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

(11) **EP 1 422 488 B2**

(12) **NEW EUROPEAN PATENT SPECIFICATION**
After opposition procedure

(45) Date of publication and mention of the opposition decision:
25.01.2017 Bulletin 2017/04

(45) Mention of the grant of the patent:
26.02.2014 Bulletin 2014/09

(21) Application number: **03005976.0**

(22) Date of filing: **18.03.2003**

(51) Int Cl.:
F28F 21/04 *(2006.01)* ***F28F 19/02*** *(2006.01)*
F28F 9/10 *(2006.01)*

(54) **A heat exchanger with a silicon carbide set of tubes and double tube plates in enamelled steel**

Wärmetauscher mit Siliziumkarbid-Röhren und emaillierten Stahl-Rohrplatten

Echangeur de chaleur avec tubes en carbure de silicium et plaques tubulaires en acier émaillé

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR

(30) Priority: **19.11.2002 IT MI20022449**

(43) Date of publication of application:
26.05.2004 Bulletin 2004/22

(60) Divisional application:
13187710.2 / 2 685 201

(73) Proprietor: **Pfaudler GmbH**
68723 Schwetzingen (DE)

(72) Inventors:
- **Artusi, Gianni**
  30027 San Dona Di Piave (IT)
- **Barison, Nicola**
  30033 Noale (IT)

(74) Representative: **Parker, Andrew James et al**
Meissner Bolte Patentanwälte
Rechtsanwälte Partnerschaft mbB
Widenmayerstraße 47
80538 München (DE)

(56) References cited:
DE-A1- 2 326 365
DE-A1- 19 610 501
DE-A1- 19 714 423
FR-A- 650 058
GB-A- 273 605
GB-A- 311 245
GB-A- 618 236
GB-A- 1 112 265
GB-A- 2 234 807
US-A- 3 923 314
US-A- 5 323 849
US-A- 5 515 914
US-A- 5 630 470

EP 1 422 488 B2

Description

Field of the invention

[0001] The present invention relates to a heat exchanger with a set of tubes and tube plates and more particularly a heat exchanger suited for the treatment of highly corrosive fluids or the ones for which a high level of purity must be ensured.

State of the art

[0002] Heat exchangers are known for processing highly corrosive fluids or fluids with special purity requirements, wherein the tube plates are of a suitable material, such as solid PTFE. The tubes are sealed with the plate by means of threaded ring nuts, directly tightened in a threading provided in the PTFE. This solution presents drawbacks connected with the not satisfactory mechanical resistance of the plates, especially at high temperatures, which limits the possible applications of the exchanger and renders frequent maintenance necessary.

[0003] A possible alternative is the use of PTFE coated steel plates; the coating is necessarily thin, which renders it not always sufficiently impermeable, and unsuitable for providing a proper sealing for the tubes passing through the plate.

[0004] This requires complicated construction for properly fixing and sealing the tubes, and a relevant danger of seepage of the circulating fluid is anyway present.

[0005] DE 2326365 represents the closest prior art and relates to a heat exchanger consisting of ceramic tubes mounted between two double tube plates.

Summary of the invention

[0006] The above mentioned problems have been solved, according to the present invention as defined in claim 1.

Brief description of the drawings

[0007] In the attached figures are represented:

- Figure 1: overall view of the exchanger according to the invention where (11) is the set of tubes with silicon carbide tubes, (12) are the tube plates in enamelled steel, (14) is the central shell in enamelled steel, and (13) are the end distributors;
- Figure 2: a detail of the tube plate in PTFE according to the prior art, double O ring seal (24), threaded ring nut (22) with threading (23) on the PTFE;
- Figure 3: a detail of the double tube plate according to the prior art, in PTFE coated steel, where (32) is the coating in PTFE, (33) O ring seal, (34) locking through screw, (35) through holes;
- Figure 4: a detail of the single tube plate (41) according to an example not claimed, with O ring seal (42), threaded ring nut (43), and intermediate bushing (44);
- Figure 5: a detail of the double tube plate according to an example not claimed, with O ring seal (51) on the inner plate and an O ring (52) on the outer plate, a single locking ring nut (53), intermediate bushing (54) hole (55) for the conveyance of possible fluid leakages;
- Figure 6: a detail of the double tube plate according to the invention, with O ring seal (62) on the inner plate (61), O ring seal (67) on the outer plate (65) locking bushing (66), steel ring nut (63), intermediate bushing (64), elastic seal system support L-profile (68);
- Figure 7: a detail of the double tube plate with locking screw (74) of the two plates with gasket (73) between the plates.

