(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 321 026**
**A2**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **88202808.7**

(51) Int. Cl.4: **A63C 1/40 , A43B 5/16**

(22) Date of filing: **08.12.88**

(30) Priority: **14.12.87 NL 8703017**

(43) Date of publication of application:
**21.06.89 Bulletin 89/25**

(84) Designated Contracting States:
**DE NL SE**

(71) Applicant: **STAMICARBON B.V.**
**Mijnweg 1**
**NL-6167 AC Geleen(NL)**

(72) Inventor: **Van den Aker, Martinus Cornelis Adrianus**
**Beilerstroom 8**
**NL-5032 ER Tilburg(NL)**

(54) **Skate.**

(57) The invention relates to a skate, substantially comprising a gliding element, a skate body and a shoe, which includes as part of the skate body a tubular part from fibre-reinforced matrix material, into which the gliding element is fitted, characterized in that the tubular part is constructed in such a way that its coefficient of thermal extension in the longitudinal direction of the gliding element virtually equals that of the gliding element, by the use of continuous fibres having a coefficient of extension below zero with matrix material having a coefficient of extension above zero, the fibres being present in the matrix material in at least two directions. Because the coefficients of thermal extension of tubular part and gliding element are equal, no shear stresses occur.

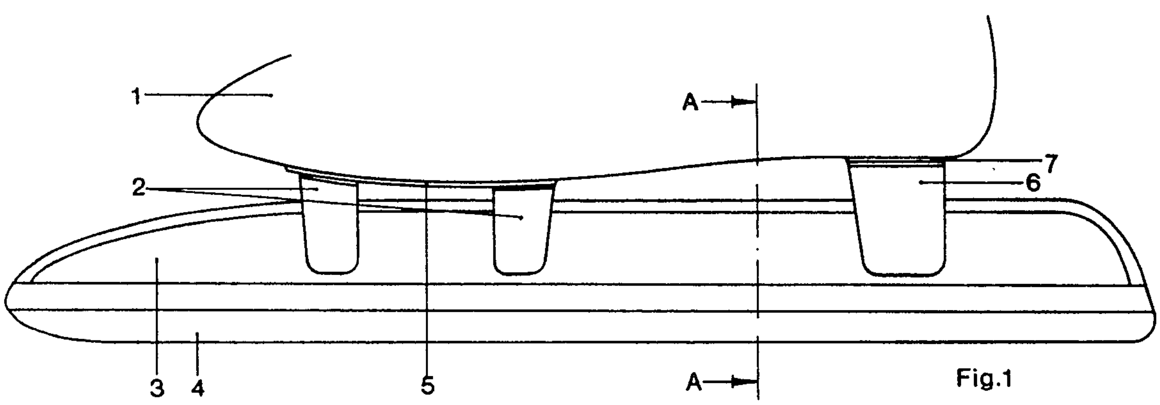

Fig.1

EP 0 321 026 A2

# SKATE

The invention relates to a skate substantially comprising a gliding element, a skate body and a shoe, which includes as part of the skate body a tubular part from fibre-reinforced matrix material into which the gliding element is fitted. A skate body generally comprises a tube, a sole and heel support and a sole and heel plate, on which the shoe is mounted.

Such a skate is known from WO-A-87/05818. In the development of a skate body, the aim is to combine the lowest possible skate body weight with sufficient flexural stiffness and torsional strength. Therefore, the skate is made of a fibre-reinforced plastic material which combines a low weight with a high flexural stiffness and torsional strength.

The disadvantage of this known skate is that, in the case of temperature changes, shear stresses occur between the skate body and the gliding element, due to differences in coefficient of extension between the fibre-reinforced plastic material used for the tube of the skate body and the gliding element. Temperature changes occur as a result of the large difference between production temperature, storage temperature and use temperature. This may eventually result in the bond between skate body and gliding element being broken.

The object of the invention is a skate that does not have the said drawback.

This is achieved according to the invention by the tubular part being constructed in such a way that its coefficient of thermal extension in the longitudinal direction of the gliding element is virtually the same as that of the gliding element, by the use of continuous fibres having a coefficient of extension below zero with matrix material having a coefficient of friction above zero, the fibres being present in the matrix material in at least two directions.

The matrix material reinforced with continuous fibres may also be referred to as the composite.

