Jan. 27, 1942. R. W. ERDLE ET AL 2,271,454

METHOD OF FORMING A REPRODUCTION OF AN ARTICLE

Filed June 25, 1938 2 Sheets-Sheet 1

Fig. 1.

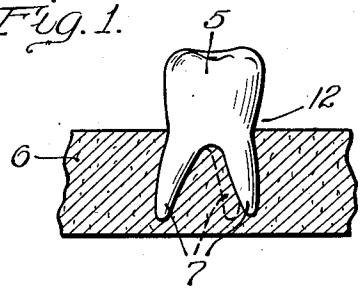


Fig. 2.

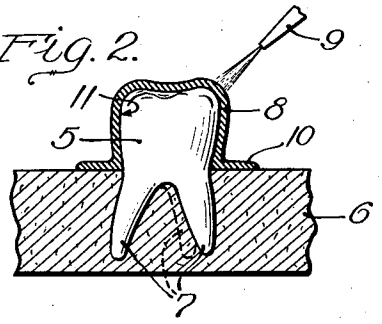


Fig. 3.

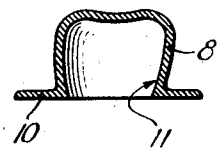


Fig. 4.

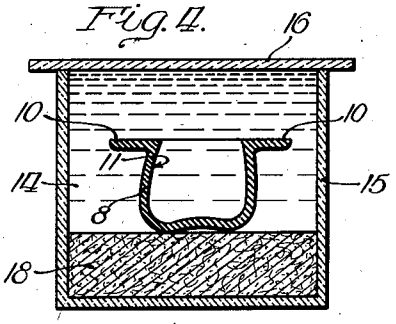


Fig. 5.

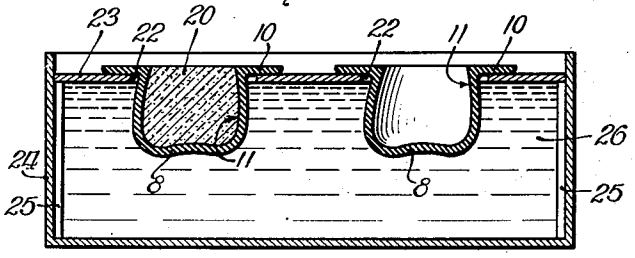


Fig. 9.

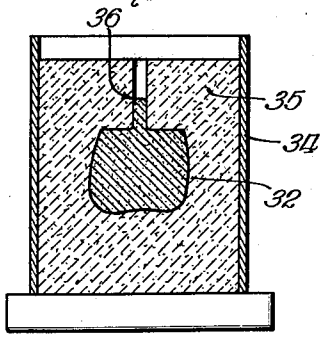


Fig. 6.

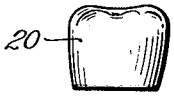


Fig. 8.

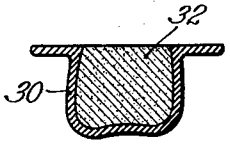


Fig. 10.

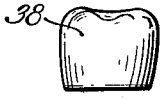
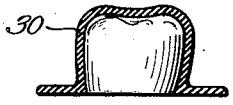


Fig. 7.



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Attys.

Jan. 27, 1942. R. W. ERDLE ET AL 2,271,454

METHOD OF FORMING A REPRODUCTION OF AN ARTICLE

Filed June 25, 1938 2 Sheets-Sheet 2

Fig. 11.

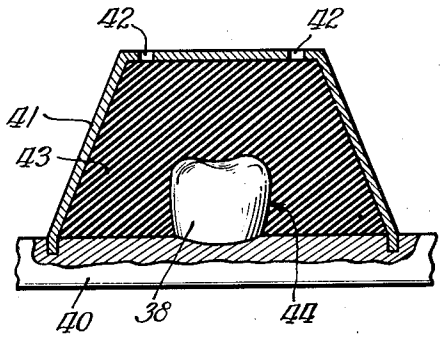


Fig. 12.

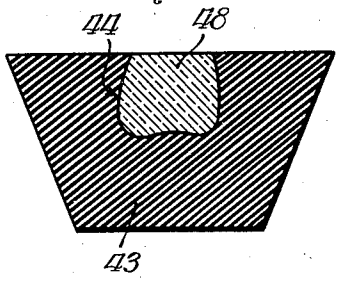


Fig. 13.

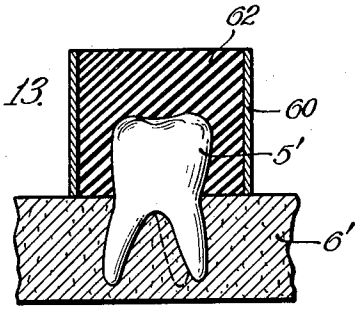


Fig. 14.

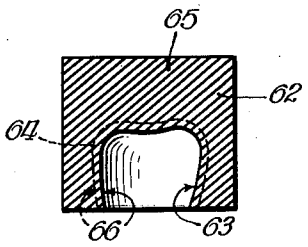


Fig. 15.

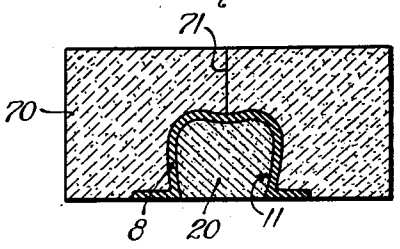


Fig. 16.

