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RETAINER AND METHOD FOR PRODUCTION THEREOF

Description

Introduction

The invention relates to a method for producing a retainer according to the preamble of claim 1.

In the context of the present application, the "contour" of the teeth is understood effectively as their topography. This means that the detection of the contour of the teeth involves detecting the surface of a tooth which is to interact with the retainer in such a way that the treating physician has as much information as possible about which form the retainer should have globally as well as locally, in order to fit the teeth as closely as possible.

Prior art

Retainers of the type described above have been known for some time. These basically serve to fix the tooth position of a patient. This means that a status quo with respect to the position of the teeth is fixed by means of a retainer in order to prevent possible changes in the tooth position over time.

The use of retainers in the course of a post-treatment is particularly typical in orthodontic treatment. The latter involves actively influencing the tooth position of a patient, wherein forces are applied to the teeth by means of suitable devices, thereby changing the position or orientation of the teeth over time. After such an orthodontic treatment is completed and the use of the respective device is stopped, the teeth are inclined to return to their former position. If no post-treatment is undertaken, the result obtained by means of the active treatment will at least partially regress, thus nullifying the active treatment.

Therefore, following the active treatment, it is typically recommended to use a retainer that fixes the newly created tooth position. To achieve this, such retainers are connected to a plurality of teeth, wherein the retainer is adapted to absorb forces due to a desired inherent movement of a tooth and distribute it to the other teeth. A movement of the tooth is thus prevented. Such retainers are known, for example, from DE 20 2012 004 419 U1 and DE 102 45 008 A1, wherein in the latter document a "2-point retainer" is described, which is firmly connected with only two teeth.

In the known retainers, it has been found to be particularly disadvantageous that a precise adaptation of the respective retainer to the individual contour of the teeth to be fixed is on the one hand very complex and on the other is usually characterised by only low precision even with careful processing by an experienced dental technician. This is mainly due to the production of retainers known today, which are adapted in a manual process by bending a starting material, typically a metal strand, to the shape of a respective dental impression. The precision of such processing is naturally limited, wherein the finished retainer may have a distance to a tooth to be fixed in the order of a few millimetres. In order to close this "gap" between the retainer and the tooth, it is then necessary to provide a correspondingly larger splice, which reliably encloses the retainer despite its large distance from the tooth and thus connects it to the tooth with a force fit. This is detrimental to both the wearing comfort of the retainer and its durability, as shear forces occurring during chewing, which act on the retainer or its bonding, occur more greatly the greater the “engagement surface" they offer in the oral cavity. This often leads to a retainer detaching itself locally and then having to be manually fixed again. This frequently results in breakage of the retainer.

Furthermore, the known retainers have the disadvantage that their purely passive effect can be "activated" by slight accidental bending of the retainer. Thus, it happens regularly that a retainer is bent accidentally in an interdental region, in which it extends freely from one tooth to the adjacent tooth i.e., is unbonded, for example as a result of an active chewing force. The deflection locally reduces the projected length of the retainer resulting in the retainer then drawing the adjacent teeth towards each other. This means that the retainer is changed by means of the unwanted deformation from a passive to an active element, which now no longer is effective purely by fixing, but actively influences the tooth position. However, such an influence must be avoided at all costs, since active tooth treatment is typically already completed at the time of retainer use and further tooth movement is undesirable. If a deformation of a retainer occurs, it may even be necessary to replace it completely.

Another disadvantage of today's retainers is their fixing effect, which can be referred to as "blocking". This blocking is understood to mean that a retainer well-known according to the prior art achieves the desired stabilising effect. However, the teeth are so strongly coupled to each other that any load acting locally on a tooth is distributed substantially uniformly onto all teeth. An independent movement in a sagittal direction is largely prevented because of the retainer. The same applies to vertical movements and rotations of the teeth about their vertical axis. As a result, the force effect due to external forces for each individual tooth decreases permanently, with the result that the alveolar bone, in which the teeth are anchored at their roots, is less stimulated than without the retainer, as is the case under "natural conditions". However, this stimulation is particularly important because it leads to stimulation of the bone tissue, whereby this is retained. If the stimulation of the bone tissue decreases, it will recede. This lowering of the forces on each individual tooth thus has the consequence that the alveolar bone regresses in the area of the "blocked" teeth since the influence of external forces on the bone tissue decreases locally.

It is clear from the foregoing that two types of tooth movement must be distinguished. On the one hand, tooth migrations occur. These are a continuous movement of the tooth back into a misalignment. These tooth migrations are to be prevented by the retainer. On the other hand, teeth also have a certain inherent mobility, as a result of which the teeth can be moved in all directions, in particular under the influence of chewing loads, with a certain amount of play (approx. 0.2 mm). The teeth return to their original position after the load has subsided. However, these inherent movements are extremely important because of the associated stimulation of the bone tissue and should be restricted as little as possible by a retainer.

From EP 1 782 748 A1, a retainer is known, which comprises a zirconium oxide, i.e., a ceramic material. Due to the fact that the zirconium oxide is not deformable, the retainer is milled out or ground out of a block. Zirconium oxide is characterised by a high flexural strength, it is therefore very rigid and unyielding. Due to the inherent danger of breakage of the brittle ceramic material, the known retainer is very thick-walled and voluminous. However, in the case of the known retainers, these properties lead precisely to the disadvantage of the "blocking" described above, by which the movements of the teeth in the alveolus (tooth socket) become restricted and unphysiological, which ultimately leads to a regression of the bone tissue.

A method for producing a retainer is known from US Pat. No. 4,516,938.

Problem

The present invention has for its object to overcome the disadvantages of the known retainers.

Solution

With regard to the retainer described above, the aforementioned object is achieved according to the present invention by a method for producing a retainer according to claim 1.

With regard to the feature of the disclosed retainer that a carved surface of the retainer faces a surface of a tooth against which the retainer abuts when in its installed condition, and an upper side or a lower side of the retainer corresponds to the original surface of the metal sheet, is advantageous because, in this way, a bend-free separation of the retainer is possible or takes place. This means that the retainer is manufactured in the form in which it will ultimately be placed on the teeth of a patient. A bending of the metal sheet for the production of the retainer would also not be possible at all with a preferably used material with super-elastic properties since no permanent deformations can be carried out. The retainer according to the invention is thus an end product that can be used without further processing. The advantageous final treatment in the form of an electropolishing should not be taken into account at this point.

In a particularly preferred manner, the retainer is formed from a nickel-titanium alloy, in particular nitinol. Nickel-titanium alloys and Nitinol are shape memory materials, which are particularly well suited for the retainer according to the invention, since they have a what is known as "pseudoelastic" material behaviour (also called "superelasticity"). With regard to the present invention, this material behaviour means that the retainer itself can experience relatively large deflections without being plastically, that is permanently, deformed. The elastic region of the shape memory material is unusually large due to a phase transformation within the material under tension and can exceed the elastic range of a "normal" steel, as is commonly used today for retainers, up to twenty times. This leads to the particular advantage that such a retainer according to the invention can in practice not be plastically deformed, which means that a "kink" or other accidental permanent deformation of the retainer is not possible. Consequently, it is not possible for the retainer according to the invention to be inadvertently "activated" due to a local deflection of an individual tooth as a result of its inherent mobility (for example, due to the action of high local chewing forces, e.g., due to biting on a grain). Consequently, a movement of the teeth caused by the retainer comparable to an orthodontic treatment is excluded when using the retainer according to the invention.

Furthermore, the shape memory material is advantageous in view of the above-described problem of lack of stimulation of the alveolar bone. This is due to the fact that short-lasting changes in the position of the teeth, which are due to local forces acting on individual teeth, i.e., in the context of their inherent mobility, are enabled due to the pseudo-elasticity of the material, i.e., extremely low elastic restoring forces. By a reversible, elastic deformation of the retainer the applied force yields and the tooth can be deflected to a natural extent in the alveolus, that is the tooth socket in which the tooth is suspended by collagen fibres. Once the force ceases, both the retainer and the effected tooth will return to their original shape or position.

Moreover, the pseudo-elasticity of the shape memory material has a favourable effect on the durability of the retainer according to the invention. Thus, it is not subject to the risk of deformation-induced breakage or "fatigue" of the recovery properties.

