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D E C I S I O N
of 17 August 1999

Case Number: T 0226/96 - 3.3.6

Application Number: 89908326.5

Publication Number: 0423213

IPC: D01F 6/62

Language of the proceedings: EN

Title of invention:

Dimensionally stable polyester yarn for high tenacity treated cords

Patentee:

AlliedSignal Inc.

Opponent:

Rhone-Poulenc Viscosuisse SA Patentabteilung
Hoechst Aktiengesellschaft Zentrale Patentabteilung

Headword:

Polyester yarn/ALLIEDSIGNAL

Relevant legal provisions:

EPC Art. 54, 56

Keyword:

"Novelty - yes"
"Inventive step - yes"

Decisions cited:

-

Catchword:

-



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Boards of Appeal

Chambres de recours

Case Number: T 0226/96 - 3.3.6

D E C I S I O N
of the Technical Board of Appeal 3.3.6
of 17 August 1999

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Decision under appeal: Interlocutory decision of the Opposition Division
of the European Patent Office posted 12 January
1996 concerning maintenance of European patent
No. 0 423 213 in amended form.

Composition of the Board:

Chairman: P. Krasa

Members: G. Dischinger-Höppler
M. Lewenton

Summary of Facts and Submissions

I. Two notices of opposition were filed against European patent No. 0 423 213, relating to dimensionally stable polyester yarn for high tenacity treated cords. Objections under Article 100(a) EPC (lack of novelty and inventive step) were raised by the opponents relying, inter alia, upon the following citations:

- (1) US-A-4 195 052 (& DE-A-2 747 803),
- (2) US-A-3 690 362,
- (3) EP-B-0 169 415 and
- (5) JP-A-116 414/84 (English translation).

During the opposition and appeal proceedings, the following further documents were referred to:

- (3A) EP-A-0 169 415,
- (6) US-A-4 491 657 (cited in the patent in suit), and
- (7) Ludewig, Polyesterfasern, Chemie und Technologie, Akademieverlag, 1975, page 482.

II. By an interlocutory decision, the opposition division decided to maintain the patent in amended form according to the auxiliary request submitted during oral proceedings. The opposition division took the view that the subject-matter of Claim 1 of the main request lacked novelty over the comparative run 4 of Example 1 of document (3A).

III. The patent proprietor and opponent I, both, lodged an appeal against this decision. Opponent II responded to the proprietor's appeal. With letter dated 9 February 1999, opponent II declared himself no longer to be a party to the appeal proceedings. By letter of 11 August 1999, opponent I withdrew his appeal. In the following the opponents will, for sake of convenience, be referred to as respondents.

IV. During oral proceedings which took place on 17 August 1999 in the absence of the respondents, the appellant (proprietor) submitted a new set of 16 claims as a sole request, the independent claims reading:

"1. A process for the production of a drawn polyethylene terephthalate yarn which translates to a high tenacity dimensionally stable tire cord, comprising:

(A) extruding a molten melt-spinnable polymer containing at least 90 mol percent polyethylene terephthalate and having an intrinsic viscosity of 0.8 or greater through a shaped extrusion orifice having a plurality of openings to form a molten spun yarn,

(B) solidifying the spun yarn gradually by passing the yarn through a solidification zone which comprises

(a) a retarded cooling zone and
(b) a cooling zone adjacent said retarded cooling zone wherein said yarn is

rapidly cooled and solidified in a blown air atmosphere,

- (C) withdrawing the solidified yarn at sufficient speed to form a crystalline, partially oriented yarn with a crystallinity of 3 to 15 % and a melting point elevation of 2 to 10 °C, and
- (D) hot drawing the yarn to a total draw ratio between 1.5 : 1 and 2.5 : 1

to obtain a terminal modulus of at least 20 g/d (18 cN/dtex).

- 7. A drawn polyethylene terephthalate multifilament yarn containing at least 90 mol percent polyethylene terephthalate and having the following combination of properties:

- (A) a terminal modulus of at least 20 g/d (18 cN/dtex),
- (B) a dimensional stability defined by $E_{4,5} + FS < 13.5 \%$,
- (C) a tenacity of at least 7 g/d (6.2 cN/dtex),
- (D) a melting point elevation of 9 to 14 °C, and
- (E) an amorphous orientation function of less than 0.75.

