Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2916146 A1 2014/12/24

(21) 2 916 146

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) **Date de dépôt PCT/PCT Filing Date:** 2014/05/30
(87) **Date publication PCT/PCT Publication Date:** 2014/12/24
(85) **Entrée phase nationale/National Entry:** 2015/12/18
(86) **N° demande PCT/PCT Application No.:** EP 2014/001469
(87) **N° publication PCT/PCT Publication No.:** 2014/202182
(30) **Priorité/Priority:** 2013/06/22 (DE10 2013 010 460.2)

(51) **Cl.Int./Int.Cl.** ***F28D 9/02*** (2006.01),
A23L 3/22 (2006.01), ***F28D 7/16*** (2006.01),
F28F 9/02 (2006.01)

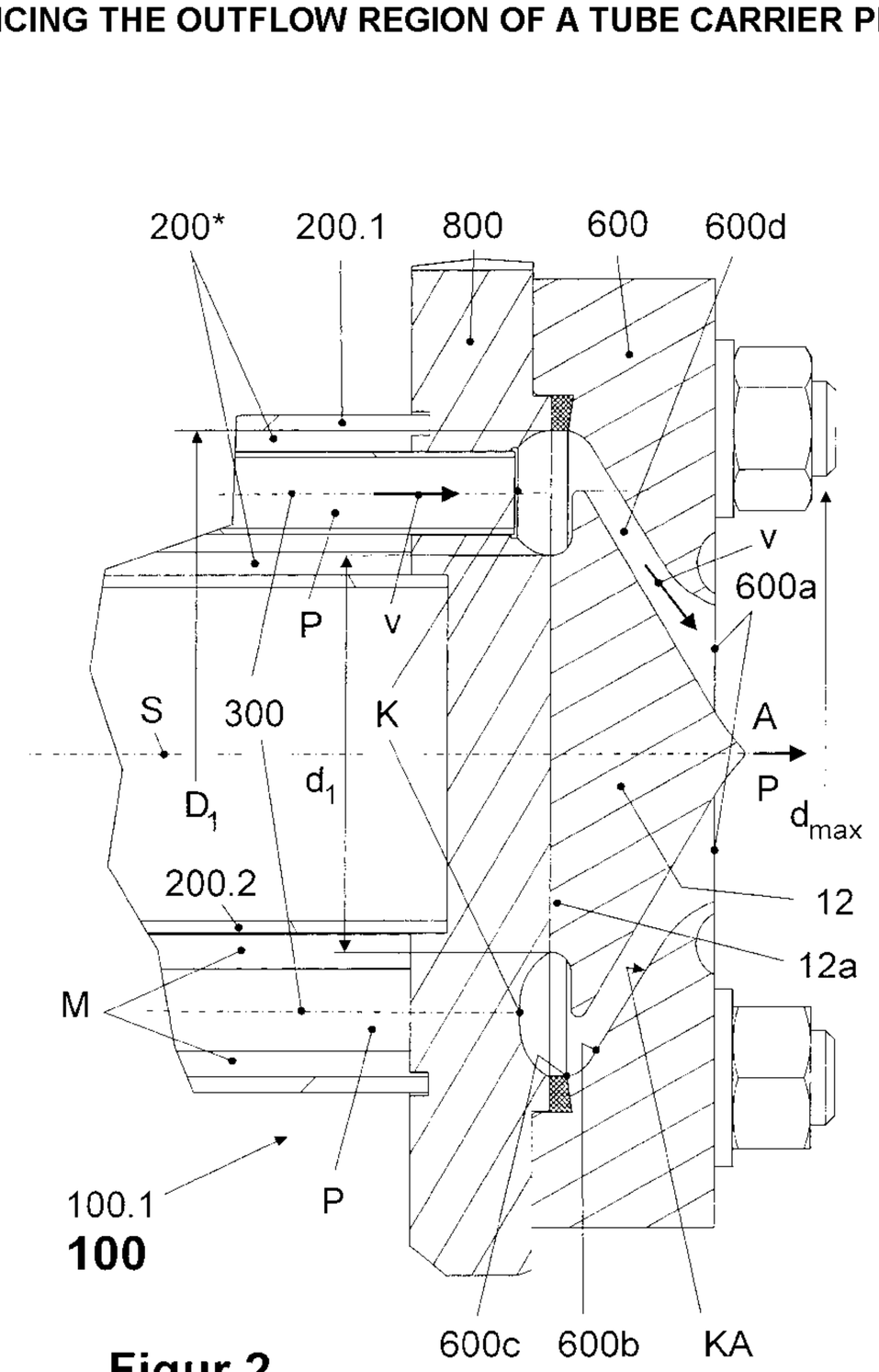
(71) **Demandeur/Applicant:**
GEA TDS GMBH, DE

(72) **Inventeurs/Inventors:**
ROLLE, ULRICH, DE;
LUTKEBRUNS, GUNTER, DE;
SCHWENZOW, UWE, DE;
ASSING, HUBERT, DE;
GRIMM, MARKUS, DE;
SPEEMANN, RALF, DE

(74) **Agent:** RIDOUT & MAYBEE LLP

(54) **Titre : DISPOSITIF PERMETTANT D'INFLUER SUR LA ZONE DE SORTIE D'UNE PLAQUE SUPPORT DE TUBES D'UN ECHANGEUR DE CHALEUR A FAISCEAU DE TUBES**

(54) **Title: APPARATUS FOR INFLUENCING THE OUTFLOW REGION OF A TUBE CARRIER PLATE OF A TUBE BUNDLE HEAT EXCHANGER**



Figur 2

(57) **Abrégé/Abstract:**
The invention relates to an apparatus for influencing the outflow region of a tube carrier plate of a tube bundle heat exchanger, in particular for the food and beverage industry, and in this case in particular for temperature-sensitive and/or viscous food products in

