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Mill rollers and abrasion resistant surface coatings for mill rollers

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(62) Divisional of:
199858482

(71) Applicant(s)
The Track Shop Pty Ltd

(72) Inventor(s)
Timothy Stuart Falkenhagen

(74) Agent/Attorney
Ahearn Fox,GPO Box 1149,BRISBANE QLD 4001

(56) Related Art
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ABSTRACT

A sugar mill roller including a roller body of substantially circular cross-section having a plurality of circumferentially running machined ridges formed to be substantially parallel and spaced along a substantial part of the roller body, each machined ridge including one or more land portions, and a ridge capping on one or more of the land portions, each ridge capping including a plurality of layers of weld supporting therein a wear resistant material.

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COMPLETE SPECIFICATION FOR A PETTY PATENT

Name of Applicant:	THE TRACK SHOP PTY LTD
Actual Inventor(s):	TIMOTHY STUART FALKENHAGEN
Address for Service:	AHEARNS Patent & Trade Mark Attorneys, GPO Box 1149 Brisbane, Queensland, 4001
Invention Title:	**"MILL ROLLERS AND ABRASION RESISTANT SURFACE COATINGS FOR MILL ROLLERS"**

The following statement is a full description of this invention, including the best method of performing it known to us:

"MILL ROLLERS AND ABRASION RESISTANT SURFACE COATINGS FOR MILL ROLLERS"

TECHNICAL FIELD

THIS INVENTION relates to mill rollers and abrasion resistant surface coatings for mill rollers and has particular application to sugar mill rollers, and for illustrative purposes, reference will be made to such application. However, it is to be understood that this invention could be used in other applications where mill rollers would be improved by having abrasion resistant surface coatings applied thereto.

BACKGROUND ART

In the sugar industry, sugar cane is typically crushed between rollers arranged for rotation about parallel axes in pairs or in groups of three or more. Generally, each roller has a plurality of machined ridges extending circumferentially around the roller thereby forming a surface of alternate ridges and valleys. The valleys or grooves are typically evenly spaced along the roller. The grooved arrangement provides for gripping of the sugar cane fibre as it passes between the rollers, the groove of an upper roller being operatively aligned with the ridges on its opposing lower roller or rollers. The grooves are generally V-shaped in cross-section separated by ridges which are of generally triangular cross-section. This arrangement of grooves and channels has occasionally been referred to in the art as "meschaert" grooves.

British Patent No. 2,025,260 addresses the problem of rollers wearing smooth by providing an assertion that rings of corrosion resistant material, with a granular material, such as industrial diamonds or a mixture of tungsten carbide and cobalt

may be provided. This specification teaches that industrial diamonds may be coated onto the rings by a galvanic process.

In the art generally, there is usually a gap provided between the apex of each ridge on one roller and the bottom of each groove on an adjacent roller, the gap being provided to receive the sugar cane juice squeezed from the sugar cane. The resulting mat of sugar cane fibres (known as bagasse) has a tendency to slip around the roller if there is insufficient grip on the roller surface.

A sugar mill roller is usually constructed as a cast iron roller mounted on a shaft and turned by a belt, chain, direct drive or other such drive means. Wear resistant material has on occasion been provided on the caps of the ridges of grooved rollers, but only at intermittent locations around the circumference of the roller. This approach has been taken partly because it was believed that the intermittent application of the abrasion resistant material, in what is often termed a "dot-dash" arrangement, produced the best gripping surface for the milling of sugar cane. Typically, conventional hardfacing matrix is used, including, for example, high speed steels, austenitic manganese steels, austenitic high chromium irons, cobalt or copper based alloys, or nickel-chromium-boron alloys according to the practices set forth in Jones, F D, & Horton, H L, Machinery's Handbook, ISBN 0-8311-1155-0. In applications other than sugar mill rollers, it has been an option for abrasion resistant material such as chips of tungsten carbide to be laid up in the matrix to form a hardfacing composite using the hardfacing materials listed in this reference or in mild or stainless steel

weld. More recently, chromium carbide hardfacing has been applied as a relatively thin layer of hardfacing onto the tips of the ridges and particularly in a dot-dash arrangement on sugar mill rollers, but for sugar mills rollers, hardfacing composites have not been used because it has been too difficult to place the weld on the tips of the ridges.

After a period of use, sugar mill rollers require refurbishment due to the hardfacing wearing smooth, causing slippage of the bagasse between the rollers. Accordingly, in order to refurbish such a roller according to traditional technology, the entire roller is removed from the mill, broken up and recast into a new roller.

This approach is costly in terms of replacing the entire roller and requires a significant downtime for the sugar mill in having the roller removed and replaced. There are also costs for heavy transport for removing such rollers from and delivering such rollers to site.

It is an object of the present invention to provide a hardfacing for a mill roller, particularly a sugar mill roller, which provides for superior grip onto the material being milled. It is another object of the present invention to provide hardfacing for a mill roller, particularly a sugar mill roller, which has improved wear characteristics. It is a further object of the present invention to provide a hardfacing gripping surface for a sugar mill roller which substantially retains its gripping characteristics throughout its life cycle. It is a further object of the present invention to provide a sugar mill roller which lasts longer than traditional sugar mill rollers and/or is more

economical to refurbish.

It is generally an object of the present invention to provide a mill roller having a wear resistant surface and a method of forming same which will be reliable and efficient in use. Other objects and advantages of the present invention may become apparent from the following description of the invention.

DISCLOSURE OF INVENTION

With the foregoing in view, this invention in one aspect resides broadly in a sugar mill roller including:

a roller body of substantially circular cross-section having a plurality of circumferentially running machined ridges formed to be substantially parallel and spaced along a substantial part of said roller body, each said machined ridge including one or more land portions, and a ridge capping on said one or more land portions, each said ridge capping including a plurality of layers of weld supporting therein tungsten carbide particles.

Preferably, each machined ridge includes two or a multiple of two land portions, separated by a wall portion and one or more of the layers of weld are supported on respective ones of the land portions against the wall portion. A land may also be considered to be provided atop the uppermost wall portion. It is further preferred that the roller body be formed of grey cast iron, and the ridge capping includes a first layer of stainless steel weld. The first layer preferably includes no wear resistant material. The stainless steel first layer is preferably 309 stainless steel. The layers of weld forming the ridge capping are preferably a hardfacing composite as described below.

Preferably, the weld is applied by inert gas shielded arc

welding, such as, for example, metal inert gas (mig) welding or tungsten inert gas (tig) welding, characterised in that the weld pool first applied to the or each land portion is formed from a stainless steel welding rod without any wear resistant material added thereto and the successive layers are formed from a mild steel welding rod used to form respective weld pools impinged with a particulate wear resistant material, until a ridge capping of desired profile is formed substantially all the way round the roller, the process being repeated for each ridge.

The hardfacing is preferably formed as a hardfacing composite by impinging the particulate wear resistant material into the weld pool, allowing the weld pool to solidify, and progressively laying up successive layers of said hardfacing as hereinbefore described.