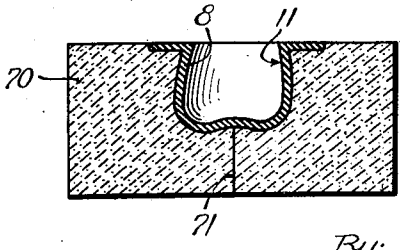
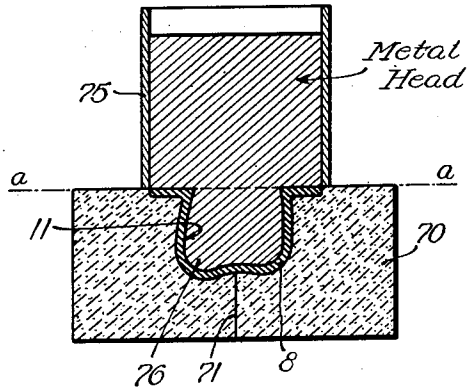


Fig. 17.



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By: Brown, Jackson, Boettcher & Dienner Attys.

Patented Jan. 27, 1942 2,271,454

UNITED STATES PATENT OFFICE

2,271,454

METHOD OF FORMING A REPRODUCTION OF AN ARTICLE

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Application June 25, 1938, Serial No. 215,810

27 Claims. (Cl. 18—55)

This invention relates to a method of forming a reproduction of an article upon the same scale or upon a reduced or an enlarged scale.

While the invention is particularly useful in making artificial teeth, it is not limited to such use but may be employed for forming reproductions of other articles as suitable and desired.

In making artificial teeth, the tooth porcelain or other tooth material with which it is desired to reproduce definite selected teeth shrinks upon firing same to bring it to hard and vitrified form. As a result, if it is desired to duplicate any selected tooth in its exact size, it is necessary to produce an unfired tooth sufficiently oversize to allow for this shrinkage. If it is desired to make an oversize or an undersize reproduction of the original tooth it is necessary to take into account the desired final size of the reproduction and the shrinkage which takes place upon firing the porcelain. For example, if it is desired that the fired porcelain reproduction be larger than the original tooth and the porcelain has a linear shrinkage of 12% upon firing, it is necessary to have an unfired specimen which is sufficiently larger than the original to take care of the shrinkage and also the amount of oversize desired. Upon firing, the increased size allowed for shrinkage is lost and the fired reproduction will be oversize the desired amount. Should it be desired to produce a fired reproduction smaller than the original, the unfired specimen will be larger than the original, but the oversize will be less than the amount allowed for shrinkage where a duplicate upon the same scale is desired, so that after the loss in size upon firing the reproduction will be the desired amount smaller than the original.

It is known in the art to use enlarged master patterns for reproducing the desired teeth, and various schemes have been provided for securing the enlargement of these patterns. According to one scheme, enlarging machines of many and varied designs have been employed, and in other cases skilled artisans have carved or otherwise fashioned the enlarged master patterns for use in forming the desired reproductions.

These prior schemes, however, are incapable of getting true and accurate reproduction of extremely fine character, especially with reference to the definite lines and other details which characterize the natural teeth. Moreover, these prior schemes require considerable time to produce the enlargement, and they cannot produce more than a single unit at a time. In the case of enlarging machines, these machines are difficult to keep in adjustment, it being particularly difficult to keep the cutter and tracer in accurate positive relation to each other, and continuous adjustments are required to get down to final cutting, all of which introduces many possible errors.

By using a refractory material consisting principally of ground quartz mixed with an agent, such as soda-glass, patterns which will be enlarged by conversion of the quartz upon firing may be formed, but this necessitates a multiplicity of steps because of the inability to secure the desired amount of expansion in one step. Where a multiplicity of steps are necessary to secure the desired amount of enlargement, the cost and time required are increased and the fine details desired in the reproduction are lost.

One of the main objects of our invention is to provide an improved method of forming reproductions of articles and, more particularly in the illustrated embodiment of the invention, an improved method of forming very accurate reproductions of natural teeth, which reproductions may be upon the same scale or upon a reduced or enlarged scale, and follow faithfully all definite lines and other details which characterize the natural teeth.

It is also an object of our invention to accomplish the reproduction expeditiously and without enlarging machines, skilled artisans, or the use of agents such as soda-glass as above referred to, and in a manner which will enable production of as many reproductions as desired at the same time.

Another and more specific object is to provide a step in the method of forming the reproduction which comprises forming an impression, usually in the form of a flexible sheath, over the original tooth or other article, removing the sheath from the article, expanding the same to secure the desired enlargement thereof, and forming in the expanded sheath an enlarged pattern for use in producing, for example, an unfired tooth oversize in amount to take care of the shrinkage of the porcelain or other material upon firing, or with the oversize in amount to produce any desired enlargement or reduction in size of the final reproduction.

Another object is to secure various degrees of enlargement of any selected article or master over a wide range without loss of accuracy in the reproduction and without the necessity of repeated steps to obtain the desired degree of enlargement. If desired, however, the method of enlargement herein disclosed may be carried out

in repeated steps within the scope of the present invention.

Another object is to keep the expanded sheath in the desired expanded state during the formation of the enlarged pattern therein.

Another object is to produce repeatedly any intermediate stage of enlargement with exactness.