- 12. A high tenacity, dimensionally stable treated tire cord prepared from the yarn of claim 7.

- 13. A rubber article incorporating as reinforcing material the high tenacity, dimensionally stable

cord of claim 12.

14. A composite incorporating as reinforcing material the drawn yarn of claim 7.

15. A drawn polyethylene terephthalate yarn obtained by the process of Claim 1 and which, when twisted into a 315x315 twists/m (8x8 twists/inch) 1000 denier (1100 dtex) 3-end greige cord and tensilized by the sequence of dipping into a first blocked diisocyanate dipping solution, stretching at 227 °C (440 °F) for 40 seconds, dipping into a second resorcinol-formaldehyde latex dipping solution, and relaxing at 227 °C (440 °F) for 60 seconds, provides the following treated cord property combinations:
 - (a) a dimensional stability defined by LASE-5 of at least 2.3 g/d (2.0 cN/dtex) at 4 percent free shrinkage, and
 - (b) a tenacity of at least 7.0 g/d (6.2 cN/dtex) at 4 percent free shrinkage,said dimensional stability and said tenacity being determined by interpolation of LASE-5 versus free shrinkage data to 4 percent free shrinkage."

V. The appellant argued in essence

- that the subject-matter as claimed in accordance with the independent claims was novel with respect to the cited prior art;

- in particular, that the subject-matter of Claim 1 was novel with respect to run 4 of Example 1 of

document (3A) which did not give a product having a terminal modulus above 20 g/d, a crystallinity of 3 to 15 % as defined in the patent in suit and a melting point elevation of 2 to 10°C for the undrawn yarn;

- that document (3A) did not disclose a drawn yarn having a dimensional stability expressed as $E_{4,5} + FS$ in combination with a melting point elevation and a high terminal modulus as in Claim 7 of the patent in suit nor the treating conditions for obtaining a cord in accordance with Claim 15;
- that document (3A) was the closest prior art for assessing inventiveness in particular of the process claim, because it uses a retarded cooling zone;
- but that the claimed subject-matter was inventive because there was no motivation in document (3A) to redesign the known process in a manner to obtain a drawn yarn having a terminal modulus of at least 20 g/d and which translated into a low drop in tenacity when transformed into a cord;
- that even if one started from document (5) for assessing inventive step of the drawn yarn, the cited prior art would not prompt someone skilled in the art to try to provide a yarn having the particular combination of properties set out in Claim 7.

VI. In their written statements, the respondents presented,

in essence, the following arguments:

- Run 4 of Example 1 of document (3A) anticipated the subject-matter of Claim 1.
- Considering that the teaching of document (1) was included in document (3A) by reference, the subject-matter of Claim 7 was also anticipated.
- The subject-matter of Claims 1, 7 and 15 was, in any case, not inventive for lack of any particular effect in comparison to the disclosure of documents (3A), (2) or (5).

VII. The appellant requested

that the decision of the opposition division be set aside and the patent maintained on the basis of

- Claims 1 to 16 as submitted during oral proceedings,
- pages 2 to 13 and page 14, lines 1 to 40 of the specification and figures 1 to 10 of the patent as granted.

The respondents requested in writing that the appeal be dismissed.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

The new claims correspond to the claims of the main request considered by the opposition division with the exception that Claim 15 has been restricted to yarns obtained by the process of Claim 1 as is disclosed in the application as originally filed (see page 2, lines 10 to 28, page 11, line 24 to page 13, line 24 and Examples 1 and 2). The amendment does not, therefore, contravene Article 123(2) and (3) EPC.

As is correctly set out in the contested decision, all other amendments made to the claims as granted also comply with the requirements of Articles 123(2) and (3) EPC. This was not disputed at the appeal stage.