In addition, the shape memory material is relatively soft due to the low modulus of elasticity, which makes it easier to deform elastically. Failure of a bonding point to a tooth is thus less likely than in retainers according to the prior art. Furthermore, the low stiffness with regard to the sagittal and vertical deformation possibility of the individual teeth is positive since the retainer couples or blocks the bonded teeth with less rigidity. Accordingly, a retainer formed by a shape memory material is also preferable in view of a lower blocking effect.

By preferably using a nickel-titanium alloy, in particular Nitinol, a previously existing conflict of interest in the use and design of retainers is solved. On the one hand, efforts are made to connect the teeth in a force-transmitting manner with one another in order to counteract undesired tooth movements or tooth migrations. On the other hand, the physiological inherent mobility of the individual teeth should be limited as little as possible. Both are possible with the method according to the invention or with the retainer according to the invention, but not with the previously known retainers. This is the case since nickel-titanium alloys, in particular Nitinol, are distinguished by the fact that (elastic) deformation can take place under rapidly occurring loading and no deformation of the retainer is caused by slowly occurring loading. This is particularly advantageous since in chewing movements, only the desired rapidly occurring movements of the teeth in the context of their inherent mobility are enabled, while continuous movements or tooth migration of the teeth towards a misalignment are particularly prevented. Even if deflections are permitted, there is always a small restoring force towards the starting position of the retainer. Although, for example, steel also has a certain restoring force, this is however much lower and there is a high probability that the steel will bend permanently and thus will no longer exert any restoring force but, on the contrary, will exert a force on the teeth which directs them into a misalignment.

In a disclosed retainer, which is sectionally bondable in bonding sections by means of a bonding material with the respectively adjacent teeth in a force transmitting manner, preferably embeddable in a bonding material adhering to the respective tooth, it is also particularly advantageous if in each of the bonding sections a maximum distance between a respective tooth surface and a position of the retainer having the smallest distance to said tooth surface measured perpendicularly to the respective tooth surface is not more than 0.1 mm, preferably not more than 0.01 mm, more preferably not more than 0.005 mm. Such a retainer is particularly precisely adapted to the natural contour of the respective teeth. This is advantageous in that insertion of such a retainer is particularly easy for the person skilled in the art since the retainer in practice engages exactly on the teeth only in a single position. An accidentally “oblique" fitting is therefore almost impossible. Furthermore, the exact adaptation, as explained above, favours the use of thin bonding sections, which in turn has a positive effect on the durability of the retainer and its susceptibility to failure. In addition, a thin layer of the bonding material is also perceived as less disruptive to the patient.

Advantageously, the retainer is locally shaped such that it can project at least partially into at least one dental interspace between two adjacent teeth such that relative movement between the retainer and the teeth directed longitudinally to the retainer is blocked even when the retainer rests on the teeth in an unbonded condition.

“Unbonded condition” here means that the retainer is not yet bonded in a force-transmitting manner with the teeth, therefore, for example, could be removed by hand again from the oral cavity. In a “bonded condition", however, the retainer is firmly bonded to the teeth, in particular adhered. The described shaping of the retainer is possible exclusively by means of the method according to the invention. A formation of regions which protrude into the dental interspaces is impossible by means of the usual deformation methods according to the prior art.

The shaping of the retainer in the manner described offers a number of advantages. For this purpose, reference is made to the above-described problem of "blocking". This arises from the fact that the retainers commonly used today couple the teeth together very strongly, so that an independent inherent movement of the teeth is severely limited. The associated problem of regression of the alveolar bone has already been described above. By guiding the retainer into the dental interspaces, the effect is now achieved that the "free length", that is to say the length over which the retainer rests against the teeth between two adjacent teeth freely, that is to say “unbonded”, is considerably longer in the retainer according to the invention than in known retainers. In the case of the latter, the retainer extends essentially rectilinearly between two adjacent bonding points, that is to say on the shortest possible route. By contrast, in the case of the retainer according to the invention, to some extent a "detour" is taken by guiding the retainer into the dental interspaces. This has the consequence that a “fitted length" of the retainer according to the invention, that is a processed length thereof, is significantly longer than the processed length of a conventional retainer. Here, the pseudoelastic behaviour of the nickel-titanium alloy or Nitinol has a particularly advantageous effect, because especially in cases where a pseudoelastic material is used, a significant increase in deflection capacity can be achieved by extending the short distance between two teeth. Due to the increased length between two splices, the flexibility of the retainer is further increased. If, however, a rigid material such as ceramic is used for a retainer, although this may also be designed so that it protrudes between dental interspaces of adjacent teeth, this however does not increase the flexibility or elasticity of the retainer; rather it will not enable sufficient inherent movement of the teeth because of the rigidity of the ceramic.

Finally, the increased free length between two bonding points has the advantageous effect of reducing the described blocking of the teeth in comparison with the prior art. This is related to the fact that the coupling of a respective tooth to the respectively adjacent tooth is lower the longer the connecting piece which couples the two teeth to one another is. This greater freedom of movement manifests itself in practice in that, when using the retainer according to the invention, the individual teeth can move much more freely in the sagittal as well as in the transverse and vertical direction than when using a conventional retainer. In addition, the tooth is allowed to rotate and change in its axial inclination. The problem of lack of stimulation of the alveolar bone is thus largely eliminated. However, the coupling effect of the teeth in the transverse direction, that is the coupling which is to be achieved in principle by means of the retainer, is not adversely affected by the greater free length of the retainer according to the invention.

The greater free length in the disclosed retainer is also a positive for its durability. Thus, in the case of the retainer according to the invention, fractures of the arch or the respective bonding point are comparatively rare. This is because the arch is easier to deform freely than in the prior art retainers. In the latter, deformations must be reduced over the short distances, the deflections sometimes lead to breakage of the retainer or breakage of the adjacent bonding point.

Furthermore, the high accuracy of fit, which is formulated here by the adjustment of the retainer into the dental interspaces, is fundamentally positive for the wearing comfort of the retainer. Reference is hereby made to the above statements.

In an advantageous embodiment of the retainer, the arch locally has a curvature radius of 1.0 mm or less, preferably 0.5 mm or less, more preferably 0.2 mm or less. Such a small curvature radius is present, for example, in the region of a dental interspace. At such a location, the arch of the retainer tapers locally to a "tip". Further, such "sharp" curvatures in the arch may be suitable for replicating topographies local to the tooth surfaces. A formation of such bending radii is not conceivable in conventional retainers.

The disclosed retainer is particularly advantageous if the arch has a parallelogram-shaped, preferably rectangular, cross-section, wherein edge lengths of the cross section are max. 0.7 mm, preferably max. 0.5 mm, more preferably max. 0.3 mm. A square cross section is particularly suitable. A "square" design of the retainer primarily offers the advantage of “torque control", that is the stabilisation of the inclination or the axial incline of the teeth. This is due to the fact that the square retainer can "tilt" well with the bonding material of the bonding point and thus prevents it from the respective rotational movement. By contrast, conventional retainers have a round or oval cross-section, by means of which such stabilisation is not given due to a lack of tilting of the retainer cross-section with the respective splice.

The small cross-sectional size of the disclosed retainer moreover leads to the fact that the bonding points to the tooth surface can be comparatively flat. This has a favourable impact on the one hand on the durability of the retainer, since an engagement surface for shear forces is kept low, and on the other hand on the wearing comfort, since the patient only feels a slight unevenness on the tooth surfaces.

Preferably, the disclosed retainer is used as a "6-point retainer" and as such is bonded with more than two teeth or more than three teeth in a force transmitting manner. Nevertheless, use as a "2-point retainer" is basically conceivable.

With regard to the bonding of the retainer with the teeth, it is particularly advantageous if the retainer can be completely enveloped in the bonding section by the bonding material. This means that the retainer is surrounded at the bonding sections on four sides by the bonding material. Thus, when the retainer is in its installed condition, the retainer is at least in sections completely within the plastic mass, so that in the relevant section no part of the retainer is exposed or is visible. In this way, a particularly durable bonding of retainer and tooth is created.

In a particularly advantageous embodiment, the retainer is also designed in one piece. This is the normal case using the method according to the invention, since in the course of carving out the retainer from the sheet, a single coherent piece is formed, which forms the complete retainer. Nevertheless, it is conceivable to assemble the retainer according to the invention from a plurality of individual parts.