Detailed description of preferred embodiments

[0008] In Fig.1 is briefly represented a heat exchanger comprising a set of tubes in silicon carbide (SiC) (11) and tube plates in enamelled steel (12) as the essential members. Depending on the plates which may be enamelled indifferently on one or both the two faces, both the central shell (14) and the end distributors (13) may be provided in enamelled steel.

[0009] A characteristic and original aspect of the heat exchanger according to the invention is represented by the enamelled tube plates substituting the traditional ones in PTFE (PolyTetraFluoroEthylene) see Fig. 2 reference 21 or the ones in PFTE-coated steel (see Fig.3 reference31).

[0010] Another original aspect is represented by the seal systems between the end of the SiC tube and the tube plate (see. Fig. 6). These seal systems, especially studied for the various embodiments of enamelled tube plates (enamelling only on the distributor side face, only on that of the shell side which is not claimed or on both), can also be adopted for traditional tube plates with tubes in SiC or in glass and represent an improvement with respect to the traditional solutions.

[0011] The improvement achieved with the present invention overcomes the drawbacks of the above mentioned prior art exchangers and in particular (with reference to figure 2 for the plate in solid PTFE and figure 3 for the plate in PTFE-coated steel):

- The plate in solid PTFE (Fig.2, reference21), normally of the glass fiber filled type, can be used up to a maximum temperature of 165°C, beyond which a rapid decline in the mechanical resistance values of this material is observed.

[0012] In addition, being PTFE essentially a plastic material, the tube plate may deform over time and bend under pressure, subjecting the ends of the SiC tubes (particularly the most exterior ones with respect to the set of

tubes) to flexing stress beyond their ultimate stress. For this reason in practice they do not exceed ϕ 300 mm.

- For sealing the tubes on the glass-filled solid PTFE tube plates threaded ring nuts (22) also in glass-filled PTFE are provided, which press a gasket generally of a double O ring type (24). The threading (23) on the PTFE (plastic material) tends to loosen with time the higher the temperature as well as the amplitude and the frequency of the thermal cycles. Accordingly, frequent inspections of the locking moment of the PTFE ring nuts are required to avoid leakages from the sealing.
- The PTFE coated steel plates (Fig.3, reference 31) are not subjected to permanent progressive deformations. However, being the coating (32) necessarily thin, it has certain porosity and as a consequence is not completely impermeable. Furthermore, in this low thickness neither the threading required for the locking ring nuts of the O ring gasket nor the housings for the gaskets themselves can be formed, as it is however possible to do for the plates in solid PTFE. One must therefore resort to the solution represented by the double plate with O ring (33) in the intermediate area. To allow for the tightening of the O rings between the two plates through screws (34) passing through holes in the plate, are used and thus the PTFE coating is drilled accordingly. In correspondence of such holes (35) an appropriate seal system must be provided, which will however constitute a point of discontinuity in the coating with a danger of seepage of the circulating fluid.

[0013] With the enamelled tube plate the following advantages may be achieved:

- The coating is not porous, but perfectly impermeable and cleanable like glass;
- The high mechanical resistance of the steel plate allows the use of large-sized plates, well beyond 300 mm diameter;
- It is suitable to be easily implemented in a double embodiment with enamelling on one or on both faces and with an intermediate circuit for leakage collection (see Fig.7 reference 71) delimited on the circumference of the O ring gasket reference 73 with a drainage hole (72) in the lower part, wherein an appropriate device for signalling the leakage itself may be screwed thereto (for example a manometer with min/max pressure contacts). In this way, the fluids are prevented from entering into contact with each other, an event to be avoided with chemically incompatible fluids or fluids which must not contaminate each another. The collected fluid allows for an immediate identification of whether the leakage is on the tube side or the shell side.
- All the threaded couplings for the locking ring nuts are metallic and therefore much more reliable than those in PTFE.