Another object is to provide an improved method capable of producing enlargements of many patterns at the same time.

Other advantages and adaptations of the invention will be apparent from the following detailed description, taken in connection with the accompanying drawings in which:

Figure 1 is a more or less diagrammatic view showing the first step of setting up the natural tooth or other article on a layer of material such as modeling clay;

Figure 2 is a similar view showing the next step of forming the flexible sheath over the tooth;

Figure 3 shows the flexible sheath in section after removal from the tooth;

Figure 4 shows more or less diagrammatically the step of expanding the flexible sheath;

Figure 5 shows the step of forming enlarged stone patterns in a plurality of enlarged flexible sheaths;

Figure 6 is a view of one of the enlarged stone patterns after removal from the flexible sheath;

Figure 7 shows the step of forming a second flexible sheath upon the enlarged stone pattern;

Figure 8 shows the step of forming a wax pattern in the second flexible sheath;

Figure 9 shows the step of investing the wax pattern and the manner of forming an enlarged master metal pattern;

Figure 10 is a view of the enlarged master metal pattern;

Figure 11 shows the step of forming the flexible mold over the enlarged master metal pattern;

Figure 12 shows the step of forming the enlarged unfired porcelain tooth in the flexible mold;

Figures 13 and 14 show an alternative manner of forming the flexible sheath over the natural tooth or other article or original pattern; and

Figures 15, 16 and 17 show a method of making the enlarged master metal pattern directly in the enlarged flexible sheath formed over the natural tooth or other article or original pattern.

Referring now to the drawings, the first step in the illustrated embodiment of the invention is to set up, as desired, the natural tooth 5 or other article or original pattern which it is desired to reproduce, for example on a layer of material such as modeling clay, as indicated at 6 in Figures 1 and 2. The root portions 7 of the tooth may be embedded in the material 6, as shown, for the purpose of supporting the tooth in the desired position. Of course the tooth or other article may be set up and supported in any other suitable manner.

The next step in the process is to form a flexible sheath 8 over the article. While various sheath materials are contemplated as will hereinafter appear, this material is preferably a rubber latex material in the form of a liquid or semi-liquid rubber latex solution, of which there are a number on the market.

The latex material is preferably sprayed upon the tooth 5 as by means of a spray gun indicated more or less diagrammatically at 9 in Figure 2, but it is to be understood that other methods, such as painting or dipping, may be used to produce a suitable flexible negative over the selected pattern. Where the sheath 8 is formed by spraying, painting, or dipping, successive coats of the latex material are preferably applied to the tooth or other article, each coat being dried out by means of a jet of air or otherwise, until a sheath or shell 8 is built up of such thickness that it retains its shape when set or coagulated and removed from the article 5. The sheath 8 preferably has a generally uniform wall thickness. A suitable thickness has been found to be about $\frac{1}{32}$ of an inch, although the sheath may be thicker or thinner as desired. The latex material lends itself admirably to application by spraying, and the spraying of the material against the natural tooth or other article 5 reproduces extremely accurately on the inner surface of the sheath 8, which contacts the article 5, all details of said article. The flexible sheath 8 is preferably provided with an integral flange 10 formed during formation of the sheath.

Upon completing the formation of the sheath 8 to the desired thickness and after it is dried out and coagulated to form the rubber shell, this shell is removed from the original pattern by stripping it therefrom. We find that allowing the sheath to set over night produces the desired set or coagulation of the sheath and allows it to reach its full elastic strength, but this, of course, may vary. The flexibility of the rubber sheath permits its removal from the article 5 notwithstanding undercuts and other formations which might otherwise prevent such removal. The rubber shell or sheath 8 which now retains its shape after removal from the article 5 defines a cavity or matrix 11 which is a true negative of the natural tooth or original pattern 5, and produces faithfully all definite lines and other details which characterize the original pattern.

The next step is to treat the flexible sheath 8 with an agent which will expand the sheath to enlarged size. This is preferably accomplished by providing a bath 14 of the desired agent in a glass or other suitable container 15 closed at the top by a cover 16, and placing the sheath 8 in this bath 14. The sheath 8 absorbs the agent 14, and, by this absorption, swells or expands to increased size. If the wall thickness of the sheath is substantially uniform, the expansion is substantially uniform, and the enlargement of the cavity or matrix 11 produced by expansion of the sheath is an extremely accurate reproduction of all definite lines and other details of the natural tooth or other article 5 on an enlarged scale. The spraying of the material forming the sheath makes it possible expeditiously to secure the desired uniformity in the wall thickness of the sheath. Care should be taken to see that the flexible sheath is placed in the bath 14 in such position that no air is entrapped, and in such manner that the agent may be absorbed substantially equally along all surfaces of the sheath 8. A base 18 of cotton or other suitable material under the flexible sheath serves this purpose.

It has been found that many organic solvents are well adapted to serve as expanding agents, as will hereinafter appear.

For example, chloroform is an exceedingly satisfactory solvent for the purpose described, but other solvents and other agents are contemplated within the scope of the present invention. Where chloroform is used as the solvent, the amount of expansion of the sheath is preferably controlled by diluting the expanding liquid or solvent with a liquid which may be mixed with the expanding liquid or solvent to

reduce the sheath expanding action thereof. Alcohol and acetone are suitable liquids for this purpose as they have no appreciable effect in themselves in producing expansion, the physical properties of alcohol making it more suitable than acetone. Other substances for reducing the activity of the expanding liquid are contemplated within the scope of the present invention. Such substances should, of course, be miscible with the solvent.