In another aspect, this invention resides broadly in a method of applying hardfacing to a sugar mill roller, the method including:

providing a roller body of substantially circular cross-section;

machining a plurality of circumferentially running ridges on said roller body, said ridges being substantially parallel and axially spaced along a substantial part of said roller body, each said ridge including one or more land portions, and

on each said ridge, forming a weld matrix on the or each innermost land portion by successively applying weld on the previous layer until a ridge capping of desired profile is formed substantially all the way round said roller body, at least some of said layers of weld having particulate wear resistant material

supported therein.

Preferably, the method includes machining a wall portion on each said ridge so as to provide one or more land portions on each side of the wall portion, and applying weld against each side of the wall portion in successive layers until the height of the wall portion is substantially reached. It is further preferred that the method includes applying one or more further layers of weld to each respective ridge to substantially encapsulate said wall portion.

Preferably, the weld is applied by metal inert gas (mig) welding or tungsten inert gas (tig) welding, characterised in that the weld pool first applied to the or each innermost land portion is formed from a stainless steel welding rod without any wear resistant material added thereto and the successive layers are formed from a mild steel welding rod used to form the respective weld pools impinged with a particulate wear resistant material, until a ridge capping of desired profile is formed substantially all the way round each ridge.

In another aspect, this invention resides in a sugar mill roller including a roller body formed in accordance with the method as hereinbefore described.

In another aspect, this invention resides broadly in a roller assembly including:-

a mounting shaft;

a plurality of shell portions, each said shell portion being mountable to said mounting shaft and shaped for abutment together to form a roller cap;

each said shell portion having an outer perimeter and an

inner diameter of a dimension permitting tight engagement of said roller cap onto said mounting shaft, and

a hardfacing capping applied to the outer perimeter of each said shell portion.

The roller caps may have a substantially smooth outer surface for receiving the hardfacing, but preferably, the roller caps include a plurality of grooves extending circumferentially about the outer perimeter as hereinbefore described.

The roller cap may include shell portions connectible to form an annular shell element, or be comprised of a unitary annular shell element, each of a plurality of shell elements being abuttable to one another to form the roller assembly.

In sugar milling applications, the ridge profile is generally between 15 mm and 80 mm pitch, but more commonly, either 25 mm, or 37.5 mm, or 50 mm pitch. The wall portion is of a suitable thickness to perform as a dam preventing the weld from falling onto the other land area. The combination of application of weld layers is adapted to produce a weld profile which when solidified is of substantially triangular cross-section.

The combination of welding torch angle, pre-machined roller ridge profile, rotational speed of the roller (weld surface speed), raw materials, preheat and specific welding consumables provides the finished profile for a sugar mill roller to be used in an as-welded condition. The weld is preferably applied whilst the roller is rotated with its longitudinal axis in the horizontal plane.

In a further preferred form of the sugar mill roller, the roller cap includes fixing means for fixing to the mounting

shaft. For example, where the roller cap is in the form of arcuate segments, pairs of semi-circular sectional pieces or triplets each having segments with internal radii at 120°, and so forth may be provided. The segments are abuttable to form a roller end cap which is removable and replaceable on the mounting shaft to form the sugar cane roller. The mounting shaft is adapted suitably to receive the segments by provision of complementary fixing means operatively engagable with the fixing means on the respective segments.

The fixing means may for example include one or more flange portions disposed circumferentially about the internal arc of circumference and at each respective end of each roller cap. Each flange portion may further include an aperture extending therethrough in a coaxial direction and through which fastening means, such as a bolt, screw or such like may be passed to fasten the roller cap to the mounting shaft through corresponding apertures on the mounting shaft.

Preferably, however, a collar or sleeve with a flattened portion extending axially along its entire length is provided, the collar being adapted to fit on the shaft and receive the hard-faced shells which include a complementary internal land on their respective internal bores. The roller end caps are fixed, such as by bolting, onto the ends of the collar.

Preferably, the wear resistant hardfacing is made by using ARM-2 weld wire as manufactured and supplied by Abrasion Resistant Materials Pty Ltd, at a suitable current, typically 200 to 260 amps, and a suitable electrical potential, typically 22 to 26 volts in a mig atmosphere at a linear rate sufficient to

coat the required net area required for the weld. This weld wire conforms to BS2901 Part 1 1970A18 and AWS A5.18 E70S-6.

The tungsten carbide grit may be added into the molten weld pool during the welding process, by any suitable means, and is preferably to mesh size 12/35.

It has been surprisingly found that abrasion resistant hardfacing material provided as described above provides a superior gripping surface for sugar cane milling. Moreover, experimental trials of the hardfacing of the present invention have shown that the grip sometimes even improves with use, and this is believed to be due at least in part to the acidic juices in sugar cane juice preferentially eroding away part of the weld matrix, thus providing a more pronounced profile of the hard tungsten carbide grit particles which key into the bagasse fibre mat upon contact. There is also believed to be a contribution to the erosion from frictional wear of the bagasse on the weld matrix.

Where the shell portions are provided in arcuate portions, they are suitably connected circumferentially to form respective annular shells. Preferably, each shell portion includes a ridge profile as hereinbefore described.

In order that this invention may be more readily understood and put into practical effect, reference will now be made to the accompanying drawings which illustrate a preferred embodiment of the invention and wherein:-

Figs. 1 to 4 are diagrammatic sectional detail views of preferred embodiments of respective ridge profiles after application of hardfacing composite;

Fig. 5 is a diagrammatic sectional detail view of the ridge wear profile of Fig. 4 after a typical part cycle of use;

Fig. 6 is a diagrammatic collective representation of self-roughening of the wear profile of Figs. 1 to 4;

Fig. 7 is an exploded view of a hard-faced roller assembly mounted onto a bearing shaft;

Fig. 8 is an end view of the roller assembly of Fig. 7;

Fig. 9 is a section on A-A of Fig. 8 showing part of the roller assembly;

Fig. 10 is a diagrammatic sectional detail view of abrasion resistant material applied to caps of the grooves of the roller of Figs. 7 to 9, and

Fig. 11 is a diagrammatic sectional detail view of an alternative application of the abrasion resistant material of Fig. 10.

Referring to Figs. 1 to 4, the respective ridge profiles 23 are of a variety of shapes as shown. In Fig. 1, the ridge profile includes five land portions 29 above a base portion 24 separated from one another by two successive projections 25. The projections provide four wall portions 30. In Figs. 2 to 4, there are only three land portions and two wall portions, but in Fig. 3, there is a sloping wall portion 29a between the lower land portions and the adjacent wall portions.

In Figs. 1 to 4, weld material is represented by a triangle and dot fill pattern and the machined ridge profile by the cross hatching. It will be appreciated that in an actual ridge profile,

there will be some erosion of the machined ridge profile by the molten weld material and some intermingling of the material of the ridge profile and the weld whilst the metal is molten. It will also be appreciated that the actual profile of the weld pool after solidification would vary slightly from the circular arcuate sections shown diagrammatically in the relevant Figs.

It will be appreciated that the pre-machined profile shapes may vary from the preferred forms shown in Figs. 1 to 4, but for any profile, it is preferred that the ridge profiles 23 be substantially symmetrical. The ridge profile 23 shown in Fig. 2 is applicable to general applications, however, the ridge profile shown in Fig. 1 is preferred for larger pitch rollers. In each case, weld layers 1 to 9 are applied successively as required to the ridge profile 23.

