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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :		(11) International Publication Number:
B32B 9/00, D02G 3/00	A1	WO 94/08783
		(43) International Publication Date: 28 April 1994 (28.04.94)

(21) International Application Number: PCT/US93/09341

(22) International Filing Date: 1 October 1993 (01.10.93)

(30) Priority data:

07/965,686	22 October 1992 (22.10.92)	US
08/113,563	26 August 1993 (26.08.93)	US

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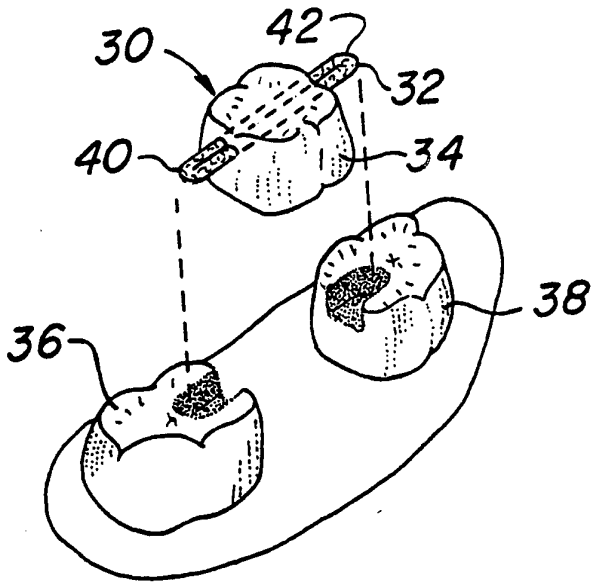
(81) Designated States: AU, CA, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: CERAMIC REINFORCED DENTAL APPLIANCES, DEVICES AND RESTORATIONS



(57) Abstract

Ceramic fiber materials (32), such as ropes and meshes are utilized in the fabrication and reinforcement of various dental appliances, devices and restorations. In one embodiment, ceramic fiber materials (32) are utilized as reinforcement and pontics (30) which are provided with wings (40, 42) which may be flexible or covered with the material of the pontic (30) making them rigid. By using the ceramic fiber materials (32) of the present invention, heat hardened materials (34) may be utilized, such as porcelains and heat cured composite resins, may be utilized to provide pontics (30) and other appliances and devices which are considered by many to be superior to light cured composite resin materials. The ceramic fiber materials (32) may be utilized in various other dental appliances including inlaid periodontal splints, anterior perio-splints and post-orthodontic retainers and as reinforcement or repairs in dentures or orthodontic appliances.

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CERAMIC REINFORCED DENTAL APPLIANCES, DEVICES AND RESTORATIONS

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority of United States application serial number 08/113,563, filed August 26, 1993, by the inventor herein and of United States application serial number 07/965,686 filed October 22, 1992, filed by the inventor herein and entitled *Method and Product for Improved Ceramic Fiber Reinforced and Filled Thermoplastic and Thermosetting Resin Systems*. The subject matter of this latter application is incorporated herein by reference the same as if set forth at length.

FIELD OF THE INVENTION

The present invention relates to ceramic reinforced dental appliances, devices and restorations. More particularly, the present invention relates to various types of pontics, splints, reinforcements and the like utilizing ceramic fiber materials, which may be etched and/or silanated in the form of ropes, tapes and meshes which may be utilized in connection with hardenable materials and particularly high temperature materials such as porcelains, heat cured composite resins and heat processed acrylic resins.

BACKGROUND OF THE INVENTION

Much work has been done in the field of restorative and cosmetic dentistry. For example, attention is directed to the previous work of the inventor herein as described in United States Patent 5,098,304 - Scharf wherein glass fiber materials in the form of random and uniform meshes, braided and woven rope, thread and other suitable shapes are utilized in composite resins for restoring and/or splinting teeth.

Other workers in the field have attempted restorative work utilizing other materials, including Shoher, et al. who disclose in United States Patent 4,826,436 the use of pontics

using a plurality of flexible metal arm connectors which extend from a common member forming a bridge.

Golub has disclosed the use of silk material in United States Patent 4,728,291 and more recently in United States Patent 5,120,224 disclosed a method of splinting teeth or attaching a pontic using an ultra-thin laminate containing a fabric such as alumina.

However, none of the prior art suggests the structure, materials and improvements provided by the present invention described herein.

SUMMARY OF THE INVENTION

The present invention is directed to a method of creating reinforced dental appliances, devices or restorations utilizing a ceramic fiber material within hardenable materials and particularly heat hardenable materials such as porcelain or heat cured composite resin, as well as the various dental appliances and devices such as pontics, splints and denture or orthodontic appliance base reinforcements or repairs utilizing a ceramic reinforcing fiber material within a hardenable material and particularly heat hardened material such as porcelain or heat cured composite resin.

