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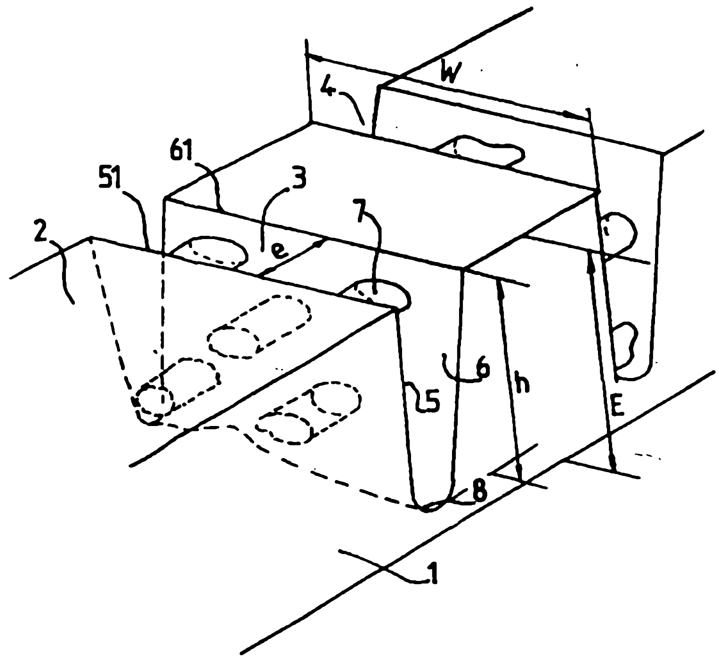
(54) Title: TREAD PATTERN AND METHOD FOR MAKING SAME

(54) Titre: SCULPTURE DE BANDE DE ROULEMENT ET PROCEDE DE FABRICATION

(57) Abstract

The invention concerns a tyre running tread (1) with thickness E, said tread being provided with a plurality of cuts (3, 4, 27) delimited by gum walls (5, 6), said walls being perpendicular or oblique relative to the tread running surface (2). The invention is characterised in that the two main walls (5, 6) of at least one cut (3) located in the portion of the running tread affected by the crush of the tyre while running are linked by at least a linking gum element (7) and the total linking surface S_E of the linking element(s) is not more than 80 % of the surface delimited by the geometrical contour L of minimum length and enclosing said total linking surface S_E. The invention also concerns the method for producing a cut with at least one linking element.



(57) Abrégé

Bande de roulement (1) d'épaisseur E pour pneumatique, ladite bande étant pourvue d'une pluralité de découpures (3, 4, 27) délimitées par de parois de gomme (5, 6), lesdites parois étant perpendiculaires à ou obliques par rapport à la surface de roulement (2) de la bande de roulement, caractérisée en ce que les deux parois principales (5, 6) d'au moins une découpure (3) située dans la partie de la bande de roulement affectée par l'écrasement au sol du pneumatique en roulage sont reliées par au moins un élément de liaison en gomme (7) et en ce que la surface de liaison totale S_E du ou des éléments de liaison (7) est au plus égale à 80 % de la surface délimitée par le contour géométrique L de longueur minimum et enveloppant ladite surface de liaison totale S_E. Procédé pour réaliser une découpure pourvue d'au moins un élément de liaison.

TREAD PATTERN AND METHOD OF MANUFACTURE

The invention relates to treads for the manufacture of new tyres or for the recapping of tyres, and in particular to the patterns for said treads which comprise a large number of cutouts in the form of grooves and/or incisions. It also relates to a production method making it possible to produce such treads.

In order to adapt the performance of types to the increasingly improved performance of new vehicles, it is becoming necessary, inter alia, to increase the level of the adhesion performance of the tyres on a wet road, without for all that adversely affecting the other types of performance thereof. "Adhesion" is understood to mean both the adhesion properties of the tyre in the direction transverse to the displacement of the vehicle (cornering ability) and those of the tyre in the direction longitudinal to the displacement of the vehicle (possibility of transmitting a braking or driving force to the ground).

In order to increase the adhesion potential of a tread of a tyre travelling on a road covered with water, it is known to provide this tread with a pattern formed of a plurality of cutouts formed at greater or lesser depths in said tread, said cutouts opening on to the surface of said tread in contact with the road (this surface is called the rolling surface).

"Cutout" quite obviously means formed in the tread, be it by removing material once the tread has been vulcanised or be it by moulding in a mould for moulding said strip and comprising moulding elements which project on the moulding surface of said mould, each moulding element having a geometry identical to the geometry of the desired cutout. As a general rule, a cutout made in a tread is defined by at least two walls of rubber which face one another, said walls being separated by an average distance representing the width of the cutout, the intersection of said walls with the rolling surface forming rubber ridges. Several types of cutout can be distinguished, for example:

- grooves or furrows characterised by a width greater than about 10% of the thickness of the tread;

- incisions of relatively low width compared with the thickness of the tread; under certain conditions of stress, these incisions may close, at least partially, in contact with the road; the walls facing one another come into contact with one another at least over a more or less large part of the surfaces of said walls (the ridges formed by an incision on the rolling surface are in contact, which causes the incision to close).

Some cutouts may open into at least one other cutout. The trace of a cutout on the rolling surface of a tread follows an average geometric profile determined as the geometric profile located at an average distance from the ridges formed by the walls of said cutout on the rolling surface. The centre axis of the trace of a cutout on the rolling surface corresponds to the straight line of the least-error squares of the distances of the points of the average profile from the trace of said cutout. Furthermore, it is usual to define the groove ratio of a pattern as the following ratio: area of the cutouts on the rolling surface divided by the total area of contact between the tyre and the road.

By effecting a plurality of cutouts which open on to the rolling surface, a plurality of rubber ridges is created to break up the layer of water which may be present on the road, so as to keep the tyre in contact with the ground and to create cavities forming channels intended to collect and remove the water present in the zone of contact of the tyre with the road since they are arranged so as to open outside the zone of contact.

An example of such a pattern is found in US Patent 1,452,099, which describes a tread provided with a plurality of regularly spaced incisions of transverse orientation.

However, the increase in the number of cutouts rapidly results in a substantial decrease in the rigidity of the tread, which has an adverse effect on the performance of the tyre, and even on the adhesion. "Rigidity of the tread" is understood to mean the rigidity of the tread under the combined actions of compressive stresses and shearing stresses in the region affected by the contact with the road. Conjointly, the presence of numerous cutouts forming channels for evacuating water results in a level of travelling noise on a dry road which is nowadays considered as a nuisance which it is desired to reduce to as great an extent as possible, very particularly on vehicles of recent design. This travelling noise is amplified by the cyclical movements of closing and opening of the cutouts which are associated with the friction of the walls of said cutouts when they are closed.

In French Patent 1 028 978, a solution to this problem is proposed which consists in providing the tread with a plurality of circumferential incisions of low depth over the rolling surface of the new tread so as to increase the flexibility of said tread solely in the vicinity of the rolling surface.

However, since the tyre, once mounted on a vehicle, is intended to provide good performance during the entire life of said tyre (that is to say, until its tread has worn down to a level corresponding at least to the legally permitted level), it is necessary to provide a tread having a pattern which ensures the lasting quality of the adhesion performance on wet ground.

The object of the present invention is to develop a tread for a tyre which manages to combine a very good level of adhesion to a wet road and to a dry road with a low emission of noise while travelling when new and during at least a major part of the life of said tread. Complementarily, one of the objects of the invention is to control the evolution of the performance with the wear of the tread.

According to the invention, a tread is proposed, of thickness E in a rubber mix, intended to be placed radially on the outside of a tyre, said tread being provided with a rolling surface which is intended to come into contact with the road during the travel of the tyre. The tread is provided with a large number of cutouts such that a plurality of cutouts is affected by the zone of contact of the tyre with the road. Each cutout is defined by the space enclosed mainly between two opposing walls, said walls being perpendicular to or oblique to the rolling surface, and each cutout has a depth at most equal to the thickness E of the tread, the depth of said cutout being measured as the distance in a radial direction between the points of the contour of said cutout which are farthest from the rolling surface of the new tyre and said rolling surface. Furthermore, two main walls of at least one cutout located in the part of the tread affected by the loading on the ground of the tyre during travel are connected by at least one rubber connecting element.

The reference S_E is given to the total connection surface on each of the walls of said cutout equal either to the total intersection surface of the connecting element in the case of a single element or to the total of the intersection surfaces of all the connecting elements in the case of several elements, and the total surface of each of the main walls of said cutout is referenced S_T.

The tread according to the invention is characterised in that:

- the two main walls of at least one cutout located in the part of the tread affected by the loading on the ground of the tyre during travel are connected by at least one rubber connecting element, the connecting element(s) having with each of the walls a connection surface S_E corresponding to the total of the intersection surfaces of each connecting element, said surface S_E on each of the walls being at least 10% of the surface S_T of said wall,

- all the points of the outer contour of the surface of intersection of at least one connecting element with one of the walls are located at a distance from the rolling surface which is strictly less than the depth of the cutout,

- and in that, on each of the main walls, the connection surface S_E is at most 80% of the surface S_G, the surface S_G being equal to the surface, measured on said wall of the cutout, defined by the geometric contour L of minimum length traced on said wall and enveloping the connection surface S_E.

In a preferred aspect, the invention provides a tread (1, 26) of thickness E of a tyre, provided with a rolling surface (2), said tread (1) being provided with a plurality of cutouts (3, 4, 27), each cutout (3) being defined by the space defined principally between two opposing walls (5, 6), said walls being perpendicular to or oblique to the rolling surface (2), and having a depth h, measured as the maximum radial distance measured between the points of the walls of said cutout which are radially farthest away, at most equal to the thickness E of the tread, characterised in that:

- the two main walls (5, 6) of at least one cutout (3) located in the part of the tread affected by the loading on the ground of the tyre during travel are connected by at least two rubber connecting elements (7), the connecting elements(s) (7) having with each of the walls (5, 6) a connection surface S_E corresponding to the total intersection surface, said surface S_E on each of the walls being at least 10% of the surface S_T of said wall,
- all the points of the outer contour of the surface of intersection of at least one connecting element (7) with one of the walls (5, 6) are located at a distance from the rolling surface (2) which is strictly less than the depth of the cutout,
- and in that, on each of the walls, the connection surface S_E is at most 80% of the surface S_G, the surface S_G being equal to the surface, measured on said wall of

the cutout, defined by the geometric contour L of minimum length and enveloping the connection surface S_E.