It is believed that tungsten carbide dispersal throughout the matrix and multiple pass layer weld adhesion both to the roller and to each layer give an advantage to each of the ridge profiles 23 shown in Figs. 1 to 4. The combinations of layers numbered 1 to 9 in Fig. 1, 1 to 7 in Fig. 2, 1 to 9 in Fig. 3 and 1 to 5 in Fig. 4 are followed so that when the molten weld solidifies the final weld shape is of substantially triangular cross-section. The ridge profiles 23 described above have been applied to a standard grey cast iron roller, in spite of the expected difficulties in the relatively high carbon content of the cast iron affecting the re-welded profile by diffusion of carbon into the weld. Layers 1 and 4 in Figs. 1 to 3, or layers 1 and 2 in Fig. 3 are stainless steel "butter layers" first applied to the innermost land portions without any wear resistant

grit added.

Clearly, the dimensions could be proportioned up in scale to accommodate larger profiles of larger rollers. The larger pitch rollers would also need similar profiles machined in the ridges to achieve similar results. The ridge profile 23 in Fig. 1 is a minimum nine weld pass profile; the ridge profile 23 in Fig. 2 is a minimum seven weld pass profile, and the respective ridge profiles 23 in Figs. 3 and 4 are for a minimum seven or nine weld pass profile, or a minimum five weld pass profile respectively. The profile shown in Fig. 3 has been found to be of limited efficacy, though it is still believed to represent an advance on the prior art.

Although the successive beads of weld are generally applied in numerical order as given in the respective Figs., the order may be changed to, for example 1, 4, 2, 5, 3, 6 and then 7 in Fig. 2. A similar method may be applied to Figs. 1, 3 and 4 with successive beads of weld applied on alternate sides of the projection 25. Indeed, it may be convenient to place both "butter layers" first on the innermost land portions.

Referring to Fig. 5, the ridge profile 23 has worn down to a worn surface shown at 26, with more of the base portion 24 wearing than the cap portion 27. An undercut portion 28 has been found to form in experimental trials of the invention on milling of sugar cane after milling about one million tonnes of sugar cane.

Indeed, it has also been surprisingly and advantageously found that the wear resistant coating of the present invention increases its grip on the bagasse, since it appears that the

substrate in which the carbide is embedded partially wears away from the surface of the cap portion 27, exposing the angular grits of carbide material for gripping the bagasse. Moreover, it has been unexpectedly found that a sugar mill roller with hardfacing of the present invention applied thereto will last through an entire crushing season without requiring refurbishment.

As shown in Fig. 6, a sugar mill roller portion 40 has a ridge profile shown generally at 41. A hardfacing composition of the present invention is applied to the ridge tops shown typically at 42. A magnified portion 45 is shown in separate views at 51, 52, 53 and 54. The magnified portion includes a surface 46 of mild steel embedded with wear resistant tungsten carbide grits, some of which are exposed and shown typically at 47.

As the surface of the hardfacing wears, some of the grits 47 are broken away from the matrix, the original surface being shown in dotted outline at 48 in views 52, 53 and 54. The surface 46 wears or erodes away to expose new grits as shown at 50 in views 53 and 54.

Referring to Figs. 7, 8 and 9, a roller assembly 10 includes a plurality of roller shell sections, one of which is shown typically at 11 in Fig. 7, each mounted on a collar 18 which in turn is mounted on a shaft 12. In order to hold the roller shell sections 11 on the shaft 11 and collar 18, there are provided two respective end shell sections 13.

Each end shell section 13 and shell section 11 includes seven co-axial apertures shown typically at 15, the location of

which are better displayed in Fig. 8, where the respective apertures 15 have respective bolts inserted, as shown typically at 14. Each end of the collar 18 includes respective blind apertures shown typically at 17 which are threaded for receipt of the respective bolts 14. Each shell section 11 and end shell section 13 also includes a central bore 16 through which the shaft 12 is passed. The shell sections 11 include a land 19 which engages with a complementary key 20 on the collar 18 to prevent the shell sections 11 rotating on the collar 18.

Referring to Fig. 9, each end shell section 13 and shell section 11 includes a plurality of ridges shown typically at 21 and interposed therebetween, a plurality of grooves shown typically at 22 extending circumferentially about their respective outer perimeters.

Referring to Fig. 10, a portion of an end or centre shell section 13 or 14 is shown in sectional view. Each ridge 21 includes a ridge cap portion 31 upon which a plurality of abrasion resistant welds 33 are provided to provide an abrasion weld cap 32. In this embodiment, the grooves 22 are not capped with weld material.

Referring to Fig. 11, the ridges 21 and grooves 22 are provided with a plurality of abrasion resistant welds 33 in a similar fashion to those provided on the abrasion resistant weld cap 32 shown in Fig. 10. However, the entire surface of the ridges 21 and grooves 22 are provided with the abrasion resistant welds 33 to form an abrasion resistant weld coating 34.

The shape shown in Figs. 10 and 11 are very difficult to form any other way with inert-gas metal-arc (mig) carbide

hardfacing except by elevating the roller from the horizontal and inclining it on its longitudinal axis.

A clearer understanding of the method of the invention may be obtained from the following example in which a sugar mill roller was hardfaced and tested.

EXAMPLE

The rotating speed of roller to apply weld layers was in the range of from 21.7 mm to 22.3 mm per second for the butter layer weld and hardfacing layers. The rotating speed of roller to apply final capping weld was 19.35 mm to 20.02 mm per second. The welding torch angle was 18° from the vertical when applied to the uppermost (that is, horizontal) perimeter of the roller. This can also be varied up to 25° to weld the bottom layers in pre-machined ridge profile 23 as shown in Fig. 6.

The current was in a range of from 200 A to 300 A and the voltage from 22 V to 26 V on ARM - 1 and 2 wires. These wires are 0.9 mm wires which conform to BS2901 Part 1 1970A18 and AWS A5.18 E70S-6. The preheat temperature of the grey cast iron rollers was 100°C $\pm$ 5°C prior to welding. ARM 1 wire is mild steel and ARM 2 wire is 309L stainless steel.

A further technique may be utilised where ARM - 2 wire is used as a butter layer without ARM STD 1 tungsten carbide grit in the weld. Then ARM -1 wire with ARM STD 1 tungsten carbide grit is immediately welded onto the first butter layer weld bead and dilution of the first butter layer by the second layer creates a unique matrix and weld metallurgy. This affects weld bead shape and cooling characteristics and appear to affect the solidification (as opposed to melting) of the tungsten carbide

in the weld pool. This produces a superior bond to grey cast iron rollers and in particular reduces the problem of longitudinal underbead cracking in the heat affected zone.

Although it will be appreciated that the hardfacing composite may be applied to a solid roller in accordance with the present invention, in the case where a roller has a plurality of roller shell sections as shown in Fig. 7, those roller shell sections may be unbolted from the roller collar and replaced by replacement cylindrical portions. The worn out roller shell sections may be recycled by separating the hardfacing composites and the substrate according to any suitable process. On occasions, one or more shell sections of a roller may wear more than the remainder. In such a case, only the shell sections so worn need be replaced, reducing the cost of maintaining the roller, or alternatively, the shell sections may be rearranged to even out the wear.

