

Internal distribution code:

- (A) [] Publication in OJ
(B) [] To Chairmen and Members
(C) [X] To Chairmen

D E C I S I O N
of 11 May 1995

Case Number: T 0631/92 - 3.3.3

Application Number: 85105534.3

Publication Number: 0165425

IPC: E21B 43/22

Language of the proceedings: EN

Title of invention:

Thermally stable mobility control reagents for harsh environment reservoirs

Patentee:

AMERICAN CYANAMID COMPANY

Opponent:

Allied Colloids Limited
Chemische Fabrik Stockhausen GmbH Patentabteilung

Headword:

-

Relevant legal provisions:

EPC Art. 54(2), 56

Keyword:

"Novelty (affirmed) - use in required conditions not disclosed"
"Inventive step (affirmed) - interpretation of prior art documents in the light of the technological context of their publication date - prejudice overcome"

Decisions cited:

T 0026/85; T 0153/85; T 0295/87; T 0406/86; T 0666/89;

Catchword:

-



Case Number: T 0631/92 - 3.3.3

D E C I S I O N
of the Technical Board of Appeal 3.3.3
of 11 May 1995

Appellant: AMERICAN CYANAMID COMPANY
(Proprietor of the patent) 1937 West Main Street
P.O. Box 60
Stamford
Connecticut 06904-0060 (US)

Representative: Diehl, Hermann O. Th., Dr.
Diehl & Glaeser, Hiltl & Partner
Patentanwälte
Postfach 19 03 65
D-80603 München (DE)

Respondent 1: Allied Colloids Limited
(Opponent 01) P.O. Box 38
Low Moor, Bradford, BD12 0JZ (GB)

Representative: Lawrence, Peter Robin Broughton
GILL JENNINGS & EVERY
Broadgate House
7 Eldon Street
London EC2M 7LH (GB)

Respondent 2: Chemische Fabrik Stockhausen GmbH
(Opponent 02) Patentabteilung
Bäckerpfad 25
D-47705 Krefeld (DE)

Representative: Klöpsch, Gerald, Dr-Ing.
Patentanwalt
An Gross St. Martin 6
D-50667 Köln (DE)

Decision under appeal: Decision of the Opposition Division of the
European Patent Office dated 8 April 1992, issued
in writing on 11 May 1992 revoking European patent
No. 0 165 425 pursuant to Article 102(1) EPC.

Composition of the Board:

Chairman: C. Gérardin
Members: R. Young
J. A. Stephens-Ofner

Summary of Facts and Submissions

- I. The mention of the grant of European patent No. 0 165 425, relating to thermally stable mobility control reagents for harsh environment reservoirs, in respect of European patent application No. 85 105 534.3, filed on 7 May 1985 and claiming a US priority of 21 June 1984 (US 622 899) was announced on 15 November 1989 (cf. Bulletin 89/46).
- II. Two Notices of Opposition were filed on 10 July 1990 (OI) and 13 August 1990 (OII), respectively, in each case on the grounds of lack of novelty and lack of inventive step (Article 100(a) EPC), and, in the case of OI, also on the ground of insufficiency of disclosure (Article 100(b) EPC).

The Oppositions were supported inter alia by the documents:

- D1: US-A-3 679 000;
D2: US-A-4 293 427;
D4: Davison et al., "Polymer Flooding in North Sea Reservoirs", Society of Petroleum Engineers of AIME, June 1982, pages 353 to 362; and
D7: McClaghry, "Factors which affect the viscosity of water soluble polymers" (Thesis), Imperial College, London University (November 1981), pages i, ii, 53, 58 to 60 and 96 to 104.

- III. By a decision which was given at the end of Oral Proceedings held on 8 April 1992 and issued in writing on 11 May 1992 the Opposition Division revoked the patent. The decision was based on a set of eleven claims which had been filed during the oral proceedings. Claim 1 reads as follows:

"A method for recovering petroleum from a subterranean petroleum-bearing deposit which comprises injecting as a viscosity control agent an aqueous polymer solution of 2-acrylamido-2-methylpropanesulfonic acid or a salt thereof and an acrylic monomer into the area of said deposit through at least one input well to cause said petroleum to flow from said area for collection through at least one output well, characterised by injecting in the absence of oxygen, and in the presence of divalent metal ions, a water-soluble copolymer containing from 30-70 mole percent of 2-acrylamido-2-methylpropanesulfonic acid or a salt thereof and from 70-30 mole percent of an acrylic monomer and the temperature at the petroleum-bearing deposit being at least 60°C."

Claims 2 to 11 relate to elaborations of the method of Claim 1.

During these oral proceedings, the ground of opposition under Article 100(b) EPC was withdrawn (cf. minutes of the oral proceedings, paragraph 2, last sentence).

According to the decision, it was held that the subject-matter of Claim 1, although novel, nevertheless lacked inventive step. On the one hand, the closest state of the art document D4 dealt with the same problem as the patent in suit, namely the selection of commercial polymers for EOR - enhanced oil recovery - a) at formation temperatures higher than 60°C, b) in the absence of oxygen and c) in the presence of divalent metal salts. On the other hand, the document D7 disclosed that copolymers of the sodium salt of 2-acrylamido-2-methylpropanesulphonic acid (AMPS) were resistant to precipitation by

divalent metal ions. Consequently, the skilled person would be led by D7, which was published after D4, and also by D1, which disclosed the use in EOR of copolymers as defined in Claim 1, at least to try these compounds in the procedure of D4.

