July 4, 1961 J. J. CLANCY 2,991,176

METHOD FOR MAKING DENTAL AMALGAMS AND PRODUCT THEREOF

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Fig. 1.

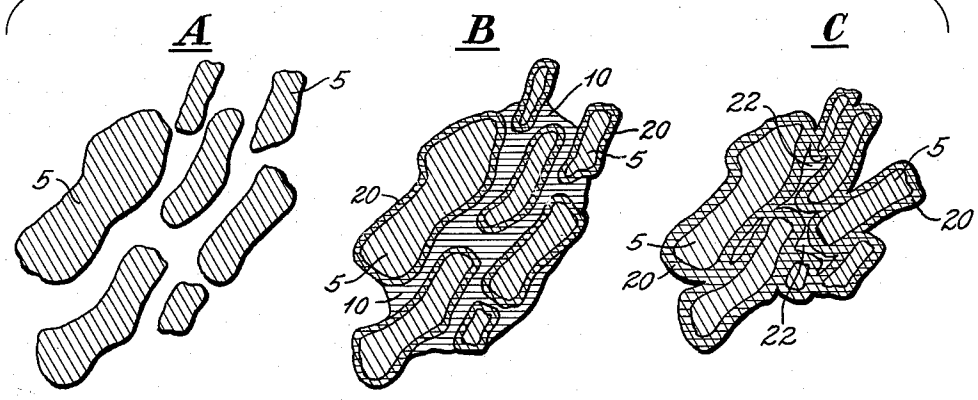
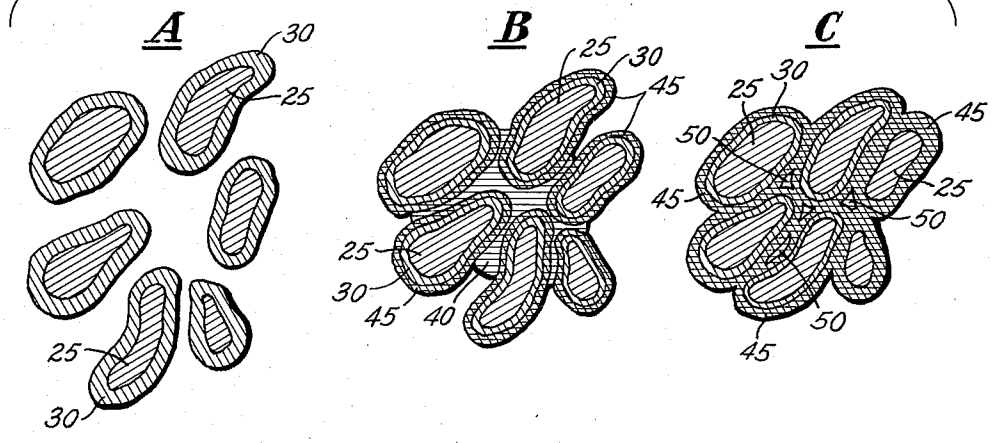


Fig. 2.



INVENTOR
John J. Clancy

BY Thomas, Weisman & Russell
ATTORNEYS

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METHOD FOR MAKING DENTAL AMALGAMS AND PRODUCT THEREOF

John J. Clancy, Westwood, Mass., assignor, by mesne assignments, to The L. D. Caulk Company, Milford, Del., a corporation of Delaware

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This invention relates to a novel method of preparing dental amalgam alloy and the resultant amalgum filling thereof. More particularly, the invention utilizes a procedure wherein an inner core, inert to the solvent action of mercury, is first plated or coated with silver-tin dental alloy, and this alloy coated core is used in place of the usual type of solid silver-tin alloy in making the ordinary type of dental amalgam alloy.

In carrying out the procedure of this novel method, it is contemplated that coating is achieved by means of a ball mill; the particles to be coated are placed in this type of generally well known mill, and the latter filled to the desirable extent with a multitude of small silver-tin alloy particles, preferably of a size commensurate with the particles to be coated, and the mill operated in the usual fashion. The inert core spoken of in the foregoing may be of such materials as silica, nickel, copper, alundum, alumina, zirconates, titanates, silicates or ceramic bodies, etc. So far as the dental amalgam be concerned, all of these except copper, would ordinarily be totally inert to the action of the mercury used in the preparation of the amalgam.