3. *Novelty*

3.1 Subject-matter of Claims 1 and 15

Lack of novelty was raised by the respondents on the basis of document (3A), in particular of run 4 of Example 1 disclosed therein for the purpose of comparison. This document discloses a process for the production of polyester fibres suitable for the production of tire cords having a high strength in combination with low shrinkability and high fatigue resistance (see page 1, line 33 to page 2, line 4), hence of tire cords having high tenacity and being dimensionally stable. This process consists in extruding from a spinneret having 250 holes molten polyethylene terephthalate (PET) having an intrinsic viscosity (IV) of 0.9 or higher and containing at least 90 mole% of ethylene terephthalate recurring units in

the molecule chain. The extruded yarn is maintained for a certain time at a temperature either higher than the melting point or lower than the melting point but higher than the crystallization-initiating temperature to delay cooling, and thereafter by application of blown air cooled and solidified. This yarn is then withdrawn and subjected to hot drawing to a total draw ratio of between 1.4:1 as in run 9 and 2.1:1 as in comparative run 4 (see page 3, line 23 to page 4, line 20, page 7, lines 19 to 26, Example 1 and Table 1).

Whereas the above process features correspond to those of the process according to Claim 1 of the patent in suit, the latter further requires that the withdrawing of the solidified yarn must be at sufficient speed to form a crystalline, partially oriented undrawn yarn (POY) with a crystallinity of 3 to 15% and a melting point elevation of 2 to 10°C and that the final drawn product yarn has a terminal modulus of at least 20 g/d (18 cN/dtex).

As is evident from the patent in suit (page 2, lines 34 to 40) the process parameters of Claim 1 result in a product yarn having the combination of features as set out in Claim 7, including a terminal modulus of 20 g/d or more. This feature is, hence, redundant with respect to the definition of the process of Claim 1.

In Table 1 of document (3A) a crystallisation degree is given for the undrawn yarn of all the listed runs. Run 4 has a value (14.7%) within the claimed range of 3 to 15%. The board recognizes that in the patent specification, crystallinity is determined from the

density of the yarn, whereas according to document (3A) it is determined by X-ray wide-angle diffractometry or can be calculated from the birefringence of the yarn (page 8, lines 15 to 21). However, since Claim 1 is not restricted to a particular method of determining the crystallinity, the value given in Table 1 for run 4 must be considered to be within the range given in Claim 1 of the patent in suit.

In contrast, document (3A) is totally silent about any elevation of the melting point of the polymer during production of the **undrawn yarn**. Contrary to the respondent's opinion, any such elevation cannot be unambiguously inferred from the context of the document either. The only melting points which are mentioned in document (3A) relate to the **drawn yarn** after a particular hot drawing and stretching treatment (Table 1) or after a hot drawing and relaxing treatment (Table 2). The respondents, referring to the melting point of 259°C given in Table 1 for the **drawn yarn** of run 4, suggested that the starting polymer had the same melting point as in the patent in suit, i.e. 249°C, and concluded that the resulting melting point elevation of 10°C was within the claimed range.

There is, however, not any indication that the composition of the starting polymer used for extrusion in document (3A) is necessarily identical with that of the present patent and would, therefore, have the same melting point of 249°C. As a rule, the melting point of a product generally depends on its purity grade, which - in its turn - varies with the method and conditions used for manufacturing. The PET in document (3A) is made from dimethylterephthalate and ethylene glycol

(Example 1) while the patent in suit suggests use of terephthalic acid instead of dimethylterephthalate. Further considering that different kinds and amounts of ester-forming ingredients may be copolymerized in the PET-units (page 3, lines 26 to 31), the board is convinced that different purity grades and hence different melting points may result for the products exemplified in document (3A) on the one hand and in the patent in suit on the other hand. It should be noted in this connection that the board is further convinced that any interrelationship of features such as stress and strain (see Figure 11.2 in document (7)), or spinning speed and density, crystallinity or melting point respectively are only valid for a particular polymer composition and cannot - without due consideration of the exact composition - be generalized, in particular not for any melt-spinnable polymer containing at least 90 mol percent polyethylene terephthalate and having an intrinsic viscosity of at least 0.8.

Neither is it possible to infer from the teaching of document (3A) that the melting point of the **undrawn yarn** might necessarily be the same as for the **drawn yarn**. On the contrary, all examples given in the patent in suit show that the melting point of the **drawn yarn** is higher than that of the **undrawn yarn** (Tables I, II, IV and V). In addition, it has not been shown, nor is it evident, that under the conditions given in Example 1 of document (3A) for the production of the **undrawn yarn**, there was any increase of the melting point at all. Again it can be seen from the examples of the patent in suit (Example II and Table IV) that - depending on the spinning conditions - the increase in

the melting point might be zero. On the other hand, it may also be well above the upper limit of 10°C of the claimed range.