If the disclosed retainer is observed in its plan view as if framed by a notional inner enclosing parabola and a notional outer enclosing parabola, wherein the inner enclosing parabola rests against the innermost points of the retainer and the outer enclosing parabola rests against the outermost points of the retainer, then such a retainer is preferable, in which locally in the region of a dental interspace a maximum distance measured perpendicular to the inner enclosing parabola between the inner enclosing parabola and the outer enclosing parabola is at least 1.0 mm, preferably 1.5 mm, more preferably 2.0 mm. This distance between the enclosing parabolas can be understood as a measure of the "penetration depth" of the retainer into the dental interspaces. The further the retainer follows these interspaces, the more precisely it fits on the teeth and the longer is the free length between adjacent bonding points. In that regard, a retainer with the described distances is particularly advantageous.

Furthermore, it can have an advantageous effect if the retainer has an at least partially roughened surface, wherein preferably all surfaces (lower side, upper side, front side, rear side) of the retainer are roughened. Such a roughening allows a better bond between the retainer and the material, by means of which the retainer is bonded to the teeth.

In an advantageous embodiment, the retainer is treated by means of an electropolishing or plasma polishing. The advantages of such a retainer are already explained above.

Finally, it is particularly advantageous if the nickel-titanium alloy has an AF temperature between 25°C and 35°C, preferably between 27°C and 33°C, more preferably between 29°C and 31°C. It has been found that the closer the AF temperature is to the temperature at which the workpiece is used, which in the case of retainers corresponds to the body temperature of about 37°C, the more reliably the desired region of the stress-induced martensite plateau is achieved in the elongation of the material.

On the basis of a method of the type described at the beginning, the underlying object is achieved according to the invention by a method for producing a retainer according to claim 1.

First, the modelled contour of the teeth is converted into a model, preferably a digital model, and the retainer is designed on the basis of the model. The designed retainer is then carved out from the metal sheet on the basis of the model by means of a computer-controlled method so that after carving out the metal sheet, the retainer is immediately in its final shape, wherein a carved surface of the retainer faces a surface of a tooth against which the retainer abuts when in its installed condition, and an upper side or a lower side of the retainer corresponds to an original plane of the metal sheet. The retainer is carved out from the metal sheet such that it has its final shape immediately after being carved out.

The invention is based on the idea that an improvement in the precision of the adaptation of the retainer to the respective tooth contours of the patient leads to a considerable improvement in both the effect of the retainer and the wearing comfort. Furthermore, accidental treatment errors based on inadvertent activation of a retainer can be avoided.

The method according to the present invention allows a significant increase in the precision of the manufactured retainer over retainers known today in the form that locally a distance of the retainer from the respective tooth surface on which it is to rest is very low. From the detected contour, a particularly precise model for a retainer can be prepared by means of the use of a computer with corresponding CAD software (*computer* *aided design*). From this model, finally, by means of a *computer aided manufacturing* (CAM) process, the retainer can be automatically carved out of the sheet in exactly the form dictated by the CAD model. This procedure is therefore also referred to as a "CAD-CAM method". Due to the fact that the retainer according to the invention is carved out of the sheet, this method is what is known as a subtractive method.

As a result, the method according to the invention consequently produces a retainer which exactly fits the contour of the detected teeth and has a secure fit. In particular, a subsequent deformation or processing of the retainer - be it mechanically or manually - is not necessary or, when advantageously using a nickel-titanium alloy, in particular Nitinol, with its pseudoelastic properties, is not possible because the material returns to its starting position after an imposed deformation. The retainer according to the invention thus has its final shape (both globally and locally) as soon as it has been carved out of the metal sheet, without further adjustments being necessary or possible. This leads to several advantages, which are described below:

The bonding points at which the retainer is bonded to the respective tooth can be made significantly flatter than is the case in the prior art. This means that a layer thickness of the required plastic, which forms the bonding point, is lower. This is due to the fact that the retainer rests very closely to or directly on the corresponding tooth surface. The plastic layer, by means of which such retainers are typically bonded to the teeth, needs accordingly a comparatively small extent in a direction perpendicular to the tooth surface, in order to completely enclose or embed or envelop the retainer. Bridging free spaces between the retainer and the tooth, as is regularly required in the prior art, is not necessary. On the one hand, a "flat" bonding point considerably increases the wearing comfort of such a retainer. This has primarily a more comfortable fit, since the spatial extent of the foreign body, which the retainer together with the bonding material ultimately represents in the patient's mouth, is very low. This also facilitates oral hygiene for the patient. On the other hand, a thin bonding point leads to the fact that, due to its small dimension within the oral cavity, the bonding point has a significantly lower surface than is customary in bonding points according to the prior art, and consequently is exposed to significantly lower shear forces or chewing forces. The latter is particularly advantageous for the durability of a retainer made by the method according to the invention since the probability of detachment of the retainer from one or more teeth due to such force effects is significantly reduced. With regard to the durability of a retainer formed from a nickel-titanium alloy, it is also advantageous that less stress, i.e., tension, in the retainer-tooth bond is formed by the pseudo-elasticity of the nickel-titanium alloy, when force is applied by mastication and consequent tooth excursion, which in the worst case could lead to a stress break.

The lack of plastic deformability of a retainer formed by a shape memory material is also the reason why such retainers are not yet available on the market. Thus, the production methods known today, which - as described - provide an individual moulding of the retainer by bending to the respective row of teeth to be fixed, are not suitable or possible for forming such a retainer of a nickel-titanium alloy, since this is not permanently or plastically deformable. Only by means of the method according to the invention - namely by carving out the retainer from a metal sheet in compliance with the specified orientation - is the use of a shape memory material even conceivable.

Another important advantage of a precisely shaped retainer lies in its simplicity with regard to its application or insertion with a patient. In retainers according to the prior art, the attending physician is quickly tempted to apply points of the retainer manually to the tooth and finally to bond it, where a distance between the retainer and the tooth to be fixed is relatively large. By this application, the retainer is elastically deformed and accordingly develops a restoring force that tends to move the retainer back to its previous position. By fixing the retainer to the tooth, this restoring force is preserved and acts on the respective tooth. This means that the retainer no longer acts as a purely passive element, which merely fixes the teeth in their current position, but activates them and causes a movement of the respective tooth due to the action of force. By contrast, due to the manufacturing process according to the invention, the retainer is adapted so precisely to the teeth that such inadvertent activation thereof is hardly possible and, in particular, unnecessary. Consequently, the process of the subsequent treatment success is significantly increased and the use of a retainer much safer than in the prior art.

The retainer is carved out from the metal sheet such that a shaped surface of the retainer, in a fitted state thereof, faces a tooth surface against which the retainer is seated, and which is adapted corresponding to the respective surface contour of the respective teeth, and an upper side or lower side of the retainer corresponds to the original sheet plane. The “upper side" and “lower side" of the retainer are understood to mean the surfaces thereof, which are respectively aligned parallel to one another. Using the example of Figure 1 of the embodiments, the upper side of the retainer is the surface that is visible to the viewer of the figure. The “shaped surface" refers to the surface of the retainer, which results from carving it out of the metal sheet. The shaped surface is consequently that plane which is arranged perpendicular to the plane of the drawing in Fig. 1 of the exemplary embodiments. The shaped surface is typically applied to the surface of the respective teeth to be fixed. At least this shaped surface sits partially against the tooth surface. The opposite plane facing away from the tooth surface can be considered equally as a shaped surface.

This orientation in the carving out of the retainer from the metal sheet makes it possible to produce the same directly in the form in which it is later applied to the teeth of the respective patient. In particular, the curved profile, which viewed globally is approximately parabolic, is directly automated with a corresponding tool “retractably", so that the retainer is cut out without bending or deformation of the material. DE 102 45 008 A1 already mentioned above is basically also a method for carving out a retainer removably from a metal sheet, reference being made to the embodiment of Figure 4 of said document. However, in the case of the retainer described here, the shaped surface or processing plane referred to coincide with the upper side or lower side of the retainer. As a result, the retainer carved out is in effect "flat" (which is thus necessary because of the clearly enlarged adhesive end sections) and must be moulded onto the teeth in a further step, wherein it is typically bent. Such an additional step, which is typically done manually, in turn involves the risk of inaccuracy in the fit of the retainer and is in particular not necessary by the method according to the invention.

