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D E C I S I O N
of 22 November 1995

Case Number: T 0210/92 - 3.2.1

Application Number: 84901497.2

Publication Number: 0173684

IPC: F16J 15/44

Language of the proceedings: EN

Title of invention:
Segmented labyrinth-type shaft sealing system for fluid turbines

Patentee:
BRANDON, Ronald E.

Opponent:
Asea Brown Boveri AG

Headword:
-

Relevant legal provisions:
EPC Art. 56, 104(1), 111(1)

Keyword:
"Inventive step - after amendment - yes"
"Decision re appeals - remittal (no)"
"Costs - apportionment - equity - (no)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0210/92 - 3.2.1

D E C I S I O N
of the Technical Board of Appeal 3.2.1
of 22 November 1995

Appellant: (Proprietor of the patent)
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Respondent: (Opponent)
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Representative: -

Decision under appeal: **Decision of the Opposition Division of the European Patent Office dated 20 January 1992 revoking European patent No. 0 173 684 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: F. A. Gumbel
Members: P. Alting van Geusau
B. J. Schachenmann

Summary of Facts and Submissions

I. European patent No. 0 173 684 was granted with effect from 7 February 1990 on the basis of European patent application No. 84 901 497.2 filed on 8 March 1984.

II. In a notice of opposition filed on 5 November 1990 the respondent (opponent) requested revocation of the patent in its entirety on the grounds that its subject-matter lacked novelty and an inventive activity having regard to the prior art disclosed in:

D1: DE-C-2 513 582 and
D2: US-A-3 594 010.

II. By a decision announced at oral proceedings on 3 December 1991, with written reasons posted on 20 January 1992, the Opposition Division revoked the patent.

The Opposition Division held that the remaining difference between the subject-matter of Claim 1 of the patent in suit and the sealing arrangement for a turbine shaft disclosed in D1 related merely to a different working direction of the sealing-segments biassing springs. Since D2 disclosed biassing springs urging the sealing segments away from the turbine shaft during the run-up condition, which was the purpose of the biassing springs in accordance with the patent in suit, it would be obvious to the skilled person to combine the teachings of D1 and D2 in order to avoid damage to the sealing rings during the run-up condition and since he would thereby immediately arrive at the subject-matter of Claim 1 of the patent in suit this claim was considered to lack inventive subject-matter.

III. An appeal was lodged against this decision on 9 March 1992 with payment of the appeal fee on the same day. With the Statement of Grounds of Appeal, filed on 18 May 1992, the appellant filed amended claims, requesting maintenance of the patent in amended form.

IV. In a communication dated 18 February 1993 the Board drew the parties' attention to the disclosures of CH-A-387 069 (D3), a document cited in the description of the patent, which, although not directly concerned with the run-up problems of a steam turbine, appeared to solve the problem of automatic radial movement of the sealing ring posed in the patent in suit. The sealing rings disclosed in D3 would appear to function in the same manner as claimed in the patent and the Board expressed doubt whether the amended claims contained inventive subject-matter when taking into account the disclosure of D3.

V. With letter dated 21 June 1993 the appellant filed a new Claim 1 which was based essentially on the subject-matter of the granted claims 1 and 2 and was delimited with respect to D3.

VI. Oral proceedings were held on 22 March 1994.

At the oral proceedings the respondent introduced the document DE-B-1 187 874 (D4), cited in the European search report but not referred to earlier in the opposition or appeal proceedings. This document was considered to disclose circumferentially arranged sealing segments which comprised spring means between adjacent ends of the sealing ring segments and appeared to be particularly relevant for the subject-matter claimed.

The appellant objected to the introduction of the new prior art and requested that the proceedings be continued in writing. He also requested an apportionment of costs incurred for the oral proceedings in his favour.

At the end of the oral proceedings the Chairman announced that the proceedings would be continued in writing and that a decision on the request for apportionment of costs would be given in the final decision. The parties were given a time limit of three months from the notification of the minutes of the oral proceedings to present their submissions.

VII. In a communication pursuant to Article 110(2) EPC, dated 28 September 1994, the Board made some observations to which the parties were invited to comment upon.