Consequently, it has not been proved that spinning of fibres from the particular polyethylene terephthalate described in Example 1 of document (3A) at a spinning speed of 2500 m/min in accordance with run 4 inevitably results in the claimed melting point elevation.

Hence, the process of Claim 1 is, in the board's judgment, distinguished from what is disclosed in Example 1, run 4, of document (3A) by the feature of applying spinning conditions such that in the undrawn yarn the melting point is increased by 2 to 10°C.

The claimed process is also novel with respect to the other cited prior art documents, because neither of them discloses the above feature concerning the claimed increase in melting point.

The same conclusion as to novelty necessarily applies to the yarn of Claim 15; the novelty of which was never contested.

3.2 Subject-matter of Claims 7 and 12 to 14

In view of run 4 of Example 1 of document (3A), the respondents also attacked the novelty of the subject-matter of Claim 7. However, document (3A) is totally silent about any specific value for a dimensional stability of the drawn yarn as defined by the sum of the elongation at a load of 4.5 g/d and the free shrinkage ($E_{4,5} + FS$). This fact was not disputed by the

respondents. They argued, however, that a yarn having a dimensional stability of < 13.5%, as required in Claim 7, was known from document (1) (e.g. from Table IV, by the addition of elongation value of 6.75 and shrinkage value of 5.0) and that the teaching of document (1) was included in document (3A) by way of reference since the Japanese version of document (1) was cited therein.

The elongation values referred to in document (1) relate to the elongation during a final thermal treatment stage including a third drawing. This fact renders questionable already whether these elongation values can be compared with a drawn yarn elongation at 4.5 g/d load at all. Moreover, the respondent's line of argument cannot be accepted for the following reasons:

Document (1) is referred to in document (3A) as an existing prior art process for producing a drawn polyester yarn with improved fatigue resistance and low shrinkability exhibiting the drawbacks of yarn breakage and unstable production due to the rapid cooling of the fibres just below the spinneret. These drawbacks are clearly not wanted in the process and product of document (3A) (see page 2, line 33 to page 3, line 9). Nothing hints at the respondent's suggestion that the specific properties related to the dimensional stability of the yarn of document (1) are, indeed, included in the yarn of document (3A). This is particularly true for the yarn of comparative run 4 of Example 1 in respect of its dimensional stability when expressed as $E_{4,5} + FS$, because this run shows an exceptionally large shrinkage factor of 12.2%. Compared with the shrinkage factors ranging from 4.2% to 7.8% as

given in document (1) (Tables I to IV), such a high factor would require a very low elongation value $E_{4,5}$ in order to give for the sum of $E_{4,5} + FS$ a value of below 13.5%. No such elongation values at a load of 4.5 g/d can be inferred from document (3A). It has not been overlooked that the shrinkage factors in document (3A) have been determined at a higher temperature (210°C) than those of document (1) (175°C), but a reliable correlation of these factors has not been demonstrated by the respondents.

Hence, it is not permissible for the purpose of assessing novelty to combine features of the yarns disclosed in documents (1) and (3A), with the consequence that the yarn of Claim 7 is novel with respect to document (3A).

It is further novel in regard of document (1) and all the other cited prior art documents, if only for the reason that none of them discloses, explicitly or implicitly, a particular increase in melting point for the drawn yarn.

This conclusion also extends to the tire cord of Claim 12, the rubber article of Claim 13 and the composite of Claim 14 which all include the yarn of Claim 7 as a basis material.

4. *Inventive step*

4.1 Technical background

The patent in suit relates to a polyester multifilament yarn with high modulus and low shrinkage particularly

useful for textile reinforcement of tires. To this end, treated cord tenacity and dimensional stability are of particular interest (page 2, lines 7 to 8 and 17 to 19).

According to the patent in suit, there existed already a multifilament polyester yarn with high initial modulus and low shrinkage, and a yarn tenacity which translates into reduced tenacity when the yarn is converted to the treated tire cord. This translation is the so-called yarn to treated cord conversion efficiency. It is further said that document (6) discloses a high modulus, low shrinkage polyester yarn which requires a low terminal modulus to achieve good yarn to treated cord conversion efficiency, but that the low terminal modulus is carried over into a low tenacity cord. Moreover, rapid cooling of the filaments immediately after spinning is said to yield a yarn with poor mechanical quality due to excessive filament breakage (page 2, lines 19 to 27).