It will of course be realised that the above has been given only by way of illustrative example of the invention and that all such modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of the invention as claimed in the following claims.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A sugar mill roller including:

a roller body of substantially circular cross-section having a plurality of circumferentially running machined ridges formed to be substantially parallel and spaced along a substantial part of said roller body, each said machined ridge including one or more land portions, and a ridge capping on said one or more land portions, each said ridge capping including a plurality of layers of weld supporting therein tungsten carbide particles.

2. A sugar mill roller according to Claim 1, wherein one or more of said layers are formed by adding the tungsten carbide particles to a molten weld pool of mild steel.

3. A sugar mill roller according to Claim 1 or Claim 2, wherein said roller body is formed of grey cast iron, and said ridge capping includes a first layer of stainless steel weld not having particles of tungsten carbide.

Dated this 29th day of August

THE TRACK SHOP PTY LTD

by their Patent Attorneys

AHEARN FOX

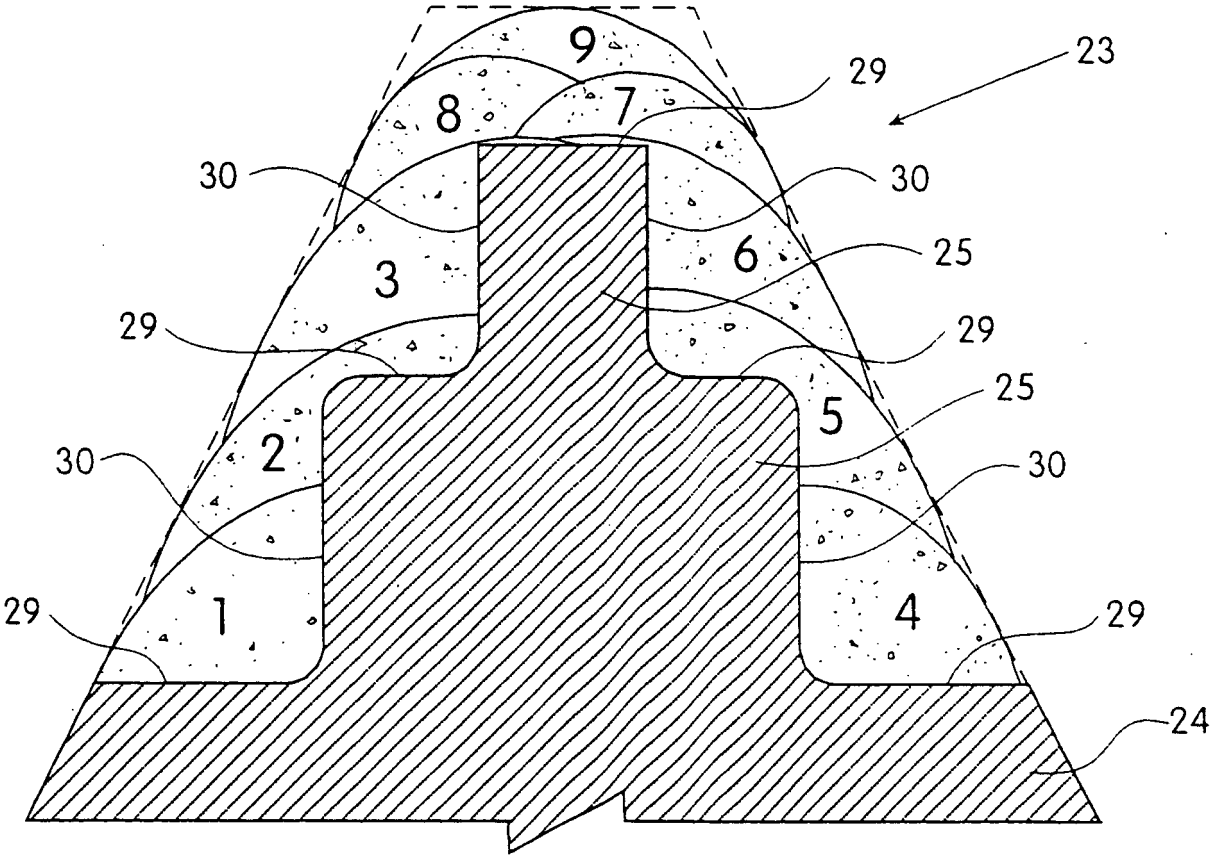

