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The invention relates to an expansion anchor according to the preamble of Claim 1. An expansion anchor of this type is equipped with a stud and at least one expansion sleeve surrounding the stud, an expansion cone being arranged on the stud, which expansion cone widens the expansion sleeve radially, and in particular forces the expansion sleeve radially outwards, when the expansion cone is pulled into the expansion sleeve. The invention further relates to a method for producing such an expansion anchor.

A generic expansion anchor is known, for example, from US 2010/0135743 A1. It is used to anchor components to a borehole in a solid substrate, for example concrete. The known expansion anchor has an elongated stud which is provided with an expansion cone in the region of its forward end. The expansion cone widens towards the forward end, that is, against the extraction direction. An expansion sleeve is arranged on the stud offset from the expansion cone in the extraction direction. This expansion sleeve is mounted on the stud so as to be displaceable on to the expansion cone towards the forward end of the stud. The expansion sleeve has on its outer side radially projecting elevations with which the expansion sleeve can interlock with the inner wall of the borehole in the substrate. The expansion anchor is hammered into the borehole against the extraction direction with its first end leading, and the stud is then pulled a short distance out of the borehole again in the extraction direction. After the expansion anchor has been hammered into the borehole, the expansion sleeve interlocks with the inner wall of the borehole and is therefore held back in the borehole as the stud is pulled out. The expansion cone of the stud is thereby pulled into the expansion sleeve, whereby the expansion sleeve is expanded on account of the increasing diameter of the expansion cone. As this happens the expansion anchor becomes jammed with the expansion sleeve in the substrate, so that tensile loads can be transmitted into the substrate. This basic principle can preferably also be used in the invention.

According to said document US 2010/0135743 A1, an expansion element is provided from a material with a Vickers hardness of approximately 218 HV to 290

HV, and a sleeve from a material with a Vickers hardness of approximately 218 HV to approximately 290 HV.

It is an object of the invention to specify an especially reliable expansion anchor with especially good load values, which at the same time is especially simple to produce. It is a further object of the invention to specify an especially simple, advantageous and reliable production method for such an expansion anchor.

The object is achieved according to the invention by an expansion anchor having the features of Claim 1 and a production method having the features of Claim 8. Preferred embodiments of the expansion anchor are specified in the dependent claims.

An expansion anchor according to the invention is characterised in that the expansion sleeve has a Vickers hardness greater than 350 HV in the region of its forward end oriented towards the expansion cone, while the hardness of the expansion sleeve decreases towards the rearward end of the expansion sleeve. In particular, the hardness of the expansion sleeve decreases, starting from 350 HV, towards the rearward end of the expansion sleeve.

The basic concept of the invention may be seen in a particular hardness progression according to which the forward region of the expansion sleeve, which is displaced radially by the expansion cone and pressed against the surrounding borehole wall as the expansion anchor is inserted, has high strength, that is, a hardness greater than 350 HV, at least zonally and preferably throughout, while the rearward region of the expansion sleeve is of lower strength. Tests and simulations have shown that an expansion anchor can thereby be obtained which has especially good load characteristics particularly in cracked concrete, and which at the same time can be produced in an especially simple and advantageous manner.

In this context it has been recognised according to the invention that the reason for the good load characteristics in cracked concrete may lie in the residual preloading which arises in the anchor stud of a preloaded anchor after a crack in which the expansion anchor is located has opened by a small amount, for example 0.3 mm to 0.5 mm. In the case of conventional expansion anchors with hardnesses in the forward sleeve region of between 80 HV and 300 HV a significant reduction in the preloading force, in some cases even to zero, has been observed in the event of such a crack opening. By contrast, when a hardness greater than 350 HV was chosen for the forward sleeve region according to the invention, significantly higher residual preloadings were observable. These higher residual preloadings according to the invention after a crack had opened may in turn result in better anchoring in the borehole, with the result that the expansion anchors according to the invention are displaced significantly less far in the borehole, in the event of crack opening and with high tensile loading, than expansion anchors with lower peak hardness of the expansion sleeve. According to the invention, therefore, especially good load characteristics can be achieved in cracked concrete.