IV. On 17 June 1992, a Notice of Appeal against the above decision was filed, together with payment of the prescribed fee.

In the Statement of Grounds of Appeal filed on 21 September 1992 and in subsequent written submissions, the Appellant (Patentee) argued substantially as follows:

- i) D1 did not mention divalent salts and therefore did not suggest that the polymers it disclosed would be useful in systems comprising such ions.
- ii) D4, although giving information on the long-term stability of polymer solutions under harsh conditions, and dealing with 140 different polymers, did not mention the AMPS copolymers of Claim 1. This was because the skilled person would expect such AMPS copolymers to behave like acrylamide polymers. These, according to D4, hydrolysed to carboxylates, which precipitated by reaction with divalent metal ions such as calcium. The blocking effect of such precipitates on subterranean formations meant that D4 represented a prejudice against the use of AMPS copolymers such as those defined in Claim 1.
- iii) D7 stated that the application of the new synthetic (AMPS) polymers for mobility control under reservoir conditions would be very limited. It contained no long term measurements nor any suggestion that AMPS polymers had better thermal stability in the presence

of divalent ions, nor that the ratio of AMPS to acrylamide might be critical for such thermal stability. On the contrary, the AMPS sulphonate groups were taught to be similar to the carboxylate groups of sodium acrylate polymers for providing thermal stability. The stability of AMPS copolymers as used under the combined conditions of absence of oxygen, presence of divalent ions and temperatures of at least 60°C could not be derived from D7. The skilled person had no reason to combine it with D4.

- V. Respondents I and II (Opponents OI and OII, respectively), on the other hand, argued in essence:
- i) D1 specifically taught the use of AMPS copolymers as defined in Claim 1 for oil recovery. The reference to the use of mineral containing waters was a clear indication that this was done in the presence of divalent ions. The residual features of a temperature over 60°C and anaerobic working were in any case entirely conventional, and applied to the vast majority of modern wells, in particular those in the North Sea. Consequently, the claimed subject-matter lacked novelty or at any rate inventive step.
 - ii) D7 taught that AMPS copolymers with an acrylate content of less than 30% did not form insoluble calcium salts whereas the acrylate polymers did. It was therefore obvious to select AMPS polymers for any environment where salt precipitation was expected to be a problem, and to have a sufficient presence of AMPS to ensure a useful effect. Thus it was to be expected that copolymers poor in AMPS would be less suitable, whilst the maximum AMPS content was limited by the diminishing return on thickening effect and financial considerations, so that the copolymers defined in Claim 1 were obvious.

- iii) No prejudice against the use of AMPS copolymers could be derived from D4 because the generic term "polyacrylamides" did not cover the AMPS groups, or the polymers containing significant amounts of them.
- iv) The commercial reality of the situation was that AMPS copolymers tended to be more expensive and there had to be a price incentive to use them. In the early 1980's this was not the case, which was why D4 tested only relatively cheap polyacrylamide and natural polymers. The claimed subject-matter merely amounted to the selection of the polymers of D1 that had a reasonable cost.

VI. The parties cited a number of documents for the first time. In particular, the Appellant cited:

D7*: pages 105 and 110 of the document D7 previously cited by the Respondent I (Statement of Grounds of Appeal);

D14: R. W. Dexter et al., "The Effect of Anionic Co-Monomers on the Hydrolytic Stability of Polyacrylamides at High Temperatures in Alkaline Solution", Symposium on Advances in Oil Field Chemistry, presented before the Division of Petroleum Chemistry Inc., American Chemical Society, Toronto Meeting, 5 to 11 June 1988 (submission dated 21 September 1993); and

D18: Oil and Gas Journal, 5 April 1982, OGJ Report, Tables E, F and G (submission dated 21 March 1995).

Furthermore, Respondent I cited, in submissions dated 21 April 1993 and 10 May 1993, i) a list of temperatures of North Sea Oil Fields, ii) a diagram based on the latter, and iii) pages 545 to 562 of a Geological Memoir, identified in the list i). These have been renumbered by the Board as D15, D16 and D17 respectively.

VII. An amended set of eleven claims was filed by the Appellant on 10 May 1995.

VIII. Oral proceedings were held before the Board on 11 May 1995. In addition to the set of claims filed on 10 May 1995, which formed the main request, the Appellant submitted, during these oral proceedings, a further set of eleven claims as auxiliary request No. 1 and the set of claims originally filed on 8 April 1992 as auxiliary request No. 2.

Claim 1 of the main request reads as follows:

"A method for recovering petroleum from a subterranean petroleum-bearing, harsh environment deposit being at a temperature of at least 60°C, comprising the steps of preparing a copolymer containing from 30-70 mole percent, 2-acrylamido-2-methylpropane-sulfonic acid or a salt thereof and from 70-30 mole percent of an acrylic monomer under conditions conducive to oxygen elimination, preparing in the absence of oxygen a solution of said copolymer with water containing divalent metal ions, and injecting in the absence of oxygen said aqueous solution into an area of said deposit through at least one input well to cause said petroleum to flow from said area for collection through at least one output well."