FIG. 1

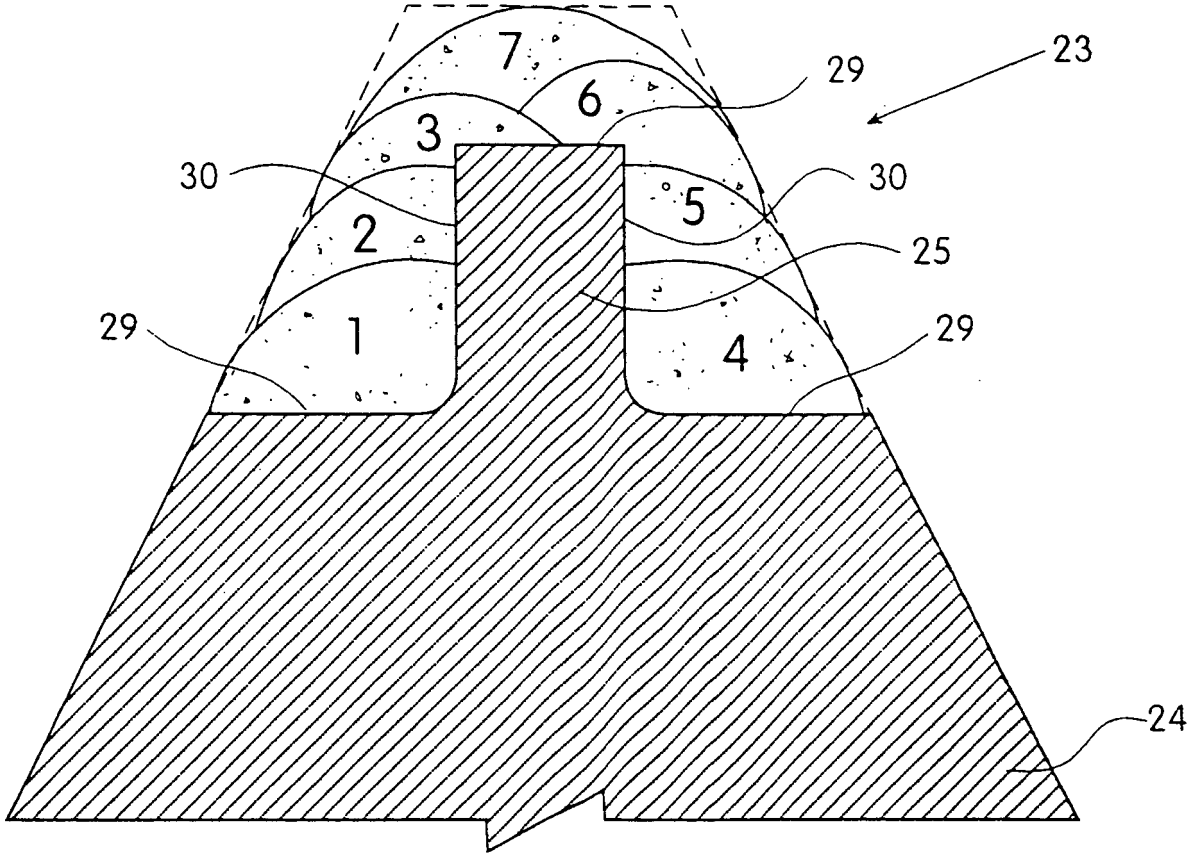

FIG. 2

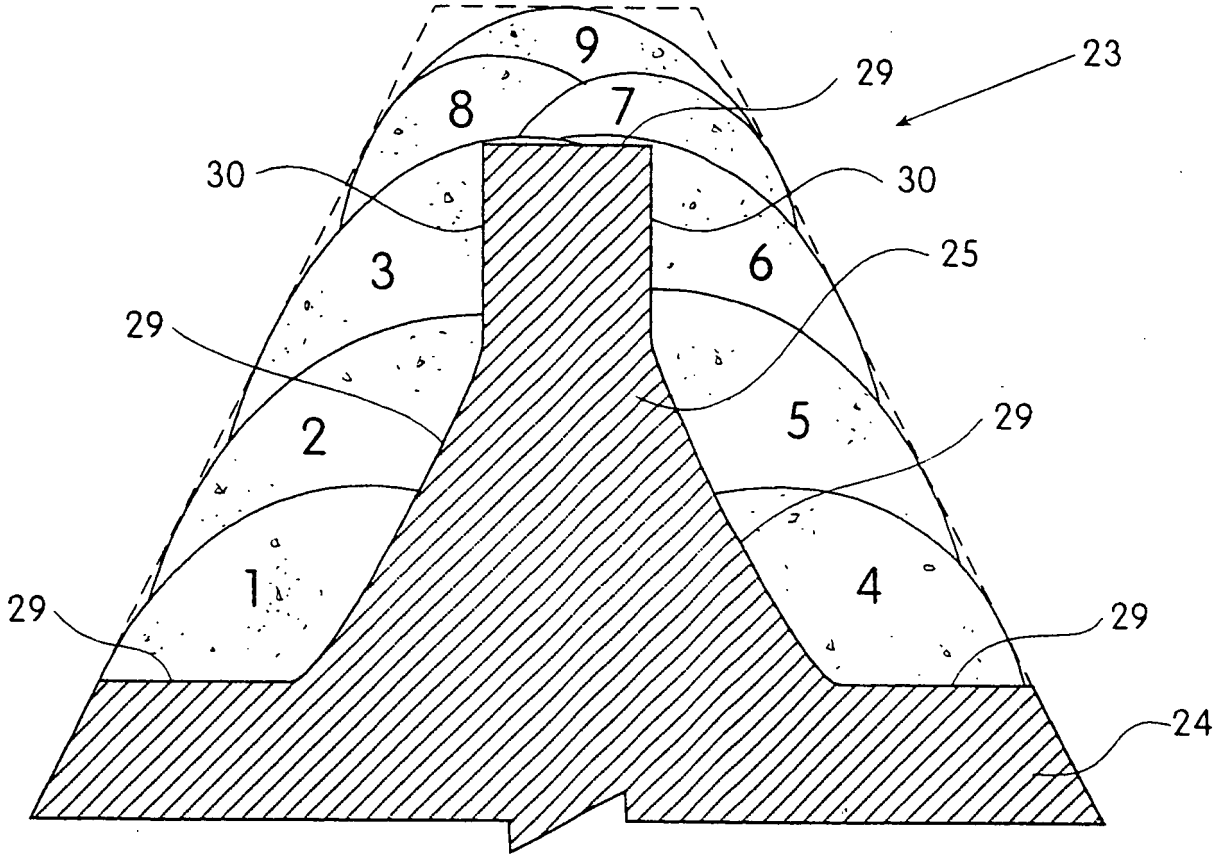

FIG. 3

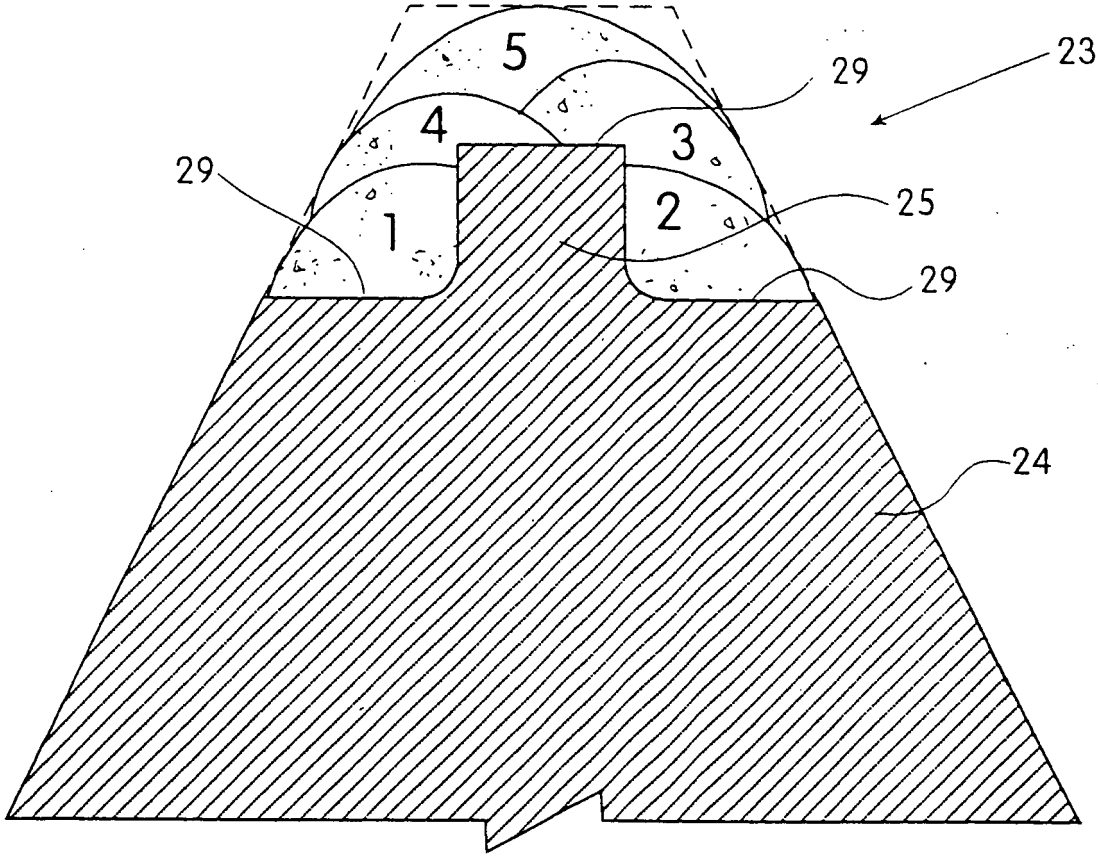

FIG. 4

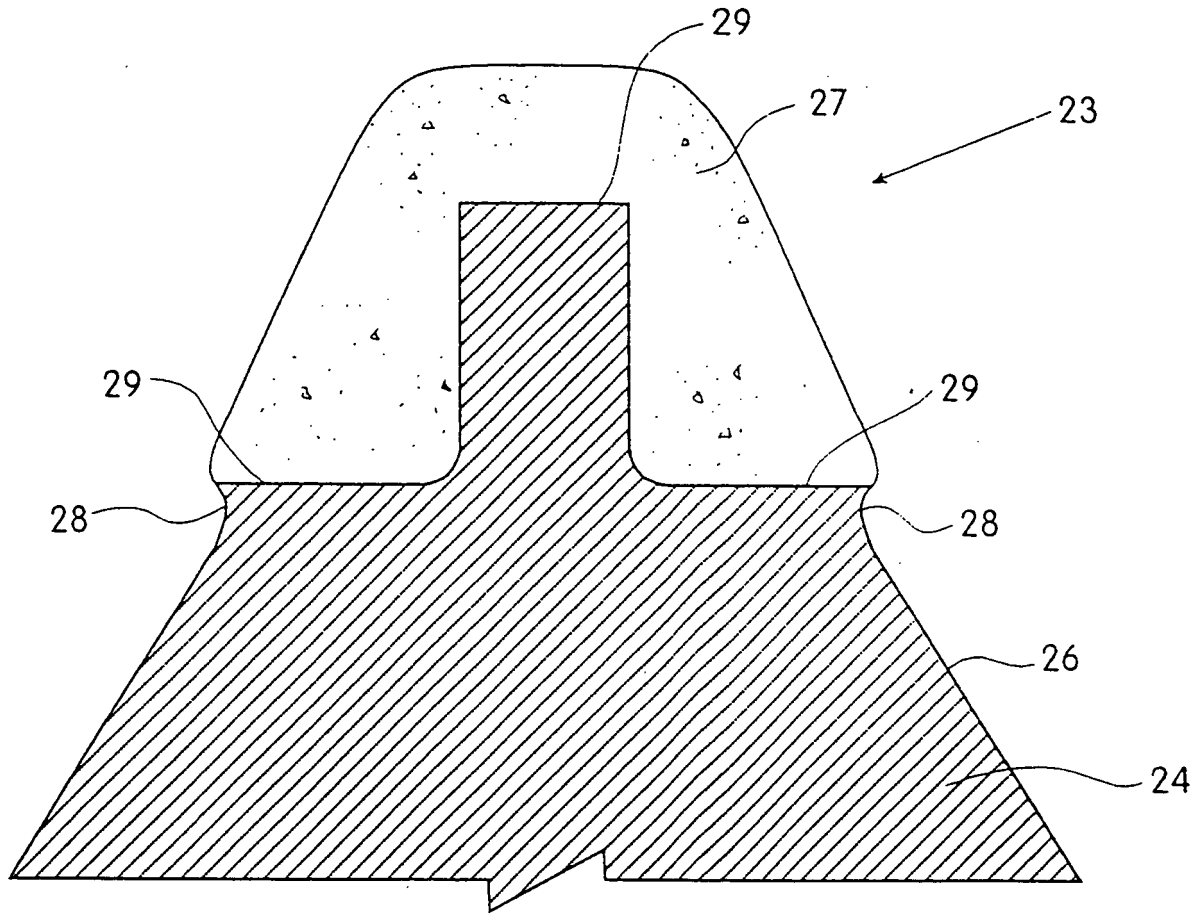

FIG. 5

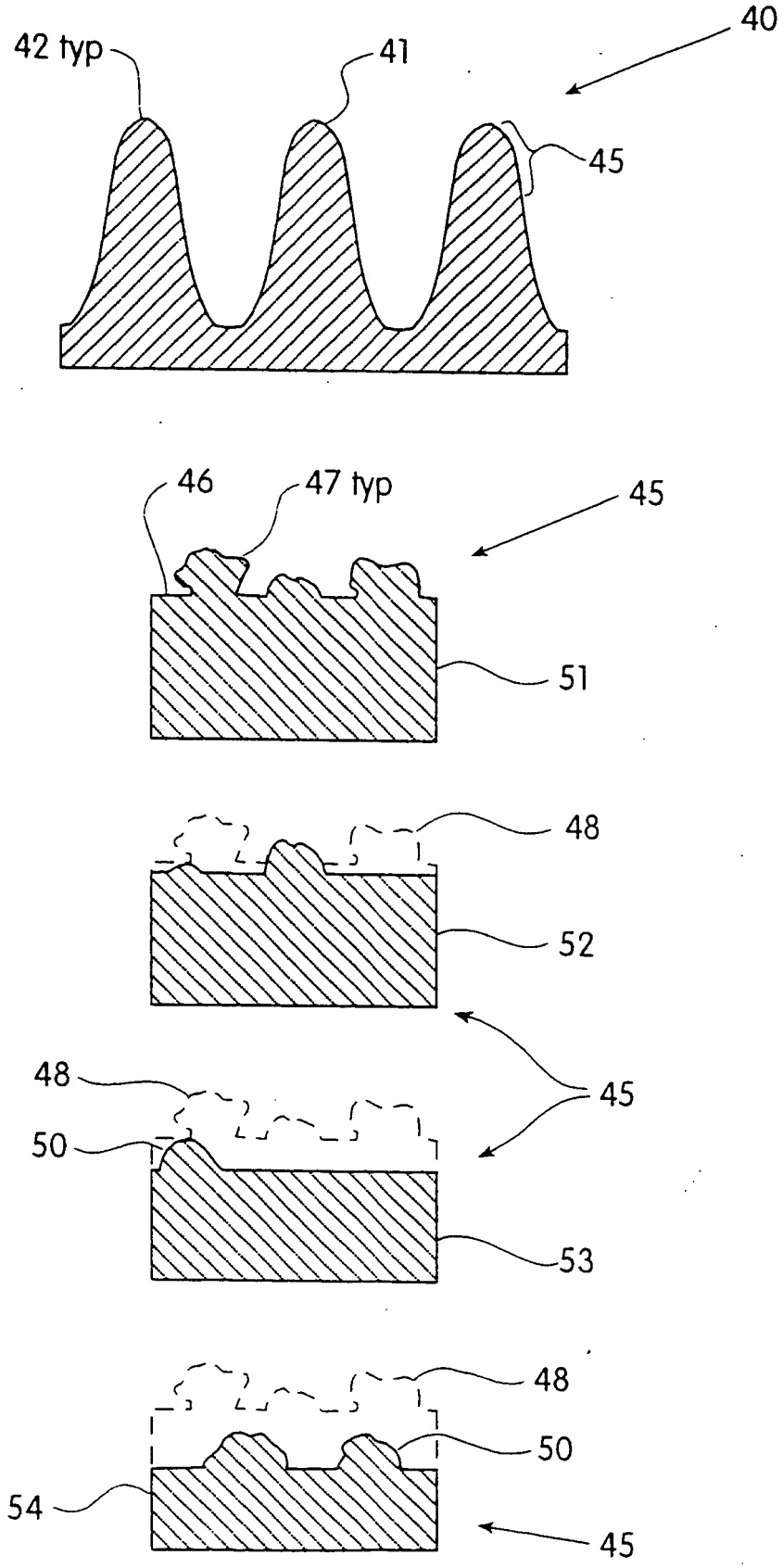

FIG. 6

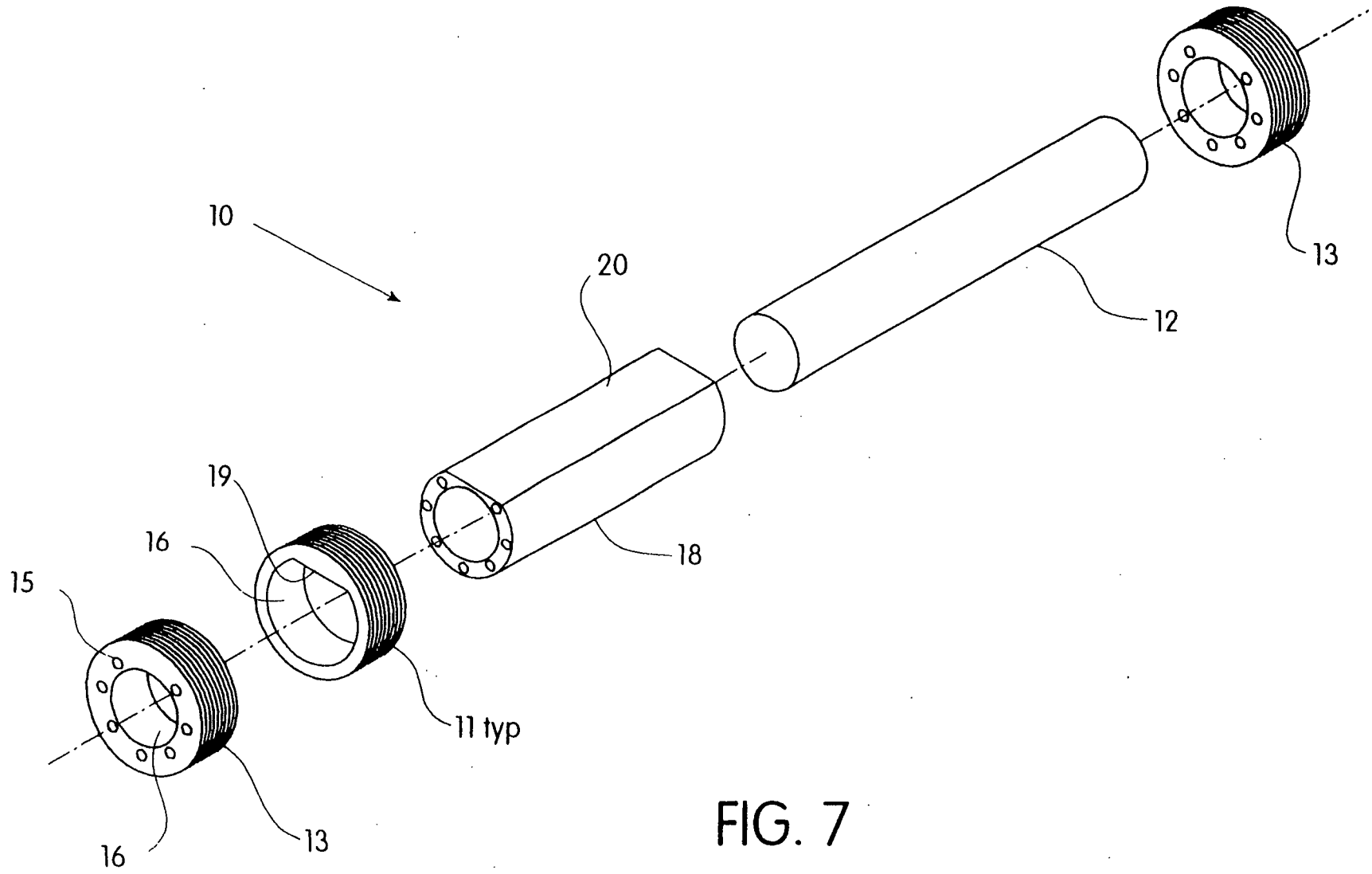

FIG. 7

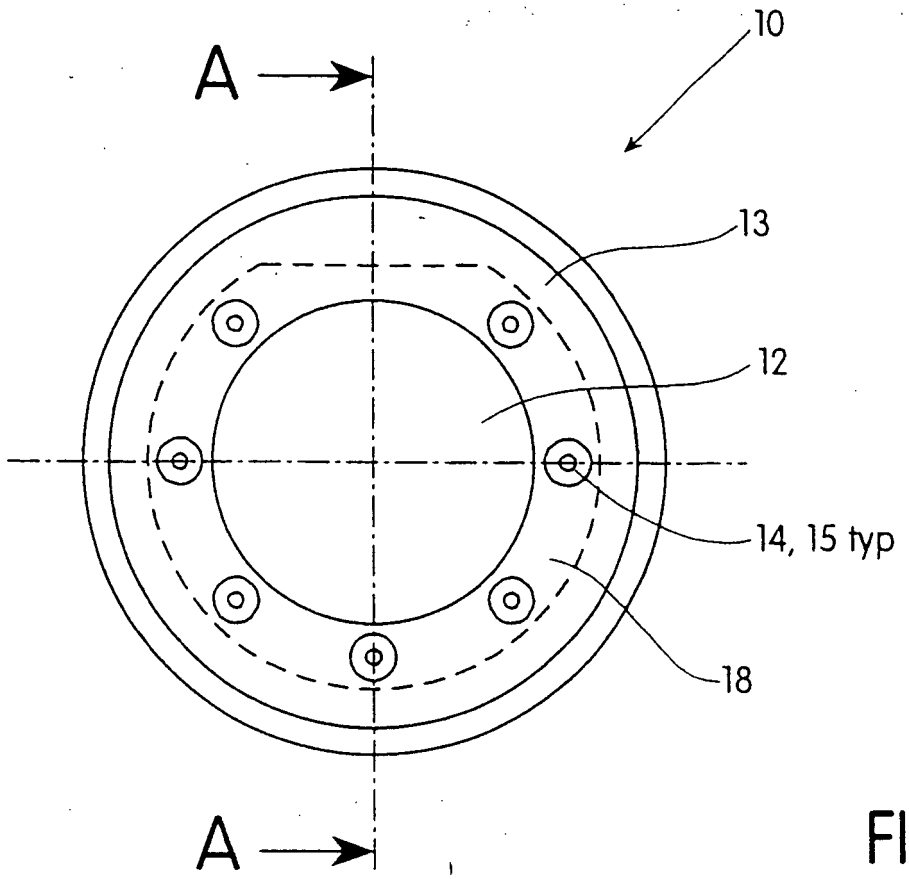
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FIG. 8