(21) **2 916 146**

(13) **A1**

(57) **Abrégé(suite)/Abstract(continued):**
the dairy industry, for example desserts, sauces or concentrates, according to the preamble of claim 1. The object of the present invention is to develop an apparatus of the generic type in such a way that the tendency for deposits to form in the region of the tube carrier plate through which a product has flowed out is considerably reduced. This is achieved in that the annular space-like outlet channel (600d) has, at least overall in the region thereof between a maximum outside diameter (d¿max¿) of the outlet-side displacement body (12) and the second connection opening (600a), a channel passage cross section (A_s) which has a constant passage cross section over the entire length of the defined region and which, in this region, corresponds to a total passage cross section (NA_i) of all of the inner tubes (300), through which a product flows in parallel, of the number (N), which inner tubes each have an individual passage cross section (A_i) (figure 2).

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

(43) Internationales Veröffentlichungsdatum
24. Dezember 2014 (24.12.2014)

WIPO | PCT

(10) Internationale Veröffentlichungsnummer
WO 2014/202182 A1

(51) Internationale Patentklassifikation:
F28D 9/02 (2006.01) *F28F 9/02* (2006.01)
F28D 7/16 (2006.01) *A23L 3/22* (2006.01)

(21) Internationales Aktenzeichen: PCT/EP2014/001469

(22) Internationales Anmeldedatum:
30. Mai 2014 (30.05.2014)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
10 2013 010 460.2 22. Juni 2013 (22.06.2013) DE

(71) Anmelder: **GEA TDS GMBH** [DE/DE]; Voss-Strasse 11/13, 31157 Sarstedt (DE).

(72) Erfinder: **ROLLE, Ulrich**; Münsterstrasse 10, 48351 Everswinkel (DE). **LÜTKEBRUNS, Günter**; Dinkelblick 16, 48599 Gronau-Epe (DE). **SCHWENZOW, Uwe**; Bolderkamp 2b, 48683 Ahaus (DE). **ASSING, Hubert**; Sabstätte 23a, 48683 Ahaus (DE). **GRIMM, Markus**; Alte Markstrasse 5, 23883 Klein-Zecher (DE). **SPEEMANN, Ralf**; Grüner Weg 55a, 48341 Altenberge (DE).

(81) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare nationale Schutzrechtsart)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare regionale Schutzrechtsart)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, RU, TJ, TM), europäisches (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

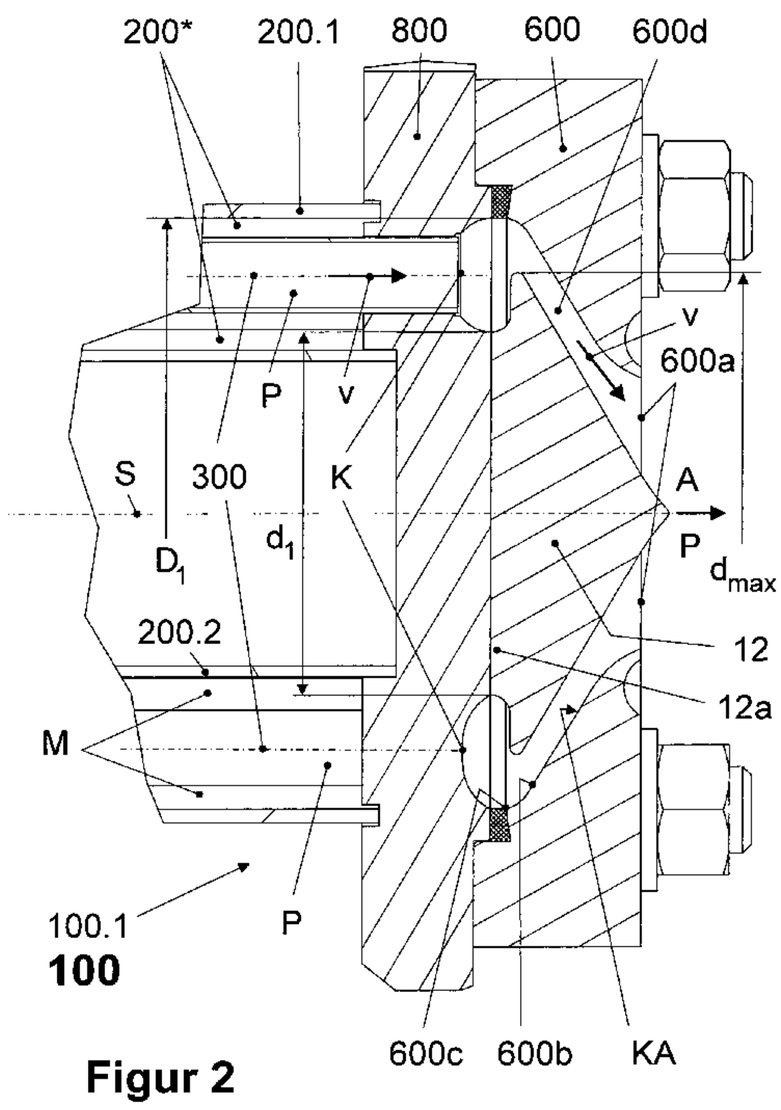
Erklärungen gemäß Regel 4.17:

— *Erfindererklärung (Regel 4.17 Ziffer iv)*

[Fortsetzung auf der nächsten Seite]