Claims 2 to 11 of the main request relate to elaborations of the method of Claim 1. In particular, Claim 2 is a dependent claim directed to a method "wherein the copolymer is stored under conditions conducive to oxygen elimination."

Claim 1 of the auxiliary request No. 1 differs from Claim 1 of the main request by the insertion, before the word "absence", of "substantial"; the insertion, after the word "injecting", of "as a viscosity control agent"; and the replacement of "an area", by "the area".

The remaining Claims 2 to 11 of this request correspond to Claims 2 to 11 of the main request.

Claims 1 to 11 forming auxiliary request No. 2 correspond to Claims 1 to 11 respectively of the set of claims filed on 8 April 1992 and forming the basis of the decision under appeal (cf. section III, above).

IX. The Appellant requested that the decision under appeal be set aside and the patent maintained on the basis of the claims as filed on 10 May 1995 (main request), on the basis of the claims filed in the course of the oral proceedings in the appeal (auxiliary request No. 1), or on the basis of the claims filed on 8 April 1992 (auxiliary request No. 2).

The Respondents requested that the appeal be dismissed.

Reasons for the Decision

1. The appeal is admissible.
2. The first question to be decided in relation to the sets of claims forming the main request and auxiliary requests numbers 1 and 2 is whether such claims should be admitted for consideration in this appeal.
 - 2.1 Admissibility of the main request.

As is apparent from section VII., above, Claim 1 of the main request was filed for the first time the day before the oral proceedings: that is, more than two-and-a-half years after the Statement of Grounds of Appeal was filed. Its subject-matter differs in various aspects from Claim 1 of the set of claims (filed on 8 April 1992) forming the basis of the Statement of Grounds of Appeal. No justification was offered for the filing of amended claims at such a late stage of the proceedings.

From section VIII., above, it is apparent that Claim 2 is directed to subject-matter which is new in comparison with the claims as granted. As stated in the decision T 0295/87 (OJ EPO 1990, 470), the addition of such claims, which have no counterpart in the granted version of the claims in the patent in suit, cannot be regarded as an attempt to respond to any ground of opposition under Article 100 EPC. They represent, in effect, amendments which go beyond the objections to validity actually raised and are not, therefore, either necessary or appropriate within the meaning of Rule 57 (1) and 58 (2) EPC. In the decision T 0406/86 (OJ EPO 1989, 3029), which itself refers to the principles regarding the allowability

of late-filed alternative sets of claims laid down in decision T 0153/85 (OJ EPO 1988, 001), the Board took the view that where such amendments were not clearly allowable they might justifiably be refused.

In the present case, the claims are, for the reasons set out below, not clearly allowable under Article 123(2) and 123(3) EPC.

Consequently, following the principles set out in the decisions quoted above, the Board, in the exercise of its discretion, rejects the main request of the Appellant.

2.2 Admissibility of auxiliary request No. 1

The claims of this request, which correspond to those of the main request with additional amendments to take account of certain objections under Article 123(2) and 123(3) EPC, were not filed until the oral proceedings were already under way. They are also, for the reasons set out below, not clearly allowable, and the discretionary considerations set out in respect of the main request also apply.

Consequently, the Board, in the exercise of its discretion also rejects the auxiliary request No. 1 of the Appellant.

2.3 Admissibility of auxiliary request No. 2

The claims of this request were filed on 8 April 1992, i.e. before the appeal was filed, and form the basis of the Statement of Grounds of Appeal. There can therefore be no objection that they were filed late.

Consequently, the auxiliary request No. 2 of the Appellant is admissible.

3. *Allowability of the amendments*

3.1 Main request

3.1.1 The phrase "preparing a copolymer under conditions conducive to oxygen elimination, preparing in the absence of oxygen a solution of said copolymer with water containing divalent metal ions, and injecting in the absence of oxygen said aqueous solution into an area of said deposit..." in Claim 1 is stated by the Appellant in an annotated version filed together with the claims on 10 May 1995 to be supported by the description on page 3 at lines 6 and 7. Closer examination shows, however, that the passage relied upon, which corresponds to the description of the application as filed and reads "The copolymer itself should also be prepared and stored under conditions conducive to oxygen elimination" requires both the preparation and storage of the copolymer to be under conditions conducive to oxygen elimination. Claim 1, in contrast, omits the second of these two stages. To this extent, therefore, it presents a new level of generalisation which is not derivable from the documents of the application as filed.

3.1.1.1 The argument of the Appellant, that the storage step is in any case optional is not reflected by the wording of the description. This presents the preparation and storage as inseparable.

3.1.1.2 The further argument, that the storage period could be so short as to be negligible is beside the point, because there is no particular upper limit imposed.

Consequently, the subject-matter of Claim 1 contravenes the provisions of Article 123(2) EPC.

3.1.2 Looked at another way, if Article 69(1) EPC were applied to the relevant passage of the description for determining the extent of protection of Claim 1 as granted, any limitation (in this case on the presence of oxygen) applying to the "preparation" of the polymer derived from the phrase "The copolymer should also be prepared and stored..." would necessarily apply also to its "storage".

Since, however, Claim 1 has been amended explicitly to include one of these limitations (preparation) but not the other (storage), the protection conferred has in this respect been extended compared with that of Claim 1 as granted.