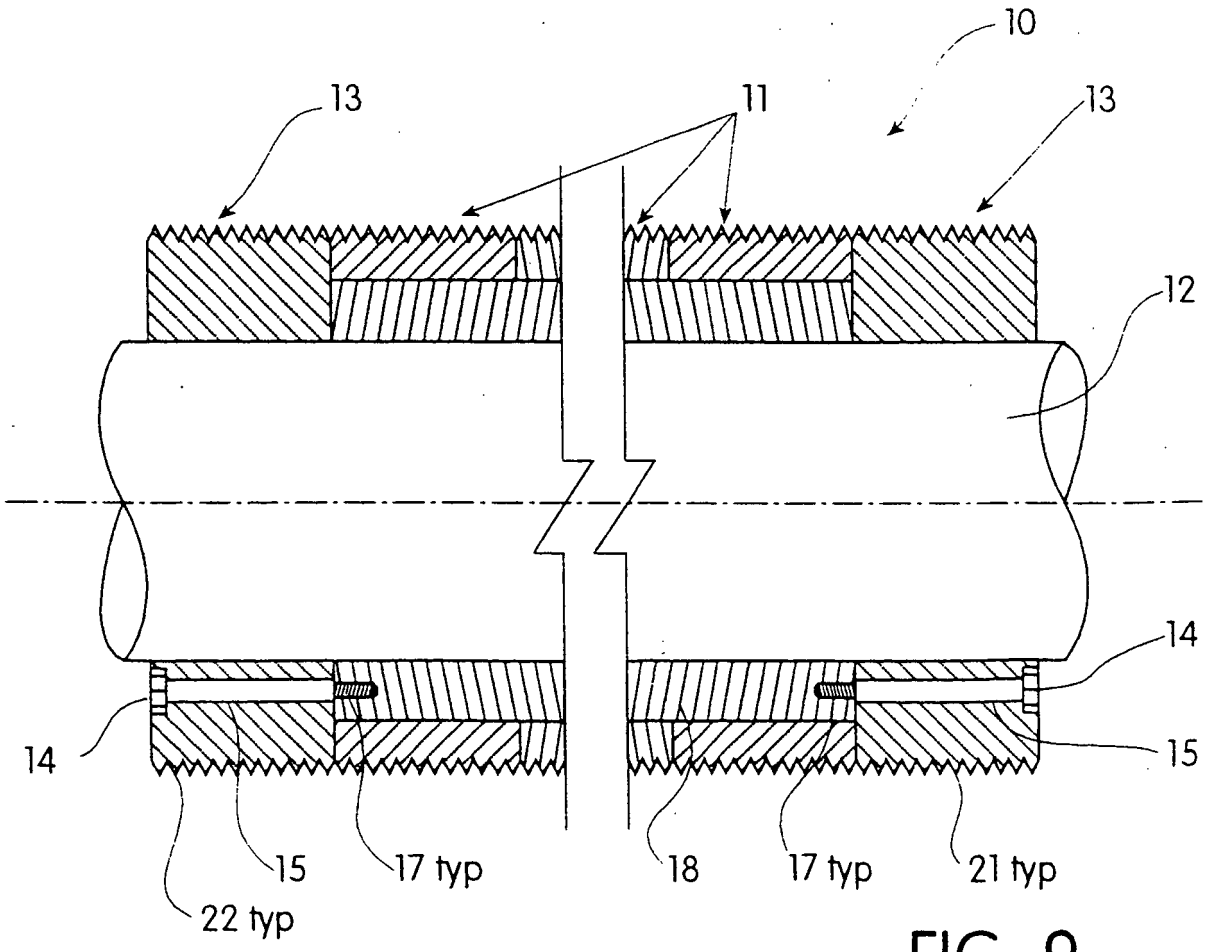
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FIG. 9

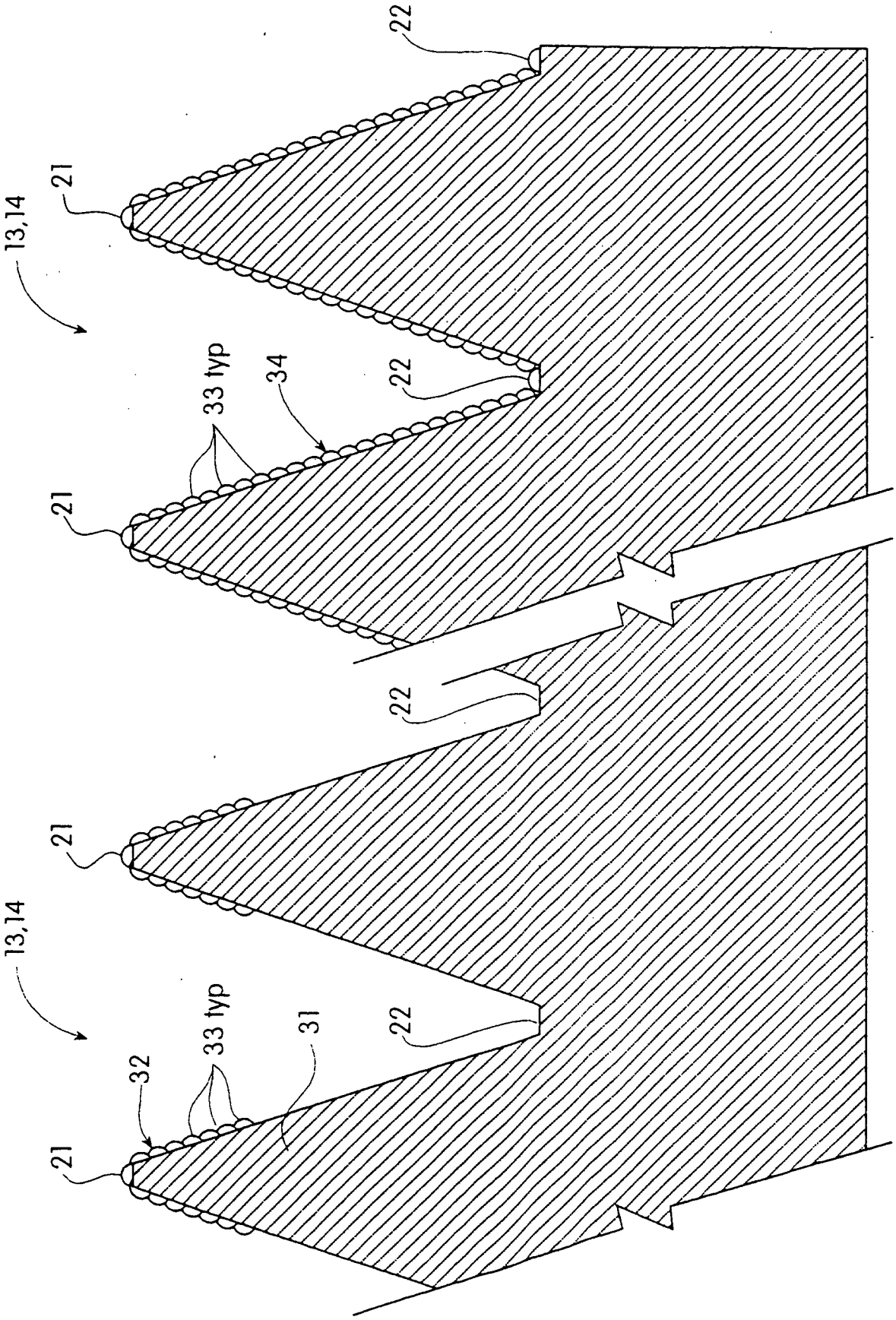

FIG. 10

FIG. 11