[0014] With the new sealing systems between the end of the SiC tube and the tube plate the basic needs are considered, which are however met by the traditional seal systems (generally made with fluoro-elastomer O ring gaskets of Kalrez^R and Viton^R type or FEP-coated Silicone (C_2F_4/C_3F_6 copolymer), or other materials with high corrosion resistance), and that is:

- accomplish the pressure seal between tube and tube plate,
- prevent direct contact of the tube with the tube plate (both elements in rigid material) in such a way as to avoid breakage due to localised peaks of stress,
- allow the sliding of the tube (in the hole of the tube plate) for the automatic compensation of the different expansion between set of tubes and shell of the exchanger,
- prevent that the sum of subsequent translations of the tube, which may also occur always in the same direction, may cause the tube itself to unthread from the hole of the plate. This is achieved by a "translation limiter" consisting in the reduction in diameter of the ring nut head (reference 43, 53, 66), which prevents the tube from exiting beyond the ring nut itself.

[0015] Fig.4 shows an example of the exchanger with a single tube plate (41), with enamelling on the shell side, in which the O ring seal gaskets (42) are locked by the threaded ring nut (43) by means of the intermediate bushing (44).

[0016] The following new prerogatives for the double tube plates are further added.

[0017] For the double tube plate enamelled only on the inner face (shell side) Fig.5 which is not part of the claimed invention, the seal on the inner (by O ring reference 51) and the outer (by O ring reference 52) tube plate can be simultaneously achieved by a single locking of the threaded ring nut (53) by means of the intermediate bushing (54) in steel or in PEEK (phenylpolyetherketones of Du Pont), which is fitted with holes (55) for conveying possible fluid leakages to the outside.

[0018] For the double tube plate enamelled on both sides (Fig.6), the two seals on the tube are separate. For the inner plate (shell side) (61) the seal is implemented by means of a double O ring gasket (62) pressed by an intermediate bushing in steel or in PEEK (64) by the screwing of a steel ring nut (63) in the corresponding thread provided in the tube plate.

[0019] For the outer tube plate (distributor side) (65), the use of a ring nut for the locking of every single tube not being possible, the required pressure for pressing the O ring seals (67) has been provided by means of a special bushing in glass-filled PEEK or PTFE (66), being pressed by the tube plate. This pressure is applied during the coupling step of the two single plates by the locking of the screws located on an outer peripheral circumfer-

ence of the enamelled area to avoid any point of discontinuity in the coating (see fig.7 reference 74). The type of seal is characterised by a high degree of elasticity in the axial direction made by means of a mechanical spring system or an adequate number of overlapping O ring gaskets (68), in addition to those provided for pressure seal.

[0020] An underlying L-profile ring (69) ensures support to this elastic system regardless of the position of the underlying seal ring nut on the inner plate.

Claims

1. A heat exchanger comprising a set of tubes consisting of SiC tubes (11) mounted between two double tube plates (61, 65) in steel by means of a pressure seal system at the end of, and on the outer surface of, each tube (11), in which the tube (11) can axially slide therein to compensate for thermal expansions, wherein
   the distributor side surfaces of the distributer tube plates (65) of the double tube plates (61, 65) are enamelled, and
   wherein the pressure seal system comprises a bushing (66) in glass-filled PEEK or PTFE which, includes a portion with a reduced diameter preventing the tube (11) from exiting beyond the bushing itself (66), wherein
   the bushing (66) is located within an enamelled aperture passing through the enamelled distributer side tube plates (65) and which is pressed by a reduced diameter portion of said aperture against an O-ring seal (67), wherein further
   the pressure is applied during a coupling step of the two tube plates of the double tube plates (61, 65) by locking screws (74) located on an outer peripheral surface of the enamelled area of the distributer side tube plates (65),
   wherein the shell side tube plate (61) is enamelled on the shell side, and wherein the seal between the ends of the tubes (11) and the shell side tube plate (61) is obtained through double O ring gaskets (62, 67) pressed in such a way: the seal (62) on the shell side tube plate (61) is obtained by a double 0 ring gasket (62) pressed, by means of an intermediate bushing (64) in steel or in PEEK, by screwing of a steel ring nut (63) in the corresponding threading provided on the shell side tube plate (61).