Although there have been some improvements in the past 100 years in the alloys used in making dental amalgams (generally confined only to the constituents of the alloy) the standard silver-tin alloy, making its advent approximately a century ago, has been the recognized and long acceptable amalgam used in the dental field. Dental amalgam alloys upon the market vary slightly in composition, the trinary of these groups including copper, and as an example of a quaternary type of alloy, is mentioned the type which may include such constituents as silver, tin, zinc, and copper. The proportions of these four or more metals have been known and agreed upon for decades, the standard form of the binary compound comprising approximately 26% of tin, and approximately 74% of silver. However, despite decided improvement in the specific type of silver-tin alloy, be it binary, trinary or quaternary, little has been done with respect to the type of granule or ultimate silver alloy particle that is utilized in everyday dental practice.

In providing for a different type of base alloy particle for use in dental amalgams, the basic factors contributing to good performance have not been overlooked. Amalgams formed from the alloy of this invention exhibit all of those characteristics which are necessary and which are consistent with good dental practice. For example, the amalgams formed with the alloys comprising the coated particles as contemplated by this invention, may be so manipulated as to exhibit all of those proper and standard limits of shrinkage and/or expansion as is customarily required by the dental profession. Also, not only may the expansion rates of such amalgams be controlled within standard and desired limits but, in addition, the amalgams formed from the particles of this invention may be properly annealed within the meaning of good manufacturing practice. The heterogenous silver-tin alloys of the instant invention, when amalgamated, also form fillings having the required "edge strength" as well as over-all, characteristic permanence within the prescribed limits of the industry.

It is accordingly a primary object of the instant invention to provide a novel type of alloy for use in dental

amalgams wherein the core of the alloy particles consists of materials which are inert, or relatively inert to the chemical affinity of mercury. In this respect, almost any type of readily available substance may be utilized. For example, and having particular reference to the non-metals, such cure can be of substances such as silica, alumina, etc.; and having reference to metallic core substances, such metals as copper or nickel, and particularly the latter, are useful.

Another objective of the invention is to provide an alloy for use in dental amalgams which not only produces excellent results, but also, because of use of the inert inner core, as described briefly above, substantially reduces the cost of the alloy, and therefore, the ultimate cost of the amalgam filling itself. In the practice of the instant invention, it is contemplated in this respect that not only is there a substantial reduction in the amount of the comparatively expensive elements (silver and tin) but also, that substantially less mercury is needed for the amalgam mix. As to the latter, it is to be observed that in practicing the process of this invention and the ultimate method of amalgamation thereof, the mercury content of the amalgam can be substantially reduced; i.e., to between about 40% to about 50% of the entire mass.

Another object of the invention is the provision of an alloy for use in dentisty, which, being made up of coated inert and non-conducting cores, such particles, when finally placed in the tooth in the form of amalgam, substantially reduce heat transmission therethrough. It is manifest that if the referred to cores consist of such chemically inert inorganic, refractory materials as silica, alumina, and the like which are extremely resistant to heat transmission, an amalgam filling, made up of hundreds and more accurately, thousands of such small particles, all having such inert cores, results in a filling having a substantially reduced potential of heat transmission.

Another object of this invention is the provision of an alloy for use in dentistry, which, employing the referred to coated inert and non-conducting cores, when finally placed in the tooth in the form of amalgam, substantially reduces the thermal coefficient of expansion thereof. The materials of the prior art have a thermal expansion of more than twice that of the tooth; consequently, when hot and cold foods or liquids come in contact with the restored tooth, the differences in expansion and contraction between the tooth structure and the amalgam cause "percolation" or leakage around the margins of the filling. A filling made from hundreds of thousands of such small inert particles, having a coefficient of expansion approaching that of the tooth, substantially reduces the dangers of percolation or leakage.

As a further object of the invention the method thereof is designed to produce alloy particles which in all other respects meet standard requirements and conditions for dental amalgams and measure up to those high qualities made a requisite by the dental profession.