It is understood that the present invention is intended to cover the use of ceramic reinforcing materials within all types of hardenable materials, including, but not limited to, currently available photo, chemical, or heat cured resins or combinations thereof. However, the present invention concerning the use of the ceramic fiber materials finds particular application in connection with materials such as porcelains, heat cured composite resins and materials heat treated for the purpose of hardening.

The present invention includes pontics wherein the ceramic fiber material extending from the lateral faces of the pontic may be flexible or may be coated with porcelain or heat cured composite resin to form a rigid wing structure. The ceramic fiber material includes all forms of material including braided and woven ropes, tapes, random and uniform meshes and other types of fabric and sheet material.

In accordance with the present invention, porcelain or heat cured composite resin splints reinforced with ceramic fiber may be created which may be inlaid into recesses formed in the teeth to be splinted. Additionally, anterior or posterior periodontal splints or post-orthodontic retainers may be fabricated utilizing the ceramic fiber reinforcing material within porcelain or a heat cured composite resin for superior results.

The ceramic fiber reinforcement material of the present invention may be utilized to reinforce or repair dentures or orthodontic appliances.

The term ceramic fiber is defined and used herein broadly to include various high temperature glassy type fibers which may be made from pure or substantially pure silica, various silicates, metal oxides and various other fibers provided with a coating or treatment of silica on their surface.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of illustrating the invention, there are shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

Figure 1 is a plan view of a uniform mesh comprised of ceramic fiber material which may be utilized in practicing the present invention.

Figure 2 is a plan view of a random mesh comprised of ceramic fiber material which may be utilized in practicing the present invention.

Figure 2A is a plan view of a tape comprised of ceramic fiber material which may be utilized in practicing the present invention.

Figure 3 is a plan view of an interwoven braided or woven thread or rope comprised of ceramic fiber material which may be utilized in practicing the present invention.

Figure 4 is a view in perspective of one embodiment of a pontic about to be inserted between adjacent prepared teeth.

Figure 4A is a view in perspective of another embodiment of a pontic which may be inserted between adjacent prepared

teeth.

Figure 5 is a view in perspective of the pontic of Figure 4 inserted between the adjacent prepared teeth and bonded or cemented in place on one side.

Figure 6 is a view in perspective of another embodiment of a pontic in accordance with the present invention about to be inserted between adjacent prepared teeth.

Figure 6A is a view in perspective of another embodiment of a pontic in accordance with the present invention which may be inserted between adjacent prepared teeth.

Figure 7 is a view in perspective of the pontic of Figure 6 mounted between adjacent prepared teeth and bonded or cemented in place on one side.

Figure 8 is a view in perspective of another embodiment of a pontic in accordance with the present invention.

Figure 9 is a view in perspective of another embodiment of an anterior tooth pontic about to be inserted between adjacent prepared teeth.

Figure 10 is a view in perspective of the embodiment of the pontic of Figure 9 inserted between adjacent prepared teeth and cemented in place on one side.

Figure 11 is a view in perspective of another embodiment of an anterior tooth pontic about to be inserted between adjacent prepared teeth.

Figure 12 is a view in perspective of the embodiment of the pontic of Figure 11 mounted between adjacent prepared teeth and bonded or cemented in place on one side.

Figure 13 is a view in perspective of an inlay prepared in accordance with the present invention and about to be inserted into a series of adjacent prepared teeth which may serve to restore missing or unhealthy tooth structure or as a posterior periodontal splint.

Figure 14 is a view in perspective of the inlay of Figure 13 mounted within the prepared teeth and cemented in place.

Figure 15 is a view in perspective of an anterior periodontal splint or post-orthodontic retainer prepared utilizing ceramic reinforcing fibers in accordance with the present

invention.

Figure 16 is a view in perspective of the anterior periodontal splint or post-orthodontic retainer applied to anterior teeth.

Figure 17 is a front elevation view (palatal view) of a denture base or orthodontic appliance reinforced or repaired with a ceramic fiber material in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like numerals indicate like elements, there is shown in Figures 1, 2, 2A and 3 some of the various forms of ceramic materials which may be utilized in practicing the present invention.

The present invention is directed to the use of ceramic materials as hereinafter broadly defined in various applications in dentistry and the specific applications, methods, devices and appliances disclosed herein and their equivalents.

As used herein, the ceramic fiber materials are as disclosed and defined in my co-pending United States patent application serial number 07/965,686, the teachings of which have been incorporated herein by reference. Briefly and basically, the term "ceramic fibers" as used herein in both the specification and claims includes, but is not limited to, fibers made from substantially pure or pure silica, various silicates, metal oxides and other fibers, such as carbon, which are coated or provided with a silica treatment on their surface. Some examples of ceramic fibers which may be utilized in the practicing of the present invention include aluminosilicate fibers and zirconia fibers. Such fibers are commercially available from Imperial Chemical Industries, Ltd. ("ICI") of Wilmington, Delaware. Other ceramic fibers which are currently available include high grade ceramic fibers sold under the trademark Nextel™ by 3M Corporation. One example of the composition of Nextel™ fibers is, by weight, 62% aluminum oxide (Al_2O_3), 14% boron oxide (B_2O_3) and 24% silicon dioxide (SiO_2). Another example of ceramic fibers usable in practicing the present invention are those sold by JPS Glass Fabrics, a

division of JPS Converter and Industrial Corporation of Slater, South Carolina, under the trademark Astroquartz™. The Astroquartz™ ceramic fibers are comprised of substantially pure silica (99.5% SiO_2). These are sometimes referred to as quartz fibers. An example of a fiber treated with silica on its surface is a carbon fiber treated with silica on its surface and sold under the trademark Nicalon™ commercially available from Nippon Carbon Co. of Japan, that is, it has a surface of ceramic material and a core of a different material.