Consequently Claim 1 of the main request contravenes the provisions of Article 123(3) EPC.

3.1.3 The protection conferred by Claim 1 is also extended compared with that of Claim 1 as granted, firstly by the omission of the features:

- that the copolymer is "water soluble"; and

- that it is injected "as a viscosity control agent",

and secondly by the replacement of the phrase "the area" by the broader wording "an area".

Consequently, Claim 1 also contravenes Article 123(3) EPC in these respects.

3.2 Auxiliary request No. 1

Although Claim 1 of this request contains a number of amendments designed to meet the objections arising as detailed under section 3.1.3, above, the defects established under sections 3.1.1 and 3.1.2, above, have not been removed.

Consequently Claim 1 of this request fails to meet the requirements of Articles 123(2) and 123(3) EPC.

3.3 Auxiliary request No. 2

The claims of this request correspond to those underlying the decision under appeal. They are considered allowable for the same reasons as given in the decision under appeal (paragraph II., 2.).

In any case, no objections were raised against the allowability of these claims.

Thus, the substantive issues of the appeal are considered only in respect of the claims of auxiliary request No. 2.

4. *Late-filed documents*

The documents D7* and D14 to D18, although filed well outside the nine-month opposition period, are of an essentially neutral, factual character, to provide corroborative support for facts, evidence and arguments which have already formed part of the

proceedings. Furthermore, the Appellant had provided detailed arguments to show that these late-filed citations did not affect the outcome and moreover had made no formal request that the Board refuse, under Article 114 (2) EPC, to admit them for consideration.

The Board therefore sees no need to exclude these documents from the proceedings. The above-mentioned documents are thus admitted to the proceedings.

5. The patent in suit is concerned with the use of polymers for control of viscosity of aqueous media used in flooding operations for enhanced oil recovery (EOR) from petroleum-bearing deposits of harsh environment reservoirs, that is wells (a) exhibiting temperatures of at least 60°C at the petroleum-bearing deposit and (b) being characterised by the presence of water containing divalent metal ions. Under these conditions, however, the viscosity of commercially used polymers such as acrylamide-ammonium polyacrylate copolymers breaks down (patent in suit, title, and page 2, lines 11 to 23).

- 5.1 Such difficulties, however, which are typical of North Sea reservoirs, are well known, as is also recognised in D4, which is considered, in line with the decision under appeal, to be the closest state of the art.

According to D4, the use of polymer solutions to enhance oil displacement efficiency by seawater injection in North Sea oil reservoirs has been investigated by evaluating over 140 polymers for viscosity retention and porous media flow performance under high temperature, high salinity, and high pressure (page 353, Abstract).

Seawater in the North Sea has a salinity of 3.6%, with a fraction of divalent hardness ions to total cations of 13.6%. For North Sea formation (connate) waters the corresponding values lie in the ranges 2 to 20% and 1.5 to 35%, respectively.

It is the combination of high temperature (70 to 150°C), high salinity and high divalent metal fraction that reduces the chemical stability of most polymer types to levels that rule out their use as mobility agents under these conditions. This applies in particular to polyacrylamide (page 356, right column, first paragraph; page 358, first paragraph).

Predicting the behaviour of EOR systems is largely intuitive; the mathematical models currently available are of little help (page 359, second complete paragraph).

The crucial test for polymers (with a sealed capillary viscometer) is their effectiveness in retaining their viscosity in seawater solution at high temperature (page 354, left hand column, first complete paragraph).

For North Sea application a polymer solution would require to be five times more viscous than seawater and to lose less than 10% of its viscosity in 500 days at 90°C (page 355, "Results and Discussion" first paragraph).

In a screening of thermal stability by heating deoxygenated seawater polymer solutions in sealed glass ampoules, all polyacrylamide solutions formed white precipitates at 90°C within 60 days.

Precipitation seems to be caused by calcium and magnesium ions. No precipitation can be seen in

distilled water or sodium chloride solutions of polyacrylamide after 500 days. The thermal instability of a seawater solution of polyacrylamide with a 31% degree of hydrolysis becomes severe at temperatures above 70°C. Dissolved oxygen does not cause the polyacrylamide to degrade under the test conditions. (page 355, right column, last paragraph to page 356, left column, first paragraph).

The mechanism of precipitation from polyacrylamide solution is consistent with the hydrolysis of amide groups to carboxylate, which then interacts with divalent metal ions to form an insoluble salt (page 356, left column, last paragraph).

Scleroglucan polymers have the most potential for North Sea use (pages 359 and 360, "Conclusions").

- 5.2 Compared with this state of the art, the technical problem underlying the patent in suit can be seen as the definition of a method for preventing the substantial breakdown of the polymer viscosity at a temperature of at least 60°C and in the presence of divalent metal ions, over a long period of time (of the order of hundreds of days).
- 5.3 The solution proposed according to Claim 1 of the patent in suit is to use, as a viscosity control agent, a water-soluble copolymer containing from 30-70 mole percent of 2-acrylamido-2-methylpropanesulfonic acid or a salt thereof and from 70-30 mole percent of an acrylic monomer, an aqueous solution of which is injected in the absence of oxygen.

