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Beschwerdekammern | Boards of Appeal | Chambres de recours

T 103

Case Number: T 124 /82

DECISION

of the Technical Board of Appeal 3.2.1

of 18 October 1983

Appellant: UNION CARBIDE CORPORATION
270, Park Avenue
New York, N.Y. 10017 (US)

Representative: Schwan, Gerhard, Dipl.-Ing.
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Decision under appeal: Decision of Examining Division 115 of the European Patent Office dated 13 May 1982 refusing European patent application No 79 103 171.9 pursuant to Article 97(1) EPC

Composition of the Board:
Chairman: G. Andersson
Member: P. Ford
Member: K. Schügerl

Summary of facts and submissions

I. European patent application No. 79 103 171.9, filed on 28 August 1979 and published on 19 March 1980 under publication number 0 008 766, was refused by decision of Examining Division 115, dated 13 May 1982. The decision was based on the independent claim 1, on the dependent claims 2, 3 and 5-7, received on 5 January 1982 and on the dependent claims 4 and 8 as originally filed.

Claim 1 reads as follows:

1. In a threaded connection to be loaded in an axial direction at elevated operating temperature, said connection comprises two pieces (i) having coincidental axes and (ii) having different coefficients of thermal linear expansion wherein one piece is a threaded male piece and the other piece is a threaded female piece, characterised by providing, at ambient temperature, a taper such that the change in radial clearance per unit of length between the opposing threads of each piece is equal to the expression $A = \Delta T \tan \theta$ wherein:

A = the difference in the coefficients of thermal linear expansion of the materials of which each piece is comprised, in the axial direction;

T = the operating temperature of the connection minus ambient temperature; and

θ = the acute angle formed by the loaded face of the thread of either piece with the axes

.../...

said radial clearance increasing in the direction of the loading of the piece having the higher coefficient of thermal linear expansion.

II. The stated ground for the refusal was that the subject matter of claim 1 did not involve an inventive step having regard to US-A-3 506 377.

III. Against this decision, the appellant lodged an appeal on 5 July 1982, and duly paid the fee for appeal. The statement setting out the grounds of appeal was received in due time.

The appellant requested that the decision should be set aside and that a European patent should be granted, based on the documents on file, or alternatively that oral proceedings should be held.

The appellant submitted that the problem solved by the invention does not exist at all in the device according to the US document, and that the reasoning of the Examining Division was substantially based on an ex post facto analysis.

IV. In the course of the preliminary study of the appeal, the rapporteur directed the appellant's attention to the following publications:

Wiegand & Illgner, Berechnung und Gestaltung von Schraubenverbindungen, 3rd Edition, Chapter 3.53 and

DE-U-1 992 295, page 1, a document cited in the search report.

V. Finally, the appellant replaced the pages 2 and 3 of the description as originally filed, by new pages 2, 3, 3a and 3b.

Reasons for the decision

1. The appeal complies with Articles 106 - 108 and Rule 64 EPC; it is, therefore, admissible.

2. The amendments to the description indicate the background art according to the documents now available and disclose the invention as claimed in the claims now on file. These amendments are therefore in conformity with Rule 27(1)(c) and (d) and with Rule 36(1) EPC. Furthermore, because these amendments do not add subject-matter which extends beyond the content of the application as filed, they do not contravene Article 123 (2) EPC. They are, therefore allowable.

3. The available documents representative of the state of the art are exclusively concerned with a well-known characteristic of threaded nut and bolt connections: due to the axial load on the system, the nut will be compressed and the bolt expanded, so that the distribution of load over the individual threads is uneven. There is thus a need to provide for a more equal distribution of the loads. The problem has been solved by providing special geometrical configurations of the cooperating parts, especially by using different pitches (see the cited chapter in "Wiegand & Illgner" and DE-U-1 992 295). As such slightly different pitches are very difficult to produce, a tapered thread for one piece of the same pitch as the cooperating piece has been proposed (see the cited document "Wiegand & Illgner" figure 3.42 and figure 3.43).

4. US-A-3 506 377 discloses for such a conical thread a formula for the half-angle of the pitch cone as a function of the stress, the modulus of elasticity and the angle formed by the loaded face of the thread with the axis.