(54) Title: APPARATUS FOR INFLUENCING THE OUTFLOW REGION OF A TUBE CARRIER PLATE OF A TUBE BUNDLE HEAT EXCHANGER

(54) Bezeichnung : VORRICHTUNG ZUR EINFLUSSNAHME AUF DEN ABSTRÖMBEREICH EINER ROHRTRÄGERPLATTE EINES ROHRBÜNDEL-WÄRMEAUSTAUSCHERS



Figur 2

(57) Abstract: The invention relates to an apparatus for influencing the outflow region of a tube carrier plate of a tube bundle heat exchanger, in particular for the food and beverage industry, and in this case in particular for temperature-sensitive and/or viscous food products in the dairy industry, for example desserts, sauces or concentrates, according to the preamble of claim 1. The object of the present invention is to develop an apparatus of the generic type in such a way that the tendency for deposits to form in the region of the tube carrier plate through which a product has flowed out is considerably reduced. This is achieved in that the annular space-like outlet channel (600d) has, at least overall in the region thereof between a maximum outside diameter (d_{max}) of the outlet-side displacement body (12) and the second connection opening (600a), a channel passage cross section (A_s) which has a constant passage cross section over the entire length of the defined region and which, in this region, corresponds to a total passage cross section (NA_i) of all of the inner tubes (300), through which a product flows in parallel, of the number (N), which inner tubes each have an individual passage cross section (A_i) (figure 2).

(57) Zusammenfassung:

[Fortsetzung auf der nächsten Seite]

WO 2014/202182 A1

WO 2014/202182 A1

Veröffentlicht:

— *mit internationalem Recherchenbericht (Artikel 21 Absatz 3)*

Die Erfindung betrifft eine Vorrichtung zur Einflussnahme auf den Abströmbereich einer Rohrträgerplatte eines Rohrbündel-Wärmeaustauschers, insbesondere für die Nahrungsmittel- und Getränkeindustrie, und hier insbesondere für temperatursensible und/oder viskose Lebensmittelprodukte der Molkereiindustrie, beispielsweise Desserts, Soßen oder Konzentrate, nach dem Oberbegriff des Anspruchs 1. Es ist Aufgabe der vorliegenden Erfindung, eine Vorrichtung der gattungsgemäßen Art derart weiterzubilden, dass die Neigung zur Bildung von Ablagerungen im Bereich der abgeströmten Rohrträgerplatte deutlich reduziert wird. Dies wird dadurch erreicht, dass der ringraumförmige austrittsseitige Kanal (600d) wenigstens überall in seinem Bereich zwischen einem größten Außendurchmesser (d_{max}) des austrittsseitigen Verdrängerkörpers (12) und der zweiten Anschlussöffnung (600a) einen Kanaldurchtrittsquerschnitt (A_s) aufweist, der einen konstanten Durchtrittsquerschnitt über die gesamte Länge des definierten Bereichs besitzt und der in diesem Bereich einem Gesamtdurchtrittsquerschnitt (NA_i) aller parallel durchströmten Innenrohre (300) der Anzahl (N), die jeweils einen Einzeldurchtrittsquerschnitt (A_i) besitzen, entspricht (Figur 2).

Apparatus for Influencing the Outflow Region of a Tube Carrier Plate of a Tube Bundle Heat Exchanger

TECHNICAL FIELD

The invention relates to an apparatus for influencing the outflow region of a tube carrier plate of a tube bundle heat exchanger, in particular for the food and beverage industry, and in this case in particular for temperature-sensitive and/or viscous food products in the dairy industry, for example desserts, sauces or concentrates, according to the preamble of claim 1.

BACKGROUND OF THE INVENTION

Indirect product heating, for example in UHT systems (UHT: Ultra-High Temperature) by a heat exchange on a wall can take place both with so-called plate heat exchanger systems or also, as in the invention described below, with so-called tube bundle heat exchangers, in which the thermal energy is transferred by the tube walls of a group of inner tubes. The food product to be treated thereby flows in the inner tubes, while a heat carrier medium, hereinafter also referred to as the heat medium within the framework of the invention, in general water or vapor, flows in the annular gap space of the casing tube, which surrounds the parallel-connected inner tube. This type of tube bundle heat exchanger is known from **DE 94 03 913 U1**.

Particularly temperature-sensitive products, like for example desserts, sauces or concentrates, in particular with a high viscosity and, if applicable, with solid-containing components like entire pieces, pulp or fibers, require an exact and quick temperature adjustment of the product for the required temperature conditions. Moreover, a thermally or mechanically gentle treatment of the product is simultaneously required during the fulfillment of the aforementioned objective. It follows from the requirement for a thermally gentle treatment that all partial quantities of a product to be subjected to a heat treatment of the type in question pass through the same required temperature level progression at the same time and over the same period of time. In other words, this means that all partial quantities are subject to the same thermal and flow-mechanical conditions at the same retention time.

Mechanically gentle treatment means that the mechanical load of the product is held as low as possible. This type of load always occurs in particular when the product is subject to shear forces. The latter notoriously occur during deflections, discontinuous cross-sectional transitions, branchings and mergings of the flow ducts.

DE 103 11 529 B3 is addressed the branching problem of the flow in the inlet area of the tube bundle plate of a tube bundle heat exchanger (e.g. **DE 94 03 913 U1**), as preferably used in UHT systems. The targeted measures suggested under the conceptual formulation specified there relate exclusively to the branching of a product into inner tubes of the tube bundle heat exchanger receiving a number of partial quantities of this product, wherein among other things a displacement body is provided, which is arranged axially symmetrically and concentrically to the tube carrier plate. This state of the art thus relates exclusively to an apparatus for influencing the inflow region of a tube carrier plate of a tube bundle heat exchanger in question. The inner tubes are thereby distributed over the entire circular area of the tube carrier plate, generally on more than one pitch circle, exclusively of a narrowly restricted central region. Under these prerequisites, there are, from the outset both in the inlet as well as in the outflow region of the respective tube carrier plate, thus during the branching and the merging of the flow, flow paths with different lengths to the inlet into the inner tubes or respectively from the outlet out of them. For this reason alone, different retention times result for the partial quantities of the product flowing through the respective inner tubes.