In respect of the appellant's interpretation of the technical content of D4, submitted in response to the discussions at the oral proceedings, it was noted that when taking into account the disclosure in column 2, line 46 to column 3, line 3 and column 3, line 34 to column 4, line 2 it would appear that the sealing arrangement disclosed in D4 provided a wide clearance under no load or low load conditions of a turbine and that with higher loads the seal segments automatically closed to a narrow clearance position.

Considering further that both D3 - which could be considered to form the closest prior art with respect to the subject-matter of the patent in suit - and D4 concerned turbine sealing means with automatic seal clearance adjustment as well as the fact that D3 and D4 were filed by the same applicant with a short time interval between their filing dates, it would appear that the skilled person being aware of these documents,

would find in D4 exactly that information as regards the details of construction so as to be able to carry out the automatic seal clearance adjustment disclosed in D3, but not further constructionally specified in this document.

It was further noted that the citing of D4 by the Respondent occurred after the 9-month period of Article 99(1) EPC but that this was in effect a late response to amendment of the granted Claim 1 to include generalised subject-matter of the granted Claim 2.

In respect of the substance of the amended Claim 1 it was observed that, although the appellant emphasised the importance of reduced friction in the area of the segment ends in order to ensure free opening and closing movement of the seal under different load circumstances, the amended Claim 1 did not appear to contain any features to this effect.

VIII. With letter dated 28 April 1995 the appellant filed amended Claims 1 to 5 and an amended description.

He requested that the decision under appeal be set aside and that the patent be maintained in amended form on the basis of the amended patent documents.

Claim 1 of this request reads as follows:

"1. An elastic fluid turbine employing seals to minimize leakage between rotating and stationary components, comprising: a segmented seal ring (13) supported by and at least partially contained in an annular groove (15) formed in a stationary casing (12) to permit motion of said seal ring between a large diameter position and a small diameter position corresponding respectively to large and small clearance of said seal ring with regard

to the rotating shaft (11), said seal ring groove being partially defined by annular abutment means (17) at an annular opening of said groove opening radially into the clearance area between said casing and said rotating shaft;
each segment of said seal ring (13) including an inner arcuate portion (100) having seal teeth (14) extending therefrom in the direction of and adjacent to said rotating shaft (11), a radially outwardly facing arcuate surface (20a) on said seal ring segment which is located opposite to a radially inwardly facing arcuate surface (21a) of said casing, and an outer ring portion (13a) disposed within said seal ring groove (15) for both axial and radial movement therein and having shoulder means (10) for making radial contact with said annular abutment means (17) on said casing and thereby limiting said small clearance position, and
a radial positioning means comprising a compressed spring means (16) biased against said ring segments (13) to urge said segments toward said large clearance position, while working fluid which is freely admitted to the annular space between said casing and said ring segments will urge said segments toward said small clearance position, whereby at low speed and small turbine loads the spring forces will predominate, while at high flows and high working fluid pressure the pressure forces will predominate, wherein
(a) the outer ring portion (13a) of each segment has a pair of annular shoulders (102) extending to either side to provide said shoulder means,
(b) the casing has a pair of annular shoulders (12a) defining said annular opening to said annular groove (15) and providing said abutment means, each shoulder on the outer ring portion contacting the respective annular shoulder on the casing in the small clearance position of the seal ring,

(c) contact between the outwardly facing arcuate surface (20a) of the seal ring (13) with the inwardly facing surface (21a) of the casing defines the large clearance position of the seal ring,
(d) the seal ring (13) has a neck portion (13c) extending outwardly from the inner arcuate portion (100) and extending with clearance through the annular entrance to the annular groove (15), and
(e) one side of the neck portion (13c) of the seal ring (13) is adapted to contact an annular radial surface (103) on one of the annular shoulders (12a) of the casing to provide a contact pressure seal at the side which is at lower turbine pressure;

characterized in that said spring means (16) include compressed springs (16) interposed between the ends of said ring segments (13) to urge said segments to said large clearance condition at low speeds and small turbine loads, each of said springs being selected to provide a force depending on its circumferential position in said segment ring;
said segmented seal ring (13) including both upper seal segments located around the upper half of said rotating shaft (11), and lower seal segments located around the lower half of said shaft;
said stationary casing (12) having an upper half and a lower half which are separated at horizontal casing joints (27), said upper seal segments being separated from said lower seal segments at said casing joints (27), locking means (26) which extend out from said casing joints to retain said springs in position between said casing and said ring segments and to provide positive circumferential location and retainment of said seal ring segments and springs;
said springs (16) which are positioned at locations (28, 29, 30) above the horizontal casing joints (27) ("upper springs") providing spring forces between the ends of