There are other obvious objects and advantages involved in the instant invention which will become more apparent from the following more detailed description, which makes specific reference to the following drawings, and wherein:

FIGURE 1 is a graphic illustration of a number of alloy particles of the prior art shown with respect to the manner in which the ultimate amalgam is obtained;

FIGURE 2 is a graphic illustration, similar to FIGURE 1, demonstrating the nature of the coated alloy particles of the instant invention, and further showing the different manner in which the provided mercury interacts with the outer silver-tin alloy coating, to obtain the ultimate amalgam.

As a prefatory matter, it is to be understood that the

present common practice of making dental amalgam alloys is to melt a combination of silver and other metals, such as tin, copper and zinc to form a homogeneous alloy, which is then cast into a bar ingot. This bar or ingot is then placed in a milling machine, lathe or other cutting device, which shaves or cuts the metal into fine particles. The shape, thickness and size of the alloy particles are quite important to the performance of the material when it is ultimately mixed with mercury to form an amalgam filling. Therefore, the actual yield of satisfactory alloy from a melt is sometimes quite low, due to the removal of the coarse particles and the very fine dust particles formed during the cutting, grinding and sieving operation. After this accurately sized alloy is annealed and washed it is ready for use by the dental operator.

To prepare a dental amalgam restoration the dental operator combines the finely comminuted alloy with a definite proportion of mercury, by rubbing the two materials together either manually or in a mixing machine. This rubbing or trituration procedure coats the surface of each of the alloy particles with mercury but does not completely dissolve them. It is estimated that only 20% to 25% of a given alloy particle actually goes into solution, leaving a center core of the original alloy. The mixed amalgam, as it is removed from the mixing device, therefore consists of a plastic mass containing free mercury, a mercury-alloy solution around each alloy particle and an alloy core. To make the actual filling the dentist packs or "plugs" the plastic amalgam into the prepared tooth cavity. By applying pressure on the amalgam the coated particles are pushed together, squeezing out the excess or "free" mercury which is then removed by the operator and thrown into discarded scrap metal. This procedure is repeated until the cavity is full.

The coated particles are touching each other if the packing is carried out properly and when the chemical reaction between the mercury and silver takes place to form a crystalline structure the alloy cores are locked tightly together, something like the stone aggregate in a concrete mix. This crystallization reaction causes the hardening of the amalgam and also imparts a slight expansion to the amalgam which locks the filling in place in the tooth. It is well recognized in the art that the amount of silver-mercury compound formed controls the amount of expansion. Therefore the ratio of these two components, together with other known components of such alloys, regulate such expansion to the desired degree. At any rate, if the pressure used in the packing of the amalgam is insufficient to remove much of the excess mercury, the free mercury left in the amalgam gradually diffuses through the coating on the alloy particles causing more solution, with more subsequent crystallization, with a very large amount of expansion; and this situation, if accentuated, results in poor strength, weak margins and high corrosion, all of which are the marks of a poor amalgam filling.

The above general description of prior art particles and the setting of the resulting amalgam as it has been practiced in the past may be better understood by reference to FIGURE 1 which diagrammatically indicates the amalgam formation. Here the several particles are indicated at **5**, in the diagram under "A." Such particles appear in the dry form, and are discrete, as they are shipped for use by the dentist. At "B" of FIGURE 1 mercury has been added to the particles and is attacking the outer surface of each to combine with the alloy thereof to form the amalgam. At "C" the completed amalgam has been appropriately "packed" in the tooth cavity, the several particles being squeezed and bonded together.

Each of the individual particles **5** is of a known form of alloy, i.e., a silver-tin type of dental amalgam alloy. Such particles of alloy are generally available in two grades: e.g., the "regular" type which is commonly considered as a "coarse cut" or of a rather large particle size material, and the finer size. The particle size of the coarser material ranges from approximately 10 microns

minimum to about 180 microns maximum. The average particle size is approximately 40 microns. All the material passes through 150 mesh screen. The referred to finer type of dental alloy is often designated as "fine cut" alloy. This is of even smaller particle size than that just referred to. All material of the "fine cut" type usually passes through a 325 mesh sieve. In either event it is thus to be appreciated that the diagrammatic showing of the figures represents particles greatly exaggerated in size, this being done for purposes of explanation only.