As shown in the description of DE 103 11 529 B3, the cross-section-like design of the known tube bundle heat exchanger generally takes place such that the average flow speed in the inner tube is also present in a connection bend, which is connected on one side with a fixed-bearing-side exchanger flange and on the other side indirectly with a loose-bearing-side connecting piece permanently connected with a loose-bearing-side tube carrier plate. The flow mechanical design of the flow pull between the connection bend and the inlet into the inner tubes in the fixed-bearing-side tube carrier plate is characterized by the following characteristics. The flow supplied via the connection bend with the average flow speed is accelerated in an annular gap cross-section narrowed in a nozzle-like manner, which is formed between the displacement body and the fixed-bearing-side exchanger flange. The resulting flow speed reaches its maximum flow speed

in a minimum annular gap cross-section (narrowest point of the annular gap cross-section). Behind the narrowest point of the annular gap cross-section, the latter extends as a result of an extending passage cross-section, since this extension cannot be compensated to the same degree by a front part of the displacement body, which expands in the inflow direction. The flow thus now experiences a delay behind the narrowest point of the annular gap cross-section. The flow breaks away as expected at a flow break point at, for example, the greatest outside diameter of the front part of the displacement body. Behind the flow break point, the cross-section of the displacement body is reduced in a rear part continuously down to a minimum cross-section of a shaft, so that a continuously expanding passage cross-section is available for the flow in cooperation with the expanding passage cross-section. The flow is thus further delayed in the region of the rear part of the displacement body until it enters the inner tubes with the average flow speed.

In order to solve the problem described above of different retention times during the branching and merging of the flow, **WO 2011/085784 A2** suggests arranging all inner tubes of the tube bundle in a circular-ring-shaped manner on a single circle and in an outer channel of the tube bundle heat exchanger designed as an annular space, wherein the inner tubes, flowed through in parallel, extend in the longitudinal direction of the outer channel and are each supported on the end side in a tube carrier plate.

This arrangement of the inner tubes is combined with respectively one axially symmetrical displacement body permanently arranged concentrically on the tube carrier plate at the inlet and the outlet of the product. The respective displacement body reaches centrally through an exchanger flange associated with the tube carrier plate, wherein the exchanger flange has a connection opening on its side facing away from the associated tube carrier plate, which preferably opens axially symmetrically via a transition, preferably designed in a conical or cone-shaped manner, free in particular of points of discontinuities up to an extended passage cross-section provided on the end side. With an inner contour formed by the connection opening, the conical or cone-shaped transition and the extended passage cross-section, the respective displacement body forms an annular space-like channel, which extends continuously from the connection opening to the tube carrier plate in its respective annular gap cross-section. The end-side areas of the

known tube bundle heat exchanger are each designed as mirror images of each other and with the same dimensions, at least respectively in connection with the outer channel, wherein this symmetry also expressly includes the two displacement bodies and the two annular space-like channels.

Almost congruent flow paths and mainly uniform heat transfer conditions thereby result in all relevant areas of the tube bundle heat exchanger for all partial quantities of the product branching and merging into the inner tubes between the product inlet and outlet.

However, congruent flow paths do not simultaneously mean that the flow pulls of the individual partial quantities are constructed with an unchanged flow speed, which avoids acceleration or respectively delay. As shown in the description of **WO 2011/085784 A2**, a first annular channel in the first exchanger flange (region of the product inlet; inlet side) and a second annular channel in the second exchanger flange (region of the product outlet; outlet side) and thus the associated flow speeds change respectively continuously and bounce-free. As a result, each of the partial quantities branched on the outlet side flow out of the inner tubes of the second tube carrier plate into a second inlet groove with a third flow speed; a delay to a minimum value of the unbranched flow then takes places in the course of the merging of the partial quantities in the largest annular gap cross-section of this second inlet groove, a second flow speed, and the unbranched flow is finally accelerated in the annular second channel to a first flow speed in the second connection opening.

With respect to the formation of deposits on the tube carrier plates, it has been shown in practical operation that, in the case of the heating of viscous dairy products, for example concentrates, the symmetrical flow geometry shown above does not lead to service-life-impacting deposits on the inlet-side and flowed-against tube carrier plate, but does lead to such deposits on the outlet-side, flowed-off tube carrier plate. These deposits occur at the transition from the outlet of the inner tubes into the extended passage cross-section. In the region of the inlet-side tube carrier plate, this extended passage cross-section, located upstream seen in the direction of flow, which is formed from the passage cross-section on the product inlet through continuous extension, leads to a swirl formation in this area, which prevents the deposits at the inlet into the inner tubes and at the webs between the inner tubes. In the region of the outlet-side and flowed-off tube carrier plate,

the extended passage cross-section located there, which then continuously reduces to the passage cross-section at the product outlet, leads to dead space areas, in which deposits preferably form in excess, whereby the service life of the tube bundle heat exchanger is reduced.

The object of the present invention is to further develop an apparatus of the generic type in such a way that the tendency for deposits to form at the second, outlet-side tube carrier plate and in the associated second, outlet-side exchanger flange is considerably reduced.