adjacent segments for pushing upper seal segments to said large clearance position while supporting the weight of the upper seal ring segments and resisting a predetermined magnitude of fluid pressure distribution forces on said upper seal segments at low turbine speeds and small turbine loads;
said upper springs being selected so that the upper ring segments will overcome spring and friction forces such that the ring segments will shift radially inward to their small clearance position for the fluid pressure distribution conditions predicted to exist on said ring segments at higher flows and higher working fluid pressure conditions;
and said springs (16) which are positioned at locations (31, 32, 33) below said horizontal casing joints (27) ("lower springs") providing spring forces for pushing said lower seal segments to said large clearance position while resisting a selected amount of fluid pressure distribution forces on said lower seal segments less the downward weight component of said segments at low turbine speeds and small turbine loads;
said lower springs being selected so that the lower seal segments will overcome their weight and spring and friction forces such that the ring segments will shift radially inward to their small clearance position for the fluid pressure distribution conditions predicted to exist on said ring segments at higher flows and higher pressure conditions."

IX. In support of his requests the appellant relied essentially on the following submissions:

Present Claim 1 has been related in its precharacterising part to the prior art disclosed in D3. The turbine shaft sealing arrangement in accordance with this prior art comprises segmented seal rings which moved automatically inwardly in the direction of the

shaft under high pressure conditions so as to minimise leakage between the rotating and stationary components. However any constructional details how this was achieved were missing.

In order to prevent damage to the segmented sealing rings and at the same time ensuring optimal sealing, which was achieved essentially by providing a large clearance position of the sealing rings at low turbine speeds and small turbine loads and small clearance under full turbine load it was necessary that the seal ring segments remained concentric with the turbine shaft under contraction movement of the segments.

As the present inventor appreciated, the successful application of such a retractable packing ring required that the spring forces acting on the segments should be differently selected depending on the pressure forces, weight forces and friction forces which each spring in its particular position must cope with. One important advantage of the claimed sealing ring design was that the springs were interposed at the circumferential ends of the segments so that closure of the sealing ring segments to the small clearance position did not require both circumferential and radial movement but only radial movement and without any appreciable friction taking place. The circumferentially directed side forces of the springs combined with the locking means for retaining and supporting springs in position between the casing and the ring segments also helped prevent the seal segments at the sides of the seal ring from sagging downward by their own weight.

An additional, important, advantage of the claimed spring and seal design was that it could be readily adapted to existing standard turbines by modifying the seal ring and incorporating the claimed spring means, without having to redesign the seal rings and turbine housing.

Document D4 did not disclose an arrangement which was normally biased to a wide clearance position at any load conditions and therefore did not disclose any solution to the problem of ensuring complete closure of the seal under higher load conditions. In fact D4 related to "floating seal" which functioned in a fully different manner when compared to the seal in accordance with Claim 1.

Since also none of the other cited documents disclosed or gave a lead to the characterising features of Claim 1 this claim should be considered to comprise inventive subject-matter.

If the Board did not feel able to issue a positive decision to the appellant because of the introduction of D4, the case should be referred back to the Opposition Division in order not to deprive the appellant from having examined by two instances the relevance of D4 and of D3, which was also not scrutinised in any detail by the Opposition Division. Because of the late filing of D4 an award of cost incurred for the oral proceedings should be decided in the appellant's favour.

X. The respondents requested dismissal of the appeal. Its submissions can be summarised as follows:

There was no doubt that the prior art disclosed in D4 indeed concerned a segmented seal ring for a turbine shaft in accordance with claim 1 of the patent in suit. In fact the seal ring arrangement in accordance with Claim 1 differed from this known ring only in that locking means were provided, which extended from the casing joints, and that the spring forces were specified in relation to their circumferential positions.