At any rate, in performing the usual operation of preparing a dental amalgam for packing a tooth cavity, a dentist mixes with such particles as indicated at **5**, a predetermined ratio of mercury. As indicated in FIGURE 1 "B," the mercury **10** is being depicted as flowing in between and around the several particles, to closely admix therewith. The mercury attacks the surface of each of the alloy particles, there being a large excess of mercury present to impart plasticity to the mix. This excess of mercury is indicated in FIGURE 1 "B" at **10**. The result of this alloy-mercury contact is a mercury-alloy solution around each particle. Such solution may come into contact with a like solution around the other particles.

With the mix in this plastic condition the dentist proceeds to pack the amalgam into the given cavity. The result is to force the particles closer together, and to also force excess mercury to the surface of the filling. Such free or excess mercury as indicated at "B" is thus forced to the top of the amalgam filling for manual removal.

During packing, such excess mercury is removed and the individual particles are pushed by manual or mechanical pressure closely together as indicated at FIGURE 1 "C." Here the solution of mercury and alloy is now considerably hardened or set, and as indicated at **20**, surrounds each individual particle and bonds (by action of the mercury) each of the several particles together. In other words, the alloy-mercury solution gradually hardens by crystallization, resulting in cementing the several individual particles together. Some excess mercury may be deposited inbetween the several particles. This is indicated at **22**, FIGURE 1 "C." However, this free mercury will eventually be absorbed by the solution phase of the alloy particles surrounding the same.

By further reference to FIGURE 1 it may be additionally appreciated that in this general description of prior art and known practices with respect to the preparation of and use of dental amalgams, a considerable portion of the valuable silver-tin alloy is actually unused and unnecessary to obtain a proper filling material. Specifically, and viewing FIGURE 1 "C" it will be seen that the major portion of each alloy particle **5** is unused and unattacked by the mercury surrounding same. The mercury interacts merely with the surface of each alloy particle, leaving the remainder unattacked and unused.

Referring to the representation of FIGURE 2, representing the use of the alloy of this invention, the individual particles are indicated at **25**. In this case the center portion of each particle is inert, and being unnecessary to the over-all reaction, may be of a non-metal or a base metal material. The numeral **25** further represents this inner core of inert material as being surrounded by the outer coating of the dental alloy to be used. As indicated above, the coating **30** may be of any suitable type of silver-tin alloy; in other words, it may represent a simple binary alloy or it may be of the more complex quaternary type, wherein both zinc and copper form an essential component. On the other hand it may represent a fundamentally copper alloy, if the type of intended use is for children, where a high degree of germicidal action is desirable.

The inner core **25** may consist of such metal particles or inorganic aggregates as nickel, silica, alumina, alundum, copper or any other readily available composition which will not readily react with mercury. Referring to FIGURE 2 "B," the particles **25**, here shown with their

coating of alloy **30**, are mixed with that quantity of mercury **40** sufficient to render the mixture or mass to that plasticity which will enable easy working to form the filling. In this instance, the mercury reacts only with the outer alloy coating **30**, and forms with such coating a silver-mercury amalgam as indicated at **45**. Referring to FIGURE 2 "C," the amalgam is shown in its final form after being well packed into the filling. The inner core **25** remains unchanged, the outer coating **30** has reacted or gone partly into solution with the mercury to form the amalgam **45**, the latter firmly bonding the several adjacent particles together, and the excess mercury due to packing in the cavity has been forced to the top where it is manually removed. Although there may be certain voids in this final filling such as those indicated at **50**, which essentially consist of small amounts of "free mercury," the latter ultimately either reacts with the undissolved coating on the alloy particle or alternatively, with the silver-mercury solution. The end result is to obtain an effective, compact amalgam wherein the several particles of same are firmly cemented to each other by the mercury-silver solution, which ultimately sets and hardens.