SUMMARY OF THE INVENTION

This object is solved by an apparatus with the characteristics of claim 1. Advantageous embodiments of the apparatus are the subject matter of the dependent claims. The apparatus according to the invention is advantageously used for products in the dairy industry according to claim 15.

The present invention addresses the outlet side of the tube bundle heat exchanger, as described in its basic structure in **WO 2011/085784 A2**, and suggests solutions for this outlet side. Within the framework of the invention, the inflow side can be designed with an inlet-side displacement body and a resulting annular space-like inlet channel, as disclosed in **WO 2011/085784 A2**. However, this type of inlet-side design is not necessarily connected with the inventive tenet; the omission of these types of inlet-side measures is possible. With the present invention, the principles inherent to the state of the art according to **WO 2011/085794 A2** shall not be abandoned, which ensure a thermally particularly gentle treatment with the same retention time for all partial quantities of the product and the mechanical load of which is to be kept as low as possible.

The invention assumes a tube bundle heat exchanger according to **WO 2011/085784 A2** with at least one tube bundle, which consists of a group of inner tubes connected in parallel and each flowed through by the product on the inside, which are arranged in a circular-ring-shaped manner on a single circle and in an outer channel designed as an annular space and extend in its longitudinal direction. The inner tubes are each supported on the end side in a first and a second tube carrier plate. The outer channel for a heating medium is restricted on the outside by an outer casing and on the inside by an inner

casing. The number of inner tubes flowed through in parallel by the product forms together an inner channel, which is provided with a product inlet designed for all inner tubes together, on one side in a first exchanger flange, and with a joint product outlet, designed on the other side in a second exchanger flange. A first and a second connection opening are arranged centrically in the first and in the second exchanger flange on its flange side facing away from the associated tube carrier plate. The second connection opening extends, opposite the direction of flow, axially symmetrically and radially in the second exchanger flange, continues up to an extended outlet-side passage cross-section provided on the end side and establishes a fluid-accessible connection to the inner tubes. An axially symmetrical outlet-side displacement body is arranged coaxially to the second connection opening and concentrically to the second tube carrier plate and is permanently connected with it. It forms an annular space-like outlet channel with an outlet-side inner contour formed by the second connection opening and its radial extension up to the extended outlet-side passage cross-section.

The fundamental inventive idea is to abandon the known tenet of the annular space-like outlet channel, which tapers continuously toward the product outlet seen in the direction of flow and to design it such that it has a channel passage cross-section at least everywhere in its region between a maximum outside diameter of the outlet-side displacement body and of the second connection opening that has a constant passage cross-section over the entire length of the defined region and corresponds in this region with a total passage cross-section of all, i.e. of the total provided number of inner tubes flowed through in parallel, each of which have an individual passage cross-section.

The most even possible, unchanged flow speed of the product, avoiding accelerations and delays, beginning at the outlet of the inner tubes in the second tube carrier plate up to the inlet into a connection bend connected to the second exchanger flange, results from this design, which means a constant passage cross-section over the entire length of the annular space-like outlet channel.

The outlet-side displacement body can thereby be provided with a definable axial engagement depth into the realized passage cross-section of the connection bend. This axial engagement depth also depends on whether the nominal passage cross-section of the connection bend, which is calculated from its nominal diameter and can deviate from

the realized passage cross-section, corresponds with the total passage cross-section of all inner tubes flowed through in parallel or was selected to be somewhat larger, if applicable. In the case of the last-mentioned facts, a continuous adjustment of the flow speed in the annular space-like outlet channel for that in the realized passage cross-section of the connection bend can then take place via the axial engagement depth of the outlet-side displacement body.

Since it is advantageous to design the first and second exchanger flange with identical shapes and dimensions in order to reduce the number of parts, as provided by an advantageous embodiment, the measures for forming the annular space-like outlet channel according to the invention manifest themselves in this case alone on the outlet-side displacement body.

In order to avoid a discontinuous enlargement of the passage cross-sections for the outflowing product, seen in the direction of flow, after the outlet from the inner tubes and namely already within the second exchanger flange and in the transition area to the annular space-like outlet channel, it is provided that the maximum outside diameter of the outlet-side displacement body reaches at least up to the diameter of the circle, on which the inner tubes are arranged and overlaps this circle, if necessary. Through an annular surface formed between a displacement foot and the maximum outside diameter of the outlet-side displacement body, a volume-reducing boundary of a passage cross-section of an annular space is thereby reached before entry of the flow into the annular space-like outlet channel, whereby the formation of a uniform flow speed is ensured.

The best possible prerequisites for the concrete realization of congruent flow paths are created in that the inner tubes of the tube bundle are arranged in the largest possible circumferential area of the tube carrier plate. This design is preferably realized such that the gap width of the annular space is designed as small as necessary for sufficient circulation with the heating medium and the circle diameter, on which the inner tubes are arranged, is designed as large as possible.

A further suggestion provides that the inner tubes of the tube bundle are arranged evenly distributed over the perimeter of the circle. Thereby and in connection with the dimension ratios described above, the flow paths from the unbranched total flow to the

respectively branched partial flow into the inner tubes and vice versa are absolutely congruent.

The realization of the annular space-like outer channel succeeds very simply in that the outer channel designed as an annular space is restricted on the inside by an inner casing, which is restricted according to a first suggestion in the shape of an inner tube or according to a second suggestion in the shape of an inner rod, wherein the inner tube and the inner rod are respectively supported on the end side in the tube carrier plate. The inner tubes arranged on a single circle are thereby located in an equidistant annular space to be designed in a relatively narrow manner, in which there are no dead spaces nor stagnating areas of the flow of the heating medium.