For a wall, the geometric contour L of minimum length enveloping the total connection surface S_E on this wall corresponds to the contour which can be traced on said wall so as to envelop all the total connection surface formed by the intersection surfaces of all the connecting elements with said wall. As a cutout is defined as being the continuous space defined by at least two main walls facing one another, the presence of at least one connecting element between said walls, according to the invention, does not interrupt the continuity of this space, whatever the level of wear of the tread comprising such a cutout.

Advantageously, the effect on the adhesion and noise performance is the more significant the larger the number of cutouts forming the pattern of a tread for a tyre are provided with at least one rubber connecting element so as to obtain both an outstanding adhesion performance without for all that adversely affecting the level of performance in terms of travelling noise.

Advantageously, and in order to obtain an optimum connection effect between the walls of the cutouts and a sufficient length of rubber ridges, each surface S_G defined by the geometric contour L of minimum length and enveloping the total connection surface S_E on one main wall of a cutout is at least 15% of the surface of the corresponding wall S_T. Preferably, the total connection surface S_E over at least one main wall of at least one cutout is at most 80% of the surface of the corresponding wall S_T, so as to preserve a volume of cutout imparting to the tread sufficient adhesion characteristics.

The tread according to the invention has several advantages:

- for cutouts oriented substantially transversely to the longitudinal direction of the tread, the impacts of the rubber ridges on the road are reduced, which results in substantial reduction of the noise emitted during travelling, and this despite a relatively large number of ridges;

- on emerging from the area of contact, the presence of connecting elements between the walls of the incisions oriented transversely and possibly between the opposing faces of the relief elements limits the oscillating movements of the rubber elements of the tyre emerging from said area which cause noise-generating vibrations, thus reducing the noise resulting from these vibrations;

- the reduction of the noise component also results from the reduction of the friction of the walls of the incisions on one another when passing into contact, the connecting elements preventing both the moving-together of the walls and the movement of one relative to the other;

- a very marked improvement in adhesion, whilst maintaining a large surface of rubber to be worn in the case of a plurality of incisions of low width, said incisions being provided with at least one connecting element.

Overall, the sources of noise which are associated with such a pattern are far less strong owing to the reduction of movement of the walls of the cutouts resulting from the presence of the connecting elements between said walls compared with a pattern which would comprise the same cutouts without any connecting element.

It goes without saying that a tread pattern according to the invention may combine both a plurality of cutouts provided with at least one connecting element with a plurality of cutouts without a connecting element, the proportion between said cutouts possibly being, for example, a function of the type of tyre comprising said pattern.

The applicant has surprisingly obtained very good results when using tyres provided with a tread of thickness E, provided with a plurality of cutouts oriented virtually in the same direction, each of said cutouts being defined by the space defined principally between two opposing walls, said walls being perpendicular to or oblique to the rolling surface, and said cutouts having a depth h.

"Depth h of a cutout" is understood to mean the maximum radial distance measured between the ridge of the cutout closest to the rolling surface of the tread when new and the point(s) of the walls of the cutout which is or are radially farthest from said rolling surface.

This depth h represents the maximum radial distance between the radially farthest points of the walls of a cutout, and is at most equal to the thickness E of the tread.

Furthermore, the tread according to one variant of the invention is such that:

- the two main walls of said cutouts are connected by at least one rubber connecting element;

- the connecting rate $T_P=S_E/S_T$ for each cutout is at least 0.10 and at most 0.80, S_E being equal to the total intersection surface of the connecting element(s) on each of the walls, S_T representing the total surface of each main wall of said cutout;

- the ratio p/h, between the average pitch p between each of said cutouts and their depth h, is at least 0.2 and at most 1.9.

In order to avoid the appearance of irregular wear of the tread and if a value of the connecting rate T_P of the cutouts is fixed, it is then preferable to select the pitch p such that the ratio p/h, in the new state, satisfies the following equation:

$$\frac{p}{h} \geq \frac{1}{5}\left(\frac{1}{T_P}\right)^{0.75}$$

Complementarily, and in order to achieve a good adhesion performance, it is judicious to select the pitch p such that the ratio p/h satisfies the following equation:

$$\frac{p}{h} \le 2(1-T_P)^{0.5}$$

It is also possible to make allowance for the average width e of the cutouts (that is to say, the average distance between the main walls of said cutouts) arranged regularly according to a pitch p on a tread so as to obtain the connecting rate T_p which makes it possible to achieve good results during travelling. The Applicant has found that good adhesion and wear results are obtained when the connecting rate T_p is at least 0.10 and is at most equal to the following value:

$$\frac{1}{\left(1+\frac{1}{3}\varepsilon\right)^{0.75}}$$

in which ε = (p-e)/h.

In a further preferred aspect, the invention provides a tread of thickness E for a tyre, provided with a rolling surface (2), said tread (1) being provided with a plurality of cutouts (3, 4), oriented virtually in the same direction, each of said cutouts (3) being defined by the space defined principally between two opposing walls (5, 6), said walls being perpendicular to or oblique to the rolling surface (2), and having a width e and a depth h, measured as the distance in a radial direction between the points of the walls of said cutout which are closest to the rolling surface and the points of said walls which are farthest away from the rolling surface of the new tyre, at most equal to the thickness E of the tread, said cutouts being spaced by an average pitch equal to p, said tread being characterised in that:

- the two main walls (5, 6) of a plurality of cutouts (3, 4) are connected by at least two rubber connecting elements (7), the connecting elements (s) (7) having a connection surface S_E equal to the total intersection surface with each of the wall (5, 6);

- and in that the ratio $T_P = S_E/S_T$, representing, on one of the main walls (5, 6) of said cutout, the connecting rate between the main walls of one and the same cutout, is at least 0.10 and at most equal to the following value:

$$\frac{1}{\left(1+\frac{1}{3}\varepsilon\right)^{0.75}} \text{ with } \quad \varepsilon = (p-e)/h.$$

Once the connecting rate T_P is less than about 0.10, the object cannot be achieved because the connecting elements do not supply sufficient rigidity, and cannot sufficiently block the movements of the walls of the cutout to which they are connected; preferably the connecting rate T_P is greater than 0.25.

On the other hand, when this rate exceeds the limit value proposed, the rigidity becomes too great and the length of active ridge is too small to maintain satisfactory adhesion performance. "Length of active ridge" of a tread of a tyre is understood to mean the total of the lengths of all the rubber ridges in contact with the road in the imprint and for a given level of wear of the tread.

Furthermore, and in order to maintain a sufficiently constant performance with the wear of the tread, it is judicious to provide for the value of the connecting rate $T_P=S_P/S_T$, evaluated for different levels of wear of the tread to decrease substantially regularly with the wear of the tyre, at least starting from a predetermined partial level of wear S_P representing, on one of the walls of said cutout, the connection surface remaining after partial wear of the tread and S_T representing the total remaining surface of said wall corresponding to the same level of partial wear of the tread. In this manner, the effect of the connecting elements on the rigidity is at a maximum when the tread is new, but decreases gradually with the increase in rigidity of said tread resulting from wear.

On the other hand, tyre rolling tests have shown that the sculpture according to the invention results in:

- an improvement in wear by reducing the sliding of the rubber against the road, be it at the moment of emerging from the zone of contact for transverse cutouts or when cornering for circumferentially oriented cutouts;

- an improvement in the fatigue strength of the base of the cutouts (that is to say, the part of the cutouts which is radially farthest to the inside of the tread);

- lower retention of stones in the cutouts provided with connecting elements.

It is also noted that the draining ability of the tyre pattern according to the invention, that is to say its ability to evacuate the water present on the road, is sufficient whatever the level of wear of the tread, which is a particularly attractive advantage for the user.

In order to obtain long-lasting efficiency of a tread pattern according to the invention with time when travelling on a wet road, the length of active ridge of the pattern in the imprint corresponding to each level of wear is preferably defined as being at least 50% of the length of active ridge on the rolling surface of the tread in the new state.

In order that the tread maintains sufficient shearing and flexural strength when subjected to the contact stresses, and this despite the presence of a very large number of cutouts, it is judicious to arrange the connecting element(s) of each of said cutouts such that the distance between the ridge closest to the rolling surface in the new state and the points of the contour of the intersection surface of said element on said wall is at most 60% of the height h of the cutout and preferably between 40% and 60%.

Another substantial improvement of the pattern of a tread according to the invention consists in effecting a plurality of cutouts provided with a large number of connecting elements distributed fairly regularly in each of the cutouts so as to ensure good regularity of the effect induced on the rigidity of the rubber elements defined by the walls of the cutout.

A tread in accordance with this latter improvement comprises a plurality of cutouts, each cutout being defined by the space defined principally between two opposing walls, said walls being perpendicular to or oblique to the rolling surface, and having a depth, measured as the distance in a radial direction of the points of the contour of said cutout which are farthest from the rolling surface of the new tyre, at most equal to the thickness E of the tread. The tread is characterised in that:

- the two main walls of at least one cutout located in the part of the tread affected by the loading on the ground of the tyre during travel are connected by a plurality of rubber connecting elements, said connecting elements having with each of the walls a connection surface S_E, said connection surface S_E on each of the walls being at least 10% of the surface S_T of said wall,

- each connecting element having with each of the walls an intersection surface S_E at most equal to (E*E/20),

- and in that the surface S_G, defined by the geometric contour L of minimum length and enveloping the entire connection surface S_E, is at least 70% of the surface S_T of said wall.

This tread imparts particularly homogenous and regular performance to the tyre, no matter what the degree of wear of said tread.

Another object of the invention is to propose a method for the production of a tread provided with a plurality of cutouts, said cutouts being provided with at least one connecting element. It clearly emerges that the conventional methods of moulding cutouts are not suitable for producing such tread patterns readily and with sufficient precision, because the fact of arranging at least one connecting element beneath the rolling surface of the tread results in it being impossible to demould said tread when a conventional moulding process is used which uses metal blades to mould incisions.

In a further preferred aspect, the invention provides a tread of thickness E for a tire, provided with a rolling surface, said tread being provided with a plurality of cutouts, each cutout being defined by the space defined principally between two opposing walls, said walls being perpendicular to or oblique to the rolling surface, and having a depth h, measured as the maximum radial distance measured between the points of the walls of said cutout which are radially farthest away, at most equal to the thickness E of the tread, characterized in that:

- the two main walls of at least one cutout located in the part of the tread affected by the loading on the ground of the tire during travel are connected by one rubber connecting element, this connecting element having with each of the walls a connection surface S_E corresponding to the total intersection surface, said surface S_E on each of the walls being at least 15% of the surface S_T of said wall and at most 40% of the same surface S_T,
- all the points of the outer contour of the surface of the intersection of the connecting element with one of the walls are located at a distance from the rolling surface which is strictly less than the depth of the cutout,
- and in that the surface S_G, equal to the surface, measured on said wall of the cutout, defined by the geometric contour L of minimum length and enveloping the connection surface S_E, is at least 90% of the surface S_T of said wall.