According to the patent in suit it is aimed, therefore, at a yarn of good mechanical quality which, at a high conversion efficiency, translates into cord with high tenacity and high dimensional stability (page 2, lines 34 to 42).

4.2 Process according to Claim 1

Of the cited prior art, only documents (3A) and (6) operate during solidification in the same way as the process of the patent in suit, namely with a retarded cooling zone followed by a rapid cooling zone (cf. in document (3A), page 7, lines 22 to 25, page 13, lines 4

to 7 and Table 1 "cooling conditions"; in document (6), column 13, lines 6 to 13; in the patent in suit, page 7, lines 10 to 11). These processes are, hence, suitable to overcome undesired filament breakage and to provide a mechanical stable yarn.

The yarn produced according to document (6) can be transformed into a cord at a conversion efficiency of around 78% (Tables 3 and 4). However, considerably higher conversion efficiency can be obtained when the yarn is produced in accordance with document (3A), especially when the undrawn fibres have a crystallinity of above 15% (see values given in Table 1 of document (3A) for the tenacity of the treated cord which has been twisted from two yarns of 1000 denier each, in comparison with the drawn yarn strength). Document (3A) qualifies therefore as the most appropriate starting point for assessing inventive step of the claimed process.

While not being directly comparable with the data in the patent in suit, high tenacity and dimensional stability of the cord product of the known process can be inferred from the treated cord data given in Table 1 of document (3A). However, the polyester fibre of document (3A) has a terminal modulus of not higher than 10 g/d.

The technical problem to be solved by the claimed process in view of the process disclosed in document (3A) can, therefore, be seen in the provision of a process for manufacturing a yarn having a high terminal modulus of at least 20 g/d and also a good mechanical quality, and which simultaneously, translates at high

conversion efficiency into cord with high tenacity and high dimensional stability.

According to present Claim 1 this problem is essentially solved by the combination of process features (A) to (D) including the particularity of withdrawing the solidified yarn at sufficient speed such that a partially oriented undrawn yarn with a crystallinity of 3 to 15% is obtained, wherein the melting point is increased by 2 to 10°C.

Having regard to the results as shown in the Examples I and II and Tables I to VI of the patent in suit this combination of features actually results in a high terminal modulus yarn giving the best combination of conversion efficiency, tenacity and dimensional stability at a particular free shrinkage (e.g. 4%). It is, therefore, plausible that the problem as defined above has been solved.

Document (3A) aims at the production of a polyester fibre having a terminal modulus of up to 10 g/d, preferably up to 9 g/d. It explicitly warns against higher terminal moduli which would translate into a large loss of strength during cord twisting (page 5, lines 19 to 27). The teaching of document (3A) is, therefore, totally unsuitable to influence someone skilled in the art to proceed contrary to the said warning with a view to obtain from a high terminal modulus yarn a cord with good tenacity.

The question remaining to be answered now is whether it was - in the light of the available prior art - obvious for someone skilled in the art to modify the process of document (3A) in the claimed way to produce a high terminal modulus PET-yarn which can be transformed into cord at high conversion efficiency in order to solve the above indicated problem.

Document (1) is silent about the terminal modulus of the produced drawn yarn, or any conversion efficiency when twisted into a cord. Likewise, document (2), while describing the production of a high tenacity cord with high dimensional stability, does not disclose the manufacturing of the yarn from which the tire cord is made, nor does it mention the yarn's terminal modulus.

The respondent's allegation that high tenacity PET yarn always exhibited a high terminal modulus of above 20 g/d and followed the graph for high tenacity PET in the stress/strain-diagram of Figure 11.2 of document (7) has, in the board's judgment, been falsified by the teaching of document (3A) in that the PET yarn disclosed therein which has a terminal modulus of below 10 g/d is suitable to be twisted into a dimensionally stable cord with high strength at good conversion efficiency. It has also been falsified by the properties of drawn yarn as shown in Tables 2 and 4 of document (6), according to which drawn yarn having a tenacity of above 7 g/d still may have a very low terminal modulus of well below 10 g/d.