D4 disclosed supporting means for the ring segments in the form of leaf springs and it would be obvious to the skilled person to provide the fixing of the seal ring arrangement in the area of the casing joints instead of to the lower casing. The selection of spring forces in relation to their circumferential position would be immediately apparent to the skilled person, considering that the object of the sealing arrangement in D4 is also the gradual closing of the segmented sealing ring under increased turbine load and thus increased fluid pressure. As a consequence the seal defined in Claim 1 would be arrived at in an obvious manner by the skilled person when taking account of document D4 and D3 and the technical knowledge in the field of turbines.

Moreover, neither from the patent nor from the application as it was originally filed it could be derived that friction was of any interest irrespective of the selection of the spring means. The original disclosure essentially concerned the selection of the springs so as to force the segments in the required position and to this effect no friction forces have to be overcome. Therefore, the formulation of the features in the last and third last paragraphs of claim 1 went beyond what had been originally disclosed in the application and as such claim 1 did not comply with the requirements of Article 123(2) EPC either.

In view of the clear situation a referral to the first instance would not appear to be appropriate.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 The current Claim 1 is based on the granted Claim 1, which now forms its precharacterising portion, and additionally comprises features of the granted dependent Claims 2, 3 and 4 as well as further details of the segmented ring seal arrangement relating to the embodiment disclosed in the drawings and description of the patent. The subject-matter of Claim 1 finds support in the application as it was originally filed (WO 85/03991), i.e. in the original claims 1, 3 and 4, and in particular, as regards the spring means (16) and locking means (26), in description on page 8, line 32 to page 9, line 5 and, as regards the distribution of spring forces, on page 9, lines 29 to 34, page 10, lines 6 to 17, page 11, third paragraph, page 12, lines 12 to 16 and line 26 to page 13, line 12.

2.2 The respondents were of the opinion that Claim 1 included added subject-matter because allegedly there was no support for the feature (see third last and last paragraph of Claim 1) that the springs were selected in any relation to overcoming friction in the movement of the seal segments.

However, considering the functioning of the segmented seal ring disclosed in relation to Figure 2 (see also original page 9, lines 29 to 34 and page 12, line 12 to page 13, line 12) the disputed functional statement in Claim 1 is the direct consequence of the different requirements of the springs positioned between the seal ring upper and lower seal segments so that, under higher working fluid pressure conditions, gradual closing of the seal ring can be ensured over its entire circumference.

Moreover, there is clear mention on page 11, lines 17 to 24 and page 12, lines 12 to 16 that also friction forces must be overcome by the springs.

2.3 Dependent Claim 2 finds support in original Claim 2 and the dependent Claims 3 to 5 correspond to the granted and originally filed claims 5 to 7, respectively.

2.4 In view of the above assessments it can be concluded that the present set of claims meets the requirement of Article 123(2) and (3) EPC.

2.5 The amendments to the description solely concern the necessary adaptation to the now claimed subject-matter and the discussion of the relevant prior art. These amendments give no rise to objections under the EPC either.

3. *Novelty*

Novelty of the subject-matter of Claim 1 follows already from the fact that none of the cited documents discloses an elastic fluid turbine employing a segmented seal ring supported by locking means which extend out from the

turbine casing joints to retain spring means interposed between the ring segments, the spring forces being selected to depend on their circumferential position in the segmented seal ring.

Novelty was in fact not disputed by the respondents.

4. *Inventive step*

4.1 Claim 1 is related in its pre-characterising portion to the closest prior art disclosed in D3.

As set out in the patent specification, the seal rings of elastic fluid turbines are vulnerable to rubbing damage caused by turbine misalignment, vibration and thermal distortion. Most of these damage causing factors are more likely to occur during starting, at low loads or following sudden loss of load (see the patent in suit column 1, lines 19 to 23).

In order to minimise possible damage to the seals and thereby reduce leakage it is disclosed in D3 that the seal ring segments are spring biased and fluid pressure loaded in a manner to automatically adjust the ring segments with respect to the turbine shaft in accordance with turbine load, i.e. so as to move the seal ring from a large clearance position under low load condition to a small clearance condition under higher loads.

However, no constructional details are disclosed in D3 how such automatic contraction and expansion of the sealing ring in accordance with the turbine load is constructionally achieved.