2. The heat exchanger according to claim 1, in which the members of the seal system between tubes (11) and tube plate (61, 65) are adapted for chemically and thermally resisting the circulating fluids under the normal operating conditions of the exchanger.

3. The heat exchanger according to claim 1, wherein the seals between the ends of the tubes (11) and the distributer side plate (65) are ensured by an elastic system indifferently formed by a series of overlapping O ring gaskets (68) or a mechanical spring, which rest on an L-profile ring (69) which ensures pressing required for each single seal following the locking of the peripheral screws (74) which fix the two plates (61, 65) forming the double tube plate one to the other.

Patentansprüche

1. Wärmetauscher, umfassend einen Satz von Rohren, der aus SiC-Rohren (11) besteht, die zwischen zwei Doppelrohrplatten (61, 65) aus Stahl mittels eines Druckdichtungssystems am Ende und an der Außenfläche jedes Rohrs (11) angebracht sind, in welchem Dichtungssystem jedes Rohr (11) axial gleiten kann, um Wärmedehnungen auszugleichen, wobei:

   die verteilerseitigen Flächen der Verteilerrohrplatten (65) der Doppelrohrplatten (61, 65) emailliert sind, und
   wobei das Druckdichtungssystem eine Hülse (66) aus glasfaserverstärktem PEEK oder PTFE umfasst, die einen Abschnitt mit reduziertem Durchmesser aufweist, der das Rohr (11) daran hindert, über die Hülse (66) selbst hinaus auszutreten, wobei
   die Hülse (66) in einem emaillierten Durchlass angeordnet ist, der durch die emaillierten verteilerseitigen Rohrplatten (65) hindurchgeht, und von einem Abschnitt mit reduziertem Durchmesser des Durchlasses gegen eine O-Ringdichtung (67) gepresst ist,

   wobei darüber hinaus
   der Anpressdruck während eines Verbindungsschritts der zwei Rohrplatten der Doppelrohrplatten (61, 65) durch Feststellschrauben (74) angelegt wird, die an einer Außenumfangsfläche des emaillierten Bereichs der verteilerseitigen Rohrplatten (65) angeordnet sind, wobei die mantelseitige Rohrplatte (61) auf der Mantelseite emailliert ist, und wobei die Dichtung zwischen den Enden der Rohre (11) und der mantelseitigen Rohrplatte (61) über doppelte O-Ringdichtungen (62, 67) erzielt wird, die folgendermaßen eingepresst sind: die Dichtung (62) an der mantelseitigen Rohrplatte (61) wird durch eine doppelte O-Ringdichtung (62) erzielt, die mittels einer Zwischenhülse (64) aus Stahl oder PEEK eingepresst wird, indem eine Stahlringmutter (63) in das entsprechende Gewinde eingedreht wird, das an der mantelseitigen Rohrplatte (61) vorgesehen ist.

2. Wärmetauscher nach den Anspruch 1, bei dem die Teile des Dichtungssystems zwischen den Rohren (11) und der Rohrplatte (61, 65) dazu angepasst

sind, den zirkulierenden Fluiden unter normalen Betriebsbedingungen des Tauschers chemisch und thermisch zu widerstehen.

3. Wärmetauscher nach Anspruch 1, wobei die Dichtungen zwischen den Enden der Rohre (11) und der verteilerseitigen Platte (65) durch ein elastisches System sichergestellt sind, das indifferent durch eine Reihe von sich überlappenden O-Ringdichtungen (68) oder eine mechanische Feder gebildet ist, die auf einem L-Profilring (69) aufliegen, der eine Andruckwirkung sicherstellt, die für jede einzelne Dichtung nach dem Feststellen der umfänglichen Schrauben (74) erforderlich ist, welche die zwei, die Doppelrohrplatte bildenden Platten (61, 65) aneinander fixieren.