5.3.1 It can be seen from the results of Example 1 as given in Table 1 of the patent in suit, the accuracy of which are uncontested, that the viscosity of a copolymer of AMPS and acrylamide, having a content of AMPS below 30 mole% and under the harsh conditions specified (90°C in the presence of 9% NaCl and 1% CaCl₂), although satisfactorily maintained for a period of 56 days, nevertheless undergoes a drastic deterioration thereafter. On the other hand, viscosity is no longer substantially lost when the copolymer contains more than 30 mole% AMPS, even after double the length of time, and in some cases after a more than a year (377 days). This effect reaches a maximum at about 40 mole% AMPS, after which, at higher molar proportions of AMPS towards 70%, the absolute thickening effect shows a tendency to diminish. This reduction in thickening effect becomes more marked as the molar proportion of AMPS approaches 100%, as is shown by the viscosity values given in Table 10.

5.3.2 The argument put forward by Respondent I during the oral proceedings, that the viscosity values given had no particular connection with the molecular weights of the polymers, is contradicted, in general terms, by the known fact that the molecular weight and viscosity of a polymer are, other things being equal, normally rather closely related to one another, and indeed that viscosity measurements are relied upon for the determination of molecular weight. It is also contradicted in more specific terms by the submission of the same party, linking the particular difficulty of achieving, in an AMPS/acrylamide polymer, a given molecular weight when the amount of AMPS is very high, with the choice of (other) polymers that are more readily available at high molecular weight, for

the purpose of viscosification (cf. submission dated 21 April 1993, page 6, third paragraph).

- 5.3.3 The use of copolymers having molar proportions of AMPS in excess of 70% is in any case excluded from the scope of Claim 1 and consequently does not correspond to the proposed solution of the technical problem.

Thus, it is credible that the claimed measures are effective to solve the stated problem.

6. *Novelty*

- 6.1 According to D1, there is described a method for secondary recovery of petroleum by water-flooding techniques, in which water-soluble polymers containing at least about 5% by weight of N-sulphohydrocarbon-substituted acrylamides, especially of 2-acrylamido-2-methylpropanesulfonic acid are used as viscosity-controlling agents (column 1, lines 10 to 33; column 2, lines 63 to 65).

The copolymers used preferably contain at least about 50 wt% of AMPS units. Most useful are homopolymers and copolymers with 5-95%, preferably 5-50% and most desirably 5-30%, of an acrylic monomer such as acrylic or methacrylic acid or a salt or amide thereof, notably acrylamide (which may be partially hydrolyzed), methacrylamide, N-(1,1-dimethyl-3-oxobutyl)acrylamide (diacetone acrylamide) etc. (column 5, lines 20 to 33).

For oil recovery purposes, very high molecular weights are required, as evidenced by an inherent viscosity of about 7.5 or higher, as measured on a solution of 0.25 g polymer per 100 ml. of 3 wt% aqueous sodium chloride solution at 30°C (column 5, lines 58 to 63).

According to Example 3, a copolymer containing 80% (by weight) of sodium 2-acrylamido-2-methylpropanesulfonate and 20% sodium acrylate is prepared having an inherent viscosity of 7.44. According to Example 6, a copolymer containing 85% sodium 2-acrylamido-2-methylpropanesulfonate and 15% acrylamide is prepared. According to Example 7 there is disclosed a 75:25 copolymer of AMPS and acrylamide (column 6, lines 19 to 25; 41 to 43, and 46 to 51).

Polymers used for EOR should be compatible with salts such as sodium chloride and provide viscosity control in the presence or absence of such salts, since natural or mineral-containing waters are often used instead of pure water for water-flooding (column 2, lines 14 to 17).

- 6.1.1 There is no reference in D1 to an absence of oxygen in the well, or to the temperature of the well, or, explicitly, to the presence of divalent metal ions.
- 6.1.1.1 The argument that the reference to "mineral-containing waters" at column 2, lines 14 to 17 means divalent salts, i.e. the presence of divalent metal ions, is not convincing to the Board, for the following reasons. Firstly, the term "mineral" is not sufficiently specific to be taken, on its own, as a disclosure of "divalent", any more than, say, "metal" is sufficiently specific, on its own, to disclose "copper". Secondly, the reference to "mineral-

containing waters" is made only in the context of sodium chloride (column 2, lines 14 to 20). Indeed, the only information given in D1 as to what extent the various polymers disclosed therein are compatible with salts is in relation to the presence of sodium chloride (cf. column 7, Table II).

Consequently, D1 does not teach the use of the polymers in the presence of waters containing divalent metal ions.

- 6.1.1.2 In any case, the compatibility with "mineral-containing waters" is not presented directly as a quality necessarily associated with all, or indeed any, of the polymers which are described and claimed in D1, but merely as a general desideratum for polymers to be used for such a purpose.

Consequently, the argument of the Respondents, that this reference alone was an invitation to use such polymers in wells containing divalent metal ions, must fail.

- 6.1.2 Nevertheless, it is a principal plank in the Respondents' arguments that the skilled person would understand D1 as containing an instruction to use its polymers in **all** wells, and consequently, in harsh environment wells of the North Sea type as defined in Claim 1 of the patent in suit, as and when these became available.