It has further been recognised according to the invention that the reason for the high residual preloadings, and therefore the superior anchoring in cracked concrete and, consequently, the especially good load characteristics of the expansion anchors according to the invention, may lie in the interaction of the forward end region of the expansion sleeve with the surrounding concrete material. Once the anchor has been set, this forward end region is pressed by the expansion cone against the surrounding borehole wall. If, according to the invention, a hardness above 350 HV, in particular above 400 HV, is selected for this forward end region, under normally prevailing conditions in the building industry, the sleeve material generally does not become plasticised, or only slightly, and the expansion system is therefore more robust, especially if a crack opens and the contact areas between expansion sleeve and concrete are reduced. This effect can lead to the observed significant improvement of the load characteristics.

Finally, it has been recognised according to the invention that although, on the one hand, a high sleeve hardness above 350 HV may bring with it the above-mentioned advantages in cracked concrete, on the other hand the high sleeve hardness may also be disadvantageous, for example with regard to manufacture of the expansion sleeve and/or with regard to the load characteristics of the anchor in other load situations. For example, the usual manufacturing process with a bending step, in particular a winding step, may be made more difficult by a high sleeve hardness, and there is an increasing probability that out of round sleeve cross sections, which in turn can negatively affect the load characteristics, are obtained. In addition, a high sleeve hardness may potentially hinder the expansion process of the expansion sleeve. Finally, a high sleeve hardness may also be accompanied by an increased tendency to corrosion.

The above dilemma is resolved by virtue of the invention in that the high sleeve hardness is provided only zonally, namely in the forward sleeve region which, when loaded by the expansion cone, is pressed against the surrounding borehole wall, and in which, therefore, the high sleeve hardness can bring about the above-mentioned advantages with regard to the load characteristics in cracked concrete. Further back on the expansion sleeve, in the rearward region, by contrast, a lower hardness is provided according to the invention. Because of this lower hardness in the rearward sleeve region, the expansion sleeve can, firstly, be expanded especially simply and reliably. In addition, an especially simple manufacturing process by bending sheet metal to form the expansion sleeve is possible, even if the zonally increased hardness is already present before this bending step. Subsequent induction hardening can also be carried out in an especially simple manner. Finally, the corrosion properties can also be significantly improved, since the regions of the expansion sleeve facing towards the borehole mouth are soft. Moreover, the low strength in the rearward region generally does not lead to deterioration of the load characteristics in cracked concrete, since the above-described mechanism takes place only on the forward side of the sleeve. Consequently, according to the invention an expansion anchor can be obtained which is especially efficient in a large number of different situations, and in addition can be produced in an especially reliable and simple manner.

Hardness in HV is understood in the usual technical sense to mean Vickers hardness. According to the invention, hardness can be understood to mean, in particular, the surface hardness on an intact expansion sleeve. In particular, the hardnesses according to the invention may be present in an unexpanded expansion sleeve, that is, in an expansion anchor in its initial state in which the expansion cone has not yet been pulled into the expansion sleeve. The high-strength region with hardness greater than 350 HV may preferably extend annularly around the entire circumference of the expansion sleeve, although interrupted by any expansion slits which may be present. However, the high-strength region may also be smaller, and cover only a region of the expansion sleeve. Several separate high-strength regions may also be provided on the forward side of the expansion sleeve. The rearward end of the expansion sleeve, towards which the hardness of the expansion sleeve decreases according to the invention, is axially opposite the forward end and/or is oriented away from the expansion cone.

According to the invention, the expansion sleeve is arranged, in particular fastened, on the stud so as to be displaceable along the stud. Where the terms “radial”, “axial” and “circumferential direction” are used here, they may relate, in particular, to the longitudinal axis of the stud, which may be, in particular, the axis of symmetry and/or the central axis of the stud. The expansion anchor may preferably be an expansion anchor which expands in a force-controlled manner. The expansion sleeve and/or the stud appropriately consist of a metallic material which may also be coated, for example, to influence friction in a specified manner. The high hardness in the forward region of the expansion sleeve may be obtained, for example, by rolling and/or induction hardening. The expansion sleeve may preferably be made of stainless steel, in particular of type I.4401 and/or A4 and/or of type I.4301 and/or A2. In this case the high hardness in the forward region of the expansion sleeve may preferably be achieved by rolling. If, alternatively, a CS steel is used for the expansion sleeve, the high hardness in the forward region may be obtained, for example, by induction hardening.