The man in the art can use the formula I as a guideline to calculate a resultant from the coefficients of extension of matrix and fibres for fibres oriented in one direction.

$$\alpha_c = \frac{V_f E_f \alpha_f + V_m E_m \alpha_m}{V_f E_f + V_m E_m} \qquad (1)$$

which is equalled by the coefficient of extension of the gliding element ($\alpha$g). The coefficient of friction of a composite reinforced with continuous fibres ($\alpha$c) can be determined from the coefficients of extension of the fibres and the matrix ($\alpha_f$ and $\alpha_m$, respectively), the volumetric proportions of the fibres and the matrix ($V_f$ and $V_m$, respectively) and the fibre and matrix elasticities ($E_f$ and $E_m$, respectively).

However, for the purpose of the present invention, the fibres are arranged at particular angles with respect to one another, which means that formula 1 cannot be used as such, since the fibres have a negative coefficient of extension in longitudinal direction but not in transverse direction.

According to the invention, the composite is composed of several layers of continuous fibres, which are oriented in, for example, longitudinal direction and transverse direction or at angles of, for example, +45¤ and -45¤ relative to the longitudinal direction, the sum of the coefficients of extension in longitudinal direction of the several layers of fibres equalling the desired overall coefficient of extension in longitudinal direction for the fibres. It may be advantageous to orient the fibres in the matrix at angles of + and 45¤ relative to the longitudinal direction, in connection with the resistance to torsion, but the invention is not limited to these angles, nor is it necessary to build up the composite from several layers, as long as the desired coefficient of extension in longitudinal direction is achieved.

Any desired value of $\alpha_c$ can be obtained, on account of the fact that the coefficients of extension of the matrix are usually more than zero, whereas those of the fibres are usually less than zero. In the table below, examples are given of fibre and matrix materials with a few materials of which the gliding element can be made, together with the coefficients of extension, without the invention being limited to these examples.

Table 1

| | Name | Coefficient of extension $K^{-1}$ | | Modulus of elasticity MPa |
|---|---|---|---|---|
| Fibres: | Carbon | - 0.5 | $10^{-6}$ | 220,000 |
| | Aramide | - 2 | $10^{-6}$ | 125,000 |
| | Dyneema/polyethylene | - 12 | $10^{-6}$ | 87,000 |
| | Glass | + 5 | $10^{-6}$ | 73,000 |
| Matrix: | Polyamide | + 95 | $10^{-6}$ | 1,300 |
| | Polycarbonate | + 60 | $10^{-6}$ | 2,200 |
| | Epoxy | + 50 | $10^{-6}$ | 3,500 |
| Steel | | + 12 | $10^{-6}$ | n.r. |
| Ceramics $Si_3N_4$ | | + 3.2 | $10^{-6}$ | n.r. |
| n.r. = not relevant | | | | |

The graph shows that matrix material with a positive coefficient of extension in combination with glass fibres only will in most cases fail to result in the desired coefficient of extension.

In the Examples IV and V, fibre and matrix combinations according to the invention are elaborated.

For obtaining a product with good mechanical properties, a high volumetric proportion of fibre material is important. The volumetric proportion of matrix material usually does not exceed 60 %.

In comparison with a metal skate tube, the space in the tube made from the composite is large. As a result, the tube may function as a resonance body, and the sound of the gliding element gliding over the ice and the gliding element hitting the ice may be amplified to the point where it becomes a nuisance. To damp these noises, the space inside the tube may be filled with foam and/or with a pre-formed foam part.

The gliding element may be made of, for example, steel or another metal or from ceramic material with a high hardness and wear resistance, for example aluminium oxide, zirconium oxide, silicon nitride and silicon carbide. It is preferably made of steel.

The heel and sole support and the heel and sole plate are preferably also made of composite material as described above. However, they might also be made of, for example, a highly filled injection moulding or casting resin. It is possible to make the heel and sole support and the heel and sole plate in one piece. The supports are fastened to the tube by gluing, welding or mechanical means. Mechanical fastening of the heel and sole support to the tube, for example by rivets or screws, has the advantage that the supports can be replaced by new or other supports and plates without damage to the tube.

The skate can be made by, for example, one of the methods described below, Examples I, II or III. The methods of Example I and II are discontinuous, while III can be carried out continuously.

In the Examples IV and V, choices of matrix and fibres with different gliding elements are indicated. In the Figures 1, 2 and 3, an example of the produced skate is shown. Figure 1 is a side-view of the complete skate. Figure 2 is a cross-section through A-A. Figure 3 shows a cross-section in case the tube is moulded in one piece. The numbers in the methods described below refer to these figures.