A close analysis of this formula reveals the following facts:

In the description of the illustrated embodiment, the stress is defined as the "stress in bolt if nut is rigid" or "stress differential" (column 3, line 20). From figure 2 and the explanations given in column 2, line 70 to column 3 line 5, it follows that - according to the inventor's concept - in the course of the tightening of the bolt, first the thread designated by "n" in figure 2 will bear the load applied by the tightening, then, on further tightening, the axial load will be increased so that the section of the bolt between the threads "n" and "n-1" will suffer an elastic deformation, designated by "ϵ" in figure 3 and in column 3 line 18. Due to this elongation, the thread "n-1" will become "active", that is, load-bearing. In this way, the process of tightening proceeds, until all the threads have become active so that the total axial force due to tightening, which is transmitted through the bolt at the section at the head of the bolt (right-hand in figure 2 from the thread "1") will be distributed "over more threads of the bolt and over threads more distant from the head of the bolt than in conventional practice" (column 3, line 65).

5. Now, the elongation ϵ is, by elementary considerations, given by $\epsilon = RS/E$ (R = length of the bolt between two

threads, i.e. the pitch, E = modulus of elasticity of the bolt), and the half-angle for the taper is given by $\alpha = \epsilon \tan\beta/R$ (see figure 3 of the US document).

The stress, which governs the elongation ϵ, is the stress differential between two sections of the bolt, lying a distance "R" apart and not the total stress in the section area between the thread "1" and the head of the bolt at the end of the tightening procedure.

6. This inference is corroborated by the formula for the desired value of the stresses in column 3 line 50. The maximum allowable bearing stress on the thread flank without galling is S_b (column 3, line 22) and if therefore the relation exists S x effective area exposed to tension = S_b x developed bearing area of one (sic!) thread (col. 3 line 50), then it must necessarily be defined as above in paragraph 5. Otherwise, if S were to be defined by the maximum value attained at the end of the tightening process in the area immediately adjacent to the head of the bolt, then the allowable value of S would be only a small fraction of the correct value indicated in paragraph 5, (1/nth, if equal distribution of the load over n threads is supposed). This is clearly an absurd result, since a screw connection has to transmit as much force as possible.

7. Further corroboration can be derived from the wording of claim 1 of the US-patent specification, in which S is defined as the stress of the weaker of the two thread members and E is the modulus of elasticity of the material forming the weaker of the two threaded members. The term "weak" is used not for the material but for the threaded member as such; it follows then that "weak" means:

"elastically deformable under stress". The "weak" member is in practice the bolt, as presupposed in the illustrated embodiments and in claim 2. In the same way as indicated in column 3, line 20 ("if nut is rigid") it has to be inferred from claim 1 that the elastic deformations (and consequently the stresses) in the other member - the "stronger" one -, should not be taken into consideration in applying the formula for the half-angle of the cone.

8. Although the disclosure of the US document may become clear only after careful study of all its parts, the skilled person will, by applying his professional knowledge to the text, come to the conclusion that the clause "stress in bolt if nut is rigid (or stress differential)" has the meaning "stress in bolt if nut is rigid", or, to be more precise, "the stress differential in the bolt responsible for the elongation ". The disclosure of the US document offers no other possibility of a meaningful interpretation.

Additionally, it must be said that the US document does not indicate why only the stresses and the elongations in the "weaker" member should be considered. It may be that some of the theoretical considerations of the inventor are not disclosed in the document.

9. The problem of the invention is to improve the strength of threaded connections between parts having different coefficients of thermal linear expansion. None of the available prior art documents deals with threaded connections of this kind. Indeed, US-A-3 506 377 contains (column 3, line 72) a reference as to "vibrations or thermal cycling", but this indication refers clearly to the expansions and the additional stresses during a relatively short heating and cooling cycle and not to the steady state at a given temperature, as it is the case according to the invention. The skilled person will, at most, deduce from this part of the disclosure, that also in cases of thermal stresses, the stress due to the mechanical load and the modulus of elasticity in that part of the threaded connection which is more deformable under the mechanical load, have the paramount importance, so that the formula for the half angle of the taper disclosed in the US document could be applied equally in cases of thermal stress.

10. The solution proposed by the applicants, however, differs completely from the teachings of the US document. Although the threaded connection is to be loaded in an axial direction, in the same way as the known threaded connection, the stresses due to the mechanical load are disregarded. Instead, the formula given as the solution relies solely on the coefficients of linear thermal expansion. Further, the solution is based on the difference of the coefficients of linear thermal expansion of both the threaded pieces in contrast to the disclosure to the US document, which is based on the assumption that one part of the threaded connection does not change its dimensions at all. In this respect, the decision under appeal is erroneous due to a misinterpretation of the term "stress differential", as shown above in paragraphs 4-8.