The ceramic fiber material utilized in practicing the present invention may be woven or braided rope or thread, woven, braided or knitted tape or cloth, uniform or random meshes or any other type of material in tape, sheet, mesh, thread or other form made of ceramic fibers. The sheet material may be woven or non-woven. Some examples of these are shown in Figures 1, 2, 2A and 3. There is shown a uniform mesh 10 in Figure 1. A random mesh 12 is shown in Figure 2. A tape 13 is shown in Figure 2A. An interwoven rope in the form of a braid 14 is illustrated in Figure 3.

The ceramic fibers utilized in practicing the present invention have a significantly higher temperature rating than the fiberglass materials disclosed in my previous patent 5,098,304, and accordingly the ceramic fibers of the present invention may be utilized more readily in dental applications utilizing porcelain and heat cured composite resins and other heat hardened materials which are considered by the profession to have superior aesthetic qualities and are considered to be more durable and more permanent.

Referring now to Figure 4, there is shown a pontic 16 which is comprised of a heat hardenable material 17, such as porcelain or heat cured composite resin matrix with a ceramic fiber material preferably in the form of a rope 18 which extends laterally from both sides of the pontic. The porcelain or heat cured composite resin 17 is formed so as to cover the lateral extensions of rope 18 to provide rigid wings 20 and 22 as shown in Figure 4, the lateral rigid wings 20 and 22

may preferably be shaped as shown with a rounded step like structure. However, it is understood that various other shapes of wings may be utilized in practicing the present invention.

As may be seen from Figure 4, the adjacent teeth 24 and 26 are prepared by having recesses formed in them of a shape which complements the shape of the wings 20 and 22, respectively. In practice, the adjacent teeth 24 and 26 may be prepared, an elastomeric mold may be taken and pontic 16 with its reinforcing ceramic fiber material 18 formed in laboratory utilizing high quality heat hardened materials such as porcelain or heat cured composite resins. Alternatively, the pontic may be fabricated on ceramic materials from composite resin materials directly in the mouth.

As may be seen in Figure 5, the pontic 16 is inserted between the adjacent prepared teeth 24 and 26 and firmly secured therein utilizing a composite resin or other suitable cementing medium as shown on one side at 28. In practice, the other side would be secured to 24 by use of a composite resin or other suitable cementing medium.

Figure 4A shows another embodiment of a pontic 19 in accordance with the present invention which utilizes a ceramic fiber reinforcing material 21 in the form of a tape or mesh.

Referring now to Figures 6 and 7, there is shown another embodiment of a pontic in accordance with the present invention wherein pontic 30 is provided with a ceramic fiber reinforcement material 32 in the form of a rope or a double rope folded tightly together. The ceramic reinforcement material is mounted in a matrix of heat hardened material 34 such as porcelain or heat cured composite resin. The ceramic fiber reinforcing material extending from pontic 32 is not coated with the hardened material 34 of pontic 30, and remains flexible until inserted into the adjacent teeth. The adjacent teeth 36 and 38 are prepared by forming recesses therein as shown to accept the flexible wings 40 and 42, respectively, of pontic 30.

As shown in Figure 7, pontic 30 is inserted between the prepared adjacent teeth 36 and 38 and is secured to the adjacent teeth by a suitable composite resin or other suitable cementing medium as shown at 44.

Figure 6A shows another embodiment of a pontic 35 in accordance with the present invention wherein the ceramic fiber reinforcing material 33 is in the form of a tape or mesh.

Referring now to Figure 8, there is shown another embodiment of a molar pontic 46 which is comprised preferably of a heat hardened material 48 such as porcelain or heat cured composite resins. However, it is understood that with respect to all of the embodiments contained herein, that other types of materials other than heat hardened materials may be utilized, such as light or chemical cured composite resins and the like, and their use is considered to fall within the scope of the invention. However, the use of the ceramic fiber support materials herein enables use of the more desirable heat hardened materials such as porcelain and heat curable composite resins. Accordingly, although the description herein may refer on occasion to the preferred heat hardenable materials such as porcelain for convenience, it is understood that all hardenable materials used in dentistry with the ceramic fiber reinforcing materials fall within the scope of this invention.