According to the invention the expansion sleeve is forced radially outwards by the tapering surface of the expansion cone and his pressed against the borehole wall in the substrate when the expansion cone is displaced axially relative to the expansion sleeve in the extraction direction of the stud. The expansion anchor is thereby anchored in the borehole. The extraction direction is preferably disposed parallel to the longitudinal axis of the stud, and/or points out of the borehole. Advantageously, the distance of the surface of the expansion cone from the longitudinal axis of the stud increases oppositely to the extraction direction, that is, with increasing distance from the load-absorption means. The surface of the expansion cone may be strictly conical but does not need to be.

In the case of a so-called stud anchor, the expansion cone may be arranged in a fixed manner on the stud. The expansion cone is then pulled into the expansion sleeve by a common axial movement of the stud and the expansion cone relative to the expansion sleeve. In this case the expansion cone is preferably formed integrally with the stud. Alternatively, in a so-called sleeve anchor, the expansion cone may be a part separate from the stud and preferably connected to the stud by means of corresponding threads. The expansion cone may then be pulled into the expansion sleeve, preferably at least partially, by rotation of the stud relative to the expansion cone, which rotation is converted into an axial movement of the expansion cone relative to the stud by a spindle drive formed by the corresponding threads.

The expansion sleeve preferably has at least two expansion segments which are connected to one another via a web. In particular, it may then be provided that at least one of the expansion segments has a hardness greater than 350 HV in the region of its forward end, the hardness of the expansion segment decreasing in the direction of the rear end of the expansion segment. The expansion sleeve may also have three or more expansion segments. The expansion anchor may also have more than one expansion sleeve and correspondingly more than one expansion cone.

It is especially preferred that the expansion sleeve has a hardness greater than 350 HV and less than 500 HV in the region of its forward end oriented towards the expansion cone. This embodiment takes account of the fact that, with hardnesses above 500 HV, the sleeve material becomes very brittle, and that a practicable expansion of the expansion sleeve can then frequently no longer be achieved.

Advantageously, it may be provided that the expansion sleeve has a hardness of less than 340 HV, preferably less than 300 HV, at least in a rearward region. As already explained above, a relatively lower hardness in the rearward region may, among other advantages, enable an especially simple and reliable assembly of the expansion sleeve around the stud and especially good expansion behaviour, and the corrosion properties may be especially advantageous. Said rearward region, which has a hardness of less than 340 HV or 300 HV, may preferably be further removed from the expansion cone than the forward region in which the hardness is greater than 350 HV. Preferably, said rearward region, which has a hardness of less than 340 HV or less than 300 HV, may overlap axially with a web of the expansion sleeve, that is, it may, in particular, be located at least partially in the so-called connection region which serves to fix the expansion sleeve to the stud. In this connection region, a hardness of less than 340 HV, in particular less than 300 HV, may be advantageous, since this region is frequently heavily deformed as the expansion sleeve is wound around the stud. The expansion sleeve may appropriately have in the web a hardness of less than 340 HV, in particular less than 300 HV. The web described in this paragraph may be, in particular, a web which connects two expansion segments.

Because the contact between expansion sleeve and borehole wall in the expanded state of the expansion anchor frequently takes place only in the most forward 3 to 5 mm of the expansion sleeve, the forward region, in which the hardness is greater than 350 HV, may preferably have a length in the axial direction of less than 10 mm.

It is further advantageous if the wall thickness of the expansion sleeve decreases, at least in some regions, in the direction of its forward end. The expansion behaviour can thereby be still further improved. The expansion sleeve preferably has a narrowed region in which the wall thickness of the expansion sleeve decreases towards its forward end, and an adjoining rearward region with a substantially constant wall thickness, the hardness in the narrowed region advantageously being, at least zonally, greater than 350 HV and/or the hardness in the region with substantially constant wall thickness is, at least zonally, less than 340 HV, in particular less than 300 HV. This is especially advantageous with regard to production, since the reduced wall thickness and increased hardness in the narrowed area can be produced simultaneously in one rolling step.

In particular, it may be provided that the expansion sleeve has at least one expansion slit. The expansion slit may separate two adjacent expansion segments, and/or the web may be formed in the axial prolongation of the expansion slit. The expansion slit starts from the forward end of the expansion sleeve and can facilitate the deformation of the expansion sleeve.

According to the invention, the stud may have a load-absorption means which may be in the form, in particular, of an external thread or an internal thread. The load-absorption means serves to induce tensile forces directed in the extraction direction into the stud. Advantageously, the expansion cone is arranged in a first end region of the stud and the load-absorption means in an opposite, second end region of the stud. In particular, the direction vector of the extraction direction may be oriented from the expansion cone to the load-absorption means.