Further aspects of the invention in this aspect are disclosed in the appended claims.

One object of the invention is to propose a method for obtaining a tread for a tyre, having at least one cutout, the main walls of which are connected by at least one connecting element, eliminating the problems of demoulding.

The method for the production of a tread of thickness E according to the invention includes following steps:

- a) production of inserts in an appropriate material, said inserts having the general shape of the cutouts desired in the tread, and of thickness equal to the width of said cutouts;
- b) removal of material in each insert to obtain (an) orifice(s) in a distribution selected beforehand, each orifice having a shape equivalent to the shape of a connecting element;
- c) insertion of the inserts produced in the preceding stages into a strip of rubber;
- d) moulding under pressure in a mould having the dimensions of the tread desired, during which the rubber mix of the tread, which has become more fluid, fills the orifices of the inserts so as to form connecting elements between the rubber walls adjacent to each insert;
- e) vulcanisation of said rubber strip followed by demoulding.

Of course, this tread may be made in the form of a strip of predetermined length, or in the form of a closed ring intended to be placed radially on the outside of the blank of a tyre during the manufacture thereof or on a tyre being recapped.

One variant of the method which has just been described may consist in effecting steps a) to c) and placing the non-vulcanised, non-moulded rubber strip on a tyre blank before proceeding with the moulding and vulcanisation of the tyre and tread assembly thus assembled.

More generally, this method, which consists in inserting inserts into a strip of rubber, may also be applied in the case of the manufacture of a tread comprising a plurality of inserts without orifice in order to mould a plurality of incisions which do not comprise connecting elements.

So as to facilitate the insertion of the inserts into the rubber strip, another variant of the method described is proposed, consisting in producing, in a non-vulcanised rubber strip, cutouts of dimensions substantially equal to the dimensions of the cutouts provided with at least one connecting element between the walls of said cutouts.

The material forming the inserts and filling the cutouts which are provided with at least one connecting element is selected so as to be able to be eliminated at least in part, that is to say, at least close to the rolling surface when new, and gradually during travelling in order permanently to maintain a great length of ridges.

The Applicant has found that paper pulp was a filling material particularly suited to this use, because this material is characterised by very low cohesion once it is in the presence of water for a sufficient time, and therefore has the advantage of being able to be eliminated gradually during travel of the tyre, or alternatively of being able to be eliminated after having been put in the presence of water and before any travel, all the more easily when the cutouts provided with at least one connecting element have a thickness of at least 0.4 mm.

One variant of this method consists in selecting as the material composing the inserts a material having a melting point sufficiently close to the vulcanisation temperature of said tread to become fluid only towards the end of the duration of said vulcanisation, taking into account the gradual increase in temperature of the rubber forming said tread, so as to permit the removal of said filling material, for example by suction or by blowing after vulcanisation of said tread. Preferably, the filling material is an alloy having a low melting point, having the advantage of being rigid during the shaping phase of the tread and during the vulcanisation phase before becoming fluid at the end of the vulcanisation of the tread so as to permit the removal of said alloy and possibly recycling it for a similar use.

The method which has just been described may also be succeeded by a grinding operation affecting virtually only the surface of the new tread and intended to make a plurality of ridges appear very distinctly on the rolling surface of said tread. Another way of obtaining a good surface state immediately on emerging from the mould may consist in arranging all the cutouts provided with at least one connecting element beneath the rolling surface of the tread and moulding said tread in a mould comprising a plurality of relief elements intended to mould a plurality of cutouts on the rolling surface and the depth of which is slightly greater than the smallest of the distances between the cutouts provided with at least one connecting element of the rolling surface. In this way, the tread, as it wears down, will gradually reveal a plurality of cutouts beneath the rolling surface of said new tread.

The invention will be readily understood with reference to the appended drawings, which represent only particular embodiments and could not be considered to be limitative.

- Figure 1 is a diagram of a section through part of a tread according to the invention;

- Figure 2 is a diagram of a section through the tread of Figure 1 effected along a wall of a cutout provided with connecting elements;

- Figure 3 is a diagram of a section through a tread effected along a wall of a cutout provided with a single connecting element according to the invention;

- Figure 4 shows a tread of a tyre comprising incisions provided with connecting elements, said incisions being oriented firstly in the circumferential direction and secondly in the transverse direction;

- Figure 5 shows the section along XX of the tread of Figure 4, showing a cutout provided with connecting elements inclined relative to the rolling surface of said tread;

- Figure 6 shows a variant of the layout of the connecting elements of a cutout;

- Figure 7 shows a diagram of a section through a tread effected along a wall of a cutout provided with a large number of connecting elements;

- Figure 8 shows, viewed in section, a variant of a tread comprising a plurality of incisions provided with a plurality of connecting elements beneath the rolling surface of said new tread;

- Figure 9 shows two variants A and B of tread patterns according to the invention which have undergone rolling tests;

- Figure 10 shows a insert used for producing variants A and B of Figure 9;

- Figure 11 shows a diagram of a variant of a cutout, the main walls and the connecting elements of which are of a rubber mix of a different type from the rubber forming the tread.

The tread 1 shown partially in the direction of its length in Figure 1 has a thickness E and a width W. One of the outer walls of said strip is intended to form the rolling surface 2 of a tyre provided with said tread; this tyre may be either a new tyre or a renovated tyre, that is to say a tyre which has travelled so far that its tread has become worn to such an extent that provision of a new tread has become necessary.

A plurality of cutouts 3, 4 are made in the tread 1 so as to extend over the entire width W of said tread 1. The cutout 3 is defined by two flat main walls 5, 6 perpendicular to the rolling surface 2 and spaced apart by an average distance e equal to the width of the cutout 3. The two walls 5, 6 defining the cutout 3 are connected at the radially innermost points 8 of the cutout with respect to the rolling surface 2. The intersection of the walls 5, 6 with the rolling surface 2 determines rubber ridges 51 and 61 respectively, one function of which is to cut the film of water which may exist between the tread and the road.

The cutout 3 is provided with five rubber connecting elements 7 which connect the walls 5 and 6 of said cutout, said connecting elements making it possible to keep said walls at a virtually constant distance, avoiding both the opening and the closure of the cutout 3.

Figure 2 shows a cross-section through the tread 1 of Figure 1 effected along the wall 6 of the cutout 3. There can be seen, distributed fairly uniformly along the wall 6, the intersection surfaces 71, 72, 73, 74, 75 of the connecting elements 7 with the wall 6, the total of said surfaces forming the total intersection surface S_E. In the present case, all the connecting elements have their intersection surfaces 71, 72, 73, 74, 75 entirely located beneath the rolling surface 2 and at a radial distance from said surface which is less than the depth h of the cutout. Furthermore, the total connection surface S_E is at most 80% of the surface S_G defined by the geometric contour L (in broken lines) of minimum length constructed on the wall 6 and enveloping all the intersection surfaces 71, 72, 73, 74, 75 of the connecting elements 7 with the wall 6. These three conditions when combined make it possible to obtain a tread pattern comprising very numerous cutouts over relatively great depths compared with the thickness of the tread, said cutouts forming numerous rubber ridges on the rolling surface 2, said pattern thus produced preserving sufficient rigidity to resist the stresses due to loading and travelling.

In known manner, the main walls of the cutouts may be plane or alternatively curved.

Advantageously, and in order to obtain an optimum effect, the tread comprises a plurality of cutouts provided with at least one connecting element and each surface S_G, defined by the geometric contour L of minimum length and enveloping the total connection surface S_E on one wall of the cutout, is at least 15% of the surface of the corresponding wall S_T.

The relative position of the connecting elements of one and the same cutout is determined so as to maintain for said cutout a great length of active ridge to come into contact with the ground, and this whatever the level of wear of the tread.

Another possible embodiment is shown in Figure 3, which shows a diagram of the section through a rib of a tread 1 effected along a wall 9 of a cutout provided with a single connecting element 10 which extends between the main walls defining said cutout. This element 10 is composed of two branches 101, 102 oriented in the direction of the width of the incision and connected together by a third branch 103 oriented in the direction of the thickness of the tread. The contour L shown in dashes corresponds to the contour of minimum length enveloping the total connection surface of the single element and passing through the ends of the branches 101 and 102. It is implicit that the spirit of the invention is preserved when the branch 103 connecting the branches 101 and 102 is extended as far as the rolling surface 2, since a single volume corresponding to the cutout is created.

Figure 4 shows in part a tread 11 of a tyre comprising incisions oriented in the circumferential direction and incisions oriented in the transverse direction, each of said incisions being provided with connecting elements and opening on to the rolling surface 112 of said tread. The tread 11 is divided axially into three annular regions marked I, II, III, the median region II being separated from the two edge regions I and III by circumferentially oriented grooves 12 and 13. So as to improve the adhesion performance of the tyre fitted with such a tread, without for all that being handicapped by travelling noise, a plurality of incisions 14 of low width oriented essentially transversely are provided in the median part II, said incisions 14 opening on either side of the part II into the grooves 12 and 13. These incisions 14 of depth h and of width e of at least 0.1 mm are arranged regularly at an average pitch p such that the ratio h/(p - e) is more than 0.9. Thus, it is possible to have a high density of ridges in the contact imprint without impairing the mechanical characteristics of the part II.

In the edge parts I and III, there is provided at least one incision 15 oriented substantially in the circumferential direction. All the incisions of transverse orientation 14 and the circumferential incisions 15 are provided with a plurality of connecting elements 141 and 151 respectively, connecting the main walls forming said incisions.

"Oriented substantially transversely" is understood to mean that the centre axes of the traces of the incisions on the rolling surface 112 form an angle of at most 45° with the transverse direction of the tread. "Oriented substantially circumferentially" is understood to mean that the centre axes of the traces of the incisions on the rolling surface form an angle of at least 75° and at most 90° with the transverse direction of the tread. The centre axis of the trace of a cutout on the rolling surface of a tread corresponds to the average direction evaluated between the points of the ridges of said cutout on the rolling surface using a method of the least-error squares of the distances.

In this manner, it is possible to obtain a tyre having good adhesion performance in the longitudinal direction of the tread owing to the presence of incisions oriented transversely in the part II and adhesion performance in the transverse direction owing to the presence of at least one incision oriented virtually circumferentially in the parts I and III, said incisions being provided with connecting elements connecting their walls.

Complementarily, it is possible to provide connecting elements also connecting the walls defining the circumferential grooves separating the part II from parts I and III.