We have found that various percentage combinations, such as 20% alcohol with 80% chloroform, and other percentage combinations of alcohol and chloroform, or alcohol and such other solvent as carbon tetrachloride, when used as the expanding liquid, produce various degrees of enlargement of the sheath. The amount of enlargement follows a curve from which it is possible to know in advance by the percentage of liquid mixture what percentage of expansion will occur when the sheath is immersed therein. Curves have been plotted for the different sheath materials and liquids, but it is not believed necessary to incorporate the same herein. Upon evaporation of the expanding liquid mixture from the sheath material the sheath shrinks to substantially the original size.

The full possible degree of enlargement for any particular expanding mixture occurs in about two hours, and after that the liquid does not produce any substantial further enlargement but holds the flexible sheath in this expanded state. This is ideal because it means that in this way the amount of enlargement of the sheath not only follows a curve from which it is possible to know in advance what percentage of expansion will occur, but the amount of enlargement is not a function of time, provided a sufficient period has been allowed for complete absorption of the expanding mixture. As a result, we may repeatedly secure any intermediate stage of enlargement with the same exactness as the full enlargement, if the same sheath material and expanding mixture are used. Any desired lesser amount of enlargement is secured by correspondingly increasing the percentage of alcohol—or other liquid for reducing the expanding action—with respect to the percentage of the active solvent, and any desired greater amount of enlargement is secured by correspondingly decreasing the percentage of this other liquid with respect to the percentage of active solvent.

It has been found that when the flexible sheath 8 is stripped from the tooth 5 there is substantially a 2% reduction in the size of the sheath due to the tension therein. It is therefore desirable in carrying out our process to enlarge the sheath an amount to take care of this 2% loss in sheath size and the 12% or other shrinkage of the porcelain in firing, as well as the amount of enlargement or reduction in size where an enlargement or reduction is desired. Of course, if the pattern or reproduction is to be formed on the same scale as the original, the sheath need be expanded in amount only to take care of the 2% loss referred to and the shringage loss of the porcelain or other reproduction.

The immersion of the flexible sheath for about two hours in chloroform, which is not diluted to control the expansion as above set forth, produces a reproduction about 81% larger than the original article or pattern, and immersion in carbon tetrachloride for about two hours produces an enlargement of about 91%. These percentages are, of course, too great if an exact scale reproduction of the natural tooth is desired where the necessary expansion of the sheath would be approximately 14%, to overcome the 2% loss in sheath size and a 12% shrinkage loss in the firing of the porcelain. However, even without diluting the solvent or expanding liquid, after about two hours no further expansion of the sheath takes place and consequently the percentages 81% and 91%, less the 12% shrinkage loss and the other 2% loss, represent substantially the upper limits of enlargement by a single step using chloroform and carbon tetrachloride, respectively. Greater enlargements are possible, of course, by repeating the enlarging process,—that is, by enlarging one sheath, forming a pattern therein, and then forming a second sheath around this pattern and enlarging the second sheath. Any desired number of such repeated enlargements may be employed within the scope of the present invention.

For example, an expanding mixture of 150 parts chloroform and 100 parts alcohol produces about 28% enlargement of the resulting reproduction, and the enlargement is an exact reproduction of the original, with the finest lines and other details faithfully reproduced. The mixture of chloroform and alcohol, in general, provides a more accurate control of the amount of expansion than a mixture of carbon tetrachloride and alcohol.

Another example of sheath material and solvent for expanding the same according to the present invention employs highly refined gelatine glue as the sheath material, and water for expanding the same. This sheath material is prepared by mixing two pounds of the gelatinous material with 1400 cc. of water, and heating at about 50° C. until the mass is of uniform texture. The gelatine is held in liquid state at 50° C. and tends to become firm upon cooling. In immersing a sheath of this material in water to expand the sheath, the water bath is preferably kept at a temperature of about 1° C. because the gelatine will tend to dissolve when the bath becomes warm. If the gelatine sheath is expanded in a solution of alum and water, an enlarged sheath is produced which is not quite so sensitive to temperature changes.

Any other rubber material which, when set, is pliable and soft, and in fact any other flexible material which may be expanded in accordance with the present invention, is contemplated within the scope of the appended claims. The solvent may be chloroform or carbon tetrachloride as hereinbefore referred to, or it may be carbon bisulphide, benzine, petroleum, ether, turpentine, or any other petroleum product or any organic or other suitable solvent.

The present invention also contemplates the use of the element of time as a means of obtaining any desired amount of enlargement of the sheath from zero to the maximum enlargement that can be obtained by the solvent used with the sheath material. By this means the amount of enlargement due to immersion of the flexible sheath in the selected solvent is varied by allowing the sheath to remain in the solvent for various periods of time, from about five minutes to two hours. This manner of controlling the amount of enlargement is possible because of the relation of the amount of enlargement with respect to the time of immersion of the sheath in the selected solvent. This method of controlling

the amount of enlargement does not have all of the advantages of the method of controlling the enlargement by the amount of dilution of the expanding liquid with a liquid or other substance which will reduce the activity thereof, but it may be employed and therefore is contemplated within the scope of the appended claims.