4.2 Starting from this known seal ring arrangement the problem to be solved by the patent in suit can be seen in the provision of a seal ring system which minimises the risk of damage and thus of leakage between the rotating and stationary parts of an elastic fluid turbine and which is applicable for use with existing turbine designs (see column 1, lines 1 to 6 and column 2, lines 59 to 61 of the patent specification).

4.3 When searching for information on how to realise the self-adjusting properties of the seal ring disclosed in D3 the skilled person would certainly find D4, a document also relating to seal rings for turbo machines, which belongs to the same proprietor as the invention disclosed in D3 and was published at about the same time.

The self-adjusting seal ring disclosed in D4 comprises a number of seal ring segments with spring means comprising a spring 4 acting on a spring plate 51 each mounted in cylindrical hole in a number of segments ends. The spring plate 51 contacts the end of the next ring segment to urge the segments to the large clearance position of the seal ring (see Figure 1).

Two opposite ring segments are connected to the turbine housing by means of tangentially positioned leaf springs mounted in the lower part of the turbine housing, the springs being prestressed in the direction of expansion of the ring segments (see column 3, lines 34 to 42 and claim 4).

4.4 The appellant disputed the interpretation of D4 and essentially submitted that the seal arrangement disclosed therein concerned a floating or bushing seal which was biased to the closed position and would only

move to a more open position when the shaft rotated. This seal did not relate to a labyrinth seal (see the letter dated 7 February 1995, page 3, points (a) and (b)).

In this respect it is to be noted that although there is no direct mention of a labyrinth seal in D4 it follows from the discussion in column 2, line 30 to column 3, line 3 of D4 that the self-adjusting segmented seal ring disclosed in D4 is for use in turbo machines with contact-free sealing means which in practice are always in the form of labyrinth seals at the position of the ring seal disclosed in D4, which is also apparent from D3.

In view of the above disclosure and of column 3, lines 34 to 42, claim 4 and the arrangement of the spring means 51, 4 of D4, there cannot be any doubt that the ring segments are biassed to the large clearance position of the ring seal.

4.5 However, a constructional arrangement of the segmented sealing ring in accordance with D4 for achieving the self-adjusting properties of the sealing ring for the turbine disclosed in D3 would not anticipate the seal ring arrangement in accordance with Claim 1.

Remaining differences essentially are that
(a) the spring means are interposed between the ends of the ring segments,
(b) locking means are provided which extend out from the casing joints to retain the springs in position between the casing and the ring segments to provide positive circumferential location and retainment of the seal ring segments and springs, and
(c) the springs are selected to give different spring forces in relation to their circumferential position so

as to ensure radially shifting of all ring segments to the required clearance position in relation to the turbine speed and load.

4.6 These features provide that the seal ring segments are supported in a floating manner with respect to the housing and the segments themselves (features a) and b)) while at the same time a predetermined wanted position with respect to the turbine shaft is maintained (feature c).

Since support of the ring segments when moving from the large clearance to the small clearance position is essentially through the springs only, it will be apparent that friction can be avoided to a great extent and since consequently a more gradual contracting movement of the seal ring arrangement can be guaranteed, seal damage can be avoided effectively. Moreover, only simple adaptations suffice to adapt existing turbines to incorporate the segmented seal ring arrangement in accordance with Claim 1.

4.7 The respondents argued that no details of the locking means were apparent from the claim and that therefore these locking means could be in the form of the leaf springs disclosed in D4.

However, Claim 1 clearly states that the locking means extend out from the casing joints to retain the springs in position between said casings and said ring segments to provide positive circumferential location and retainment of said seal ring segments and springs.

Support and attachment of the ring seal is thus effected by means of the springs interposed between the segment ends, which springs are supported by the locking means at the position of the casing joints only.

4.8 A comparison with the construction shown in Figure 1 of D4 shows that support by the leaf springs 8 does not allow any circumferential movement of the seal ring segments. Thus the support of the segments, in particular the support of the segments attached to the housing by means of leaf springs, is such that the ring is not fully floating.

Moreover, the spring means at the segment ends are not "interposed" between the ends of the segments but are mounted to one of the ends the segments and the spring force is transferred to next segment end by means of a piston like slide 51. It will be clear that such an arrangement having relatively large surfaces at the segment ends, which during contraction and expansion of the seal ring move with respect to each other, includes a risk of obstruction of free movement of the seal ring segments by friction. Furthermore, no indication is derivable from D4 about the distribution of spring forces in the circumferential direction of the seal ring arrangement.