As shown in Figure 8, the ceramic material 50 is in the form of a rope which may be in the shape of a figure eight, crossing within pontic 46 such that a loop is formed on each side of pontic 46. Pontic 46 may be mounted between adjacent teeth in a manner similar to that shown with respect to Figures 6 and 7. Further, it is understood that various other arrangements of the ceramic fiber reinforcing material passing through the pontic may be utilized. Figures 9 through 11 illustrate pontics using the ceramic fiber reinforcing material to form wings in the case of anterior teeth and the mounting into the adjacent prepared teeth. More particularly, Figure 9 shows an anterior tooth pontic 52 having a loop of

ceramic fiber reinforcing material 54 passing there-through and extending on both sides to form flexible "U" shaped wings. Pontic 52 is mounted into the adjacent prepared teeth 56 and 58 with composite resin or other suitable cementing medium 60 as more particularly illustrated in Figure 10.

Figures 11 and 12 illustrate another anterior tooth pontic 62 having flexible ceramic fiber reinforcing rope 64 passing therethrough to form a wing 63 and 65 on each side of pontic 62. Pontic 62 is mounted into prepared adjacent teeth 66 and 68 with composite resin or other suitable cementing medium 70 as illustrated in Figure 12 in a manner similar to that as described with respect to Figures 9 and 10.

Figures 9 through 11 illustrate a preferred method of arranging the ceramic fiber reinforcing material in anterior teeth in the vertical plane as contrasted to the arrangement in molars as illustrated in Figures 4 through 8 wherein the arrangement of the ceramic fiber reinforcing material is substantially parallel to the occlusal surface.

Referring now to Figures 13 and 14, there is illustrated the use of the ceramic fiber reinforcing material to form either inlay or onlay periodontal splints to stabilize mobile teeth. This inlay or onlay may also be used to restore teeth. In Figure 13, one or more of the centrally disposed teeth, and typically all of the centrally disposed teeth are somewhat mobile, sometimes referred to as loose. In order to stabilize these teeth, as is well known, they may be splinted. In accordance with the present invention, the teeth 72 are prepared by forming a grove 74 therein. A mold is then made of the grove and an inlay splint 76 is then fabricated from heat hardenable materials, such as porcelain or heat curable resin, utilizing the ceramic fiber reinforcing material 78 therein. Alternatively, the grove may be lubricated, the splint formed in the grove and then removed for heat treatment. As illustrated in Figure 14, the periodontal splint 76 is then inserted within grove 74 of teeth 72 by a suitable composite resin or other suitable cementing medium 80.

Referring now to Figures 15 and 16, there is shown an anterior periodontal splint or post-orthodontic retainer 82 fabricated utilizing ceramic fibers 84 within a matrix of heat hardenable materials such as porcelain or heat curable composite resin. This anterior periodontal splint or post-orthodontic retainer 82 is then bonded to the anterior teeth 86 as illustrated in Figure 16. Prior to bonding to the teeth, the surface of the retainer to be bonded may be etched or abraded to create microporosities and silanated.

Referring now to Figure 17, there is shown the use of ceramic fiber mesh or sheet material 88 utilized to reinforce or repair a denture base or orthodontic appliance. As shown in Figure 17, the base 90 of denture 92 is reinforced and/or repaired by using the ceramic mesh 88 with the ceramic material imbedded for added strength. Typically, the denture or orthodontic appliance is made of acrylic and the ceramic materials may be abraded or etched with hydrofluoric acid or 1.23% acidulated phosphate fluoride and silanated to increase adhesion to the acrylic. The mesh or other form of ceramic material may be used to provide added strength or to strengthen repairs of a damaged denture or other orthodontic appliance.

Where the ceramic fiber materials of the present invention are utilized in connection with composite resins, it may be desirable to abrade (i.e., by sand blasting, for example) or etch the surface utilizing hydrofluoric acid or acidulated phosphate fluoride to create microporosities in the surface of the ceramic fiber material. The ceramic material may then be silanated using one of the well known silanating materials. Some examples of suitable coupling agents, and particularly the organo-functional silanes, include vinyltrichlorosilane, vinyltriethoxysilane, vinyl-tris(beta-methoxyethoxy)silane, gamma-methacryloxypropyltrimethoxysilane, beta-(3,4 -Epoxycyclohexyl)-ethyltrimethoxysilane, gamma-Glycidoxypropyl-trimethoxysilane, gamma-Aminopropyltriethoxysilane, and N-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane. However, it is understood that the abrading or etching of the ceramic materi-

als and the treatment with silane is not an essential element of the invention described and claimed herein, and that the invention covered by the claims herein is intended to cover the invention whether or not microporosities are created by abrading or etching the surface of the ceramic fibers and whether or not a silane coupling agent is utilized.

In view of the above, the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

CLAIMS

I claim:

1. A method of creating reinforced dental appliances, devices, or restorations, comprising the step of:

utilizing a ceramic fiber material within a hardenable material.