According to a further suggestion, beneficial flow conditions in the outlet area of the inner tubes are ensured by designing the outlet-side displacement body in a mushroom-like manner, so that it ends with its displacement foot directly on the second tube carrier plate and that the maximum outside diameter of the outlet-side displacement body is reduced in a plane perpendicular to a symmetry axis of the outlet-side displacement body to an outside diameter of the displacement foot, wherein the transition is advantageously rounded in a sufficient manner.

A stabilization of the passage cross-sections in the progression of the flow of the product from the outlet from the inner tubes to the inlet into the annular space-like outlet channel continues to be ensured in that the annular space-like outlet channel merges into an annular space within the second exchanger flange on its extended passage cross-section, which is oriented coaxially to the symmetry axis, which is flush on the radial outside with an inner diameter of the extended outlet-side passage cross-section, which reaches on the radial inside up to the displacement foot and which is delimited laterally by an annular surface formed between the displacement foot and the maximum outside diameter of the outlet-side displacement body, and in that the annular space has an axial annular space width, which corresponds at least with one fourth of a tube inner diameter of the inner tube. This type of design of the annular space width almost creates parity between the circular inflow cross-section, resulting from the passage cross-section of the individual inner tube, and a cylinder-casing-like outflow cross-section of that part of an annular space which is associated with the respective inner tube.

The greatest possible reduction in the mechanical load of the product during its merging into a total flow (outlet losses during merging) is achieved in an unpredictable manner when, as provided by a further suggestion, the inner tubes lead on the end side respectively into and flush with a floor of an inlet groove, which engages from the side of the second exchanger flange in the shape of an annular recess into the second tube carrier plate. The floor is thereby distanced from the front surface of the second tube carrier plate by a recess, which also simultaneously determines the depth of the inlet groove.

Outlet losses in the above sense are thereby further reduced in that the inlet groove preferably tapers symmetrically and continuously to the outside diameter of the respective inner tube, preferably with a concave surface.

The outlet losses from the inner tubes are minimized when the respective inner tube is received in a connection bore hole in the floor of the inlet groove, which is countersunk in the shape of an inlet hopper engaging in the inlet groove and tapering continuously towards the inner tube. The shape design of the inlet hopper is thereby preferably tulip-shaped, cone-shaped, conical or coniform.

The transition between the annular space-like outlet channel in the second exchanger flange and the inlet groove in the second tuber carrier plate is designed particularly beneficially from a flow perspective when the extended outlet-side passage cross-section with its inside diameter transitions flush and continuously into an outside flank and the displacement foot with its outside diameter designed on the end side transitions flush and continuously into an inside flange of the inlet groove.

An advantageous embodiment of the apparatus provides that the inlet side of the tube bundle heat exchanger is designed such that the first connection opening, seen in the direction of flow, in the first exchanger flange extends axially symmetrically and radially and continues up to an extended inlet-side passage cross-section provided on the end side and produces a fluid-accessible connection to the inner tubes, that an axially symmetrical inlet-side displacement body is arranged coaxially to the first connection opening and concentrically to the first tube carrier plate and is permanently connected with it, and that the inlet-side displacement body together with an inlet-side inner contour formed by the

first connection opening and its radial extension up to the extended inlet-side passage cross-section forms an annular space-like inlet channel. In this respect, this design is adequate for the design on the outlet side; however, the annular space-like inlet channel is subject to different measurement criteria, for example suggested in **WO 2011/085784 A2**.

The apparatus according to the invention is particularly suitable and advantageous when used for temperature-sensitive and/or viscous products in the dairy industry, for example desserts, sauces or concentrates.

BRIEF DESCRIPTION OF THE DRAWINGS

A more detailed representation of the invention results from the following description and the attached figures of the drawing as well as from the claims. While the invention is realized in various embodiments, two preferred embodiments of the apparatus are shown in the drawing and described below according to structure and function. They show in:

Figure 1 in a meridian section, a first embodiment of the apparatus, realized on a preferably used tube bundle heat exchanger, wherein the representation is limited to the inlet- and outlet-side region of the tube bundle heat exchanger;

Figure 2 in a meridian section and in an enlarged representation, the outlet-side region according to **Figure 1**;

Figure 2a an even more enlarged representation of a section of the meridian cut according to **Figure 2** in the region of an annular space-like outlet channel in connection with a transition region to an outlet from an inner tube;

Figure 3 in a meridian section, the first embodiment according to **Figure 2** compared to a second embodiment according to **Figure 4**, wherein

Figure 4 shows, in a meridian section, an outlet-side displacement body modified with respect to **Figure 3** and a modified second tube carrier plate.

DETAILED DESCRIPTION

A tube bundle heat exchanger 100, of which a tube bundle 100.1 is shown, has in a first embodiment congruent flow paths between a product inlet E penetrated by an entire product P and a product outlet A (**see Figure 1**) for all partial quantities of product P branching and merging between the latter. This is achieved in that, in the tube bundle 100.1, which consists of a group of inner tubes 300 connected in parallel and flowed through by the product on the inside, all inner tubes 300 are arranged in a circular-ring-shaped manner, on a single circle K (**Figure 2**) and in an outer channel 200* designed as an annular space and extend in its longitudinal direction and are each supported on the end side in a first and a second tube carrier plate 700, 800. The inner tubes 300 are arranged in the largest possible circumferential area of the tube carrier plate 700, 800, preferably evenly distributed over the perimeter of the circle K. A number N of inner tubes 300 extending through the latter axially parallel to an outer casing 200.1 of the outer channel 200* and together forming an inner channel 300* passes through the first tube carrier plate 700 and the second tube carrier plate 800 on the end side (both are also called tube sheet plates) and is welded there on its respective tube outside diameter and on its respective front surface. The product inlet E is designed in a first exchanger flange 500, which is associated with the first tube carrier plate 700, and the product outlet A is designed in a second exchanger flange 600, which is associated with the second tube carrier plate 800.