If it is desired to produce a reproduction of the original article which is, for example, 6% larger than the original, the total necessary sheath expansion may be readily calculated, and from this the strength of the necessary expanding liquid can be determined, or, where time is relied on to control the amount of expansion, the amount of time the sheath is immersed in the expanding liquid can be determined.

After securing the desired expansion of the sheatn 8, the sheath is removed from the bath 14, rinsed in water, and filled with dental stone to form within the sheath an enlarged stone pattern as indicated at 20, which faithfully reproduces on enlarged scale all details of the original. The dental stone may be any stone or other material which can be poured into the sheath, and subsequently sets to a hard condition. To prevent shrinking of the sheath 8 due to evaporation of the solvent therefrom during the introduction of the dental stone into the sheath, and prior to setting of the stone pattern 20, we expose the external surface of the sheath to a liquid for preventing evaporation of the solvent from the enlarged sheath during formation of the enlarged stone pattern 20 in the sheath. Otherwise the shrinking of the sheath which follows evaporation of the solvent therefrom would exert pressure on the plastic or semi-plastic stone and cause the production of a stone pattern smaller than the fully expanded sheath.

The exposure of the external surface of the sheath to a liquid for preventing evaporation of the solvent from the sheath may be accomplished by suspending a plurality of sheaths 8 by the flanges 10 in openings 22 in a metal plate 23 supported in a container 24 in raised position by members 25 as shown in Figure 5.

The container 24 contains a bath of liquid 26 which covers the external surfaces of the enlarged sheaths 8 and prevents evaporation of the solvent from the sheaths. This liquid 26 may be the same as the liquid used as the solvent for expanding the sheaths, or it may be water or any other liquid immiscible with the solvent and which will not have any deleterious action upon the sheath material.

After the dental stone pattern 20 has set, the sheath 8 and stone enlargement are removed from the rack shown in Figure 5 and preferably allowed to stand in air for about one half hour or until the rubber sheath has recovered its full elasticity, whereupon the sheath 8 is stripped from the enlarged stone pattern 20. The stone pattern 20 is now a very accurate reproduction of the original article 5 on enlarged scale. The sheath 8 will return to substantially the original size when stripped from the pattern 20, i. e., to a size 2% smaller than the original tooth 5, and has all of its original properties, including the capability of repeated use for future enlargement without sacrifice of details in the enlarged reproductions.

The next step in the embodiment of the invention illustrated in Figures 1 to 12, inclusive, is to form a second flexible sheath 30 over the stone pattern 20. This second sheath 30 may be formed of the same material and in the same manner as the sheath 8. When stripped from the pattern 20, this second sheath is in the form of an enlarged flexible sheath 30 as shown in Figure 7. The sheath 30 is not expanded except where repeated enlargements are desired and, when not expanded, does not shrink except for the slight inherent tension within the sheath, since it is formed to enlarged size over the enlarged stone pattern.

A pattern 32 of wax or other material that can be eliminated from an investment by heat is then formed in the enlarged flexible sheath 30. This wax pattern 32 is then placed in an investment flask or ring 34 (Figure 9) and embedded in investment material 35 to form a refractory mold. After the ring 34 has been filled with investment material with the sprue or gate forming part projecting therefrom, the investment material is set and the wax pattern is eliminated by heat, as well known in the art. A suitable metal is then introduced in molten condition through the gate 36, and upon solidification forms the master metal pattern 38 which is to the desired enlarged scale and corresponds exactly with the details of the original tooth 5. Upon completion of the enlarged master metal pattern 38 the investment material is broken away and the sprue is cut off or otherwise removed, leaving the enlarged master metal pattern 38 as shown in Figure 10.

The master metal pattern 38 is then placed in position as shown in Figure 11 upon a suitable base 40 and within a flask 41 provided at the top with suitable openings 42, and a flexible mold material 43 is poured into the flask 41 through one or more of the openings 42 over the pattern 38 and preferably to a level substantially filling the flask 41. The openings 42 permit the escape of air.

The flexible mold material 43 is then allowed to set to the permanent flexible stage, as by cooling, and forms a flexible mold having a cavity 44 which is an exact negative of the tooth 5 on the desired or selected enlarged scale. The inner mold surface 44 is continuous throughout and without parting lines or the like, and forms an exact negative reproduction of all lines and other details of the tooth or other article 5.

The flexible mold material is preferably rubber or a plasticized vinyl chloride compound, but it is to be understood that gelatine, glue, and any other suitable flexible and preferably resilient material may be used within the scope of the present invention. Upon hardening of the mold body 43, the flask 41 is removed, and the master metal pattern is removed from the mold cavity 44, flexing of the mold 43 permitting such removal notwithstanding undercut or projecting parts on the master metal pattern.

Porcelain or other suitable material employed for forming the "green" or unfired artificial porcelain tooth indicated at 48 in Figure 12. The tooth material is finely ground, moistened with water or mixed with a chemically setting binder, and is packed compactly in the mold cavity 44, preferably by prolonged vertical vibration which causes the finely powdered porcelain particles to drop from the liquid mass—the finely divided porcelain having preferably been previously mixed with water, for example, to effect a better packing—and to fill the mold cavity 44 with densely packed porcelain. The packing of the porcelain in this manner provides a "green" porcelain tooth of uniformly dense structure in which shrinkage upon fire-hardening to vitrification is reduced to a minimum. Moreover, the "green"

porcelain tooth thus formed is sufficiently firm to permit removal from the mold and handling before fire-hardening.