After partial wear of the tread according to the invention, at least one connecting element of a cutout appears on the rolling surface and accordingly reduces the lengths of the ridges 145, 146 formed by each of the main walls of said cutout with the rolling surface 2. In order to alleviate this effect, and as shown in Figure 5, corresponding to a section along XX through the tread shown in Figure 4, it is judicious to arrange each connecting element 141 between a first main wall 142 and a second main wall 143 of the cutout 14 such that said element forms an angle other than 90° and preferably between 30° and 70° with the line perpendicular to the rolling surface of the new tread.

Another manner of overcoming the disadvantage which has just been mentioned, and also in order to avoid the localisation of wear on certain regions of a tread according to the invention, it is advantageous, as is the case for the incisions 14 localised in the median part II of the tread shown in Figure 4, to provide an offset in the radial direction of the position of the connecting elements between any two adjacent cutouts of substantially identical orientation. Thus, the position of the rubber ridges formed by the intersection of the walls of the cutouts is distributed randomly. The fact that the connecting elements arrive at the rolling surface after wear in a more or less offset manner makes it possible permanently (that is to say, during the entire period of use of the tyre) to maintain a great length of ridges in the region of the rolling surface affected by the contact with the road, and makes it possible to effect beneficial blurring both of the wear (the appearance of abnormal, that is to say localised, wear, is avoided), and of the travelling noise.

In the case of use requiring essentially adhesion characteristics in the longitudinal direction, it is possible to provide solely a plurality of cutouts provided with at least one connecting element, the centre axis of the traces of said cutouts on the rolling surface of the tyre forming an angle of at most 45° with the transverse direction of the tread. Conversely, in the case of use requiring essentially adhesion characteristics in the transverse direction, it is possible to provide a plurality of cutouts provided with at least one connecting element, the centre axis of the traces of said cutouts on the rolling surface of said tread when new forming an angle of at least 75° and at most 90° with the axial direction of the tread. A comparable result is obtained by producing a single continuous cutout oriented at an angle close to 90° with the transverse direction such that the centre axis of the trace of the cutout on the rolling surface forms a helix, because everything takes place in the zone of contact with the road as if the tread were provided with a plurality of cutouts virtually oriented in the circumferential direction.

The cutouts provided with at least one connecting element may be perpendicular to the rolling surface or alternatively part of them form an average angle of at most 20° with the direction perpendicular to the rolling surface of the tread when new, so as to increase the efficiency of the rubber ridges in certain uses so as to be able better to transmit a driving or braking force according to the direction of orientation of the inclination of said cutout which is selected.

Since the rigidity of the pattern of a tread increases with the reduction in its thickness resulting from the wear of said tread, it is judicious furthermore to provide that for at least one cutout, located in the part of the tread affected by the loading of the tyre and provided with at least one connecting element, the ratio $T_P=S_P/S_T$ decreases substantially regularly with the wear of the tyre at least starting from a predetermined partial level of wear, S_P representing, on one of the walls of said cutout, the connection surface remaining after partial wear of the tread and S_T representing the total surface of said wall corresponding to the same level of partial wear of the tread. In this context, Figure 6 shows, viewed in a transverse section, a wall of a cutout provided with connecting elements 7 arranged in rows virtually parallel to the rolling surface 2, the number of connecting elements 7 per row increasing as the rolling surface 2 is approached.

Figure 7 shows an advantageous arrangement in terms of connecting the main walls of one and the same cutout of a tread. In this Figure, there can be seen, regularly distributed over a main wall 66 of a cutout, a plurality of surfaces of intersection 76 of connecting elements with said wall such that the density of connecting elements is relatively great (that is to say there is a large number of elements per surface of wall). In the present case, the surface S_G defined by the contour L of minimal length and enveloping all the intersection surfaces of the connecting elements is about 90% of the total surface of the wall 66, whilst the connection surface S_E represents only 40% of the total surface. An optimum effect on the rigidity of the tread is achieved when the connecting elements are regularly distributed over the walls of each cutout.

Furthermore, advantageously, it may be advantageous to provide additional rubber elements connected to only one of the walls of a cutout provided with connecting elements to prevent the regions of the walls of said cutout located between said connecting elements from moving towards each other.

The Applicant has carried out rolling tests and rolling simulation tests with heavy-vehicle tyres of dimension 215/75 R 17.5 comprising treads according to the invention. Figure 9 shows a diagram of two types of tread pattern tested. Figure 9-A corresponds to the variant A of a tread 18 comprising a plurality of incisions 21 of width 0.1 mm, oriented transversely and spaced apart circumferentially by an average pitch p of 15 mm; this variant furthermore comprises three circumferential grooves 19 of width 5 mm which axially divide the tread into four parts, each of said parts again being divided into two by a circumferential incision 20 of width 2 mm. All the cutouts are of the same depth, 13.5 mm. Figure 9-B corresponds to the variant B of a tread 22 comprising a plurality of incisions 25 of width 1 mm, oriented in a direction forming an average angle of 15° with the transverse direction of the tyre and spaced apart by an average pitch p of 10 mm; this variant B furthermore comprises two substantially circumferential 19 grooves 23 of undulating shape of width 10 mm which axially divide the tread into three parts, each of said parts again being divided into two by a circumferential incision 24 of width 2 mm, said incisions following the same profile as the grooves. All the cutouts of the two variants A and B are of identical depth, equal on average to 13.5 mm.

Variants A and B have been produced in the following manner: after having cut out along the traces of the desired incisions a non-vulcanised rubber strip of suitable width and length, inserts are produced in sheets of paper of thickness 0.1 mm for variant A and in sheets of card of thickness 1 mm for variant B, in a number equal to the number of equivalent incisions and dimensions. Each insert is then cut out so as to produce a plurality of orifices, the shape of which corresponds to the shape of the sections of the connecting elements of the incisions. Figure 10 shows one such insert 16 provided with a plurality of orifices 17 of virtually rectangular shape; these orifices, of dimension 2 x 5 mm may be obtained, for example, by means of a laser cutting process or by punching. Then these inserts 16 are placed in the cutouts made in the non-vulcanised tread.

This tread is then placed on a non-vulcanised tyre blank before being moulded with the tyre in a vulcanisation mould. During the vulcanisation of said tread, the rubber of the tread passes through the inserts at the locations of the orifices, forming the connecting elements of the cutouts, said cutouts being filled with the material making up the inserts. In order to obtain the variants A and B, the grooves and circumferential incisions without connecting elements have been made by cutting after manufacture of the tyres comprising the treads. Of course, the additional grooves and incisions may be produced by the method according to the invention.

In the individual case, the tyres selected were tyres of heavy-vehicle type of dimension 215/75 R 17.5, the incisions provided with connecting elements of which had a connection rate T_P equal to 45% and for which the ratios S_E/S_T and S_E/S_G were equal to 45% and 40%, respectively. The groove ratios of the rolling surfaces in the new state of the two variants A and B were 15% and 18%, respectively ("groove ratio" is understood to mean the ratio between the surface of the cutouts on the rolling surface and the total surface of said rolling surface).

Adhesion tests were carried out with a heavy vehicle equipped with an additional wheel for measurement, said wheel being fitted with a tyre according to variant A or variant B. In this test, the appearance of sliding of the tyre relative to the road is determined for a given speed and under the action of a given braking force; this test is carried out on a test track having a smooth coating and on which there is a layer of water of a thickness of about 1.5 mm. A tyre of type XZE, of the same dimension and having a groove ratio of 18%, was used as reference basis. The groove ratios of the variants A and B are comparable to that of the tyre selected as a reference.

Unexpectedly, the results of the adhesion tests showed that, compared with the reference tyre, the tyres of variant A were about 15% better than the reference tyres, whilst the tyres of variant B were greatly superior to the reference tyres, by at least 30%. The difference in performance between variants A and B can be explained in part by the difference in width of the incisions.

On the other hand, tests measuring the noise emitted during travel under conditions defined by ISO Standard 362 showed, equally surprisingly, that the level of noise emitted by a tyre provided with a tread according to the invention was reduced by at least 3 dbA and at least 2 dbA for variants A and B respectively, compared with the reference tyres.

While it is known, in the case of conventional patterns for heavy-vehicle tyres, that obtaining a good noise performance is always accompanied by a reduction in the adhesion performance on smooth ground, these tests have shown that, thanks to a tread pattern according to the invention, it is possible to obtain a very significant improvement in performance, both in terms of adhesion and travelling noise.

The tread according to the invention and the manufacturing method for such a tread make it possible to obtain, with a low groove ratio, that is to say, a ratio between the surface corresponding to the cutouts and the total surface of said strip which is intended to be in contact with the ground, a performance which is at least equivalent to a conventional tread having a higher groove ratio; the large number of rubber ridges, compared with the fact that the rigidity of the tread is not substantially affected, compensates for the difference in the groove ratios.

It should be noted that the presence of connecting elements in the cutouts makes it possible for the tread to retain a rigidity which results in a loss of rolling resistance (energy dissipated during travel of a tyre equipped with said tread) which is distinctly less than that obtained with the same tyre, the connecting elements of which have been removed.

After manufacture of the tyres provided with a tread according to the invention, it is possible to eliminate the inserts partially, that is to say, solely in the vicinity of the rolling surface, so as to disengage the ridges from the incisions on the rolling surface. Subsequently, the material forming the inserts is eliminated as the tread becomes worn.

So as to obtain a better appearance of the tread when it emerges from the vulcanisation mould for said tread, it may be contemplated to provide for the cutouts provided with connecting elements to be entirely located beneath the rolling surface of the new tread, and for a plurality of cutouts without connecting elements and of a depth at least slightly greater than the distance between the rolling surface of the cutouts provided with connecting elements to be provided on said rolling surface. Such a configuration can be seen in Figure 8, which shows a diagrammatic section through a tread 26 when new, comprising a plurality of incisions 27 provided with a plurality of connecting elements 28. The rolling surface is provided with a plurality of cutouts 29 of low depth intended to play an active role during the initial use of the tread. After partial wear of the tread, the incisions 29 disappear, leaving the subjacent incisions 27.

One variant embodiment of the inserts consists in using a material in the form of a woven fabric comprising warp and weft threads, said fabric having the property of resisting the vulcanisation of said strip and being able to be eliminated gradually during the travel of the tyre, the spaces defined by the warp and weft threads permitting the moulding of the connecting elements of said cutout. The material forming the inserts may also be formed of one or more threads forming a network of threads which can be eliminated completely after vulcanisation of the tread or alternatively gradually during travel.

The manufacturing method according to the invention furthermore makes it possible to effect cutouts, the walls of which are covered with a rubber mix other than the mix forming the rest of the tread, as illustrated in Figure 11, in the particular case of an incision provided with connecting elements; of course, the method which is described for forming this type of incisions can equally well be applied to an incision not provided with connecting elements.