In the representation of the invention as depicted in FIGURE 2, the small coated particles are irregularly shaped, as indicated. If considered as "metal powders" such particles are usually made by a spraying process which tends to shape the same more like tiny balls, or droplets. These powders can also be prepared in attrition mills which tend to give irregular particle shapes. In any event the effect of ball-milling such particles to coat them in the manner stated, with an exterior alloy coating consisting of for example silver-tin, is to slightly round all uneven edges of such particles so that in the end they will take the general formation as diagrammatically indicated in this FIGURE 2 "A." In addition, such processing tends to remove all cracks and fissures in the particles used, an additional advantage of the invention.

It should be understood that in carrying out the method of this invention, the mercury dissolves the outside surface of the alloy particle and, as stated, an excess is present to impart a plasticity or workability to the amalgam. In contrast, where solid alloy particles are utilized, the original excess mercury is continually penetrating the solution on the surface of the particles and entering into solution with the undissolved core. This necessitates an extra excess of mercury to impart plasticity; hence, the substantial reduction in the mercury requirement in carrying out this invention. In applicant's method the mercury insoluble core cannot be dissolved and consequently less mercury is needed for the over-all mix. It is estimated that under these conditions the mercury content in the formation of a given amalgam utilizing coated particles can be reduced to between 40% to 50% of the mass.

As an additional adjunct and facet of this invention, I contemplate heat treating the coated particles to give a layer of silver-tin alloy of uniform composition to the surface thereof. It is also contemplated that such coating may be in the form of alternate layers of tin and silver, followed by a similar heat treating step. It is contemplated that temperatures in the neighborhood of 800° F. to 900° F. are sufficient, even for short periods of time, to effectively "cure" or bond such several layers of tin and silver to each other, these layers forming alloys adapted to react with mercury in the formation of the ultimate amalgam. Such temperatures are lower than the melting point of the particular alloy used. Coating in each instance of a single one of these elements is done by the same methods herein outlined—ball milling for the time effective to obtain a sufficient layer of tin-silver alloy. Obviously the balls of the mill are made of that material, e.g., tin, silver or alloy which it is desired to implant upon the surface of the several particles.

Having outlined the nature of the invention in the foregoing, reference will now be made to several specific examples which demonstrate the actual practice of the process and which specifically illustrate the manner in which the ultimate amalgam filling is obtained.

Example I

A ball mill of known type is charged with approximately four pounds of finely divided copper particles—here the base substance which is to be coated with the dental alloy. Also charged to the ball mill are approximately four pounds of finely ground alloy together with a substantial number of alloy balls. The latter may be of approximately one-sixteenth inch in size or even smaller. The ground alloy particles as well as the balls may be of an alloy of the usual type; that is, a simple tin-silver alloy wherein the silver constituent is approximately 70% and the tin constituent approximately 30%.

To obtain complete admixture between copper particles and alloy, a carrying fluid is provided or charged into the mill, the latter consisting of, for example, naphtha containing a suitable percentage of vegetable oil. The balls substantially contribute to effective surface to surface contact between the copper particles and alloy particles.

The ball mill is operated for a period of approximately two hours. At the end of this time, the copper particles, coated particles and alloy balls are removed from the mill. The alloy particles and coated particles are separated from the balls used in the coating procedure by sieving the admixture through a 325 mesh screen. The balls are of course retained for further use in plating additional copper or other non-alloy particles. The coated particles are separated from the solid alloy particles by a so-called "heavy medium" separation process. Such processes are well known to the art and fundamentally comprise charging the mixture of such particles to a bath, the employed liquid for separatory purposes being of a specific gravity intermediate the specific gravity of the coated particles and the solid alloy particles. Separation occurs because of the variance in specific gravity between the two types of particles, one type of lighter gravity floating and the other sinking, where other obvious separation procedures are used to separately discharge each type of product to suitable outlets. As stated, these procedures are well known and applicable to the type of separation here under consideration, the specific means for carrying out the operation being well within the skill of the art once the desideratum is made known. Also, as an alternative, certain other types of floatation, separation procedures may be used.

In any event, it will be found by visual and microscopic examination that the coated copper particles have adhered to their entire outer surface a substantial layer of the tin-silver alloy. Also, these individual particles have been somewhat rounded in contour by the action of the mill.