As a rule, the tube bundle heat exchanger 100 is made up of more than one tube bundle 100.1. The tube bundle 100.1 consists in its center part of the outer casing 200.1 bordering the outer channel 200* with the, relating to the representation position, first tube carrier plate 700 arranged on the left side and the tube carrier plate 800 arranged on the right side in the same manner. In the region of the right-side end of the outer casing 200.1, a first transverse channel 400a* leading into a first connecting piece 400a is provided on the latter, and, in the region of the left-side end of the outer casing 200.1, a second transverse channel 400b* leading into a second connecting piece 400b is provided on the latter for addition of a heating medium M.

The outer channel 200* for the heating medium M is delimited on the outside by the outer casing 200.1 and on the inside by an inner casing 200.2. The inner channel 300* is

connected on one side with the product inlet E common for all inner tubes 300 and on the other side with the product outlet A common for all inner tubes 300. A first and a second connection opening 500a, 600a is arranged centrically in the first and in the second exchanger flange 500, 600 on its flange side facing away from the associated tube carrier plate 700, 800. The second connection opening 600a extends opposite the direction of flow, axially symmetrically and radially in the second exchanger flange 600, continues up to an extended outlet-side passage cross-section 600c provided on the end side and establishes a fluid-accessible connection to the inner tubes 300. An axially symmetrical outlet-side displacement body 12 is arranged coaxially to the second connection opening 600a and concentrically to the second tube carrier plate 800 and is permanently connected with it. It forms an annular space-like outlet channel 600d with an outlet-side inner contour KA formed by the second connection opening 600a and its radial extension up to the extended outlet-side passage cross-section 600c.

Depending on the arrangement of the respective tube bundle 100.1 in the tube bundle heat exchanger 100 and its respective wiring, the inner tubes 300, with respect to the representation position, can be flowed through by product P either from left to right or vice versa, wherein an average flow speed in the inner tube 300 and thus in the inner channel 200* are labeled with v. The components, which determine the inlet- and outlet-specific conditions, then change their position accordingly. The cross-section-like design of the inner tube 300 generally takes place such that the average flow speed v is at least equal to or greater than a first flow speed v_0 in a connection bend 1000 (**Figure 4**), which can end on one side in the first exchanger flange 500 and on the other side in the second exchanger flange 600. The first exchanger flange 500 is sealed against the tube carrier plate 700 via a flange seal 900. The same goes for the second exchanger flange 600 and the second tube carrier plate 800.

In the first embodiment, the end-side regions of the tube bundle heat exchanger 100, with the exception of an inlet- and the outlet-side displacement body 11, 12, respectively connecting to the outer channel 200*, are preferably designed as mirror images of each other and with the same dimensions so that, since the present invention relates to the outlet side of the tube bundle 100.1, the following detailed description can primarily be limited to the outlet-side end region and the corresponding reference numbers of the

other end region are only cited and the structure of the inlet-side region can be developed analogously from the structure of the outlet-side region. The exchanger flange 600, 500 has, on its side facing away from the associated tube carrier plate 800, 700, the connection opening 600a, 500a, which has a nominal diameter DN and thus corresponds with a nominal passage cross-section A_0 of the connection bend 1000 connected there (**Figure 4**) ($A_O = DN^2\pi/4$).

The connection opening 600a, 500a opens in the exchanger flange 600, 500 axially symmetrically via a transition 600b (a corresponding transition is not labeled in 500) up to the extended outlet-side passage cross-section 600c provided on the end side or respectively an extended inlet-side passage cross-section 500c. The extended passage cross-section 600c, 500c is designed mainly cylindrically with an inner diameter D_1 (maximum diameter of the extended passage cross-section 600c, 500c) (**Figures 2, 2a**), and the former forms together with the transition 600b the outlet-side inner contour KA in the second exchanger flange 600 and the latter forms together with the corresponding transition in 500 an inlet-side inner contour KE in the first exchanger flange 500. The inlet-side inner contour KE forms with the inlet-side displacement body 11 an annular space-like inlet channel 500d in the generally known manner.

The below description is limited to the outlet side of the tube bundle 100.1. The axially symmetrical outlet-side displacement body 12 is provided coaxially to the second connection opening 600a and concentrically to the second tube carrier plate 800 (**Figures 1, 2, 2a, 3**), the displacement body 12 forming forms the annular space-like outlet channel 600d with the outlet-side inner contour KA formed by the second connection opening 600a, the transition 600b and the extended outlet-side passage cross-section 600c. The annular space-like outlet channel 600d has, at least everywhere in its region between a maximum diameter d_{max} of the outlet-side displacement body 12 and the second connection opening 600a, a channel diameter cross-section A_S (**Figure 2a**), which has a constant passage cross-section over the entire length of the defined region and which corresponds in this region with a total passage cross-section NA_i of all inner tubes 300 flowed through in parallel of the number N, which have respectively an individual passage cross-section A_i (A_S = const). The individual passage cross-section is thereby calculated with $A_i = D_i^2\pi/4$, wherein D_i is the tube inner diameter of the inner

tube 300. The maximum outside diameter d_{max} of the outlet-side displacement body 12 reaches at least up to the diameter of the circle K (**Figures 2, 2a**).

