly embraces the upper end of the lower mixing chamber **107**. The mixing chamber **107** however differs from the chamber **93** in that the space within the capsule is in the form of a transverse slot **108** (as best seen in FIG. **18**). This arrangement has the advantage that when the material being mixed is disposed at one end of the slot **108**, when the capsule is in the mixing device, the side walls of the slot tend to prevent the material losing adhesion until the slot has turned through 180°. This means that when using the capsule of FIGS. **17** and **18** the relationship between the speeds of rotation of the arm **14** and the capsule may not be so critical in order to produce the ideal operation referred to in which the material are carried round through 180° rotation of the capsule before adhesion is lost through centrifugal force and the materials are thrown across the capsule.

There may also be less tendency for particles of powder to be unmixed and therefore a flange corresponding to the flange **95** of FIG. **16** may not be necessary. The capsule shown in FIGS. **17** and **18** is also particularly suitable for mixing dental amalgams of mercury and metal alloy powder. Such an amalgam has very little adhesiveness to the walls of a container and thus would not be carried round by the walls of a circular receptacle. The amalgam would however tend to be carried round through 180° by the transverse slot type of container shown in FIGS. **17** and **18**.

The slot **108** is shown in FIG. **17** as having a flat bottom but it may if required have a rounded bottom.

The capsules may be formed from any suitable plastics material but in the case of that shown in FIG. **16** the piston part **94** may be formed from a softer plastics material then the rest of the chamber **93** to insure a liquid-tight fit between the piston and the walls of the chamber as well as facilitating movement of the piston **94** upwards to eject the cement. The piston **94** might also be formed from rubber or polythene as may also the cover **98** or the cover **105**.

Although the capsules are described as having liquid in the cover and powder in the mixing chamber it will be appreciated that the powder could be in the cover and the liquid in the chamber.

As mentioned earlier in some cases three or more materials may require to be mixed to form a cement, for example, some cements are formed from a powder a liquid and a catalyst. In this case the cover may be formed with a number of compartments each containing one of the materials to be mixed and the compartments all being ruptured in a similar way to discharge the materials from them into a single mixing chamber in the lower part of the capsule. The capsule shown in FIGS. **17** and **18** is particularly suitable for such an arrangement since the compartments in the cover may be spaced apart in register with the elongated slot **108**. When a number of compartments for liquid or powder are provided in the cover the underside of the cover is preferably provided with a projection which registers with the upper end of the slot **108** so that the outlets from the compartments are accurately located with respect to the slot.

Referring to FIG. **19** the capsule shown in that Figure comprises a lower mixing chamber **109** of circular cross-section.

The central portion of he bottom wall of the chamber **109** is domed as in the capsules first described above. The capsule also comprises an upper cover **110** which is formed from a resilient plastics material such as polythene, the lower portion **119** being formed from a more rigid plastics material. The cover **110** if formed with a downwardly projecting peripheral skirt **111** which tightly encircles the upper end of the chamber **109**. The upper end of the peripheral wall **112** of the mixing chamber is received within an annular slot **113** within the under side of the cover **110**.

The annular slot **113** is a close fit over the wall **112**. The thickness of the wall **112** may be slightly larger than the width of the slot so that the resilient materials of the cover will be stretched by the wall so that a tight fit is effected.

The cover **110** is formed with a circular cross-section cavity **114** the lower part of which is conically formed, the lower apex of the cone leading to an outlet aperture **115** closed by a thin wall **116**. The under surface of the wall of the cover surrounding the aperture **115** is recessed as indicated at **117** for the purpose described with reference to FIGS. **10** and **11**.

A canister **118** formed from thin aluminum is located within the cavity **114** and is shaped externally to correspond to the interior shape of the cavity. The walls of the canister may be about ten thousandths of an inch in thickness. The canister contains the liquid component of the substances to be mixed and is closed at its upper end by a thin aluminum cap (not shown) as described in the earlier arrangements. A further cap of plastics material may also be sealed over the closed upper end of the aluminum canister to secure the canister within the cover. Alternatively the canister could closed by a polythene plug covered by an impermeable skin such as if often used over bottle stoppers. The canister and thin wall **116** are ruptured by a steel pin in a similar manner to that described with relation to the canisters described earlier.

Although the provision of an aluminum or other metal canister in the arrangements described above may prevent loss of liquid by evaporation certain liquids may attack the metal of the canister. This problem may be reduced by anodising the metal of the canister or by lining the inside of the canister by a plastics material which is not attacked by the liquid. The canister will still then prevent loss of liquid by permeation. Alternatively the liquid may be contained within a container formed from a plastics which is not attacked by the liquid the outer surface of the container being coated with aluminum to prevent permeation through the walls of the container.

I claim:

1. A device for mixing together a plurality of substances comprising a structure mounted for rotation about a first axis, means for rotating said structure about said axis, a receptacle for the substances mounted on said structure at a location spaced from the axis of rotation thereof for rotation relative to said structure about a second axis inclined at an angle of less than **90°** to said first axis, and a pulley system comprising a pulley wheel rotating with said receptacle about said second axis, a fixed further pulley wheel coaxial with said first axis, an endless band encircling said pulley wheel and said fixed pulley wheel whereby said receptacle is rotated relative to said structure by said pulley system as said structure rotates.

2. A device according to claim **1** wherein one of said pulley wheels is slightly eccentric.

3. A device according to claim **1** wherein said endless band passes over idler pulley wheels rotatably mounted on the structure.

4. A device for mixing together a plurality of substances comprising a structure mounted for rotation about a first axis, means for rotating said structure about said axis, a receptacle for the substances mounted on said structure at a location

spaced from the axis of rotation thereof for rotation relative to said structure about a second axis inclined at an angle of less than 90° to said first axis, a fixed track coaxial with said first axis, a wheel rotating with said receptacle about said second axis having its periphery frictionally engaging said track so that said wheel and receptacle are rotated as said structure rotates.

5. A device for mixing together a plurality of substances comprising a structure mounted for rotation about a first axis, means for rotating said structure about said axis, a receptacle for the substances mounted on said structure at a location spaced from the axis of rotation thereof for rotation relative to said structure about a second axis inclined at an angle of less than 90° to said first axis, a track on a member coaxial with the first axis, a wheel rotating with said receptacle about said second axis having its periphery frictionally engaging said track and means to rotate said member relative to said structure.

6. A device according to claim 4 wherein said track is slightly eccentric with respect to said first axis.

7. A device according to claim 1 wherein the receptacle comprises a circular cross-section socket the outer surface of which is rotatable in a bearing on said structure and wherein the lower end of said socket is open so that the lower end of a capsule located in said socket may protrude into the air, means being provided to locate said capsule axially and rotationally in said socket.

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