- 6.1.2.1 Whilst it is true that D1 defines a method for recovering petroleum from "a" subterranean petroleum-bearing deposit (cf. Claim 1), and even states that one of its objects is "to provide an improved water-flooding technique which is susceptible of wide use

for secondary oil recovery" (column 2, lines 58 to 60), this does not amount to a statement that all wells are meant, let alone harsh environment wells of the North Sea type.

6.1.2.2 Indeed, at the date on which D1 was published (1972) there were, according to the document D17 cited by Respondent I, in which details of 57 North Sea wells, including start-up date, are given, only four wells in production in the North Sea, and all of these were gas wells (Indefatigable, Leman, Viking and West Sole).

Hence, at the time of its publication, the wells referred to in D1 could not have included North Sea oil wells.

6.1.2.3 If, however, D1 is construed at the priority date of the patent in suit (1984), when many North Sea oil wells were already producing, then the general knowledge of the skilled person at this time concerning the conditions applying in such harsh environment wells must also be taken into account.

6.1.2.4 The severe problems associated with operating in such a harsh environment, in particular the tendency of the viscosity of the copolymers or material injected in the flood-water to break down, are set out in the acknowledgment of prior art in the patent in suit (page 2, lines 11 to 19), in D4 (cf. section 5 etc., above), and in the evidence of Mr. Ryles given at the oral proceedings.

6.1.2.5 Furthermore, according to the submission of Respondent I in the Notice of Opposition, it is stated, "It had been common general knowledge for very many years (see for instance D2 ... and D7) that

water soluble viscosifying polymers tend to lose their viscosity at higher temperatures and in higher salt concentrations and it had been known for very many years that this was probably due to various factors. One such factor is degradation, such as hydrolysis, of the pendant groups (notably the conversion of acrylamide to acrylic acid). Another is precipitation of the polymer due to the formation of insoluble salts between salt-forming pendant groups, notably acrylic acid." (cf. page 5).

Thus it is not a matter of dispute that the skilled reader of D1 at the priority date of the patent in suit would have been well aware, by virtue of his general knowledge of the art, that harsh environment wells such as North Sea oil wells represented a distinct class, in terms of difficulties of EOR operation.

6.1.2.6 In the light of this general knowledge, the absence in D1 of any mention of well temperatures in excess of 60°C in combination with high salinity, as well as the fact of its publication before the advent of North Sea oil wells, means that there is no disclosure of this special class of harsh environment wells.

6.1.2.7 The argument of the Respondents, that North Sea oil wells are "conventional" wells, and that D1 applies to all conventional wells, fails to take account of the sequence of events. As pointed out above, at the time D1 was published North Sea oil wells were not conventional, and the skilled person, even at the priority date of the patent in suit, would still construe the meaning of "conventional" in D1 as at its publication date.

Consequently, the argument that the very generality of the disclosure of D1 meant that its teaching applied also to harsh environment wells, must fail.

On the contrary, in the Board's view, the skilled reader of D1 would regard the teaching of D1 as referring to the kind of oil well in which synthetic linear polymers were conventionally known at the publication date of D1 to be applicable, i.e. wells having a downhole temperature of less than 60°C and/or being non-saline.

6.1.2.8 Even if this were not the case, however, and one were to follow the line taken by the Respondents in assuming that the class of oil wells covered by the teaching of D1 generically included the specific class of harsh environment wells, the latter would in effect correspond to a particular restricted "range" of wells with which the generality in D1 overlapped, but which it did not specifically disclose.

6.1.2.9 Following the approach adopted in the decision T 0026/85 (OJ EPO 1990, 022), mentioned by Respondent I during the oral proceedings, "in assessing novelty of the invention under examination in a case where overlapping ranges of a certain parameter exist, it has to be considered whether the person skilled in the art would, in the light of the technical facts **seriously contemplate** applying the technical teaching of the prior art document in the range of overlap." (cf. also T 0666/89 (OJ EPO 1993, 495)).

6.1.2.10 In the present case, taking into account on the one hand the nature of the problems to be expected, including the difficulties of carrying out experimental tests, and on the other hand the

enormous financial losses in terms of lost oil production consequent upon failure, it must be concluded that the skilled person would not seriously have contemplated applying such a general and indeed obsolete teaching in the specifically more hazardous and problematical area of harsh environment wells of the North Sea type.

Consequently, the subject-matter of Claim 1 is considered to be novel with respect to the disclosure of D1.

6.2 According to D2 there is disclosed a method of drilling a well into a subterranean formation in which an aqueous drilling fluid containing clayey material is circulated into the well and a filter cake is formed on the wall of the well to decrease loss of fluid from the drilling fluid, there being admixed with the drilling fluid a cross-linked polymer of 8 to 70 mole percent of a (meth) acrylamide alkyl sulphonic acid or alkali metal salt thereof; from 30 to 91 mole percent of a (meth) acrylamide or N-alkyl (meth) acrylamide; and 0.2 to 4.4 mole percent a quaternary ammonium salt (Claim 1).

There is no disclosure in D2 of water flooding techniques, or EOR of any kind. Consequently, the subject-matter of Claim 1 is novel over the disclosure of D2.

6.3 According to D7, a study was made of the rheological, degradation and absorption properties of copolymers of the sodium salt of AMPS and these properties were compared with those of partially hydrolysed polyacrylamide and xanthan gum polysaccharide (page i, Abstract).