Figure 11-B shows a variant of a cutout 38 provided with a plurality of connecting elements 311 produced by following the following steps:

- at least one insert 39 is produced which comprises a plurality of orifices 31 (visible in Figure 11-A);

- a stack is formed by covering at least one insert on each of its two main faces with two layers of raw rubber (32, 33), each layer having a thickness close to the thickness of the insert;

- a pressure is exerted on either side of the stack thus formed, so as to apply each layer (32, 33) more or less strongly against the walls of the insert and so as to force each layer to penetrate into the orifices until they come into contact with each other; the contacts thus formed facilitate the handling of the insert coated with a rubber mix before placing it in the cutout provided in the raw tread;

- each insert is inserted into a non-vulcanised rubber strip;

- the strip thus formed is then vulcanised and moulded in a suitable mould. This mould may comprise relief elements projecting on its moulding surface for moulding cutouts in the form of grooves or incisions.

One variant of this method consists, first of all, in forming a stack composed of a non-holed insert and covered on its two faces with two layers of raw rubber and, secondly, holing said stack according to its thickness before inserting said stack into a strip of raw rubber and finally moulding and vulcanising said strip. In this manner, the rubber forming the tread occupies each orifice, and forms each connecting element of the cutout thus moulded.

After vulcanisation, the material forming the insert 39 can be eliminated, at least at the surface, as can be seen in Figure 11-B. The coating of the insert is effected with rubber mixes which may be of the same nature as the mix forming the tread, or alternatively of a different nature. A mix of different nature will impart to the ridges of the cutout better resistance to abrasion resulting from the contact with the road. It may also be envisaged to use two layers of rubber mixes of different nature on either side of the insert in order to make allowance, in particular, for a preferred direction of travel of the tyre. Furthermore, the layers may have different thicknesses greater than the thickness of the insert. Each layer of rubber covering the insert may be formed of one or more layers of mix.

It may be advantageous for at least one cutout provided with at least one connecting element to have at least one connecting element formed of a rubber mix of different nature and mechanical properties from the mix forming the tread.

All the variants described in the present application may be combined according to the object desired, without for all that departing from the spirit of the invention. For example, a tyre may comprise both a plurality of incisions, some of which are provided with connecting elements and the others not, said incisions being formed, for example, in accordance with one of the methods which have just been described.

The field of application of the present invention relates to all types of tyres, and in particular to highway-type tyres, whether they be intended to be fitted on vehicles of the type passenger cars, vans, heavy vehicles and in particular tyres for subway trains. More specifically, the tyres intended to be fitted on the driving axles of heavy vehicles have considerably improved adhesion and noise properties once they are provided with a tread according to the invention. The application of a tread pattern according to the invention to tyres for civil engineering machinery, and more particular to vehicles of the "dumper" type, is beneficial since it makes it possible to produce a tread having a plurality of cutouts whilst ensuring sufficient rigidity for said tread under the loading forces and the driving or braking forces.

In the field of heavy-vehicle and passenger-vehicle tyres, the best performances are obtained when at least 80% of the incisions provided with connecting elements according to the invention each have a width of at least 0.1 mm and at most 2 mm.

A tread according to the invention may also be placed on a tyre blank before being vulcanised with said tyre blank in an appropriate vulcanisation mould.

Finally, a tread according to the invention may comprise a plurality of rubber blocks defined by grooves, said blocks comprising at least one incision itself provided with at least one connecting element between the main walls of said incision; the grooves may furthermore be provided with connecting elements so as to produce a high-performance tread pattern.

"Comprises" and "comprising" when used in this specification is to be taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof

CLAIMS

1. A tread (1, 26) of thickness E for a tyre, provided with a rolling surface (2), said tread (1) being provided with a plurality of cutouts (3, 4, 27), each cutout (3) being defined by the space defined principally between two opposing walls (5, 6), said walls being perpendicular to or oblique to the rolling surface (2), and having a depth h, measured as the maximum radial distance measured between the points of the walls of said cutout which are radially farthest away, at most equal to the thickness E of the tread, characterised in that:

- the two main walls (5, 6) of at least one cutout (3) located in the part of the tread affected by the loading on the ground of the tyre during travel are connected by at least two rubber connecting elements (7), the connecting element(s) (7) having with each of the walls (5, 6) a connection surface S_E corresponding to the total intersection surface, said surface S_E on each of the walls being at least 10% of the surface S_T of said wall,

- all the points of the outer contour of the surface of intersection of at least one connecting element (7) with one of the walls (5, 6) are located at a distance from the rolling surface (2) which is strictly less than the depth of the cutout,

- and in that, on each of the walls, the connection surface S_E is at most 80% of the surface S_G, the surface S_G being equal to the surface, measured on said wall of the cutout, defined by the geometric contour L of minimum length and enveloping the connection surface S_E.

2. A tread according to Claim 1, characterised in that, for at least one cutout (3, 4, 27) having at least two connecting elements (7), the surface S_G defined by the geometric contour L of minimum length and enveloping the total connection surface S_E on one main wall of the cutout is at least 15% of the surface S_T of the corresponding wall.

3. A tread according to one of Claims 1 or 2, characterised in that all the cutouts (3, 4, 27) having at least two connecting elements (7, 28) are entirely located beneath the rolling surface (2) of the tread when new and in that, furthermore, there are provided on the surface of the tread of the new tyre cutouts (29) the depth of which is greater than the smallest of the distances between the cutouts having at least two connecting elements and the rolling surface of the tread of the tyre when new.

4. A tread for a tyre according to any one of Claims 1 to 3, characterised in that it includes a plurality of cutouts (3, 4, 14) provided with at least two connecting elements (7, 141), the centre axis of the traces of said cutouts (3, 4, 14) on the rolling surface of the tyre forming an angle of at most 45° with the transverse direction of the tread.

5. A tread for a tyre according to any one of Claims 1 to 3, characterised in that it includes a plurality of cutouts (3, 4, 15) provided with at least two connecting elements (7, 151), the centre axis of the trace of each of cutouts (3, 4, 15) on the rolling surface of said tread when new forming an angle of at least 75° and at most 90° with the transverse direction of the tread.

6. A tread for a tyre according to any one of Claims 1 to 3, characterised in that it includes, on at least one of its edges (I, III) in the transverse direction, at least one cutout (15) provided with at least two connecting elements (151), said cutout (15) being oriented such that the centre axis of the trace thereof on the rolling surface forms an angle of at least 75° and at most 90° relative to the transverse direction of the tread, and in that the median part (II) of the tread includes a plurality of cutouts (14) provided with at least two connecting elements (141), said cutouts (14) being oriented such that the centre axis of their traces on the rolling surface forms an angle of at least 0° and at most 45° relative to the transverse direction of the tread.

7. A tread for a tyre according to any one of Claims 1 to 6, characterised in that at least one of the cutouts (3, 4, 14, 15) located in the part of the tread affected by the loading of the tyre and provided with at least two connecting elements (7, 141, 151) has, on a surface parallel to the rolling surface and located radially inside said surface, a trace, the orientation of the centre axis of which is different from the orientation of the centre axis of the trace of said cutout on the rolling surface of the new tread.

8. A tread for a tyre according to any one of Claims 1 to 7, characterised in that at least one of the cutouts (3, 4, 14, 15) provided with at least two connecting elements (7, 141, 151) forms an average

angle of at most 20° with the direction perpendicular to the rolling surface (2) of the tread when new.

9. A tread of thickness E for a tyre, provided with a rolling surface (2), said tread (1) being provided with a plurality of cutouts (3, 4) oriented virtually in the same direction, each of said cutouts (3) being defined by the space defined principally between two opposing walls (5, 6), said walls being perpendicular to or oblique to the rolling surface (2), said cutouts having a depth h, measured as the distance in a radial direction between the points of the walls of said cutout which are closest to the rolling surface and the points of said walls which are farthest away from the rolling surface of the new tyre, h being at most equal to the thickness E of the tread, said cutouts being spaced by an average pitch equal to p, said tread being characterised in that:

- the two main walls (5, 6) of the cutouts (3, 4) are connected by at least one rubber connecting element (7), the connecting element(s) (7) having a connection surface S_E equal to the total intersection surface with each of the walls (5, 6);

- the connecting rate $T_P=S_E/S_T$, S_E for each cutout is at least 0.10 and at most 0.80, S_E being equal to the total intersection surface of the connecting element(s) (7) on each of the walls (5, 6), S_T representing the total surface of each main wall of said cutout;

- the ratio p/h, between the pitch p and the depth h of the incisions, is at least 0.2 and at most 1.9, limits included.

10. A tread according to Claim 9, characterised in that the ratio p/h satisfies the following equation:

$$\frac{p}{h} \geq \frac{1}{5}\left(\frac{1}{T_P}\right)^{0.75}$$

11. A tread according to Claim 10, characterised in that the ratio p/h satisfies the following equation:

$$\frac{p}{h} \leq 2(1-T_P)^{0.5}$$

12. A tread of thickness E for a tyre, provided with a rolling surface (2), said tread (1) being provided with a plurality of cutouts (3, 4) oriented virtually in the same direction, each of said cutouts (3) being defined by the space defined principally between two opposing walls (5, 6), said walls being perpendicular to or oblique to the rolling surface (2), and having a width e and a depth h, measured as the distance in a radial direction between the points of the walls of said cutout which are closest to the rolling surface and the points of said walls which are farthest away from the rolling surface of the new tyre, at most equal to the thickness E of the tread, said cutouts being spaced by an average pitch equal to p, said tread being characterised in that:

- the two main walls (5, 6) of a plurality of cutouts (3, 4) are connected by at least two rubber connecting elements (7), the connecting element(s) (7) having a connection surface S_E equal to the total intersection surface with each of the walls (5, 6);

- and in that the ratio $T_P=S_E/S_T$, representing, on one of the main walls (5, 6) of said cutout, the connecting rate between the main walls of one and the same cutout, is at least 0.10 and at most equal to the following value:

$$\frac{1}{\left(1+\frac{1}{3}\varepsilon\right)^{0.75}} \text{ with } \quad \varepsilon=(p-e)/h.$$

13. A tread for a tyre according to Claim 12, characterised in that at least 40% of the cutouts affected by the loading have at least two connecting elements and in that the connecting rate T_P of said cutouts is at least 0.25.

14. A tread for a tyre according to one of Claims 12 or 13, characterised in that the cutouts are incisions of a width at least equal to 0.1 mm and in that the ration h/(p-e) is greater than 0.9.

15. A tread for a tyre according to any one of Claims 1 to 8 or Claims 12 to 14, characterised in that for at least one cutout (3, 4, 14, 15), located in the part of the tread affected by the loading of the tyre and provided with at least two connecting elements (7, 141, 151)), the ratio $T_P=S_P/S_T$ decreases virtually regularly with the wear of the tyre at least starting from a predetermined level of wear, S_P representing, on one of the main walls of said cutout, the connection surface remaining after partial wear of the tread and S_T representing the total surface of said wall corresponding to the same level of partial wear of the tread.