The method according to the invention is particularly advantageous if the retainer is cut out of the metal sheet by means of laser cutting or wire erosion, with these methods, the carving out is affected by heat and not just by a shearing operation of two cuts moving past each other. Such cutting methods are particularly precise. Furthermore, associated devices that are capable of automatically cutting metal sheets are readily available. Alternatively, however, other methods are also conceivable, for example water jet cutting.

The method is also particularly advantageous when the contour of the teeth to be stabilised is detected intraorally. This is possible by means of "intraoral scanners". Customary impression methods, in which an impression (negative) of the teeth to be stabilised is made by means of an impression material and a positive result obtained by pouring out the impression with gypsum material, are now of a particularly high quality.

Nevertheless, the precision of an intraoral scan is procedurally better, since even with the use of good impression materials there is always drying-related shrinkage, and a loss inevitably occurs during the carry-over of the contour information from the natural tooth to the impression template and again from the template to the finished form. In addition, air inclusions regularly occur during impression taking, which negatively affect the precision of the positive. In today's conventional retainers this is irrelevant, since their precision cannot detect such small deviations between the model and the real tooth. By contrast, in retainers made by the method according to the present invention, the direct intraoral scan can provide an advantage in the end result of the retainer.

In a particularly advantageous embodiment of the method according to the invention, the metal sheet, from which the retainer is carved out, is formed by a pre-curved metal sheet, wherein a curvature axis about which the metal sheet is at least curved, extends in a non-curved state of the metal sheet in a sheet plane. A pre-curved metal sheet offers the possibility in production of making the retainer likewise curved.

In the case of a flat metal sheet, the retainer produced according to the invention has an arched shape, but the retainer has two planes that are parallel to one another. Consequently, the retainer carved out of a flat metal sheet would be able to be placed flat on a flat surface, for example a tabletop, wherein a lower side of the retainer would form a full-surface contact with the tabletop. By using pre-curved metal sheets from which the retainer is carved out, the retainer acquires an additional (vertical) dimension, as it consequently also has a curved geometry. Using the example of the tabletop, this would mean that the retainer would rest on the flat tabletop with its lower side only in places and would otherwise be lifted off the tabletop. Such a possibility of designing the retainer in an additional dimension makes it possible, if appropriate, to better adapt the retainer to the global shape of the dental arch.

In a particularly advantageous method, the retainer, after it has been carved out of the metal sheet, is electropolished or plasma-polished, whereby edges are rounded. Such treatment of the retainer reduces the microroughness and nanoroughness of its surface, thereby making it more difficult for potentially harmful germs to adhere to the surface. Furthermore, the corrosion resistance of the retainer is increased. The upper side and lower side newly created after polishing are according to the application also considered as corresponding to an "original sheet plane" according to the independent method claim, since the removal of the material by polishing is only slight, especially as the removal of material is in the micrometre range.

Exemplary embodiments

The invention described above will be explained in more detail using an exemplary embodiment which is illustrated in the figures.

These show:

Fig. 1: a plan view of a retainer according to the invention for use in the upper jaw,

Fig. 2: as for Figure 1 but used on a model of the upper jaw,

Fig. 3: a sketch of an inserted retainer on a model of a lower jaw,

Fig. 4: as for Figure 1, but as a three-dimensional grid model,

Fig. 5: a section through a tooth provided with a retainer according to the invention,

Fig. 6: an enlarged view of the retainer from Figure 5,

Fig. 6a: an enlarged view of an alternatively designed retainer, and

Fig. 7: a plan view of a Nitinol sheet with carved out retainer.

A first embodiment, shown in **Figure 1**, comprises a retainer **1** suitable for use in an upper jaw. The retainer **1** is designed as a 6-point retainer and, after it has been inserted into the respective patient, is connected with six teeth in a force-transmitting manner. The retainer **1** is shown in **Figure 1** in a plan view, so that an upper side **2** of the retainer **1** is visible.

The retainer **1** comprises an arch **3** whose global shape is parabolic. This global shape of the arch **3** is predetermined by the shape of the respective upper jaw into which the retainer **1** is to be inserted. Locally, the arch **3** has individual formations **4**, which can be divided into two categories. The first category denotes formations **4** in the form of “shallow waves" **5**, which are suitable for adapting the retainer **1** to an individual topography of the adjacent teeth. These shallow waves **5** are therefore adapted corresponding to an individual tooth shape of a patient. The second category describes "tips" **6** that form the points of the arch **3** that enter dental interspaces between adjacent teeth. In the tips **6**, the arch **3** has low radii of curvature, which are in the range of 0.5 mm to 1.0 mm. These tips **6** differ from the waves **5** by their amplitude relative to the global shape of the arch **3**.

This can be reproduced based on two enclosing parabolas **7**, **8** framing the arch **3**, which are shown by dashed lines in **Figure 1**. These enclosing parabolas **7**, **8** describe an inner borderline and an outer borderline of the retainer **1**, wherein the inner enclosing parabola **7** includes those points located furthest inward relative to the shape of the retainer **1** and the outer enclosing parabola includes those points located outermost relative to the shape of the retainer **1**. As a result, the outer enclosing parabola **8** runs essentially through high points of the tips **6**. A distance measured perpendicular to the enclosing parabola **7** between the same and the outer enclosing parabola **8** is consistently approx. 2 mm in the example shown. This value simultaneously describes the above-mentioned amplitude of the tips **6**. A parabola, which would essentially be attached by high points of the shallow waves **5**, would have a significantly smaller distance from the inner enclosing parabola **7**. That is, the amplitude of the waves **5** is small compared to the tips **6**. This can be clearly recognised by the shape of the retainer **1** shown.

The retainer **1** is formed from the material Nitinol and was cut out of a corresponding Nitinol sheet by means of a laser cutting process. In the run-up to this method step, it is always necessary to detect the respective contour to be replicated of the teeth to be stabilised. This is typically done by means of the scan of an impression mould, which is modelled on an impression of the lower or upper jaw, or by means of an “intraoral scan", which is made by means of an intraoral scanner. In the latter method, the shape of the teeth is detected directly in the patient's mouth. It is advantageous that this method is possible relatively quickly and allows higher precision than an impression method.

The result of the respective scan of the teeth is then processed by means of CAD software and a three-dimensional model of the retainer **1** is created, which is very well adapted to the scan and consequently to the real topography of the respective teeth. On the basis of the model, the laser is then programmed, by means of which the retainer **1** is cut out. This method step is also referred to as *computer aided manufacturing* (CAM).

The retainer **1** is shown in **Figure 2** in an inserted state in which the retainer **1** is initially applied loosely to the teeth. The retainer **1** is shaped in such a way that a distance between a tooth surface against which the retainer **1** rests and a position of the retainer **1** whose distance measured perpendicular to the tooth surface is the lowest, is at most

10 µm, that is 0.01 mm. Such accuracy is not feasible with retainers according to the prior art. The resulting advantages are explained in detail above.

Figure 3 shows a further example of a retainer **1'** according to the invention, wherein the retainer **1'** is suitable for use in a lower jaw. The retainer **1'** as well as the retainer **1** is connected to six teeth in a force-transmitting manner but is shown in **Figure 3** only in its inserted state, that is without the need for the bonding points necessary for bonding. Tips **6'** of the retainer **1'** protrude into dental interspaces between the teeth in such a way that displacement of the retainer **1'** relative to the teeth is blocked at least in a transverse direction. From **Figure 3** it is clear that the amplitude of the tips **6'** in the retainer **1'** turns out to be considerably larger than is the case with the retainer **1**. This results from the natural shape of the teeth.

The retainer **1** is finally shown in **Figure 4** in a three-dimensional grid model. From the illustration it is clear that the retainer **1** has a square cross section, wherein an edge length of the cross section is 0.3 mm. Likewise, both a front side **9** and a rear side **10** of the retainer **1** can be seen in **Figure 4**. These are arranged parallel to one another, wherein the front side 9 faces a tooth surface of the respectively adjacent tooth in a fitted state of the retainer **1**. The upper side **2** and a lower side **11** of the retainer are oriented perpendicular to the front side **9** and the rear side **10**.