The only documents relating undisputably to a high terminal modulus yarn are, therefore, documents (5) and (6) (see in document (5), Tables 1 and 3, in document

(6), Tables 2 and 4, comparative Examples 1, 2 and 11). Document (6) actually aims at yarns having a terminal modulus of 0 to 15 g/d (column 2, lines 6 to 14), but for comparison mentions examples having a terminal modulus of above 20 g/d. All examples of document (6) show that the process conditions have been selected to produce a very high degree of crystallinity (around 50%). Melting points or melting point increases are not shown. It is evident, however, that in the produced yarns, the tenacity conversion efficiency from yarn to cord is particularly bad for the high terminal modulus yarns.

According to document (5) the molten spun yarn is, immediately after extrusion, rapidly cooled and solidified, which includes the risk of poor mechanical quality (Example 1). Moreover, like document (6), it does not recognize any relevance of the withdrawing conditions in order to obtain a partially oriented undrawn yarn having a particular crystallinity and melting point elevation. As can be seen from the properties of the resulting drawn yarns and treated cords listed in Tables 1 to 4, conversion efficiency is very bad, thus also resulting in a poor tenacity cord although it is made from a high tenacity drawn yarn.

Hence, the board concludes that the cited prior art does not give any incentive to disregard the warning of document (3A) in respect to the terminal modulus and to propose the claimed solution of the above stated problem, which solution, therefore, involves an inventive step (Article 56 EPC).

4.3 Yarn according to Claim 15

The yarn claimed in Claim 15 is defined as a product of the process of Claim 1. As is evident from the above considerations, none of the cited prior art suggest or hints at the possibility to produce a cord with high tenacity and dimensional stability at high conversion efficiency from a yarn having a terminal modulus of at least 20 g/d. Therefore, the above conclusions also extend to the yarn of Claim 15.

4.4 Yarn according to Claim 7

The drawn PET-yarn of Claim 7 is characterized inter alia as having a terminal modulus of at least 20 g/d and a tenacity of at least 7 g/d. Yarns fulfilling these requirements are only disclosed in documents (5) and (6) which, therefore, are considered to represent the closest prior art. However, as already indicated under point 4.2 above, no cord is produced from these yarns at high tenacity conversion efficiency.

The technical problem to be solved in view of these documents is, therefore, seen in the provision of a yarn having said high tenacity and terminal modulus, but which translates at high conversion efficiency into a cord with high tenacity and high dimensional stability. According to Claim 7 this problem is essentially solved by a drawn polyethylene terephthalate yarn having, in addition, a dimensional stability defined by $E_{4,5} + FS < 13.5\%$, a melting point increase of 9 to 14°C, and an amorphous orientation function of less than 0.75.

From the results given in Tables II/III and V/VI of the patent in suit, it can be seen that only from yarns

having the claimed combination of features, a cord having high tenacity values in combination with high dimensional stability can be produced at high conversion efficiency. It is, therefore, credible that the above stated problem has been solved by the claimed combination of features.

None of the cited prior art discloses the requirement that the melting point of the drawn yarn should be increased by 9 to 14°C. Moreover, only document (6) discloses values for the drawn yarn elongation under a load of 4.5 g/d, i.e. a value for $E_{4,5}$ (column 11, lines 31 to 33 and Tables 2 and 4), which makes it possible to calculate dimensional stability defined by $E_{4,5} + FS$. However, any yarn disclosed in document (6) for which a value $E_{4,5} + FS$ of below 13.5% can be calculated, has a terminal modulus of below 10 g/d.

Therefore, the claimed multifilament yarn exhibiting the combination of features as set out in Claim 7 is also considered to be non-obvious in view of the prior art.

4.5 Subject-matter according to Claims 12 to 14

The tire cord, rubber article and composite of Claims 12 to 14 are all made from the yarn of Claim 7. Therefore, the considerations set out above in point 4.4 also apply to the subject-matter of these claims.

4.6 Patentability of dependent Claims 2 to 6, 8 to 11 and 16 is derived from that of the respective independent claims.

Order

For these reasons it is decided that:

1. The decision is set aside.
2. The patent is maintained with:
 - Claims 1 to 16 as submitted during oral proceedings,
 - pages 2 to 13 and page 14, lines 1 to 40 of the specification and Figures 1 to 10 of the patent as granted.

The Registrar:

The Chairman:

S. Hue

P. Krasa