16. A tread for a tyre according to any one of Claims 1 to 8 or Claim 15), characterised in that, for at least one cutout (3, 4, 14, 15) provided with at least two connecting elements (7, 141, 151) between a first main wall and a second main wall of said cutout, each connecting element (7, 141) forms an angle other than 90° with the direction

perpendicular to the surface of the new tread, so as to maintain a great length of ridge on the rolling surface, whatever the degree of wear of the tread.

17. A tread for a tyre according to any one of Claims 9 to 11, including a plurality of cutouts (3, 4, 14) provided with at least one connecting element (7, 141, 151) connecting a first main wall to a second main wall of said cutouts, characterised in that for two adjoining cutouts of virtually identical orientation the radial and/or axial positions of the connecting elements of each of said cutouts are different, so as to be able to conserve a great length of active ridges on the rolling surface whatever the level of wear of the tread.

18. A tread of thickness E for a tyre, provided with a rolling surface, said tread being provided with a plurality of cutouts, each cutout being defined by the space defined principally between two opposing main walls, said walls being perpendicular to or oblique to the rolling surface, and having a depth h, measured as the distance in a radial direction between the points of the contour of said cutout which are farthest from the rolling surface of the new tyre, at most equal to the thickness E of the tread, characterised in that:

- the two main walls of at least one cutout located in the part of the tread affected by the loading on the ground of the tyre during travel are connected by a plurality of rubber connecting elements, said connecting elements having with at least one main wall (66) a total connection surface S_E equal to the total of the intersection surfaces (76) of all the connecting elements with said wall, said connection surface S_E on each of the walls being at least 10% of the surface S_T of said wall,

- each connecting element having with each of the walls (66) an intersection surface (76) at most equal to $(E^2/20)$,

- and in that the surface S_G, defined by the geometric contour L of minimum perimeter and enveloping the total connection surface S_E, is at least 70% of the surface S_T of said wall.

19. A tread for a tyre according to Claim 18, characterised in that the intersection surfaces (76) of all the connecting elements are regularly distributed on the surfaces of the main walls of at least one cutout.

20. A tread for a tyre according to any one of Claims 1 to 19, characterised in that additional rubber elements are provided in at least one cutout to prevent the walls of said cutout from moving towards each other, these additional elements being connected only to a single one of the main walls of said cutout.

21. A tread for a tyre according to any one of Claims 1 to 20, characterised in that a plurality of cutouts (21, 25, 38) provided with connecting elements (311) are, at least in part, filled by at least one filling material which can be eliminated after vulcanisation of said strip.

22. A tread for a tyre according to Claim 21, characterised in that the filling material has a melting point lower than and close to the vulcanisation temperature of the tread.

23. A tread for a tyre according to Claim 21 or Claim 22, characterised in that the filling material is a material based essentially on fibres, such as paper pulp.

24. A tread for a tyre according to any one of Claims 21 to 23, characterised in that at least one cutout provided with at least one connecting element is filled with a material in the form of a woven fabric comprising warp and weft threads, said fabric having the property of resisting the vulcanisation of the tread and being able to be eliminated during the travel of the tyre, the spaces defined by the warp and weft threads corresponding to the passages of the connecting elements of said cutout.

25. A tread for a tyre according to any one of Claims 21 to 23, characterised in that a plurality of cutouts are, at least in part, filled with a material which is in the form of threads, said material being able to be eliminated after vulcanisation of the tread.

26. A tread for a tyre according to any one of Claims 1 to 25, characterised in that, for at least one cutout (38) provided with at least one connecting element (311), at least one main wall of said cutout is covered with at least one rubber mix (32, 33) other than the rubber mix (34) forming the tread, and having improved properties of abrasion resistance.

27. A tread for a tyre according to Claim 26, characterised in that the rubber mixes (32, 33) covering the facing walls of one and the same cutout are of different types.

28. A tread for a tyre according to any one of Claims 1 to 27, characterised in that, whatever the level of wear of said tread, the length of active ridge of the pattern in the imprint is at least 50% of the length of active ridge on the rolling surface of the tread when new.

29. A tread for a tyre according to any one of Claims 1 to 28, characterised in that at least 80% of the cutouts provided with connecting elements have a width of at least 0.1 mm and at most 2 mm.

30. A tread for a tyre according to any one of Claims 1 to 29, characterised in that the connecting element of a cutout which is closest to the rolling surface in the new state is arranged such that the distances between the ridge formed by one of the main walls of said cutout on the rolling surface in the new state and the points of the contour of the intersection surface of said element on said wall are between 40% and 60% of the depth h of the cutout.

31. A method for manufacturing a tread of thickness E for a tyre, said tread being provided with a plurality of cutouts provided with at least one connecting element between the main walls of each of said cutouts, including the following steps:

- production of inserts (16) in an appropriate material, said inserts having the general form of the cutouts desired in the tread, and of thickness equal to the width of said cutouts;

- removal of material in each insert (16) to obtain (an) orifice(s) (17) in a distribution selected beforehand, each orifice having a shape equivalent to the cross-section of a connecting element between two main walls of one and the same cutout;

- insertion of the inserts (16) into a non-vulcanised strip of rubber;

- moulding in a mould having the dimensions of the tread, for moulding and vulcanising said tread and forming the connecting elements in the orifice(s) (17) of the inserts (16);

- demoulding the tread after vulcanisation.

32. A method for manufacturing a tread according to Claim 31, characterised in that, in order to permit the insertion of the inserts (16) into a non-vulcanised rubber strip, cutouts of a depth less than or equal to the thickness of said non-vulcanised rubber strip are first produced.

33. A method for manufacturing a tread of thickness E for a tyre according to Claim 31 or Claim 32, characterised in that after demoulding the vulcanised tread a grinding operation is effected on the rolling surface over a sufficient depth to make a plurality of rubber ridges formed by the walls of the cutouts provided with at least one connecting element appear on the surface.

34. A method for manufacturing a tread of thickness E for a tyre according to one of Claims 31 to 33, characterised in that the tread obtained is in the form of a closed ring.

35. A method for manufacturing a tread of thickness E for a tyre according to any one of Claims 31 to 34, characterised in that the material forming the inserts is a material having a melting point less than and sufficiently close to the vulcanisation temperature of said tread to become fluid shortly before the end of the vulcanisation, taking into account the gradual increase in temperature of the rubber forming said strip, so as to permit the removal of said filling material after vulcanisation, for example by suction or by blowing.

36. A method for manufacturing a tread for a tyre according to any one of Claims 31 to 35, characterised in that the material forming the inserts is preferably a cellulosic material, such as paper pulp.

37. A method for manufacturing a tread for a tyre according to any one of Claims 31 to 36, characterised in that the cutouts provided with at least one connecting element have a thickness of at least 0.4 mm.

38. A tyre comprising a tread defined according to any one of Claims 1 to 30.

39. A tyre according to Claim 38, characterised in that it is adapted to be fitted on driving axles of vehicles of the heavy goods type.

40. A tread of thickness E for a tire, provided with a rolling surface, said tread being provided with a plurality of cutouts, each cutout being defined by the

space defined principally between two opposing walls, said walls being perpendicular to or oblique to the rolling surface, and having a depth h, measured as the maximum radial distance measured between the points of the walls of said cutout which are radially farthest away, at most equal to the thickness E of the tread, characterized in that:

- the two main walls of at least one cutout located in the part of the tread affected by the loading on the ground of the tire during travel are connected by one rubber connecting element, this connecting element having with each of the walls a connection surface S_E corresponding to the total intersection surface, said surface S_E on each of the walls being at least 15% of the surface S_T of said wall and at most 40% of the same surface S_T,

- all the points of the outer contour of the surface of intersection of the connecting element with one of the walls are located at a distance from the rolling surface which is strictly less than the depth of the cutout,

- and in that the surface $\mathbf{S_G}$, equal to the surface, measured on said wall of the cutout, defined by the geometric contour L of minimum length and enveloping the connection surface S_E, is at least 90% of the surface S_T of said wall.

41. A tread for a tire according to Claim 40, characterized in that for at least one cutout, located in the part of the tread affected by the loading of the tire and provided with one connecting element, the ratio $T_P=S_P/S_T$ decreases virtually regularly with the wear of the tire at least starting from a predetermined

level of wear, S_P representing, on one of the main walls of said cutout, the connection surface remaining after partial wear of the tread and S_T representing the total surface of said wall corresponding to the same level of partial wear of the tread.

42. A tread for a tire according to Claim 40, characterized in that, for at least one cutout provided with one connecting element between a first main wall and a second main wall of said cutout, said connecting element forms an angle other than 90° with the direction perpendicular to the surface of the new tread, so as to maintain a great length of ridge on the rolling surface, whatever the degree of wear of the tread.

43. A tread for a tire according to Claim 40, comprising a plurality of cutouts provided with one connecting element connecting a first main wall to a second main wall of said cutouts, characterized in that for two adjoining cutouts of virtually identical orientation the radial and/or axial positions of the connecting element of each of said cutouts are different, so as to be able to conserve a great length of active ridges on the rolling surface whatever the level of wear of the tread.

44. A tread for a tire according to Claim 40, characterized in that, for at least one cutout provided with one connecting element, at least one main wall of said cutout is covered with at least one rubber mix other than the rubber mix forming the tread, and having improved properties of abrasion resistance.

45. A tread for a tire according to Claim 40, characterized in that the rubber mixes covering the

facing walls of one and the same cutout are of different types.

46. A tread according to Claim 40, characterized in that all the cutouts comprising at least one connecting element are entirely located beneath the rolling surface of the tread when new and in that, furthermore, there are provided on the surface of the tread of the new tire cutouts the depth of which is greater than the smallest of the distances between the cutouts comprising at least one connecting element and the rolling surface of the tread of the tire when new.