2. A method in accordance with Claim 1 wherein said hardenable material is porcelain.

3. A method in accordance with Claim 1 wherein said hardenable material is a heat cured composite resin.

4. A method in accordance with Claim 1 wherein said hardenable material is a light curable composite resin.

5. A method in accordance with Claim 1 wherein said hardenable material is a chemical cured composite resin.

6. A method in accordance with Claim 1 wherein said hardenable material is a composite resin utilizing a combination of curing modalities.

7. A dental appliance, device or restoration, comprising:

a ceramic reinforcing fiber material within a hardenable material matrix.

8. A dental appliance, device or restoration in accordance with Claim 7 wherein said hardenable material matrix is comprised of porcelain.

9. A dental appliance, device or restoration in accordance with Claim 7 wherein said hardenable material matrix is a heat cured composite resin.

10. A dental appliance, device or restoration in accordance with Claim 7 wherein said hardenable material matrix is a light cured composite resin.

11. A dental appliance, device or restoration in accordance with Claim 7 wherein said hardenable material matrix is a chemical cured composite resin.

12. A dental appliance, device or restoration in accordance with Claim 7 wherein said hardenable material matrix is a composite resin cured by a combination of modalities.

13. A dental appliance, device or restoration in accordance Claim 7 wherein said ceramic reinforcing fiber material is within a heat cured composite resin matrix and is silanated.

14. A dental appliance, device or restoration in accordance Claim 7 wherein said ceramic reinforcing fiber material is in the form of a rope.

15. A dental appliance, device or restoration in accordance Claim 14 wherein said rope is braided.

16. A dental appliance, device or restoration in accordance with Claim 14 wherein said rope is woven.

17. A dental appliance, device or restoration in accordance with Claim 7 wherein said ceramic reinforcing fiber material is in the form of a tape.

18. A dental appliance, device or restoration in accordance with Claim 7 wherein said ceramic reinforcing fiber material is in the form of a mesh.

19. A dental appliance, device or restoration in accordance with Claim 18 wherein said mesh is a random mesh.

20. A dental appliance, device or restoration in accordance with Claim 18 wherein said mesh is a uniform grid like mesh.

21. A dental restorative device, comprising:

a pontic for replacement of one or more teeth;

said pontic being comprised of a heat hardened material;

a ceramic fiber material contained within said pontic for reinforcement; and

said ceramic fiber material extending from opposite sides of said pontic.

22. A dental restorative device in accordance with Claim 21 wherein said ceramic fiber material extending from the sides of said pontic is flexible.

23. A dental restorative device in accordance with Claim 21 wherein said heat hardened material is porcelain.

24. A dental restorative device in accordance with Claim 21 wherein said ceramic fiber material extending from the

sides of said pontic is covered with said heat hardened material forming rigid wings.

25. A dental restorative device in accordance with Claim 21 wherein said heat hardened material is a heat cured composite resin.

26. A dental restorative device in accordance with Claim 21 wherein said ceramic fiber material extending from opposite sides of said pontic is in the form of unitary wings.

27. A dental restorative device in accordance with Claim 21 wherein said ceramic fiber material extending from opposite sides of said pontic is in the form of "U" shaped members.

28. A dental restorative device in accordance with Claim 21 wherein said ceramic fiber material contained within said pontic and extending from opposite sides thereof is in the form of a continuous loop of ceramic fiber material extending from each side of the pontic.

29. A dental restorative device in accordance with Claim 21 wherein ceramic fiber material extending from opposite sides of said pontic is in the vertical plane of a pontic for replacement of an anterior tooth.

30. A dental restorative device in accordance with Claim 21 wherein said ceramic fiber material extending from opposite sides of said pontic is oriented in a plane parallel to the occlusive surface where the pontic is for replacement of a molar.

31. A method of splinting mobile teeth utilizing an inlay-onlay periodontal splint, comprising the steps of:

preparing a recess into the teeth to be splinted;

preparing a splint to be placed in the recess utilizing a ceramic fiber material contained within a heat hardened material matrix; and

cementing the splint into the prepared recess in the teeth.

32. A method in accordance with Claim 31 wherein said heat hardened material is porcelain.

33. A method in accordance with Claim 31 wherein said heat hardened material is a heat cured composite resin.

34. An inlay-onlay periodontal splint comprised of:

a heat hardened material containing a ceramic fiber material for reinforcement.

35. An inlay-onlay splint in accordance with Claim 34 wherein said heat hardened material is porcelain.

36. An inlay-onlay splint in accordance with Claim 34 wherein said heat hardened material is a heat cured resin.

37. An anterior periodontal-splint or post-orthodontic retainer comprised of a heat hardened material containing a ceramic fiber material for reinforcement wherein said heat hardened material is formed to one of the surfaces of a plurality of anterior teeth.

38. A method of reinforcing or repairing a denture or orthodontic appliance base, comprising a step of imbedding a ceramic fiber reinforcement material within an acrylic applied to the base of the denture or orthodontic appliance for reinforcement.