After completion of the packing of the porcelain and formation of the "green" porcelain tooth 48 in the mold 43, the unfired and enlarged porcelain tooth 48 is removed from the flexible mold 43, flexing of the mold permitting such removal notwithstanding undercuts, projections and the like. The unfired and enlarged porcelain tooth is then dried and fired to the desired point of vitrification. It is to be noted that the thoroughness and density of the packing of the porcelain are important. It directly influences the linear shrinkage of the porcelain upon fire-hardening. If the packing is poor, the porcelain particles are not compacted to the greatest degree, and the resulting shrinkage is greater than the shrinkage of about 12% which proper packing secures.

When the "green" porcelain tooth is fired to the desired point of vitrification, the shrinkage which occurs brings the fire-hardened and vitrified artificial tooth to the selected size, and it follows accurately all details of the original tooth 5.

The manner of forming the mold 43, packing the porcelain therein, and removing the "green" porcelain tooth from the flexible mold and firing it to the desired point of vitrification, are all more fully disclosed and claimed in the copending application of Reiner W. Erdle, Serial No. 101,740, filed September 21, 1936.

While spraying of the latex or other sheath material to form the desired sheaths as herein described has been found to be preferable, it is to be understood that other methods of forming these sheaths may be employed within the scope of the present invention.

For example, the original tooth or original pattern 5' may be set up upon a layer of modeling clay 6' as before, but within a suitable metal ring 60 as shown in Figure 13. The ring 60 is then filled with rubber latex or other suitable sheath material which, upon setting, coagulating, or hardening, for example by air cooling to the desired flexible condition, forms a soft form 62 of rubber or other sheath material. The ring 60, which may be oiled or otherwise treated to facilitate removal, is then removed and the form 62 is cut away along the dotted lines 64 (Figure 14) to form the desired sheath with the cavity 63 and with a wall thickness substantially uniform and conforming in general to the details of the pattern. The material 65 is cut away and leaves the flexible shell or sheath 66.

Another method of forming an enlarged metal master pattern of the natural tooth or other article 5 is illustrated more or less diagrammatically in Figures 15, 16 and 17. This method may be used with low temperature fusing metals, i. e., metals which fuse at temperatures which will not destroy the flexible sheath.

This latter method comprises taking the enlarged flexible sheath as shown at 8 in Figure 5, with the set pattern 20 of dental stone therein, and forming a stone mold around the sheath encased pattern as shown at 70. The mold 70 may be split at 71 in such manner that the stone pattern 20 may be removed from the mold 70 notwithstanding undercut surfaces of the sheath encased pattern. Any other suitable material than dental stone may be employed for forming the mold 70, preferably a material capable of resisting temperatures of over 300° F. The split mold 70 is separated in order to remove the encased pattern 20, and the sheath 8 is stripped from the pattern.

The flexible sheath 8 is then reinserted into position in the split mold 70 as shown in Figure 16, and in this way there is produced a rubber or sheath lined split mold, the inner surface 11 of which accurately reproduces the details of the original tooth 5, or its enlargement. Into this mold is poured or cast any metal or metal alloy, preferably which has a melting point below the temperature which will destroy the sheath 8.

There are many methods by which the metal may be cast or poured into the mold, but any method which produces an exact reproduction is suitable. One method is to have a dry and cold mold and pour the molten metal (at the melting point) into this mold. The cold surfaces cause a surface chill, and produce good results.

Another method is to introduce a metal pressure head which produces good results. To do this, a copper or other suitable tube 75 is placed over the mold opening, and the metal is poured into the mold and up into the tube 75. This creates a pressure head, and results in good casting. The mold may or may not be cold. Upon completion of the enlarged metal master pattern 76 the sheath 8 may be removed and the pattern cut away or removed from the solidified metal head portion along the line *a*—*a*.

The pressure may also be obtained by means of any casting machine which imparts a centrifugal force to the metal, and in this way forces the metal into the mold under the desired pressure.

Instead of making the mold around the sheath encased pattern 20, the pattern may be removed from the sheath and the mold made around the sheath, in which case splitting of the mold is not necessary, or the sheath may be otherwise supported for introduction of the relatively low fusing metal directly into the same.

The surface of the enlarged metal master pattern may be burnished to bring about a shine and smoothness to the surface. This affords an excellent manner of providing good permanent metal masters suitable for the preparation of the flexible molds, and which master metal patterns may be used repeatedly.

While we have illustrated and described the invention, particularly with reference to making a flexible negative, it is to be understood that a flexible positive may be made and this flexible positive thereupon enlarged by methods similar to those herein described.

There are several ways of employing this flexible positive method. For instance, a flexible positive may be made by taking a plaster or other impression of the original object. A rubber shell may then be built up on the inside of the impression, using grease or a suitable separating medium if necessary, and then after it has been built up to sufficient thickness it could be stripped out and then expanded. This enlarged positive may thereupon be embedded in an investment and, after the investment has set, may be withdrawn—or burned out—and a suitable metal thereupon cast into the cavity, thus producing an enlarged metal pattern.

Another method would be to electroplate a metal shell over the outside of the original pattern, or, to avoid undercuts, a coating could be electroplated onto a flexible duplicate of the original pattern. The pattern could thereupon be removed and the electroplated shell could be

reenforced by embedding it in metal, or plaster, or the like, and a soft grade of flexible rubber could thereupon be packed into the cavity and vulcanized, thus resulting in a rubber positive which could be expanded in the usual manner. This could be invested and cast as already described.