The invention may preferably be used with stud anchors in which the expansion sleeve does not extend as far as the borehole mouth. In particular, the stud may in this case have a stop which limits displacement of the expansion sleeve away from the expansion cone, that is, displacement in the extraction direction. Such a stop may ensure, in an especially simple manner, that the expansion sleeve reliably penetrates the borehole together with the stud. The stop is preferably an annular shoulder, which can be advantageous with regard to production and to reliability. In particular, the stop is arranged axially between the expansion cone and the load-absorption means.

The invention also relates to a production method in which an expansion anchor according to the invention is obtained. With this method the hardness greater than 350 HV in the region of the forward end of the expansion sleeve is generated in a rolling step. By using such a rolling step, the narrowed region of the expansion sleeve and the hardness greater than 350 HV can be generated at the same time. In particular, it may be provided that in the rolling step a rolling tool is used which has an axis of rotation disposed parallel to the at least one expansion slit and/or to the subsequent longitudinal axis of the expansion anchor and/or to the subsequent longitudinal axis of the expansion sleeve.

The invention is explained in more detail below with reference to preferred exemplary embodiments which are represented schematically in the appended Figures; within the scope of the invention, individual features of the exemplary embodiments shown below may in principle be implemented singly or in any combination. In the Figures:

Fig. 1 shows schematically in a partial longitudinal section a view of an expansion anchor according to the invention set in a concrete substrate;

Fig. 2 shows schematically an unwound view of the outer side of the expansion sleeve of the anchor of Fig. 1;

Fig. 3 shows schematically a longitudinal sectional view B-B through the expansion sleeve of Fig. 2 and, below it, the hardness progression along the section; and

Fig. 4 shows schematically a partial longitudinal sectional view of an expansion anchor according to the invention in a second embodiment set in a concrete substrate.

Figs. 1 to 3 show an exemplary embodiment of an expansion anchor 1 according to the invention. As shown, in particular, in Fig. 1, the expansion anchor 1 comprises a stud 10 and an expansion sleeve 20 annularly surrounding the stud 10. In the region of its forward end 51, the stud 10 has an expansion cone 12 for the expansion sleeve 20 with a neck region 11 permanently adjoining the expansion cone 12 at the rear.

In the neck region 11 the stud 10 has a substantially constant cylindrical cross section. On the adjoining expansion cone 12, the surface of the stud 10 is configured as a tapering surface along which the diameter of the stud 10 increases towards the first end 51; that is, the stud 10 widens along the expansion cone 12, starting from the neck region 11, toward its forward first end 51. The tapering surface 13 on the expansion cone 12 may be conical in the strict mathematical sense, but does not need to be.

On the side of the neck region 11 oriented away from the expansion cone 12 the stud 10 has a stop 17, for example in the form of an annular shoulder, for the expansion sleeve 20. In the region of its rearward end 52, the stud has a load-absorption means 18, configured in this example as an external thread, for inducing tensile forces into the stud 10. A nut 8 is mounted on this external thread.

As the expansion anchor 1 is set, the stud 10 is pushed, with its first end 51 leading, in the direction of the longitudinal axis 100 of the stud 10, into a borehole 99 in the substrate 5 of Fig. 1. Because of the stop 17, which limits displacement of the expansion sleeve 20 away from the expansion cone 12, the expansion sleeve 20 is also inserted in the borehole 99. The stud 10 is then pulled a short distance out of the borehole 99, for example by tightening the nut 8, in the extraction direction 101 disposed parallel to the longitudinal axis 100. As this happens, because of the friction against the substantially cylindrical wall 98 of the borehole 99, the expansion sleeve 20 is held back in the borehole 99 and the stud 10 is consequently displaced relative to the expansion sleeve 20. As this displacement occurs, the tapering surface 13 of the expansion cone 12 of the stud 10 penetrates more and more deeply into the expansion sleeve 20, so that the expansion sleeve 20 is widened radially by the tapering surface 13 in the region of its forward end 29, and is pressed against the wall 98 of the borehole 99. By means of this mechanism, the expansion anchor 1 is fixed in the substrate 5. The set state of the expansion anchor 1, in which it is fixed in the substrate 5, is shown in Fig. 1. An attachment part 6 may be fixed to the substrate 5 by means of the nut 8.