Revendications

1. Échangeur de chaleur comprenant un ensemble de tubes constitué de tubes de SiC (11) montés entre deux doubles plaques de tubes (61, 65) en acier au moyen d'un système de joint d'étanchéité sous pression au niveau de l'extrémité, et sur la surface extérieure, de chaque tube (11), dans lequel le tube (11) peut coulisser de manière axiale à l'intérieur pour compenser des dilatations thermiques, dans lequel :

   les surfaces du côté du dispositif de distribution des plaques de tubes de dispositif de distribution (65) des doubles plaques de tubes (61, 65) sont émaillées ; et
   dans lequel le système de joint d'étanchéité sous pression comprend une bague de réduction (66) en PEEK ou en PTFE remplie de verre qui comprend une partie avec un diamètre réduit qui empêche le tube (11) de sortir au-delà de la bague de réduction elle-même (66), dans lequel la bague de réduction (66) se situe à l'intérieur d'une ouverture émaillée qui passe à travers les plaques de tubes du côté du dispositif de distribution émaillées (65) et est pressée par une partie qui présente un diamètre réduit de ladite ouverture contre un joint torique (67), dans lequel en outre
   la pression est appliquée au cours d'une étape de couplage des deux plaques de tubes des doubles plaques de tubes (61, 65) par des vis de verrouillage (74) situées sur une surface périphérique extérieure de la zone émaillée des plaques de tubes du côté du dispositif de distribution (65), dans lequel la plaque de tube (61) au niveau du côté de l'enveloppe est émaillée du côté de l'enveloppe, et dans lequel le joint entre les extrémités des tubes (11) et la plaque de tubes du côté de l'enveloppe (61) est obtenu par des couronnes doubles d'étanchéité pour joints toriques l'intermédiaire de joints toriques doubles (62, 67) mises sous pression de telle manière que le joint (62) situé sur la plaque de tubes du côté de l'enveloppe (61) soit obtenu par une double couronne d'étanchéité pour joint torique (62) mise sous pression, au moyen d'une bague de réduction intermédiaire (64) en acier ou en PEEK, par vissage d'un écrou annulaire en acier (63) dans le filetage correspondant fourni sur la plaque de tubes du côté de l'enveloppe (61).

2. Échangeur de chaleur selon la revendication 1, dans lequel les éléments du système de joint entre les tubes (11) et la plaque de tubes (61, 65) sont adaptés pour résister de manière chimique et thermique aux fluides circulant dans des conditions de fonctionnement normales de l'échangeur.

3. Échangeur de chaleur selon la revendication 1, dans lequel les joints entre les extrémités des tubes (11) et la plaque du côté du dispositif de distribution (65) sont assurés par un système élastique constitué indifféremment par une série de couronnes d'étanchéité pour joints toriques qui se chevauchent (68) ou par un ressort mécanique, qui reposent sur un anneau qui présente un profil en L (69) qui assure le pressage requis de chaque joint après le verrouillage des vis périphériques (74) qui fixent l'une à l'autre les deux plaques (61, 65) qui forment la double plaque de tubes.