For expediency, the several views of the drawings are not shown on the same scale and, therefore, do not show by comparative dimensions the enlargement obtained in accordance with the present invention.

We do not intend to be limited to the precise details or steps shown and described.

We claim:

1. The steps in the method of forming a reproduction of an article which comprise forming against the article a body of material adapted to absorb a fluid and to be changed in size by the influence of the absorbed fluid thereby reproducing in said body the contour characteristics and details of the article, treating said body with a fluid adapted to be absorbed by said body to change the size of said body by the influence of the absorbed fluid while maintaining the contour characteristics and the details of the article reproduced in said body.

2. The steps in the method of forming a reproduction of an article which comprise forming against the article a body of material adapted to absorb a fluid and to be expanded by the influence of the absorbed fluid thereby reproducing in said body the contour characteristics and details of the article, treating said body with a fluid adapted to be absorbed by said body to expand said body by the influence of the absorbed fluid while maintaining the contour characteristics and the details of the article reproduced in said body.

3. The steps in the method of forming a reproduction of an article which comprise forming against the article a flexible body having the characteristic of expanding to enlarged size by absorption of a solvent thereby reproducing in said body the contour characteristics and details of the article, and treating the flexible body with a solvent to expand the flexible body to enlarged size while maintaining its contour characteristics and the details of the article on an enlarged scale.

4. The steps in the method of forming a reproduction of an article which comprise forming against the article a flexible body having the characteristic of expanding to enlarged size by absorption of a solvent thereby reproducing in said body the contour characteristics and details of the article, and treating the flexible body with a solvent, diluted with an inert substance to control the amount of enlargement, to expand the flexible body to enlarged size while maintaining its contour characteristics and the details of the article on an enlarged scale.

5. The steps in the method of forming a reproduction of an article which comprise applying a rubber latex material over the article and allowing same to set to form a flexible sheath, removing the sheath from the article, and treating the sheath with an organic solvent for expanding the sheath to enlarged size to form an enlarged matrix which is a true negative of the article on enlarged scale.

6. The steps in the method of forming a reproduction of an article which comprise forming over the article a flexible sheath of a material having the characteristic of expanding to enlarged size by absorption of a solvent, removing the sheath from the article, immersing the sheath in a solvent to expand the sheath to enlarged size, and controlling the amount of expansion of the sheath by the interval of time the sheath is immersed in said solvent.

7. The steps in the method of forming a reproduction of an article which comprise forming over the article a flexible sheath of a material having the characteristic of expanding to enlarged size by absorption of a solvent, removing the sheath from the article, and treating the sheath with a solvent, diluted with an inert substance to control the amount of enlargement, to expand the sheath to enlarged size.

8. The steps in the method of forming a reproduction of an article, which comprise applying a rubber latex material over the article and allowing same to set to form a flexible sheath, removing the sheath from the article, and treating the sheath with chloroform to expand the sheath to enlarged size.

9. The steps in the method of forming a reproduction of an article which comprise applying a rubber latex material over the article and allowing same to set to form a flexible sheath, removing the sheath from the article, and treating the sheath with chloroform diluted with alcohol in amount to secure controlled expansion of the sheath to provide a predetermined amount of enlargement of said sheath.

10. The steps in the method of forming a reproduction of an article which comprise forming against the article a flexible body having the characteristic of expanding to enlarged size by absorption of a solvent thereby reproducing in said body the contour characteristics and details of the article, treating the flexible body with a solvent to expand the flexible body to enlarged size, and controlling the amount of expansion of said body by the amount of time the body is acted upon by said solvent while maintaining the contour characteristics and the details of the article on an enlarged scale.

11. The steps in the method of forming a reproduction of an article which comprise forming against the article a body of material adapted to absorb a fluid and to be changed in size by the influence of the absorbed fluid thereby reproducing in said body the contour characteristics and details of the article, treating said body with a fluid adapted to be absorbed by said body to change the size of said body by the influence of the absorbed fluid while maintaining the contour characteristics and the details of the article reproduced in said body, and forming against the surface of the body which was formed against the article a reproduction of the article of a size different from the size of the article.

12. The steps in the method of forming a reproduction of an article which comprise forming against the article a body of flexible material adapted to absorb a fluid and to be changed in size by the influence of the absorbed fluid thereby reproducing in said body the contour characteristics and details of the article, treating said body with a fluid adapted to be absorbed by said body to change the size of body by the influence of the absorbed fluid while maintaining the contour characteristics and the details of the article reproduced in said body.

13. The steps in the method of forming a reproduction of an article which comprise applying a rubber latex material against the article and allowing same to set to form a flexible body having reproduced therein the contour characteris-

tics and details of the article, and treating the flexible body with chloroform to expand the same to enlarged size while maintaining the contour characteristics and details of the article on an enlarged scale.

14. The steps in the method of forming a reproduction of an article which comprise applying a rubber latex material against the article and allowing same to set to form a flexible body having reproduced therein the contour characteristics and details of the article, and treating the flexible body with chloroform mixed with a substance to control the amount of enlargement, to expand the flexible body to enlarged size while maintaining the contour characteristics and details of the article on an enlarged scale.