As can be seen, in particular, in Fig. 2, the expansion sleeve 20 comprises three expansion segments 21', 21", 21'", adjacent expansion segments 21 being partially separated from one another by expansion slits 22', 22". The expansion slits 22 start from the forward end 29 of the expansion sleeve 20, that is, from the end side thereof the oriented towards the expansion cone 12. In the prolongation of the expansion slits 22', 22", respective webs 23', 23" are formed, the webs 23 each connecting two adjacent expansion segments 21 to one another.

As shown, in particular, in Fig. 3, the expansion segments 21 of the expansion sleeve 20 each have, in particular in longitudinal section, a region 27 with substantially constant wall thickness. Adjoining this region 27 with substantially constant wall thickness at the front, in particular in longitudinal section, is a narrowed region 28, in which the wall thickness of the expansion segment 21 decreases towards the forward end 29.

As Fig. 3 further shows, the hardness of at least one of the expansion segments 21 in its rearward region 27 with substantially constant wall thickness is - at least in some regions, in particular level with the web 23 in the axial direction - below 340 HV and preferably below 300 HV. The hardness in this section is preferably between 200 HV and 300 HV, in particular approximately 250 HV. From there, the hardness increases towards the forward end 29 of the expansion segment 21 and reaches a hardness greater than 350 HV, in particular between 350 HV and 500 HV, in the narrowed region 28, in particular in the most forward 3 to 5 mm thereof.

In the exemplary embodiment of Fig. 1, the expansion anchor 1 is in the form of a so-called stud anchor. A further exemplary embodiment, in which the expansion anchor 1 is in the form of a so-called sleeve anchor, is shown in Fig. 4. In contrast to the stud anchor of Fig. 1, in which the expansion cone 12 is provided in an axially fixed manner on the stud 10 and, in particular, is formed integrally with the stud 10, in the sleeve anchor of Fig. 4 the expansion cone 12 is a part separate from the stud 10. It has an internal thread which corresponds to an external thread on the stud 10. In addition, in the sleeve anchor of Fig. 4, the expansion sleeve 20, which may also have multiple parts, extends as far as the borehole mouth, and at the rearward end of the stud 10 a widened head 88 is arranged non-rotatably on the stud 10.

In order to set the anchor of Fig. 4, the stud 10 is set in rotation about the longitudinal axis 100 by means of the head 88. The corresponding threads convert this rotary motion of the stud 10 into an axial movement of the expansion cone 12 relative to the stud 10 and therefore relative to the expansion sleeve 20, causing the expansion cone 12 to be pulled into the expansion sleeve 20.

According to the invention, the hardness profile of the expansion sleeve 20 of the sleeve anchor of Fig. 4 is configured correspondingly to that of Fig. 3, although with a sleeve anchor according to Fig. 4 the lower-strength rearward region 27 with substantially constant wall thickness is generally axially longer than is shown in Fig. 3.

<u>**Patentkrav**</u>

1. Ekspansionsanker (1) med
- en bolt (10) og
- et ekspansionshylster (20), som omgiver bolten (10),
- hvor der på bolten (10) er anbragt en ekspansionskonus (12), som udvider ekspansionshylsteret (20) radialt, når den trækkes ind i ekspansionshylsteret (20),

kendetegnet ved,
at ekspansionshylsteret (20) i området ved dets forreste ende (29), der vender mod ekspansionskonussen (12), har en hårdhed, der er større end 350 HV, hvor ekspansionshylsterets (20) hårdhed aftager mod ekspansionshylsterets (20) bagerste ende.

2. Ekspansionsanker (1) ifølge krav 1,
kendetegnet ved,
at ekspansionshylsteret (20) i området ved dets forreste ende (29), der vender mod ekspansionskonussen (12), har en hårdhed, der er større end 350 HV og mindre end 500 HV.

3. Ekspansionsanker (1) ifølge et af de foregående krav,
kendetegnet ved,
at ekspansionshylsteret (20) i mindst et område bagtil, som fortrinsvis aksialt overlapper med et stykke (23) af ekspansionshylsteret (20), har en hårdhed, der er mindre end 340 HV, fortrinsvis mindre end 300 HV.

4. Ekspansionsanker (1) ifølge et af de foregående krav,
kendetegnet ved,
at ekspansionshylsterets (20) vægtykkelse i det mindste områdevis aftager hen mod dets forreste ende (29).

5. Ekspansionsanker (1) ifølge et af de foregående krav,
kendetegnet ved,
at ekspansionshylsteret (20) har mindst en ekspansionsslids (22).