Degradation experiments carried out at temperatures between 25 and 80°C showed that the degradation rate of an AMPS/acrylamide copolymer (40/60 by weight) was extremely sensitive to oxygen (pages 60, 101).

Titration with calcium nitrate showed that AMPS polymers and acrylamide polymers with acrylate contents below 30% did not form insoluble calcium salts at 25°C or at 70°C. Further tests showed that a precipitate was formed if the polymer had both a high acrylate content and a high molecular weight. The AMPS group of the polymer is highly polar and is more likely to remain in solution than the acrylate group of the hydrolysed acrylamide polymer (page 98).

The activation energies of the synthetic polymer solutions (hydrolysed acrylamide and AMPS/acrylamide) were very similar, which suggests a similar degradation mechanism, whereas the activation energy of xanthan gum solutions was significantly higher (page 110).

It is clear that the application of the new synthetic (AMPS) polymers for mobility control under reservoir conditions will be very limited (cf. Abstract).

- 6.3.1 There is no disclosure in D7 of the use of the AMPS/acrylamide polymers in a well of any kind, let alone a harsh environment well.

- 6.3.2 Nor can the conclusion (that such polymers will be of limited application) be regarded as an invitation to the skilled person to use them in such an environment. On the contrary, to the extent that the skilled person might, in spite of the comprehensive discouragement contained in the above conclusion, nevertheless decide to apply the polymers in an oil

well of some kind, the same considerations apply as in the case of D1 (cf. section 6.1.2 etc., above). In other words, the skilled person would not seriously consider applying AMPS copolymers in the specific area of harsh environment wells.

Hence, the subject-matter of Claim 1 is novel over the disclosure of D7.

6.4 The remaining documents do not come closer, and were, in any case, not the subject of a specific objection of lack of novelty during the appeal.

Consequently, the subject-matter of Claim 1, and by the same token also of dependent Claims 2 to 11, is considered to be novel.

7. *Inventive step*

To deal with this issue, it is necessary to answer the question whether the skilled person would have expected that the stated problem would be solved by selecting the particular class of acrylic copolymers containing 30 to 70 mole% AMPS defined in section 5.3, above.

7.1 There is no suggestion of this in D4 itself, the closest state of the art, because this does not mention AMPS polymers. Indeed, far from hinting that such polymers might be useful under harsh environment conditions, it states, on the contrary, that the structurally related acrylamide polymers are particularly vulnerable to loss of viscosity under harsh environment conditions (cf. "conclusions", No. 2).

7.1.1 The argument of the Respondents, that the skilled person would not regard this warning as applying to AMPS polymers, because the latter were not "polyacrylamides" is not convincing to the Board. Not only is "AMPS" referred to in the prior art as a "N-sulfohydrocarbon-substituted acrylamide polymer" (D1, column 5, line 20), but it is, chemically, a substituted acrylamide. Furthermore, the comonomer with which it is typically used, for instance in D1, is acrylamide itself. Consequently, whether the AMPS component is considered on its own or in a typical copolymer together with significant amounts of acrylamide, the term "acrylamide polymer" cannot be regarded as inappropriate.

7.1.2 It is in any case clear from D4 that the vulnerability to loss of viscosity through thermal degradation is attributable to the presence of "amide groups" in polyacrylamide (cf. D4, page 360).

Thus the skilled reader of D4 would understand that the presence of significant amounts of acrylamide groups in a polymer would be sufficient to render it vulnerable to hydrolysis and thus to degradation with loss of viscosity.

7.1.3 In summary, D4 represents a strong disincentive to the skilled person to experiment with any polymer containing significant amounts of acrylamide groups or which could be regarded as a polyacrylamide.

7.2 It is true that D7 identifies the behaviour of AMPS groups as being somewhat different in that the AMPS group is highly polar and therefore more likely to remain in solution than the acrylate group of the hydrolysed acrylamide polymer (page 98, last paragraph). It is, however, clear that this

comparison is made only with respect to acrylate groups, since neither AMPS polymers nor acrylamide polymers with low acrylate contents formed precipitates with calcium ions (page 98, first sentence).

Furthermore, the activation energies of aqueous solutions of the AMPS/acrylamide and acrylate/acrylamide polymers exemplified in D7 are stated to be very similar (cf. page i, last paragraph; page 110). This is borne out by the graphical representation of loss of viscosity with time through degradation of the AMPS/acrylamide and acrylate/acrylamide polymers in Figure 5.5 (page 105) and also the conclusion of the document, which is that both types of polymer will be of very limited application (cf. page ii, Abstract).

Thus, the essential message of D7 is that AMPS/acrylamide copolymers behave, in respect of their thermal degradation properties, very similarly to acrylamide/acrylate copolymers. The latter are, however, disclosed in D4 as being particularly vulnerable to loss of viscosity under harsh environment conditions.

Hence, if the skilled reader of D4 had been in any doubt as to whether the references to the vulnerability to hydrolysis of "polyacrylamides" and "acrylamide groups" could be taken as applying also to AMPS copolymers, these doubts would have been removed by reading D7.