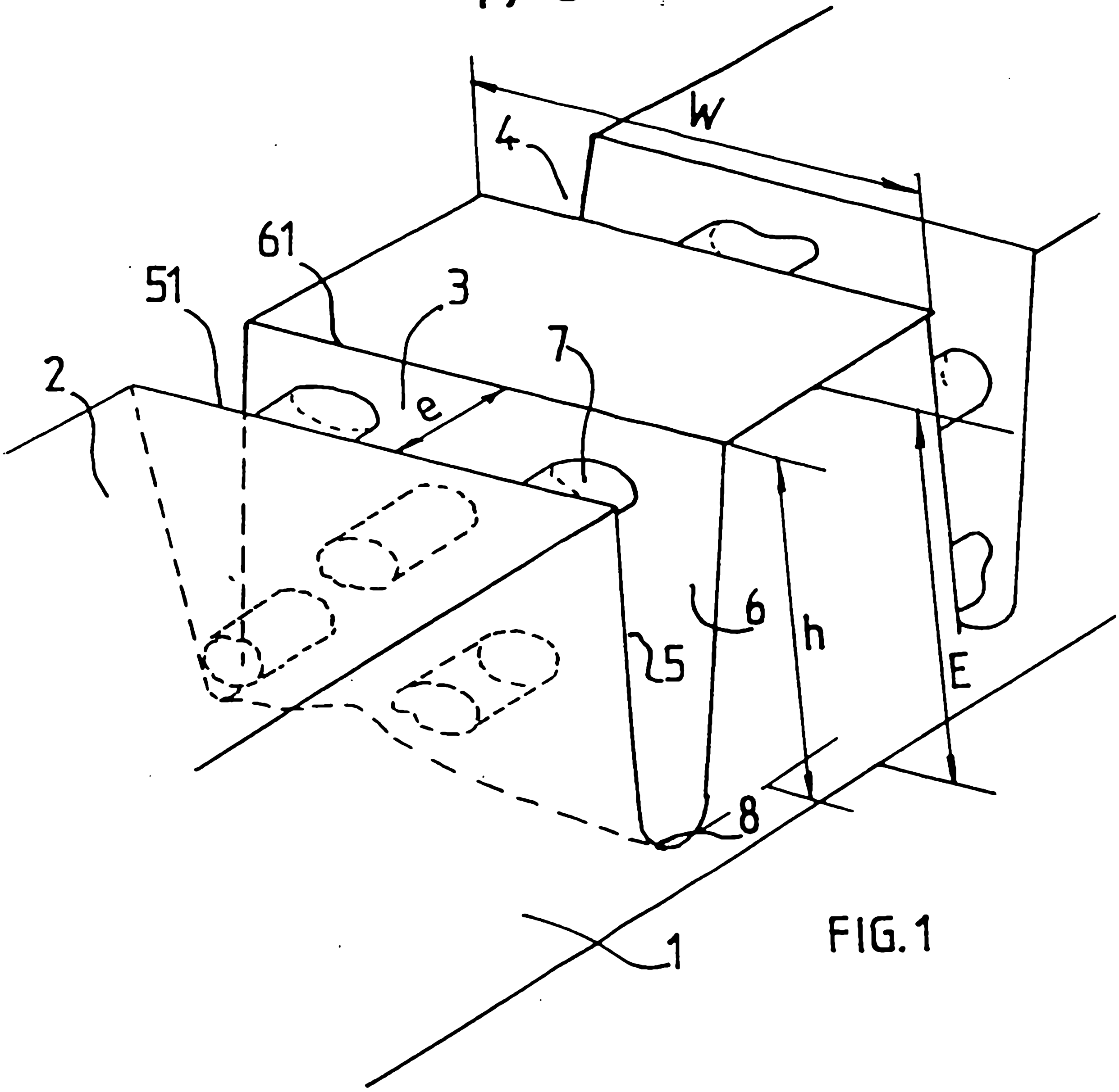


FIG.1

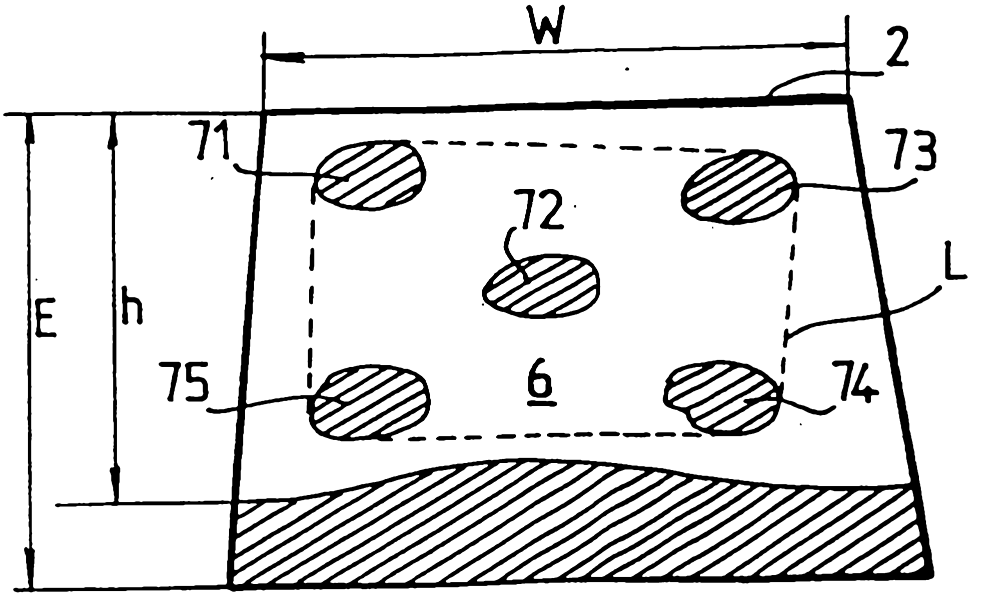


FIG. 2

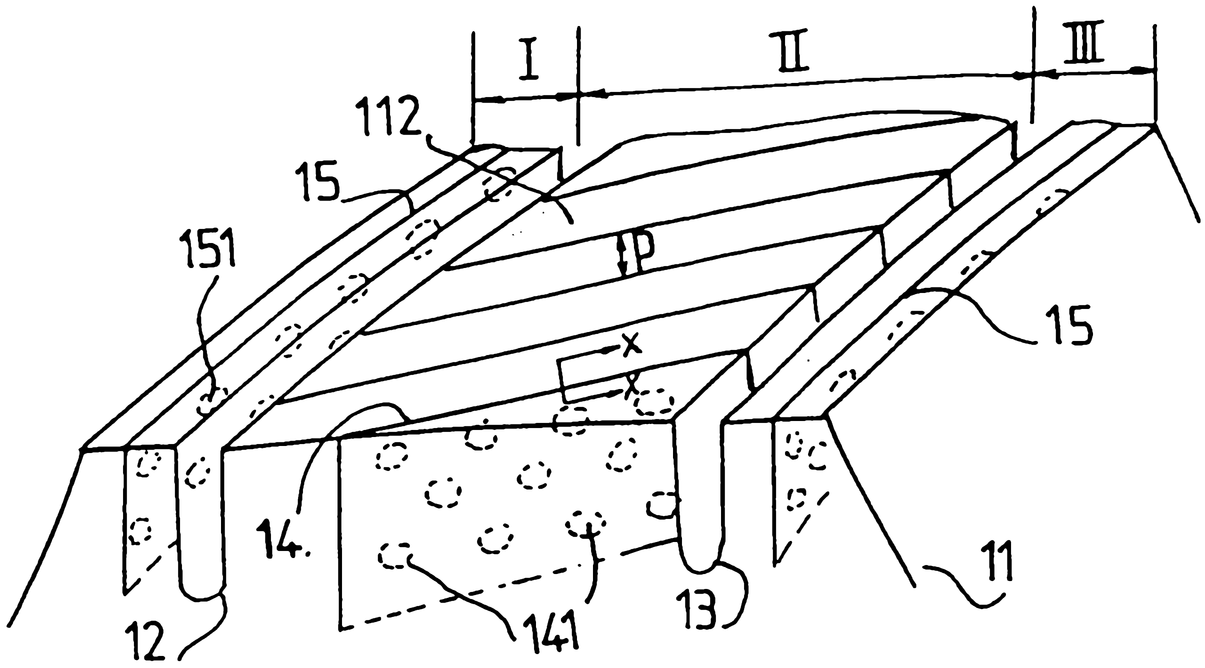


FIG. 4

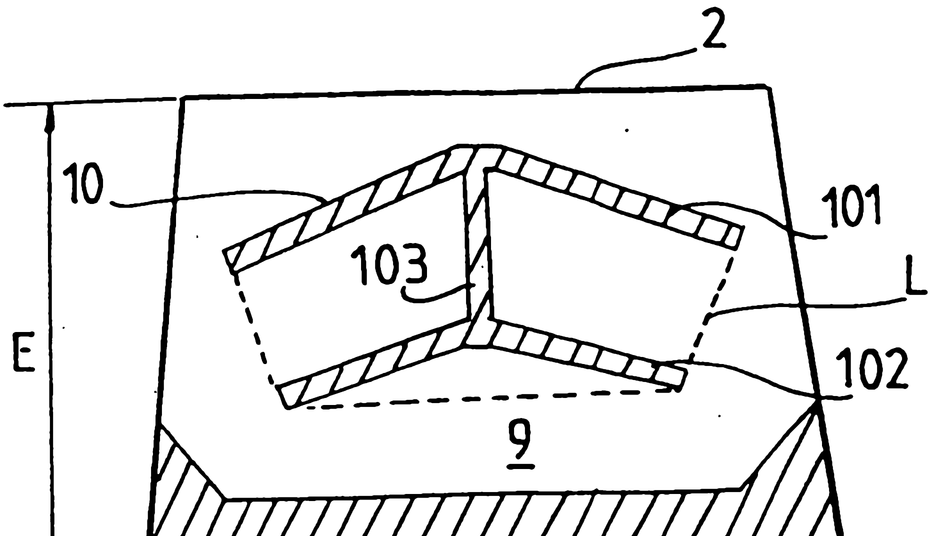


FIG. 3

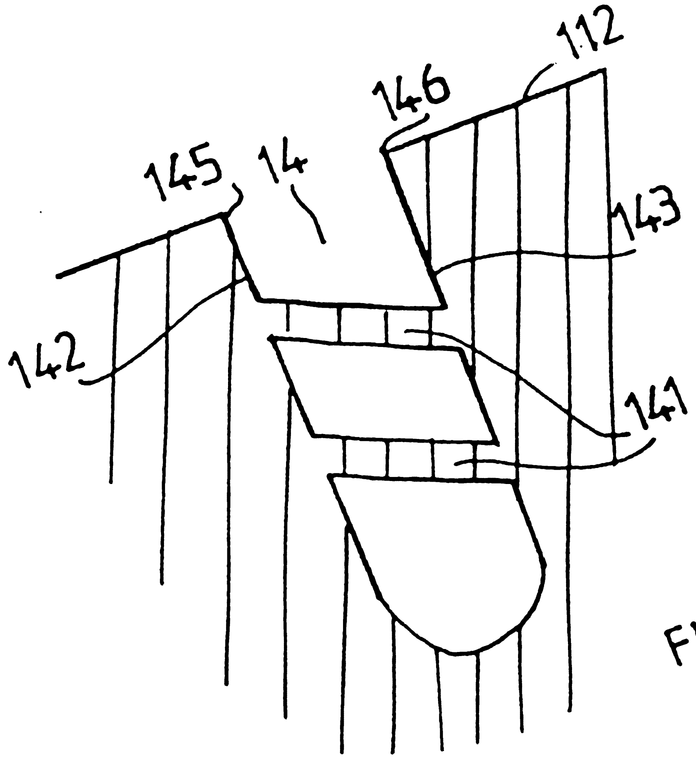


FIG.5

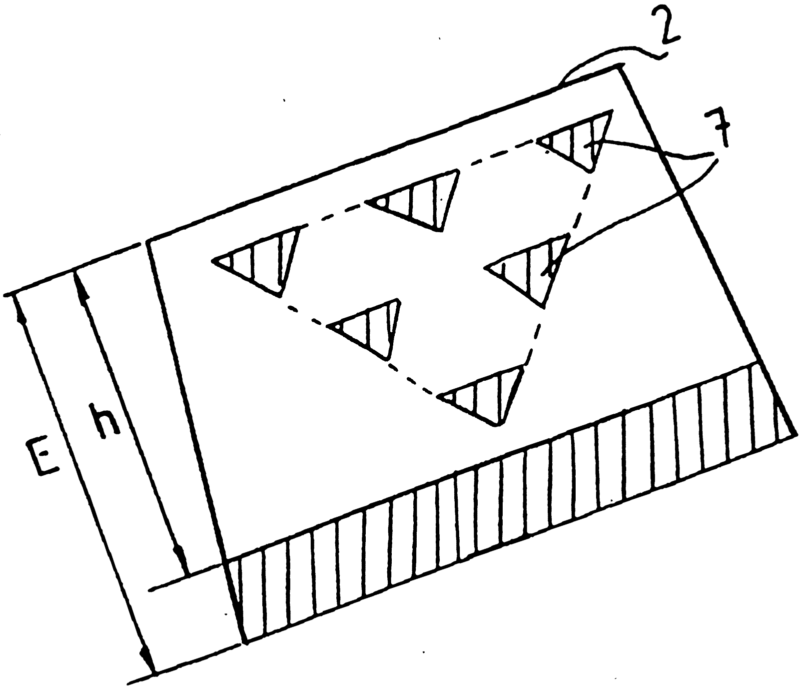


FIG. 6