The upper side **2** and the lower side **11** of the retainer **1** are respectively in one plane. These planes define a metal sheet, not shown, from which the retainer **1** was originally carved out, the metal sheet having a thickness of 0.3 mm. That is, a machining tool (laser, waterjet, erosion wire, etc.) has been moved parallel to the upper side **2** of the retainer **1** over the metal sheet according to the contour of the retainer **1**, in order to carve out the retainer **1** from the metal sheet. By this step, the front side **9** and the rear side **10** of the retainer **1** are created. These are therefore comprehensible as processing planes **12** and shaped surfaces **13**, since they represent the planes that have been processed or on which the retainer **1** has been worked out. After carving out, the retainer **1** is immediately in the form shown and can be applied to the teeth of the patient without further adjustments.

Figure 5 shows a section through an incisor tooth **14** which is provided with the retainer **1** according to the invention from **Figure 1**. Only that area of the incisor **14** which is located above the gum **15** is shown. For reasons of clarity, **Figure 6** shows an enlarged representation of the retainer **1** from **Figure 5**. The retainer **1** is embedded in a bonding material **16**, which was previously applied to an inner tooth surface **17**, in a bonding section, in which it is bonded to the incisor **14**, and abuts almost directly on this tooth surface **17**. The surface with which the retainer **1** bears against the tooth surface **17** corresponds to the shaped surface **13** of the retainer **1**, that is to say a cutting edge **18** which has been produced during the production of the retainer **1**. The upper side **2** of the retainer **1** corresponds to an upper metal sheet surface **19** and the lower side **11** of the retainer **1** corresponds to a lower metal sheet surface, wherein the upper and lower metal sheet surfaces **19** are parallel to each other. The upper side **2** and the lower side **11** of the retainer **1** are perpendicular to the inner tooth surface **17**.

In **Figure 6a**, an alternatively designed retainer **1"** is shown, which has a square cross section, and which is mounted on the incisor **14** with the bonding material **16** in its bonding section in such a way that it is completely enveloped by the bonding material **16**.

Finally, **Figure 7** shows a plan view of a Nitinol sheet **20**, wherein the process of carving out the retainer **1** from **Figure 1** according to the invention has just ended and the finished cut-out retainer **1** is still located in the Nitinol sheet **20**. The surface of the Nitinol sheet **20** and of the retainer **1** located in the plane of the drawing corresponds to the upper Nitinol sheet surface **19** or the upper side **2** of the retainer **1**. The cutting edge **18** of the retainer **1**, of which only one line **21** can be seen in **Figure 7**, runs perpendicular to the plane of the drawing. It corresponds to the shaped surface **13** of the retainer **1**, which comes to rest on the inner tooth surface **17**. A cutting edge **22** extending parallel to the cutting edge **18**, which is again only recognisable as a line **24** in **Figure 7**, is also to be understood as a shaped surface **23**, which is remote from the inner tooth surface **17** in the inserted state.

List of reference numerals

1, 1', 1"	Retainer
2	Upper side
3	Arch
4	Formation
5	Wave
6, 6'	Tip
7	Enclosing parabola

8	Enclosing parabola
9	Front side
10	Rear side
11	Lower side
12	Processing plane
13	Shaped surface
14	Incisor
15	Gums
16	Bonding material
17	Inner surface of a tooth
18	Cutting edge
19	Upper metal sheet surface
20	Nitinol sheet
21	Line
22	Cutting edge
23	Shaped surface
24	Line

Patentkrav

1. Fremgangsmåde til fremstilling af en holder (1, 1'), omfattende følgende fremgangsmådetrin:

a) en kontur af de tænder, der skal stabileres, registreres individuelt,

b) holderen (1, 1') tildannes af en plade af metal,

kendetegnet ved følgende fremgangsmådetrin:

c) den registrerede kontur af tænderne overføres til en fortrinsvis digital model, og holderen (1, 1') skitseres ud fra modellen,

d) den skitserede holder (1, 1') tildannes på grundlag af modellen ud fra pladen ved hjælp af en computerstyret fremgangsmåde, således at holderen (1, 1') efter tildannelse ud fra pladen direkte har sin endegyldige form, idet en tildannelsesoverflade af holderen (1, 1') i dennes indbyggede tilstand vender mod en tandoverflade, som holderen (1, 1') ligger an imod, og en overside (2) eller en underside (11) af holderen (1, 1') svarer til et oprindeligt pladeplan.

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** holderen (1, 1') skæres ud af pladen ved hjælp af laserskæring eller tråderosion.

3. Fremgangsmåde ifølge et af de foregående krav, **kendetegnet ved, at** konturen af de tænder, der skal stabiliseres, registreres intraoralt.

4. Fremgangsmåde ifølge et af de foregående krav, **kendetegnet ved, at** den plade, af hvilken beholderen (1, 1') tildannes, er krummet om mindst en krumningsakse, idet krumningsaksen i en ukrummet tilstand af pladen forløber i et pladeplan.