6. Ekspansionsanker ifølge et af de foregående krav,
kendetegnet ved,
at bolten (10) har en lastoptagelsesindretning (18), især et gevind, som er egnet til indføring af trækkræfter i bolten (10).

7. Ekspansionsanker ifølge et af de foregående krav,
kendetegnet ved,
at bolten (10) har en stopper (17), eksempelvis en ringskulder, som begrænser en forskydning af ekspansionshylsteret (20) væk fra ekspansionskonussen (12).

8. Fremstillingsfremgangsmåde, ved hvilken der tilvejebringes et ekspansionsanker ifølge et af de foregående krav, og ved hvilken hårdheden fremstilles større end 350 HV i området ved ekspansionshylsterets (20) forreste ende i et valsetrin.

Fig. 1

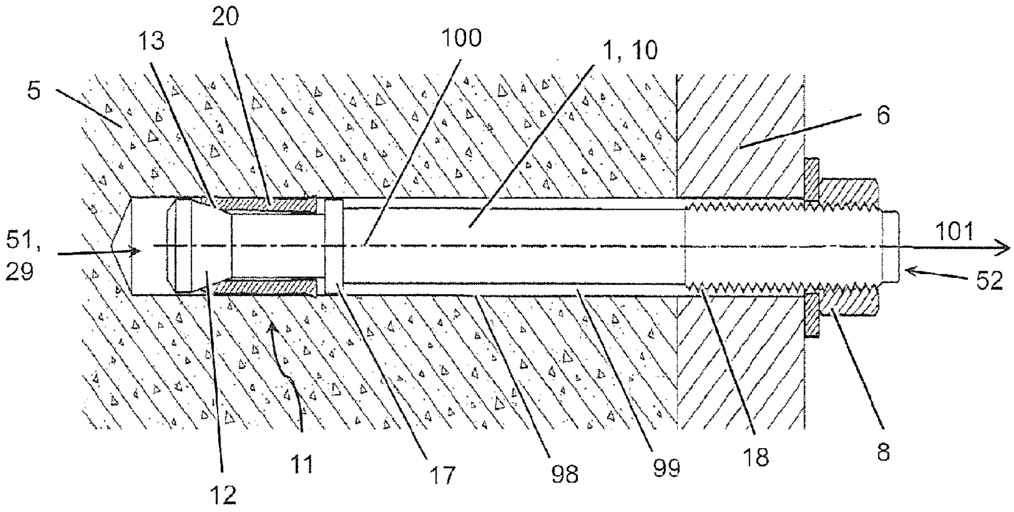

20
13
100
1, 10
5
6
51,
29
101
52
11
12
17
98
99
18
8

Fig. 2

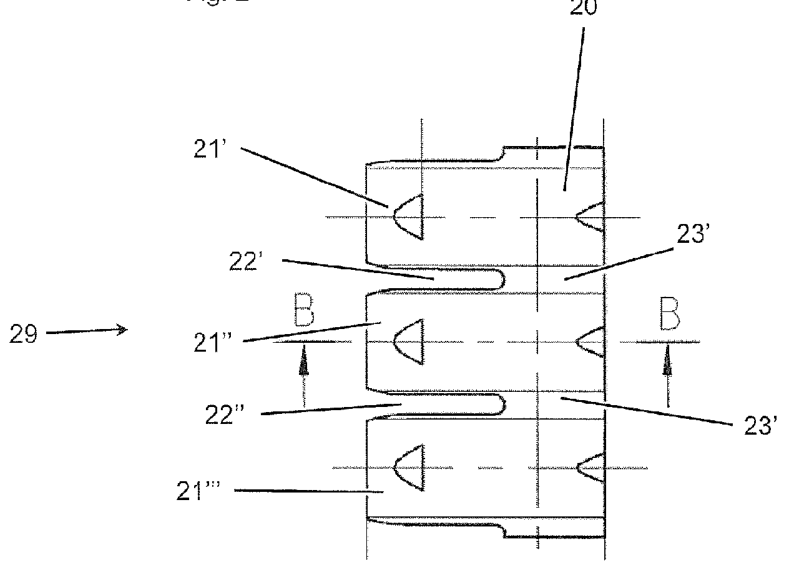

20
21'
23'
22'
29
21''
B
B
22''
23'
21'''