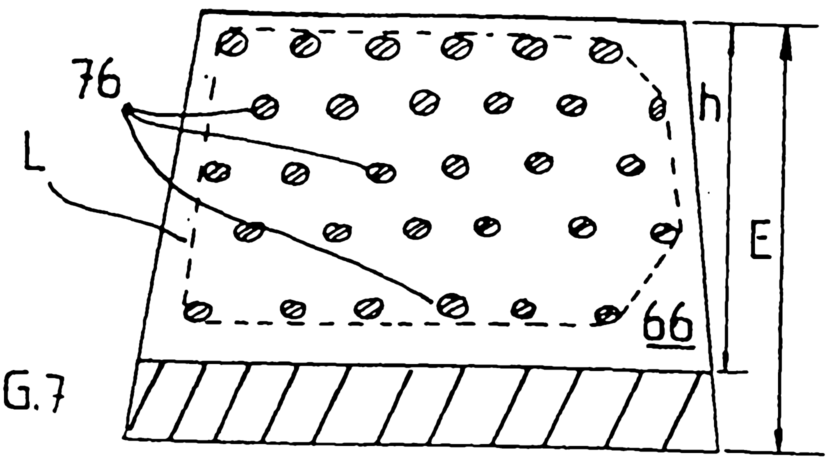


FIG.7

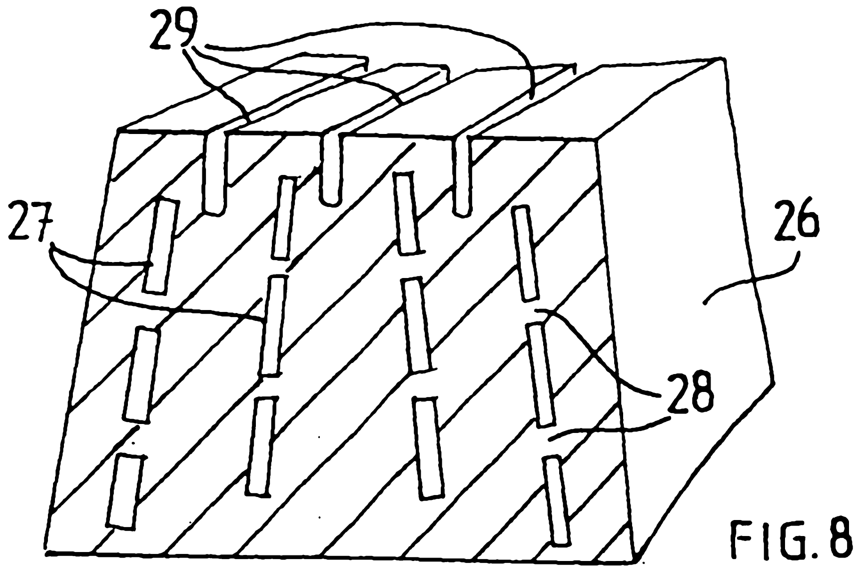


FIG.8

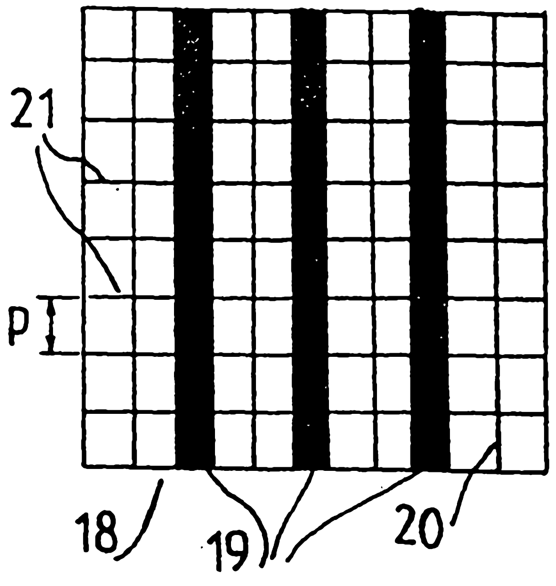


FIG.9A

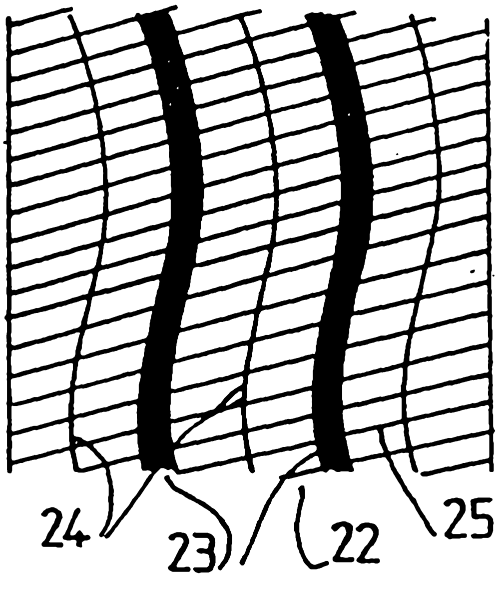


FIG.9B

FIG.9

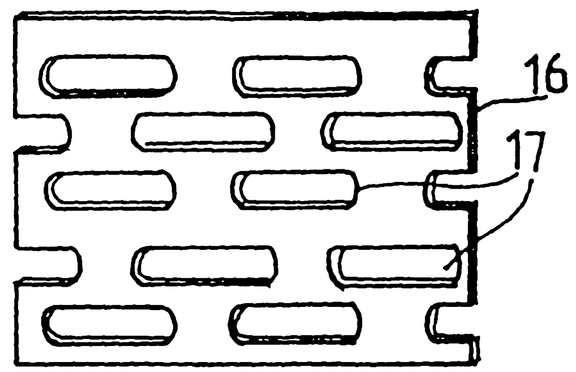
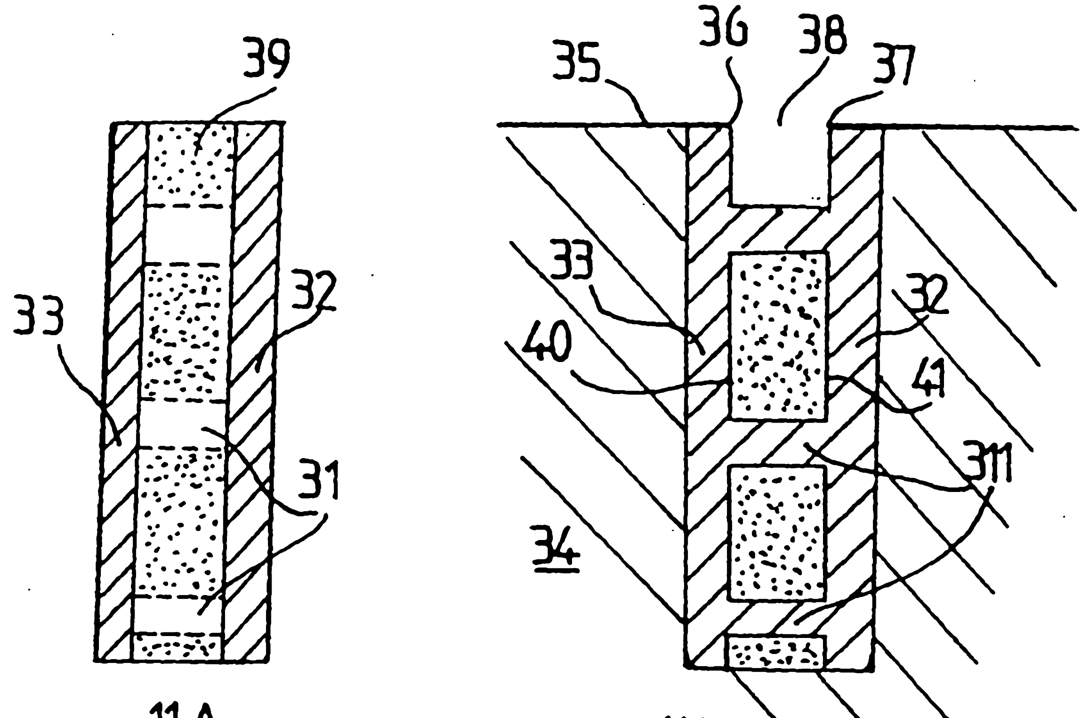


FIG. 10



11A

11B

FIG. 11