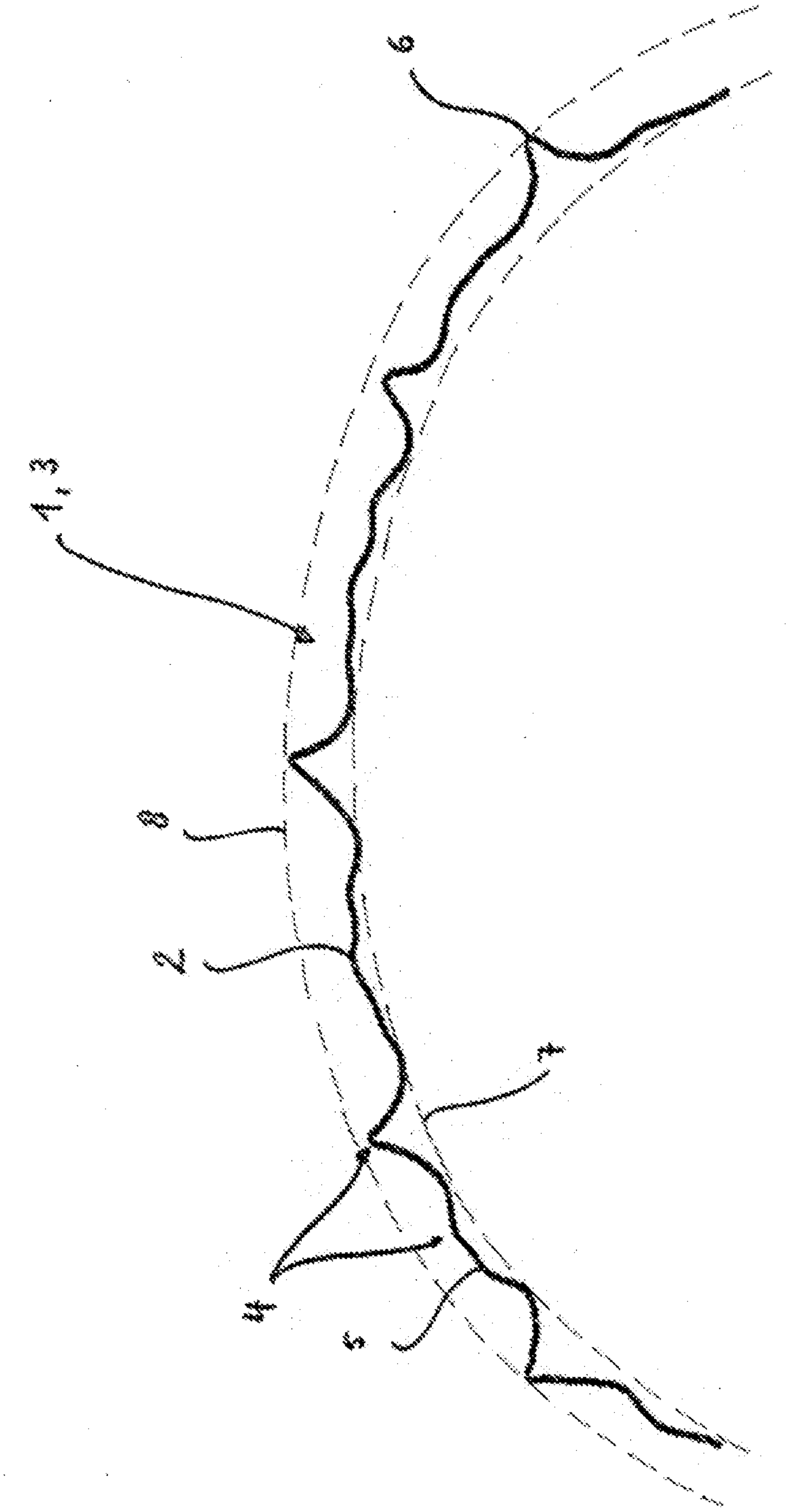

Fig. 1

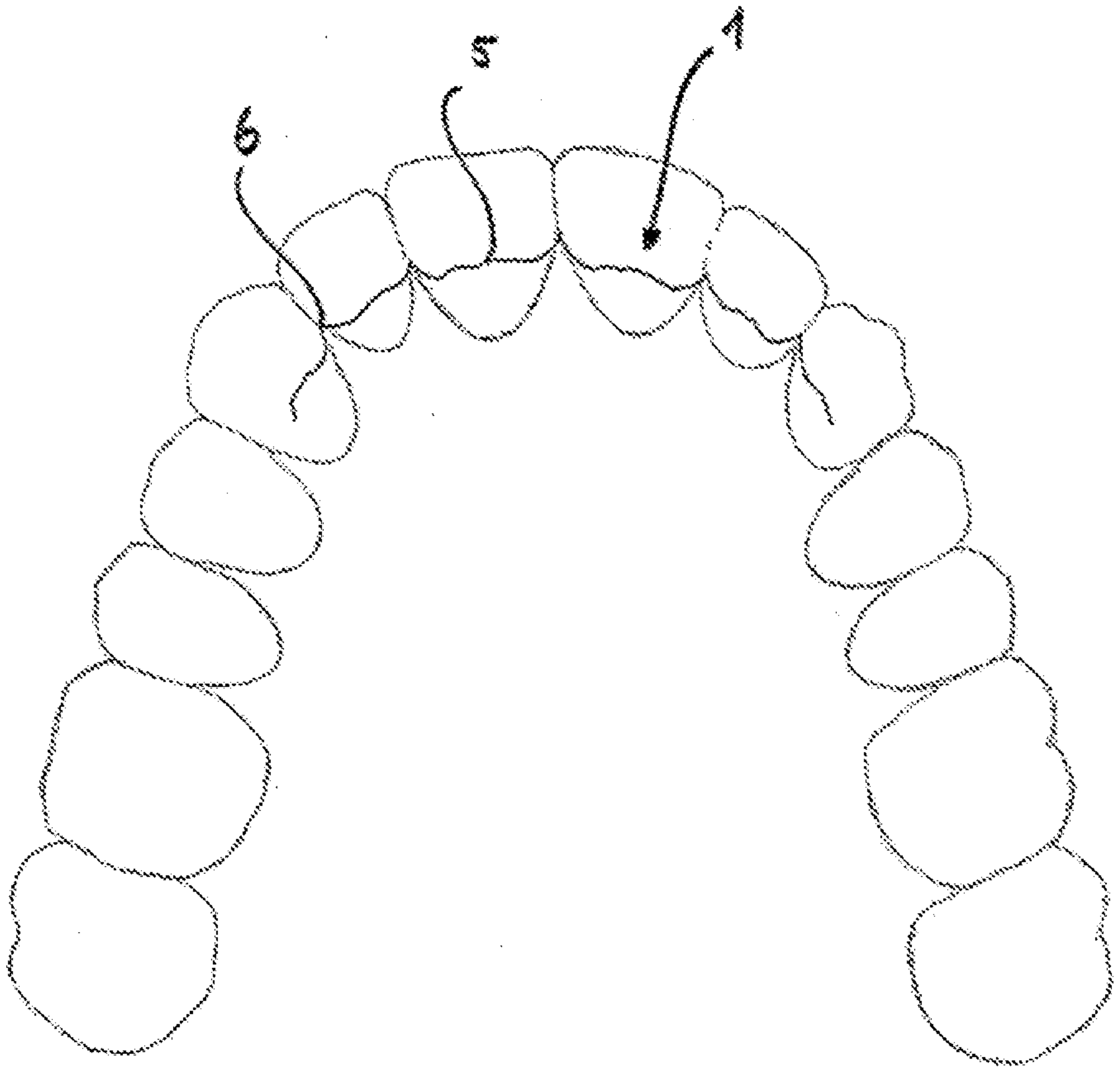

Fig. 2

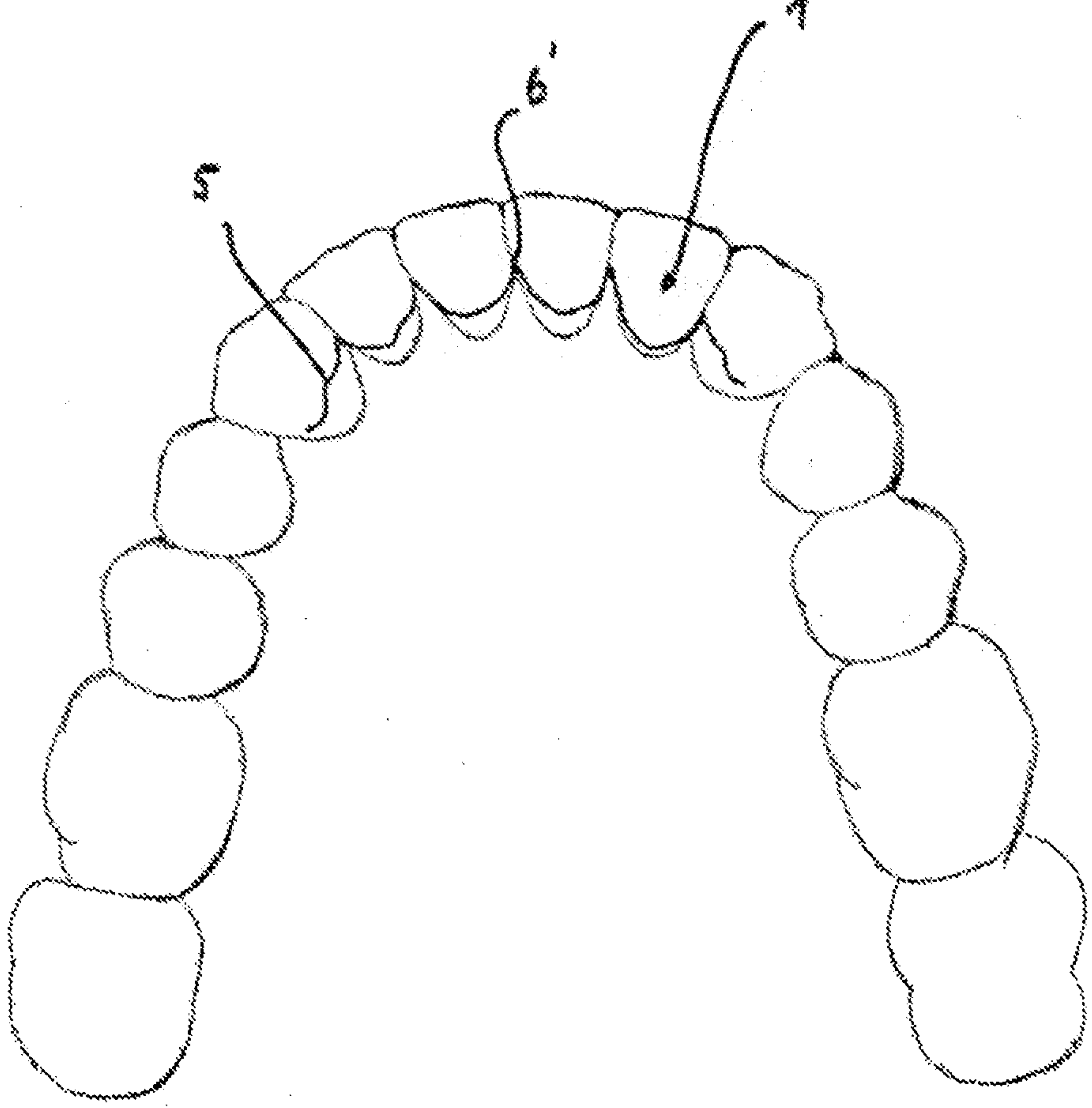