Fig. 3

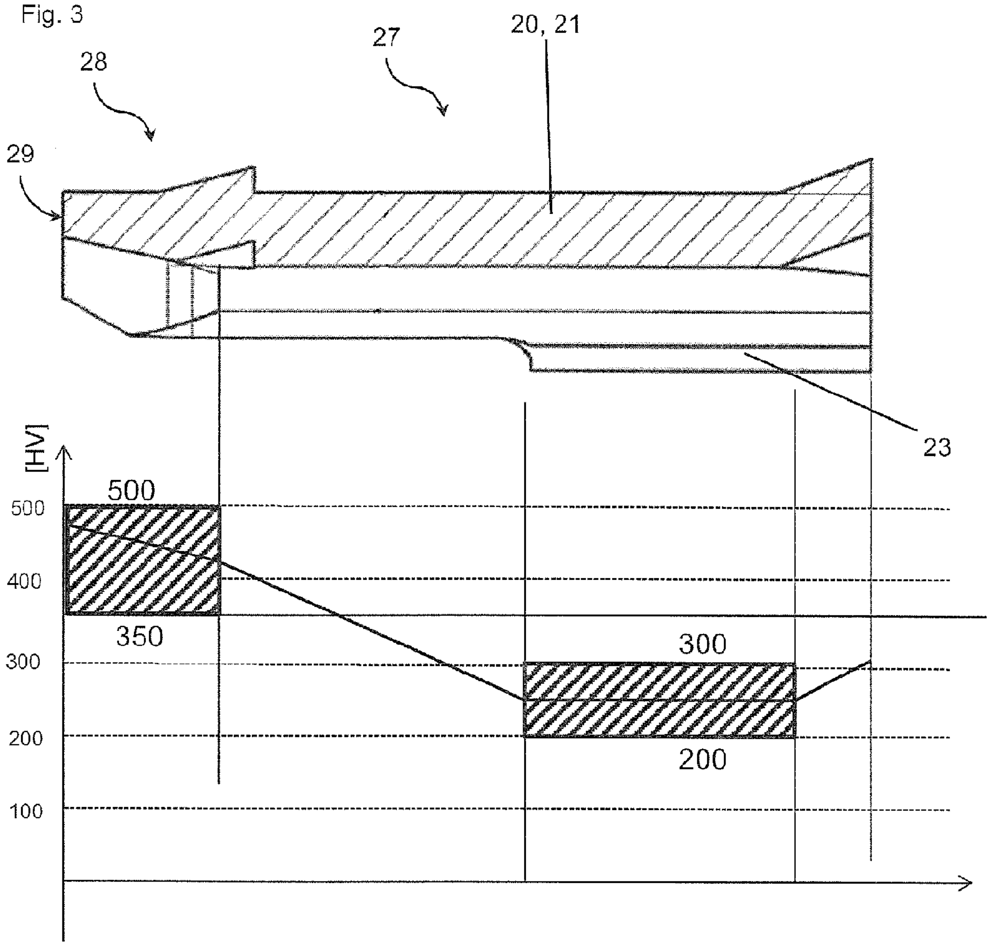
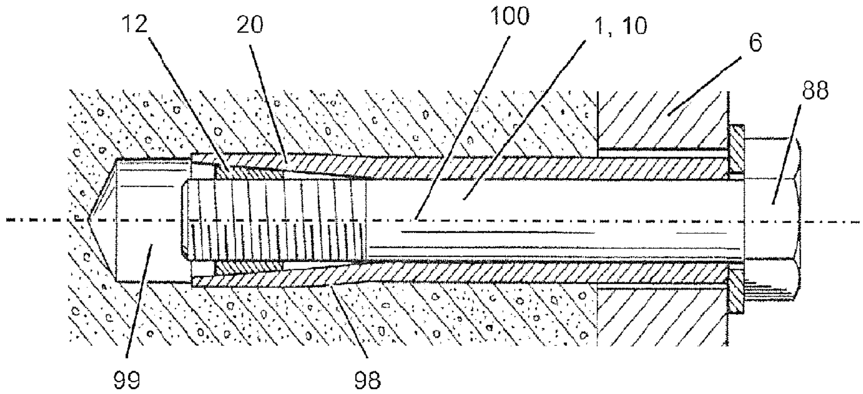

28
27
20, 21
29
23
[HV]
500
400
300
200
100
500
350
300
200

Fig. 4


12
20
100
1, 10
6
88
99
98