11. In order to arrive at the solution, the inventor, in the absence of any inducement offered by the state of the art, had to carry out a careful analysis of the circumstances of the problem; he had to develop an insight into the correlated facts which determine the strength of the threaded connection and, finally, he had to make a delib-

erate choice of the important parameters, neglecting the unimportant ones (mechanical loads). Such an activity cannot be said to be a mere result of the ordinary professional skill of the practitioner. The fact that after such an activity, inventive in character, a known means, the threaded conical form, has been chosen, cannot destroy the inventiveness of the precedent activity. Instead, it is the merit of this inventive activity to have made available the known means (taper) for the solution of a new problem. The fact that the formulas according to the US document and to the invention have some similarities in formal respects, - and that to a lesser degree than supposed by the Examining Division, as shown above - is then without significance; it would be a mere ex post facto analysis to pretend that the skilled person would be able to derive from these formal similarities the invention as claimed.

12. In its decision, the Examining Division held that "it is the differential elongation that constitutes the problem in both cases; in the case of the citation it is caused by the stress differential and in the applicant's case by the different thermal expansions. When the problem is essentially the same, the fact that the causes are different cannot ... significantly influence the choice of the solution".

Disregarding the difference explained in paragraphs 4-8 - it is not the stress differential between the two parts of the threaded connection which is considered in the document, the above statement is true only as a generalisation. In fact, it will be possible in most cases, by heightening the level of generalisation, to define a problem, which is the same for a certain state of the art

and for the invention. But to transform the actual problem, as stated in the description of the application, into a more general problem and to exploit the documents under the aspect of such a generalised problem, may be said to be one of the hallmarks of inventive activity; the ordinary skilled person is not endowed which such a power of generalisation. Therefore, as stated in the decision T05/81 of the Board of Appeal 3.2.1, OJ EPO 1982, page 249, the teaching of a document may have narrower implications for persons skilled in the art and broader implications for a potential inventor who first perceives the problem which his future invention is intended to solve. The assessment of inventive step must look at the situation solely from the practical viewpoint of the skilled person. Seen that way, the approach of the Examining Division could be regarded as an ex post facto synthesis of the two problems.

13. Concerning the assertion in the decision that it is obvious to arrive at the formula stated in claim 1, for it implies only the exercise of ordinary mathematical analysis, the following should be considered:

Once in the pathway leading from the actual problem to the final solution, the concept has been established that the different thermal expansion of the threaded pieces should be compensated by the taper in one of the pieces - and this concept must be regarded as inventive in character, as exposed above - the remaining substep, namely to indicate the mathematical formula, may well be within the reach of the average skilled person. But this substep is certainly not the essential element of the invention.

14. The indications contained in the description and also in the sub-claims 5 and 6 that the threaded parts are of unequal strength (i.e. that one material is "strong" and the other is "weak") and, further, that the connection is subject to stresses of bending and torsion - these indications are alien to the cited documents - could not be taken into account, because claim 1 does not contain any such limitations. But it is sufficiently credible that also in cases where no such limitations prevail, the teaching circumscribed by the present claim 1 will solve at least a part of the problem to be encountered in threaded connections between parts having different coefficients of thermal expansion. There is consequently no need to introduce further limitations into the present claim 1.

15. The subject matter of claim 1 and of the dependent claims therefore involves an inventive step (Article 56 EPC). The claims are therefore allowable (Article 52(1) EPC).

16. No request has been made for reimbursement of appeal fees according to Rule 67 EPC. The circumstances of this case would also not justify such a reimbursement.

ORDER

For these reasons, it is decided that:

1. The decision of the Examining Division 115 of the European Patent Office is set aside.

2. The case is remitted to the first instance with the order to grant a European patent on the basis of:

   the description, page 1 and 4-12 as filed, and pages 2, 3, 3a and 3b, received on 1 August 1983;

   claims 1-3 and 5-7, received on 5 January 1982 (in line 3 of claim 1 "comprises" has to be replaced by "comprising");

   claims 4 and 8 as originally filed (in line 4 of claim 8 "threaded" has to be replaced by "threadless").