The resulting, coated particles, are then amalgamated by the addition thereto of a quantity of mercury. Mercury utilized will be in the proportion of approximately 45% mercury to 55% of the coated particles. After suitable mixing or "working" and placement of this alloy-mercury mixture in a tooth cavity or simulated cavity, it will be found that the resultant filling exhibits all those usual qualities necessary to meet the requirements of the dental profession. In other words, edge-stability, permanency, and characteristic controlled expansion, will be found to be present.

Furthermore, because continued action of the mercury does not result, in this instance, in continued attack upon the interior core, inasmuch as the core of each coated particle is inactive, the amount of mercury used is substantially less than that which would ordinarily be used in preparation of the filling. In the instant case, it is estimated that whereas 60% mercury would ordinarily be used, only 45% thereof, as indicated in the foregoing is necessary to obtain a proper amalgam.

Example II

Approximately three pounds of nickel particles and approximately six pounds of shot alloy of an appropriate dental alloy are charged to the ball mill. The nickel particles are of a size to pass through a 150 mesh screen, and average in particle size from about 10 microns minimum to about 180 microns maximum. The average particle size is approximately 40 microns. The size of the alloy balls is approximately one-sixteenth inch. The alloy balls in this instance may be of a trinary type, i.e., an alloy of silver, tin and copper.

An appropriate amount of silver nitrate solution as a carrying medium is charged into the ball mill. The mill is operated for a period of approximately three hours.

After this period of operation particles and alloy are removed from the mill and separated from each other by passing this physical mixture through an approximately 200 mesh screen, the balls of course being retained for future use.

Inspection of the nickel particles will indicate that by the foregoing and described action of the ball mill, the same have been completely coated by the mechanical impact of the alloy shot. The result is that each of such particles is provided with a surface covering of alloy. The particles are somewhat rounded and uneven edges removed by the action of the ball mill. These coated particles are then mixed with mercury in proper proportion, here again a proportion of about 45% mercury to about 55% coated particles, and after proper mixing and working implanted in a tooth cavity or a simulated cavity. After setting, it will be observed that the amalgam tightly adapts to the cavity walls, exhibits proper edge strength and permanency.

Here again, also, it will be found that the amount of mercury necessary to be used will be approximately 40% less than the amount of mercury used in conventional practices where solid, alloy particles form the base substance of the amalgam.

Example III

Two pounds of alumina are charged to the ball mill, together with four pounds of shot alloy. The alumina has a rather rounded configuration and, being rather short in comparison to its width, such particles are of that size to pass through a 325 sieve. The small shot of solid alloy is of a quaternary type, i.e., having four components and having a component ratio as follows: silver, 68.5%; tin, 27.0%; zinc, 1.7%; and copper, 2.8%.

To facilitate admixture and pounding action between particles and alloy balls, the mill was partially filled with a suitable carrier or liquid such as a silver nitrate solution. The latter facilitates the adherence of the silver alloy to the base component.

In the use of this material the same procedure is followed as in the foregoing examples: 45% of mercury is admixed with 55% of the coated particles and worked to the desired degree to obtain the required plasticity. After insertion in the dental cavity, excess mercury is removed during the packing of the amalgam leaving the hard cores in the filling. The mercury finds in the coating only sufficient alloy to completely react the mercury with the said alloy, the inert material of the core being unreacted. The result is a tooth filling that exhibits all of the essential attributes of conventional amalgams. However, and significantly, there is a substantial saving in the amount of mercury used, and the resultant filling, being far more resistant to heat transfer, is additionally desirable in this respect.

Example IV

In this example, the same procedure is followed as in Example 3, supra, except that several coating procedures of the base material are spaced by an intermediate heat treatment step. This additionally assures adherence of the several coatings to such base material. In each instance, after removal and separation of the coated particles from the balls (or granulated alloy particles, as the case may be), the coated particles are placed in a heating drum where they are subjected to a prolonged heat treatment at temperatures of preferably 40° F. for a period of approximately two hours. This is effective to further assure complete bonding of the dental alloy to each of the several particles. The temperature range may vary from about 300° F. to about 500° F., and the period of treatment may vary from about one to about four hours. This heat treatment step is followed by another ball mill coating procedure, following the previous examples, and after removal again from the ball mill, and appropriate separation, the now twice coated particles, are again subjected to a final heat treating step. The result is a multiple coating of the inert cores which is firmly adhered thereto, and results in a base material which fully satisfies the several requirements which must be met in the proper preparation of a dental amalgam filling.