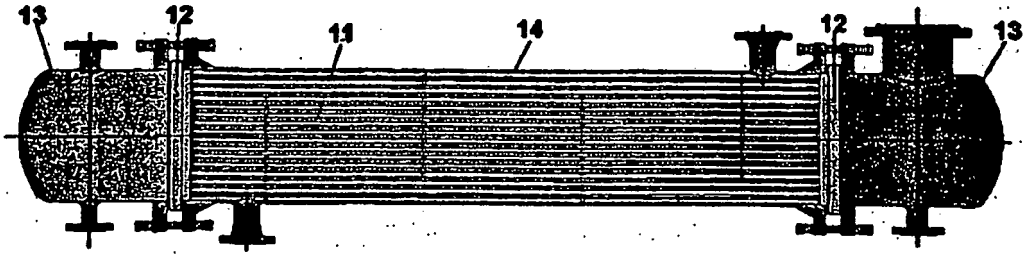

Fig.1

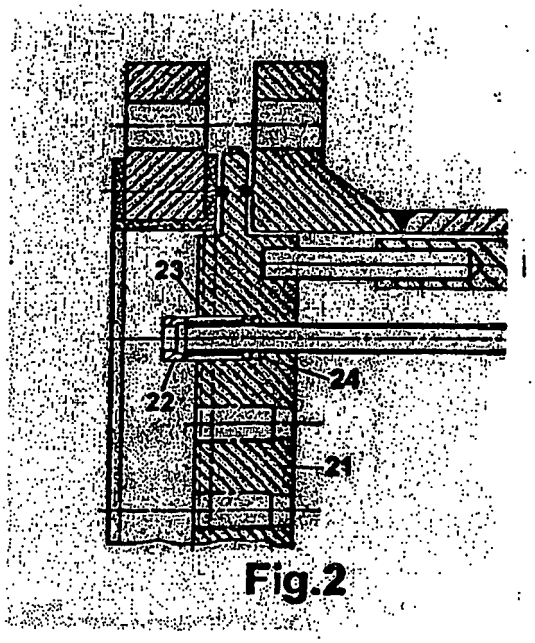

Fig.2

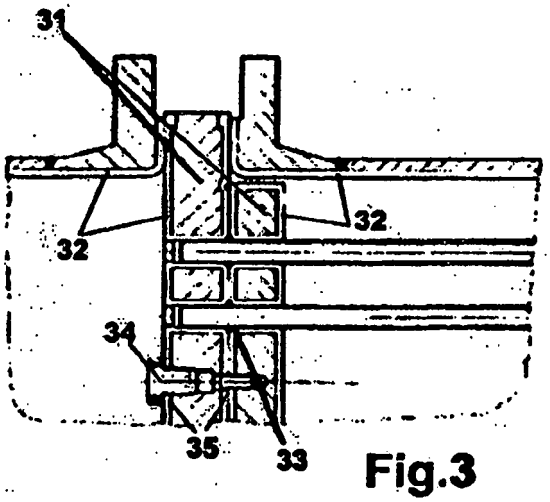

Fig.3

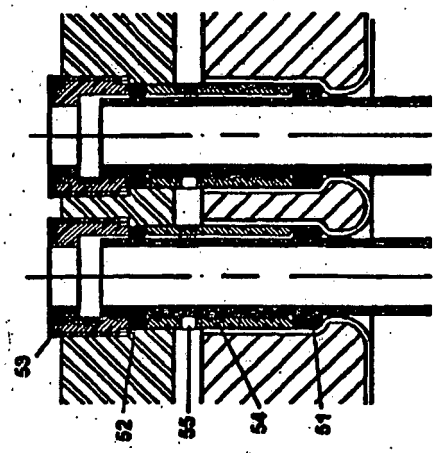

Fig.5'

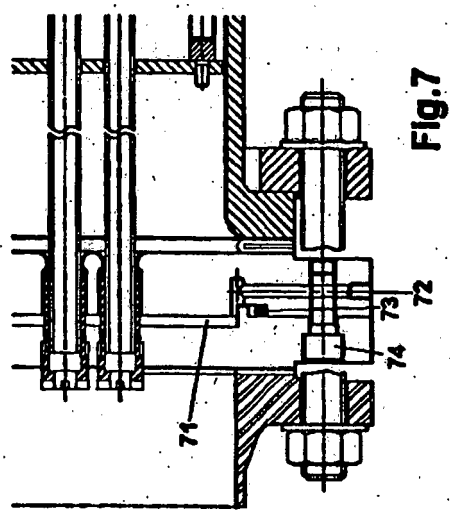

Fig.7

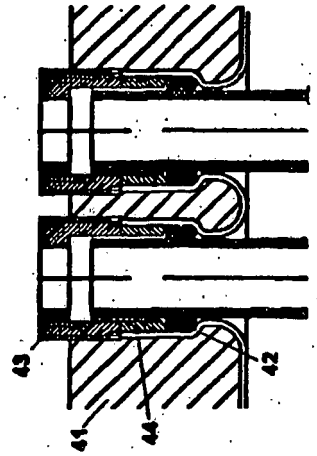

Fig. 4

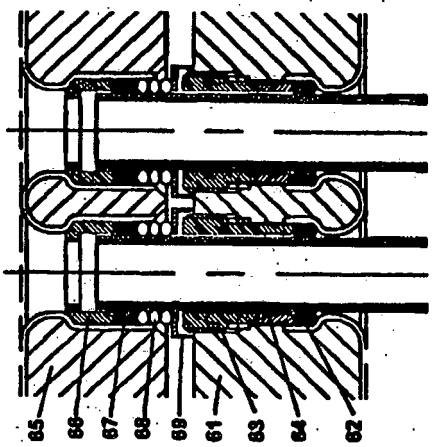

Fig.6

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- DE 2326365 **[0005]**