FIG. 1

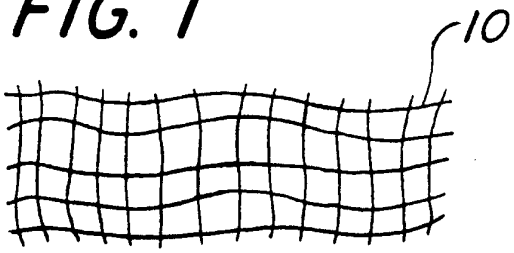


FIG. 2A

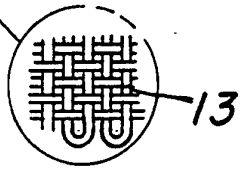


FIG. 2

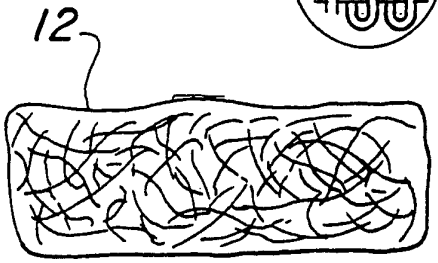


FIG. 3

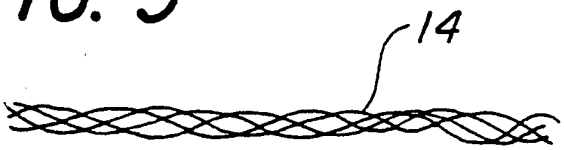


FIG. 4

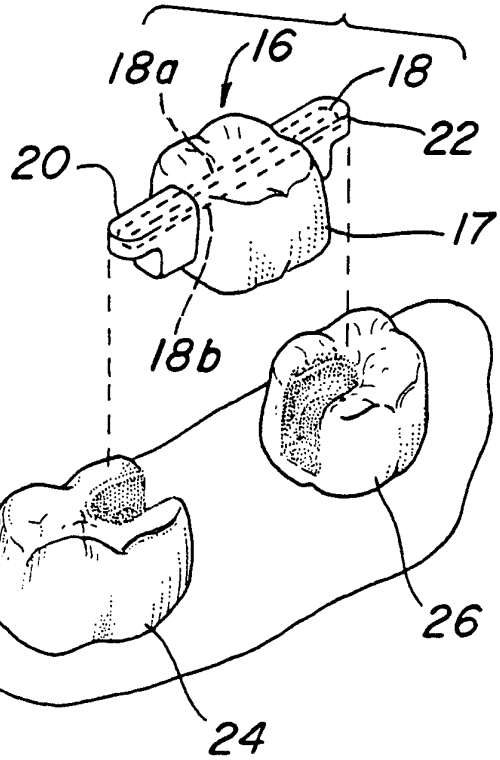


FIG. 4A

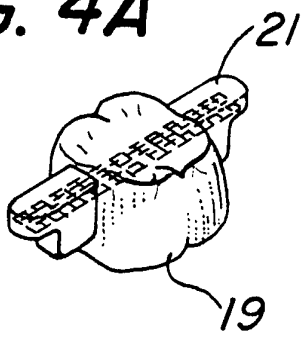
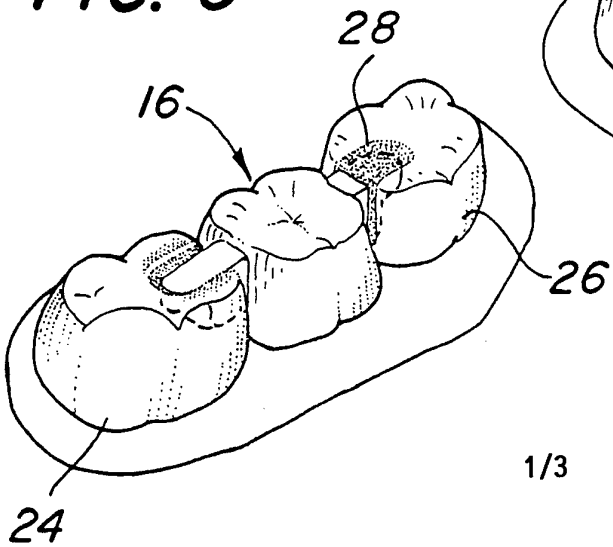


FIG. 5



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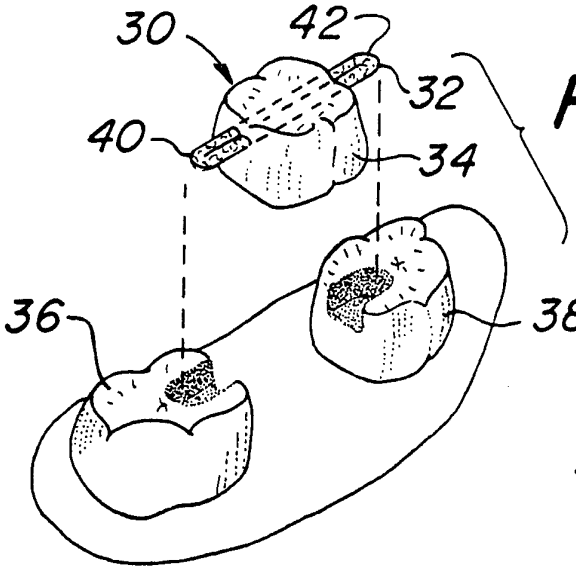
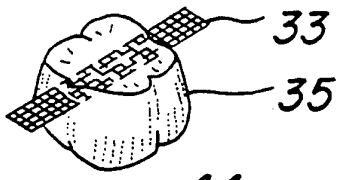