- 7.2.1 The argument that the skilled person would see in D7 an indication that AMPS copolymers were more stable than the corresponding polyacrylamides, far from being supported by the content of the document, is thus contradicted by it.
- 7.2.2 Even if the content of D7 had been such as to support the contention of the Respondents with regard to stability, however, the nature of the tests, and in particular their duration, as carried out according to D7, is in any case insufficient to form the basis for the skilled person to reconsider the teaching of D4. In particular, none of the tests were made over a period of more than one month, whereas the stability required for polymers to be used in harsh environment EOR is of the order of a year.
- 7.2.3 In this connection, the argument put forward by Respondent II at the oral proceedings, that long term tests were not necessary since a choice could be made on the basis of a short term trend, is contradicted both by the realities of oil well operation and the fact that short term stability does not necessarily imply long term stability. Indeed, it is these two considerations which form the basis of the technical problem that the patent in suit sets out to solve.
- 7.2.4 Quite apart from this, the conclusion arrived at in D7 was that the application of such AMPS copolymers would prove in any case to be "very limited".
- 7.2.5 The argument submitted at the oral proceedings by Respondent I that this limited applicability was solely in relation to absorption on rock formations

referred to in the previous paragraph (cf. Abstract, page ii) is not convincing, because the relevant wording clearly refers back to the entire content of D7.

- 7.2.6 In summary, the disclosure of D7 tends to support D4 in its teaching against the use of acrylamide polymers in harsh well environments, but in any case does not contain the kind of long term test results which would be necessary to make its findings authoritative as against those of D4 in relation to the stated problem. In general terms, it in any case does not recommend the use of AMPS copolymers.

Consequently, there is nothing in D7 which could ameliorate the disincentive created by D4.

- 7.3 The argument, put forward by the Respondents at the oral proceedings, that the skilled person would have been in a position to predict, from general electronic and steric considerations, the relative resistance of an AMPS group to hydrolytic (nucleophilic) attack compared with an unsubstituted acrylamide group, was unclear in its explanation, and was, furthermore, wholly unsupported by any, let alone any cogent evidence. It therefore amounted to no more than a mere assertion.

In this connection, the only remotely relevant evidence before the Board is the content of document D14, which concerns the effect of anionic comonomers (such as AMPS) on the hydrolytic stability of polyacrylamides at high temperatures in alkaline solution. This document was, however, not published until 1988, i.e. four years after the priority date of the patent in suit.

Consequently, no credible reason has been established for the skilled person to expect, at the priority date of the patent in suit, that the long term stability of AMPS polymers under harsh environment conditions would be significantly different from that of unsubstituted polyacrylamides.

7.4 The disclosure of D1 would not, for the reasons given under section 6.1 etc., above, be seriously considered by the skilled person in relation to harsh environment wells. It would therefore be of no assistance in attempting to solve the stated problem.

7.4.1 Even if, in spite of this, the attention of the skilled person were nevertheless for some reason to light on D1, its disclosure, although including examples of AMPS copolymers having a molar composition corresponding to that forming the solution of the stated problem, is not restricted to such molar proportions, but suggests that any AMPS copolymer with a molar content of AMPS above 5% and up to 95% would be suitable (cf. Examples 3, 6 and column 5, lines 26 to 33).

7.4.2 It is, however, clear from the uncontested results of the patent in suit, that AMPS copolymers with, say, 10 or 20 molar percent AMPS are unsuitable after 56 days under harsh environmental conditions, and thus do not meet the essential requirements for use in EOR.

Consequently, even if the skilled person were to turn to D1, he would not find the essential information corresponding to the solution of the stated problem.

7.5 Similar considerations apply a fortiori to the disclosure of D2, which, for the reasons given under section 6.2 above, is more remote than that of D1.

7.6 The remaining documents are more remote still.

7.7 It is thus concluded that none of the documents of the prior art, nor the general knowledge of the skilled person at the relevant date would have given a hint to the skilled person that AMPS groups were significantly more resistant to hydrolysis in the long term under harsh environment conditions than unsubstituted acrylamide groups. Far less was there any hint that such AMPS groups were capable, when present as only a proportion of the copolymer, of conferring hydrolytic stability on the rest of the polymer.

Consequently, the Board finds that the solution of the technical problem does not arise in an obvious manner from the cited prior art.

7.8 In the latter connection, it is the view of the Board that the content of D4, which was stated to have received wide attention in the art, as was corroborated by the evidence of Mr Ryles given at the oral proceedings and according to the submissions of the parties belonged to the general knowledge of the skilled person, is the outward and visible evidence of a well-settled and practical prejudice of the skilled person, at the priority date of the patent in suit, against the use of any synthetic linear polymers in EOR under harsh environment conditions, and in particular any such polymer containing significant amounts of acrylamide or AMPS groups and thus resembling a polyacrylamide.

Consequently, the use, according to Claim 1 of the patent in suit, of precisely such polymers under the harsh environment conditions represents an unexpected initiative against the resistance of a widely held prejudice.

8. The subject-matter of Claim 1 of the patent in suit therefore involves an inventive step, and, by the same token, so does the subject-matter of the dependent Claims 2 to 11.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the Opposition Division with the order to maintain the patent on the basis of the claims filed on 8 April 1992 and with the description as granted.

The Registrar:


P. Martorana

The Chairman:


C. Gérardin