15. The steps in the method of forming a reproduction of an article which comprise forming against the article a body of flexible material adapted to absorb a liquid and to be expanded by the influence of the absorbed liquid thereby reproducing in said body the contour characteristics and details of the article, treating said body with a liquid adapted to be absorbed by said body to expand said body by the influence of the absorbed liquid while maintaining the contour characteristics and the details of the article reproduced in said body, forming against the surface of the body which was formed against the article a reproduction of the article on an enlarged scale, and, during the formation of the enlarged reproduction, exposing the body to a substance for preventing evaporation of liquid from said body.

16. The steps in the method of making artificial teeth which comprise forming over the equivalent of a natural tooth a sheath of flexible material adapted to absorb a liquid and to be expanded thereby, removing the sheath from the tooth, treating said sheath with a liquid adapted to be absorbed by said sheath to expand the sheath by the influence of the absorbed liquid while maintaining the contour characteristics and the details of the tooth reproduced in said sheath.

17. The steps in the method of forming a reproduction of a surface which comprise, reproducing the contour characteristics and details of the surface in a body of material adapted to absorb a fluid and to be changed in size by the absorbed fluid, treating said body with a fluid adapted to be absorbed thereby to change the size of said body by the influence of the absorbed fluid while maintaining the contour characteristics and the details of the surface reproduced in said body.

18. The steps in the method of forming a reproduction of a surface which comprise, reproducing the contour characteristics and details of the surface in a body of material adapted to absorb a fluid and to be changed in size by the absorbed fluid, treating said body with a fluid adapted to be absorbed thereby to change the size of said body by the influence of the absorbed fluid while maintaining the contour characteristics and details of the surface reproduced in said body, and using the reproduction of the surface produced in said body to form a member having a reproduction of said surface.

19. The steps in the method of forming a reproduction of a surface which comprise, reproducing the contour characteristics and details of the surface in a body of flexible material adapted to absorb a fluid and to be changed in size by the absorbed fluid, treating said body with a fluid adapted to be absorbed thereby to change the size of said body by the influence of the absorbed fluid while maintaining the contour characteristics and the details of the surface reproduced in said body, and forming from said flexible body of changed size a pattern having a reproduction of said surface.

20. The steps in the method of forming a reproduction of an article which comprise, taking an impression of the article, forming against the impression a body of material adapted to absorb a fluid and to be changed in size by the absorbed fluid, treating said body with a fluid adapted to be absorbed thereby to change the size of said body by the influence of the absorbed fluid while maintaining the contour characteristics and the details of the surface formed against the impression.

21. The steps in the method of forming a reproduction of an article which comprise, taking an impression of the article, forming against the impression a body of flexible material adapted to absorb a fluid and to be changed in size by the absorbed fluid, treating said body with a fluid adapted to be absorbed thereby to change the size of said body by the influence of the absorbed fluid while maintaining the contour characteristics and the details of the surface formed against the impression, embedding the body of flexible material of changed size in an investment to reproduce the outer surface of said body in the investment, removing or eliminating said body from the investment to form a cavity, and forming a pattern in said cavity.

22. The process of producing articles in a flexible mold comprising the steps of coating with rubber-like material an article of the same shape as that to be produced, allowing the coating to dry and form a flexible mold, then removing the article to permit the contraction of the mold, then treating said mold with a solution comprising an active swelling solution and a diluting agent proportioned to expand same to predetermined fixed dimensions, then introducing hardenable reproduction material into said mold, permitting said reproduction material to harden, and then removing said formed article from said mold.

23. The process of producing articles in a flexible mold comprising the steps of coating with rubber-like material an article of the same shape as that to be produced, allowing the coating to dry and form a flexible mold, then removing the article to permit the contraction of the mold, then treating the outside surface of said mold with a solution having the ability to swell same to predetermined fixed dimensions, then introducing hardenable reproduction material into said mold, permitting said reproduction material to harden, and then removing said formed article from said mold.

24. The process of producing articles in a flexible mold comprising the steps of coating with rubber-like material an article of the same shape as that to be produced, allowing the coating to dry and form a flexible mold, then removing the article to permit the contraction of the mold, then treating said mold with a solution having the ability to swell same to a degree whereby its inner dimensions are correspondingly larger than the dimensions of the article on which it was formed, then introducing hardenable reproduction material into said mold while keeping the outer surface of said mold submerged in said solution, permitting said reproduction material

to harden, and then removing said formed article from said mold.

25. The process of producing articles in a flexible mold comprising the steps of first coating the article to be reproduced with rubber-like material, permitting the material to dry and form a flexible mold, then removing the article from the flexible mold, then swelling said mold, then introducing a hardenable reproduction material into said mold, then permitting said reproduction material to harden, and then removing the reproduced article from the mold.

26. The process of producing articles in a flexible mold comprising the steps of coating with rubber-like material an article of the same shape as that to be produced, allowing the coating to dry and form a flexible mold, then removing the article, then treating said mold with a solution having the ability to swell the same to predetermined fixed dimensions, then introducing hardenable reproduction material into said mold, permitting said reproduction material to harden, and then removing said formed article from said mold.

27. The process of producing articles comprising the steps of providing a flexible mold of rubber-like material, then increasing the size of said mold by treating the same with a solution having the ability to swell said material, then introducing a hardenable reproduction material into said treated mold, permitting said material to harden, and then removing said molded reproduction material from the mold.

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