FIG. 6

FIG. 6A



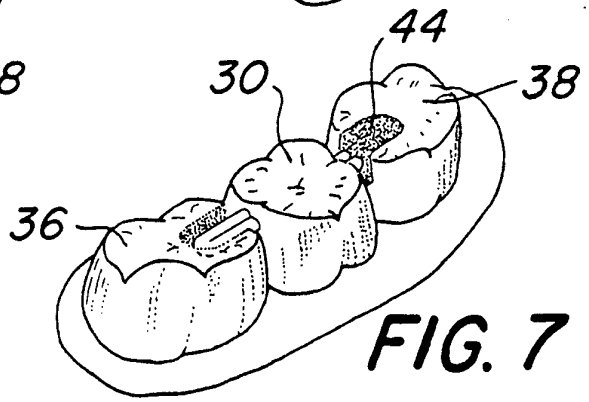


FIG. 7

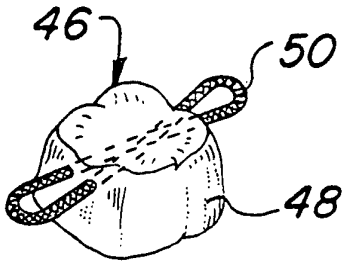


FIG. 8

FIG. 9

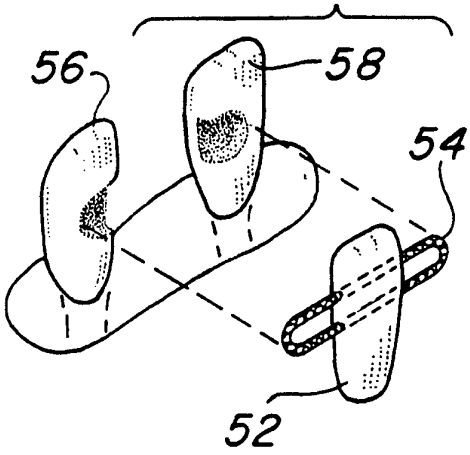
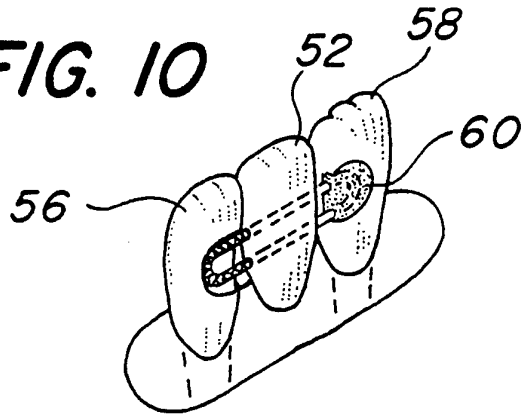
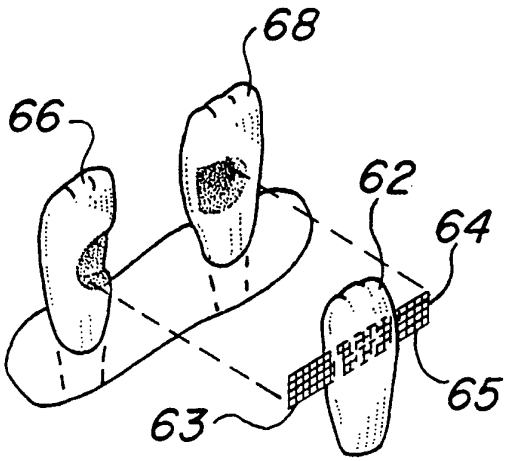