## Example I

The tube (3) consists of two shell parts. The shell parts (10) are moulded in positive and/or negative mould halves, or are vacuum-formed. For this purpose, use can be made of dry fibres, fabrics/mats or combinations thereof, to which the resin is added by injection (so-called resin transfer moulding or resin injection moulding), as well as of pre-impregnated fibres, fabrics or mats. The shell parts can also be made by thermoforming of a thermoplastic composite plate. The shell parts are glued or welded and/or mechanically fastened to the gliding element (4); this depends on, among other things, the type of matrix material used (thermosetting or thermoplastic). The space between the shell parts (Fig. 2, 11) can be filled with foam or with a pre-formed foam part. Next, the sole support (Fig. 1, 2) with the sole plate (Fig. 1, 5) and the heel support (Fig. 1, 6) with the heel plate (Fig. 1, 7) is glued, welded or mechanically fastened to the tube. On these, the skate shoe is mounted.

## Example II

The tube (3) is moulded in one piece, around a removable or non-removable core (Fig. 3, 8). The fibres, fabrics or mats are applied to the core at desired angles. The matrix is injected and polymerized. It is also possible to use semi-manufactures for this purpose. If a thermoplastic composite is used, the tube can be made by a thermoforming process. The space in the tube (Fig. 2, 11) can be filled with foam or with a pre-formed foam part. The tube is shortened to the required length and closed or rounded off (as in Fig. 1). Next, the sole support (Fig. 1, 2) with the sole plate (Fig. 1, 5) and the heel support (Fig. 1, 6) with the heel plate (Fig. 1, 7) are glued, welded or mechanically fastened to the tube. On these, the skate shoe is mounted.

Example III

The tube (moulded part 9) is continuously produced by means of pultrusion or thermoforming (so-called roll-forming). In the case of pultrusion, the fibres are pulled through a mould together with mats or fabrics. The thermosetting or thermoplastic resin can be added by injection or via a resin bath. After polymerization in the mould, the tube is shortened to the required length. Thermoforming takes place by passing a thermoplastic composite which has been heated to above the softening point through a mould or pre-heated rolls. The thermoplastic cools off in the mould or between the rolls and becomes stable, after which it can be shortened. The space inside the tube (Fig. 2, 11) can be filled with foam or with a pre-formed foam part. The ends of the tube are closed and the sole support (Fig. 1,2) with the sole plate (Fig. 1,5) and the heel support (Fig. 1,6) with the heel plate (Fig. 1,7) are glued, welded or mechanically fastened to the tube. On these, the skate shoe is mounted.

Example IV

The gliding element is made of steel with a coefficient of thermal extension of +12 . $10^{-6}$ $K^{-1}$. The skate body is made of a carbon-fibre reinforced epoxy resin. 77% of the fibres are placed in the mould at angles of +38 to 40¤ and - 38 to 40¤ and 23% at an angle of 0¤, the fibre content relative to the total composite being 48 wt.%.

Example V

The gliding element is made of silicon nitride ceramic material with a coefficient of extension of +3.2 . $10^{-6}$ $K^{-1}$. The skate body is made of a carbon-fibre reinforced epoxy resin. 78 % of the fibres are placed in the mould at an angle of 90¤, and 22% at an angle of 0¤, the fibre content relative to the total composite being 55 vol.%.

## Claims

1. Skate, substantially comprising a gliding element, a skate body and a shoe, which includes as part of the skate body a tubular part from fibre-reinforced matrix material, into which the gliding element is fitted, characterized in that the tubular part is constructed in such a way that its coefficient of thermal extension in the longitudinal direction of the gliding element virtually equals that of the gliding element, by the use of continuous fibres having a coefficient of extension below zero with matrix material having a coefficient of extension above zero, the fibres being present in the matrix material in at least two directions.

2. Skate according to Claim 1, characterized in that the combination of fibres and matrix is obtained by application of several layers of fibres on top of one another.

3. Skate according to any one of Claims 1-2, characterized in that a portion of the fibres is applied at an angle of from -10 to -50¤ and from +10 to +50¤ relative to the longitudinal direction.

4. Skate according to any one of Claims 1-3, characterized in that the volumetric proportion of the matrix material is less than 60%.

5. Skate according to any one of Claims 1-4, characterized in that the tubular part is filled with a sound-damping substance, e.g. foam.

6. Process for production of the tubular part of a skate body according to any one of Claims 1-5, characterized in that the tubular part is composed of two shell parts which are compression moulded or vacuum-formed in positive or negative mould halves using dry fibres, fabrics, mats or knitted fabrics or a combination thereof, to which resin is added.