When admixed with mercury in the fashion as referred to above, the resultant amalgam is of the same excellent type as obtained by the use of coated particles as set forth in the previous examples.

In the practice of this invention, although the mercury dissolves the outside surface of the alloy particles somewhat, some excess mercury is present to impart plasticity or workability to the amalgam. There can be no continual dissolving or reaction of mercury and alloy because of the unreactive, inner core of the several particles, whereas, and in contrast, with the usual solid particles of the prior art, the excess mercury is continually penetrating the solution on the surface of the particle and entering into solution with the undissolved core. Hence, in the prior art practice it is necessary that there be present an extra excess of mercury to impart the required plasticity as stated above. Therefore, under the conditions of use of the instant invention, the mercury content can be reduced to between about 40% and about 50% of the mass.

Accordingly, the procedure of the instant invention permits the use of coated, alloy particles, which because of their relatively inexpensive, inner core make the over-all cost of the amalgam far less. At the same time there has been no sacrifice of any of the required and essential characteristics of dental alloys in general which must necessarily follow standard practice insofar as permanency, edge strength, workability, and other important factors be concerned.

I claim:

1. The method of preparing a dental amalgam alloy comprising the steps of: placing an amount of base, finely ground material in a ball mill with solid balls of dental alloy, said material being inert to chemical affinity with mercury, operating said mill to obtain coating of said particles with said alloy by physical impact of said alloy upon said particles, removing said particles and said balls from said mill and separating said particles from said balls by screening the same, admixing mercury with said coated particles to form an amalgam admixture, and packing said admixture in a dental cavity.

2. The method of preparing a dental amalgam comprising the steps of: placing an amount of finely ground, solid particles in a ball mill, said particles being of a size to pass through a 325 mesh, said particles being of a material chemically unreactive to mercury, placing a quantity of solid balls of dental alloy in said mill, operating said mill to obtain coating of said particles and said balls from said mill and separating said particles from said balls by screening the same, admixing mercury with said coated particles to form an amalgam admixture, there being a proportion of substantially less than 60% mercury in said admixture, and packing said admixture in a dental cavity.

3. An amalgam material adapted to be used in filling a tooth comprising a plurality of coated particles, said particles having a core of material unreactive with mercury, each of said particles having a coating of dental alloy thereon, mercury in admixture with said coated particles, a mercury bond between the coatings of each of said particles and said mercury, said bond being separated from said core, said alloy being permanently adhered to the surface of each of said particles.

4. An amalgam material adapted to be used in filling a tooth comprising a plurality of coated particles, said particles comprising a core of material inert to mercury, each of said particles having a coating of dental alloy thereon, said core being of from about 10 microns to about 180 microns in size, mercury in admixture with said coated particles, a mercury bond between the coatings of each of said particles and said mercury, said bond being unreacted with said core, said alloy being permanently adhered to the surface of each of said particles by ball-milling the same, there being mercury present in said admixture in an amount less than 50%.

5. An amalgam material adapted to be used in filling a tooth comprising a plurality of coated particles, said particles having an inert core of material unreactive

with mercury, said material being selected from the group consisting of copper, nickel, alumina, alundum, and silica, each of said particles having a coating of dental alloy thereon, each of said cores being from about 10 microns to about 180 microns in size, mercury in admixture with said coated particles, a mercury bond between the coatings of each of said particles and said mercury, said bond being separate from and unreacted with said inert core, said alloy having been permanently adhered to the surface of each of said particles by common ball-milling of said alloy and said cores.

6. The material as defined in claim 3 wherein said material has a coefficient of expansion approximating that of said tooth.

7. A material as defined in claim 5 wherein said material has a coefficient of expansion approximating that of said tooth and said inert core is of a substance to substantially reduce the heat transmission of said material.

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