FIG. 10





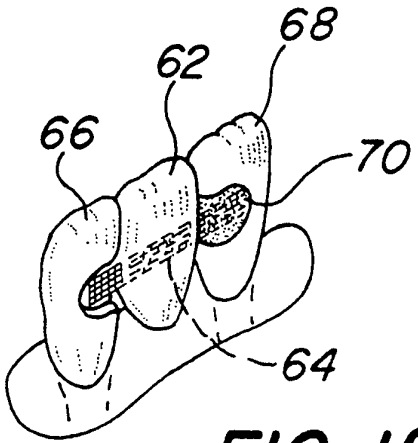


FIG. 12

FIG. 11

FIG. 13

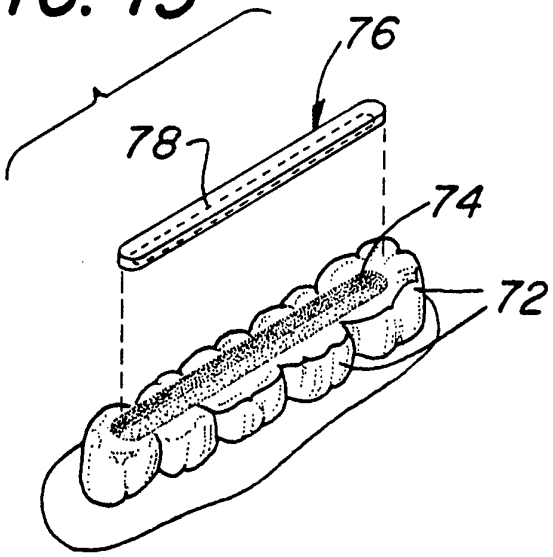


FIG. 14

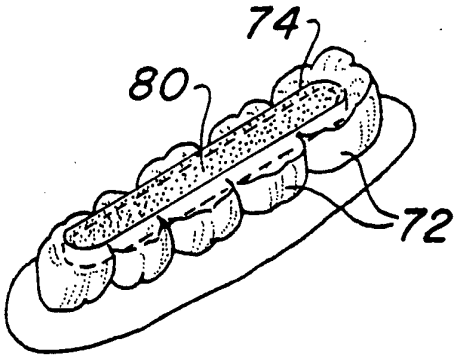


FIG. 15

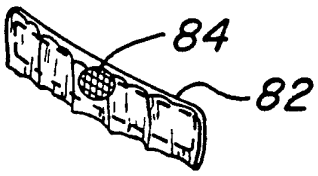
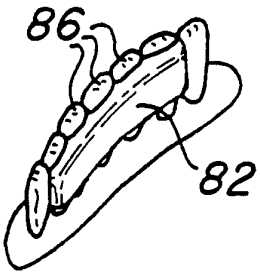


FIG. 16



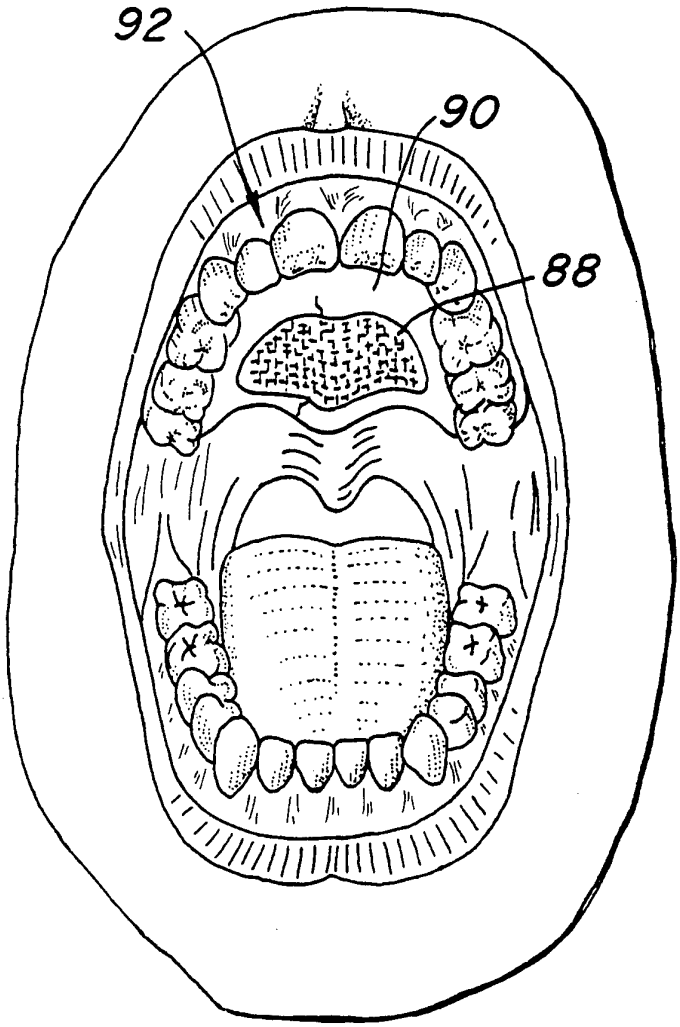


FIG. 17

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/09341

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :B32B 9/00; DO2G 3/00
US CL :428/367

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/367
433/202.1, 125, 222.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,120,224 (GOLUB) 09 JUNE 1992, see Figure 4F.	1-38
Y,P	US, A, 5,171,147 (BURGESS) 15 DECEMBER 1992, see entire document.	1-38
Y	US, A, 4,793,809 (SIGLER et al.) 27 DECEMBER 1988, see Abstract.	1-38

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	
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"O" document referring to an oral disclosure, use, exhibition or other means	
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
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Date of the actual completion of the international search 10 NOVEMBER 1993	Date of mailing of the international search report DEC 27 1993
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer PATRICK RYAN Telephone No. (703) 308-2351

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