7. Process for production of the tubular part of a skate body according to any one of Claims 1-5, characterized in that the tubular part is made in one piece, using fibres, fabrics, mats or knitted fabrics or combinations thereof, to which resin is added.

8. Process according to any one of Claims 6-7, characterized in that use is made of one or more thermoplastic composite plates.

9. Process for the production of the tubular part of a skate body according to any one of Claims 1-5, characterized in that the tubular part is made starting from fibres, fabrics, mats or knitted fabrics or combinations thereof which are shaped by pulling them through a mould, after which the tubular part is shortened to the required length.

10. Process according to Claim 9, characterized in that to the fibres, fabrics, mats or knitted fabrics or combination thereof a thermosetting or thermoplastic material suitable for impregnation is added, before shaping or during shaping by injection into the mould.

11. Mould according to any one of Claims 6-10, characterized in that at least a portion of the fibres, fabrics, mats, knitted fabrics of combination thereof is composed of fibres containing a material suitable for impregnation.

12. Tubular part for a skate body according to any one of Claims 1-5 obtained using a process according to any one of Claims 6-11.

13. Tubular part of a skate body according to Claim 12 with a gliding element fastened to it.

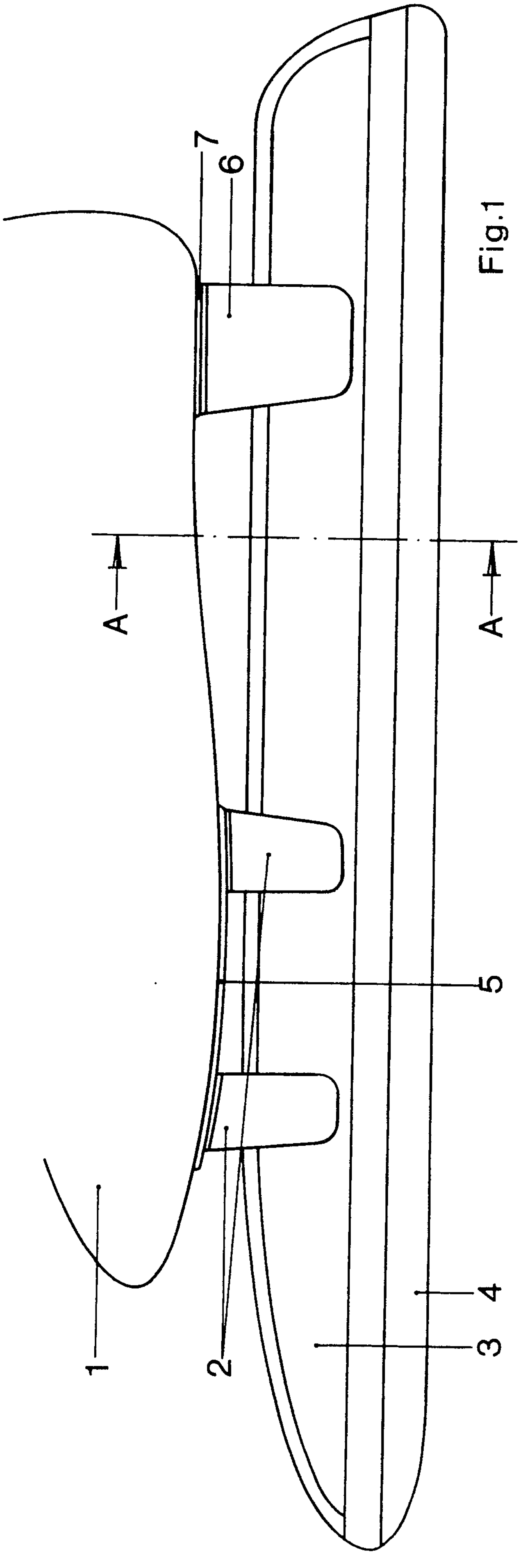


Fig.1

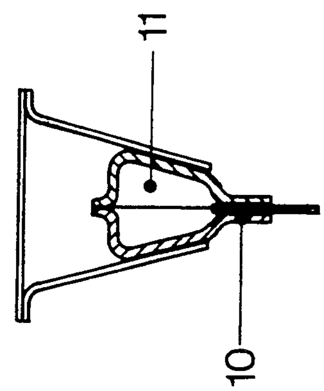


Fig.2

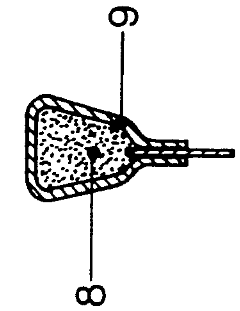


Fig.3