Fig. 3

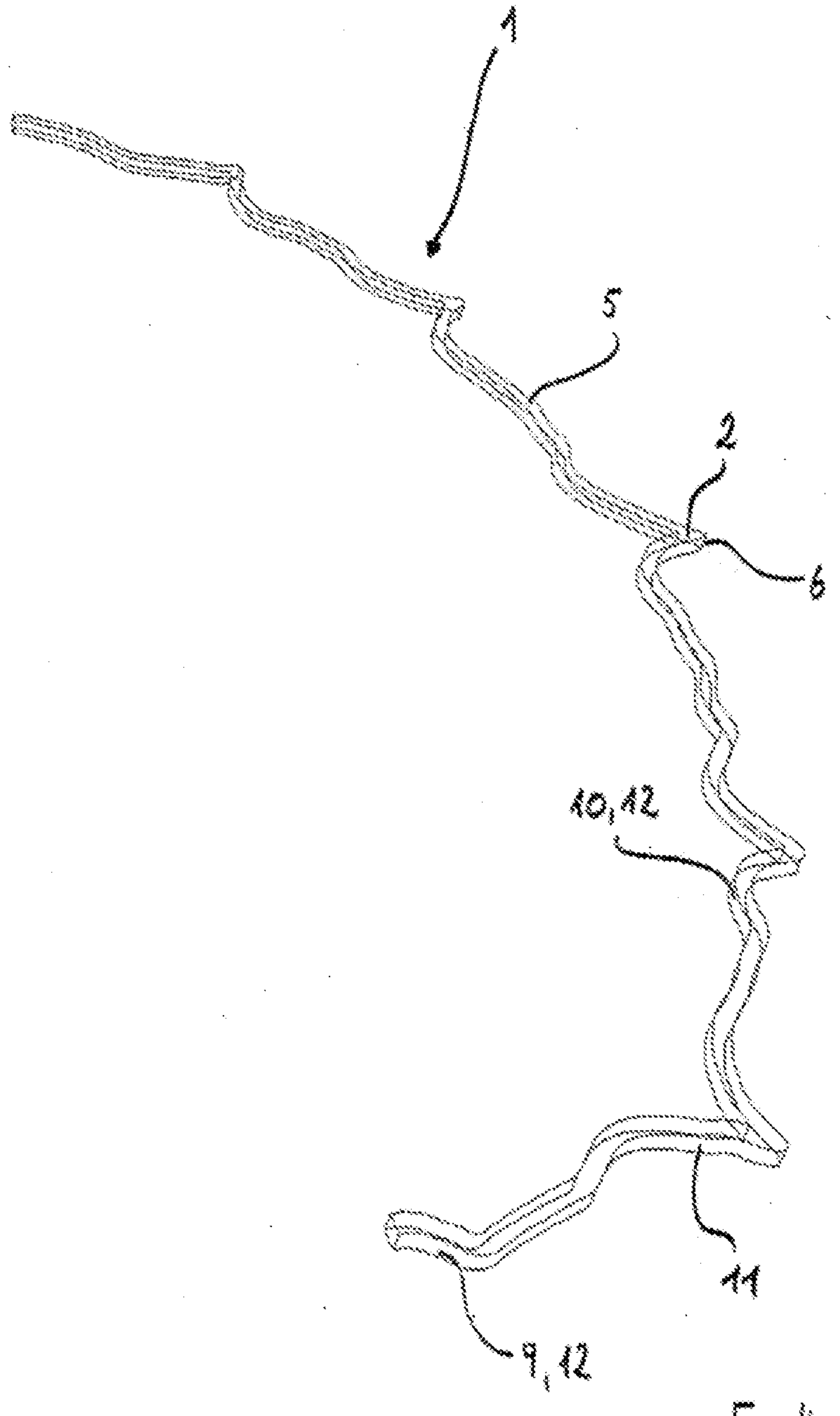

Fig.4

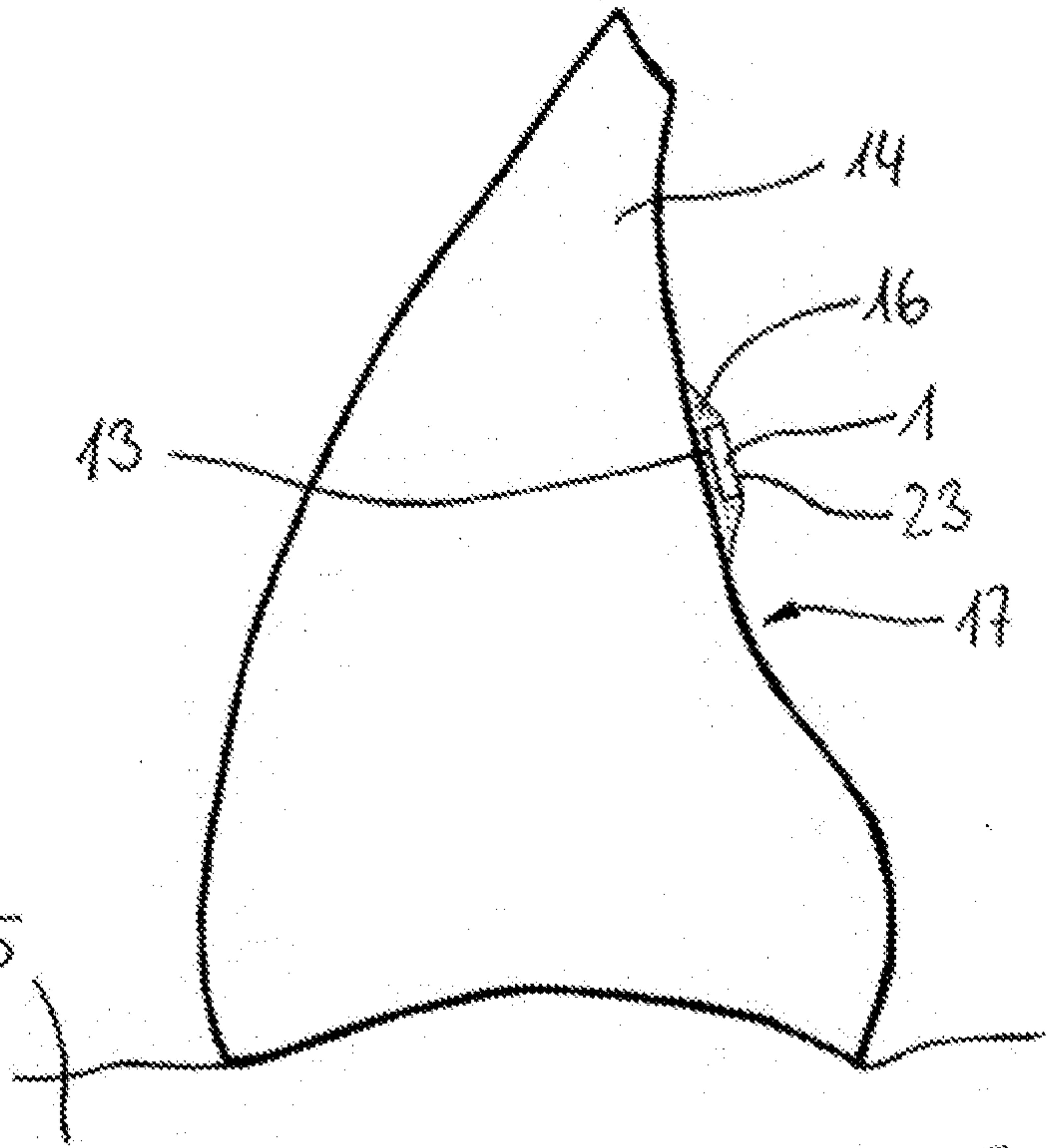

Fig. 5