Considering these constructional details of the segmented ring seal disclosed in D4, no lead can be derived from this document to further develop the arrangement known from D3 in the direction of the seal ring arrangement in accordance with the amended Claim 1 of the patent in suit because, in particular, neither the floating aspect nor the reduced friction aspect nor the easy conversion of conventional arrangements are in any way hinted to in this document.

It is also to be noted that the piston like arrangement for transfer of the spring force to the segment ends is essential to the subject-matter disclosed in D4. By means of the shafts 52 the spring means can be locked in their retracted position for easy maintenance of this known segmented seal ring, which is the object of the construction disclosed in D4.

4.9 As regards the other documents cited but not any longer relied upon by the respondent, neither D1 nor D2 discloses any additional features that could be considered to give the skilled person a hint for solving the underlying problem of the patent by means of the features claimed.

4.10 Summarising, in the Board's judgment, the proposed solution to the technical problem underlying the patent in suit and defined in the independent Claim is not only new but also inventive and therefore this Claim as well as its dependent Claims 2 to 5, relating to particular embodiments of the invention in accordance with Rule 29(3) EPC, can form the basis for maintenance of the patent (Article 52(1) EPC).

5. *Procedural considerations*

5.1 Both the documents D3 and D4, considered to be the most relevant documents for deciding novelty and inventive step of the subject-matter of the patent in suit, have been cited for the first time in the opposition appeal proceedings by the Board and respondents, respectively.

As regards D3, referred to in the description of the patent in suit, the Board follows the opinion set out in the decision T536/88 (OJ EPO 1992, 638) according to which important prior art cited in the description of

the patent for the purpose of elucidating the technical problem nevertheless forms part of the opposition or opposition appeal proceedings even if not expressly cited within the opposition period.

Although D4 was cited in the search report, in accordance with the case law of the Boards of Appeal such a document is not automatically comprised in opposition or appeal proceedings (T198/88, OJ EPO 1991, 254). However, in view of its relevance this newly introduced document had to be taken into consideration for deciding upon the patentability of the amended claims of the patent in suit.

5.2 In accordance with further Board of Appeal case law (see for example T273/84, OJ EPO 1986, 346), if a document filed for the first time in opposition appeal proceedings is relevant enough to be taken into consideration, the case should as a rule be remitted under Article 111(1) EPC to the Opposition Division so that the document can be examined at two levels of jurisdiction and the patent proprietor is not deprived of the possibility of subsequent review.

However, since the responsibility for the late citing of the document D4 lies with the respondents and the decision is not in the appellant's disfavour, it is considered to be justified that the Board exercises its discretion under Article 111(1) EPC to examining the document and decide the case having regard to this document (see also T416/87, OJ EPO, 1990, 415, point 9).

5.3 As regards the request for apportionment of costs the Board notes that in the present case the citing of D4 by the respondents in the oral proceedings held on 22 March 1994, although occurred after the 9 month period stated

in Article 99(1) EPC, was in effect a late response to amendment of the granted Claim 1 to contain generalised subject matter of the granted Claim 2, this new Claim 1 being filed with letter of 21 June 1993.

It is further to be noted that D4 was cited in the search report of the present patent, where it has been cited against original Claim 4 comprising in essence the features according to the characterising portion of present Claim 1, and that its number is printed on the cover page of the patent. Further it was referred to in the first communication of the Examining Division when denying the patentability of the subject matter of this Claim. Hence the appellant should have been aware of this document and could not therefore have been surprised by its citation.

In view of these particular circumstances and the fact that the oral proceedings were held on the request of the appellant, the Board sees no reason of equity to order an apportionment of costs in the appellant's favour (Article 104(1) EPC).

Order

For these reasons it is decided that:

1. The contested decision is set aside.

2. The case is remitted to the first instance with the order to maintain the patent with the documents filed with letter dated 28 April 1995 (Claims 1 to 5, description columns 1 to 7 and Figures 1 to 3)

3. The request for apportionment of costs is rejected.

The Registrar: The Chairman:

S. Fabiani F. Gumbel