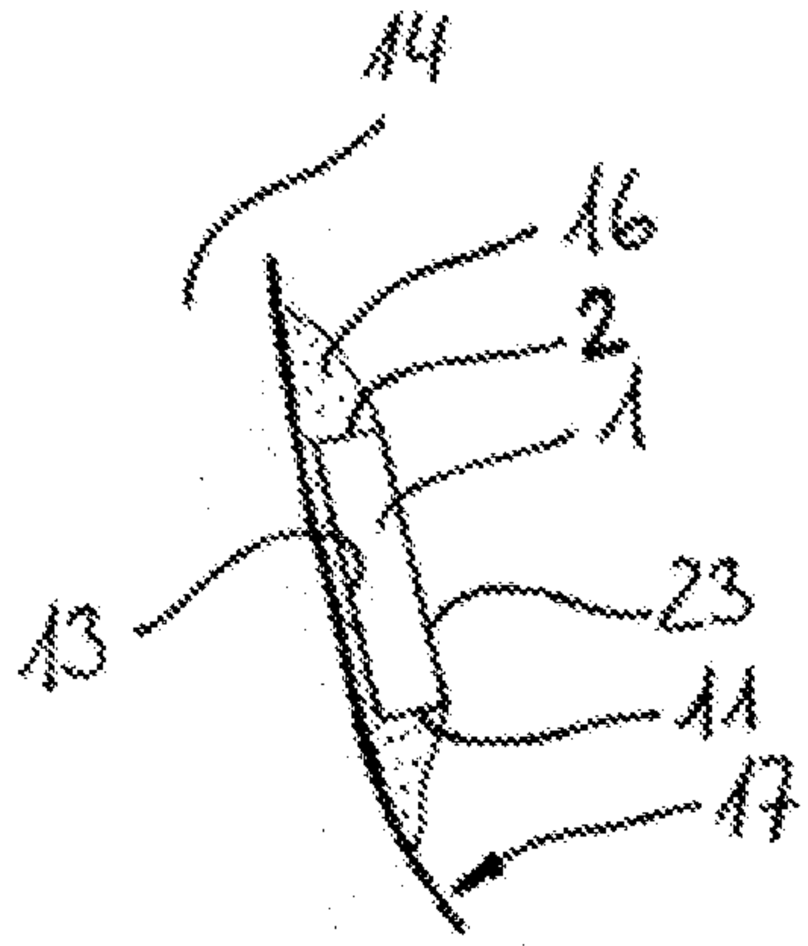

Fig. 6

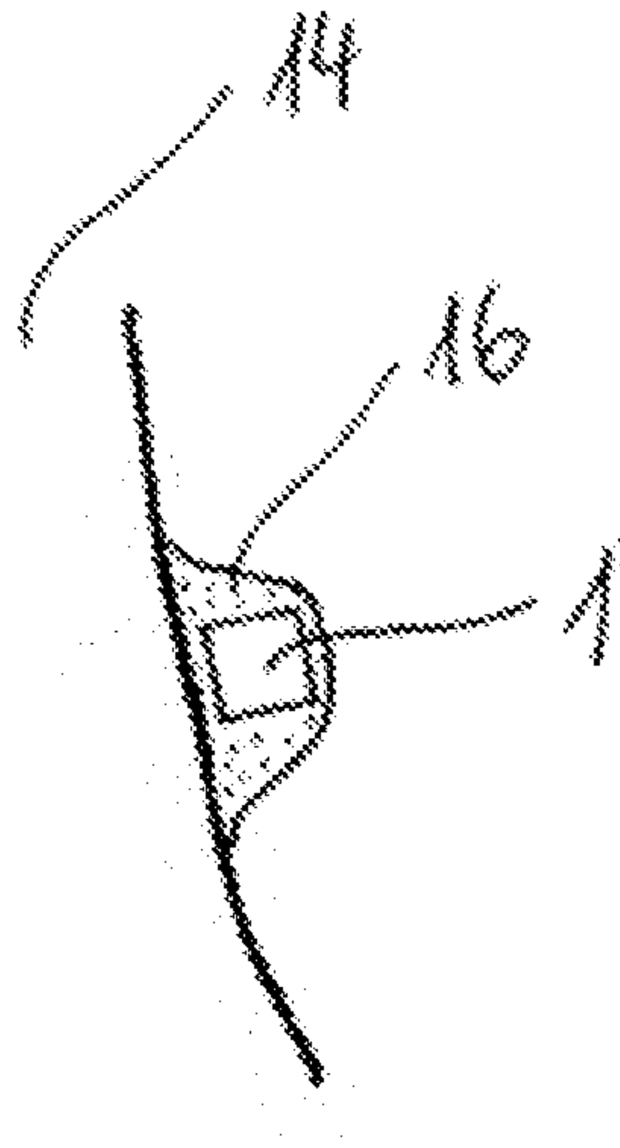

Fig. 6a

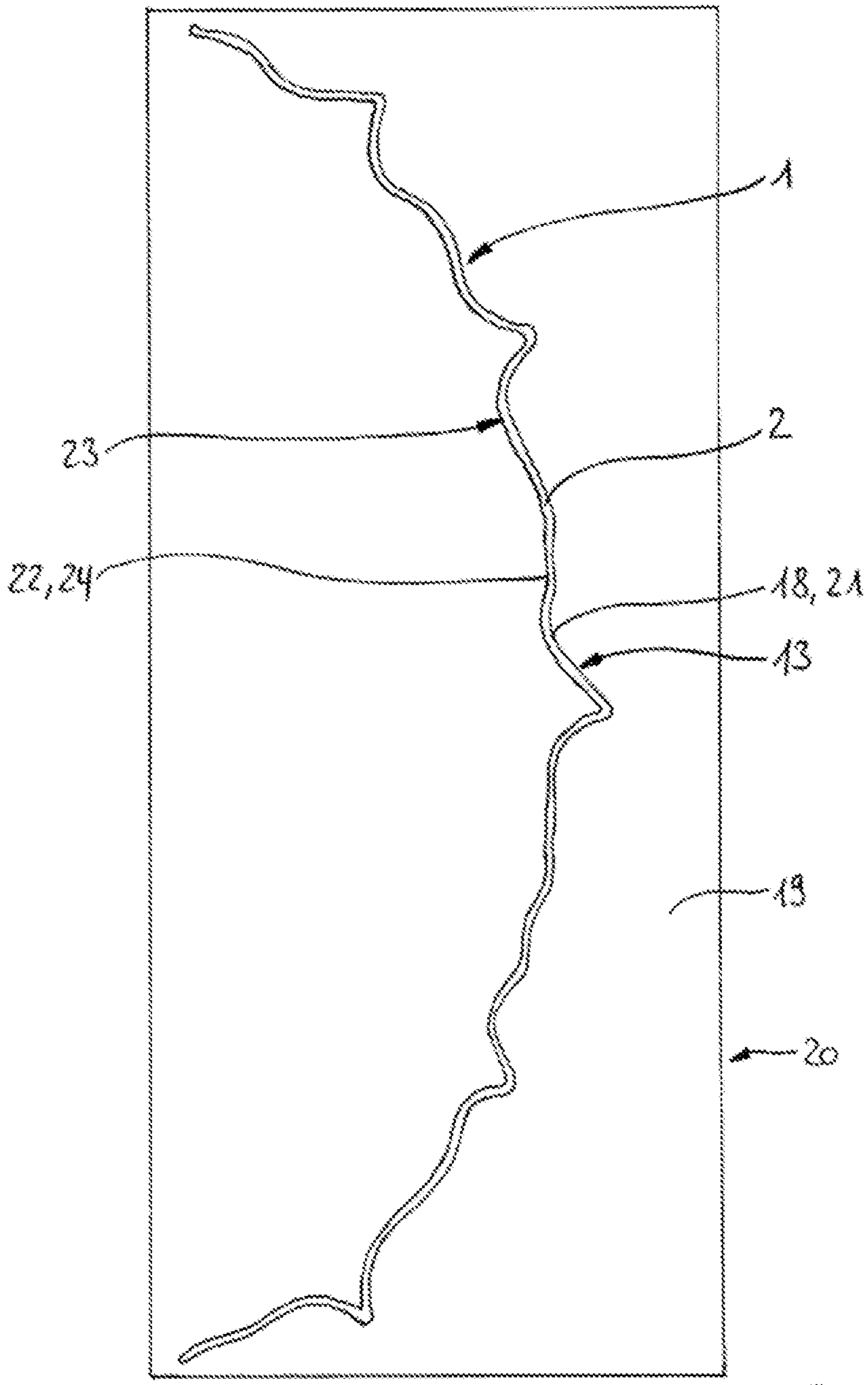

Fig.7