The outlet-side displacement body 12 is designed in a mushroom-shaped manner and it ends with a displacement foot 12a directly at the second tube carrier plate 800. The maximum outside diameter d_{max} of the outlet-side displacement body 12 is reduced to an outside diameter d_i of the displacement foot 12a in a plane perpendicular to a symmetry axis S of the outlet-side displacement body 12, wherein the transition region is preferably sufficiently rounded out (**Figure 2a**).

The annular space-like outlet channel 600d merges into an annular space R at its extended passage cross-section 600c within the second exchanger flange 600, the annular space R being oriented coaxially to the symmetry axis S, being flush radially outside with the inner diameter D_1 of the of the extended outlet-side passage cross-section 600c, reaching radially inwards up to the displacement foot 12a and being delimited laterally by an annular surface formed between the displacement foot 12a and the maximum outside diameter d_{max} of the outlet-side displacement body 12. The annular space R has an axial annular space width s, which preferably corresponds with at least one fourth of a tube inner diameter D_i of the inner tube 300 (**Figure 2a**; $s = D_i/4$; from the continuity condition $A_i = D_i^2\pi/4 = D_i\tau\tau s$).

The inner tubes 300 lead on the end side respectively into and flush with a floor 800b of an inlet groove 800a (**Figure 2a**), which engages from the side of the second exchanger flange 600 in the shape of an annular recess into the second tube carrier plate 800. The floor 800b is distanced from the front surface of the second tube carrier plate 800 by a recess r. The inlet groove 800a tapers continuously, preferably symmetrically to the outside diameter of the respective inner tube 300, wherein a concave tapering is preferred.

A second and a first connection bore hole 800d, 700d (**Figures 2a, 1**) are provided for receiving the respective end of the inner tube 300 in the tube carrier plate 800, 700, wherein the second connection bore hole leads into the floor 800b (**Figure 2a**). The second connection bore hole 800d is preferably countersunk in the shape of an inlet hopper 800c engaging in the inlet groove 800a and tapering continuously towards the

inner tube 300. The extended outlet-side passage cross-section 600c merges with its inner diameter D_I preferably flush and continuously into an outside flank and the outlet-side displacement foot 12a merges with its outside diameter d1 designed on the end side preferably flush and continuously into an inside flank of the inlet groove 800a (**Figure 2a**).

A preferred embodiment according to **Figures 1** to **4** provides that the outer channel 200* designed as an annular space is delimited on the inside by the inner casing 200.2 in the shape of an inner tube 200.2a, which is supported respectively on the end side in the tube carrier plate 700; 800. A further embodiment provides that the outer channel 200* designed as an annular space is delimited on the inside by the inner casing 200.2 in the shape of an inner rod 200.2b, which is supported respectively on the end side in the tube carrier plate 700; 800.

Figure 4 shows a second embodiment of the apparatus according to the invention, wherein here, in contrast to the first embodiment according to **Figure 3**, the second tube carrier plate 800, and if applicable also the first tube carrier plate 700, only serve to receive the inner tubes 300 and a third exchanger flange 810 is provided for receiving the outer casing 200.1. The second tube carrier plate 800 is, as described above, sealed on one side with respect to the second exchanger flange by means of the flange seal 900 and on the other side with respect to the third exchanger flange 810 by means of a further flange seal 900. The outlet-side displacement body 12 is designed larger than in the first embodiment according to **Figure 3**, and it engages in the connection bend 1000 connected to the second exchanger flange 600 by an axial first depth of engagement a1, which is designed considerably larger than an axial second depth of engagement a2 according to **Figure 3**. The flow-mechanical efficacy of this calculation was described above.

REFERENCE LIST OF THE ABBREVIATIONS

11 Inlet-side displacement body

12 Outlet-side displacement body

12a Displacement foot

100 Tube bundle heat exchanger, general

100.1 Tube bundle

200* Outer channel

200.1 Outer casing

200.2 Inner casing

200.2a Inner tube (inner casing)

200.2b Inner rod (inner casing)

300* Inner channel

300 Inner tube

400a First connecting piece

400a* First transverse channel

400b Second connecting piece

400b* Second transverse channel

500 First exchanger flange

500a First connection opening

500c Extended inlet-side passage cross-section

500d Annular space-like inlet channel

600 Second exchanger flange

600a Second connection opening

600b Transition

600c Extended outlet-side passage cross-section

600d Annular space-like outlet channel

700 First tube carrier plate (tube sheet plate)

700d First connection bore hole

800 Second tube carrier plate (tube sheet plate)

800a Inlet groove

800b Floor

800c Inlet hopper

800d Second connection bore hole

810 Third exchanger flange

900 Flange seal

1000 Connection bend/connection fitting

a_1 First depth of engagement

a_2 Second depth of engagement

d_1 Outside diameter (displacement foot 12a)

d_{max} Maximum outside diameter (displacement foot 12a)

r Recess (of the inner tube 300)

s Axial annular space width ($s = D_i/4$; from $A_i = D_i^2\pi/4 = D_i\tau\tau s$)

v Average flow speed (in the inner tube 300 and in the annular-space-like outlet channel 600d)

v_0 First flow speed (in the connection bend 1000; $v_0 = v$)

A Product outlet

A_i Individual passage cross-section (of the inner tube ($A_i = D_i^2\pi/4$))

NA_i Total passage cross-section (of all inner tubes flowed through in parallel)

A_S Channel passage cross-section (A_S = const)

A_O Nominal passage cross-section (of the connection bend; $A_O = DN^2\pi/4$)

D_i Tube inner diameter (inner tube 300)

D_1 Inner diameter (of the extended passage cross-section 600c)

DN Nominal diameter (of the connection bend ($A_O = DN^2\pi/4$))

E Product inlet

K Circle

KA Outlet-side inner contour

KE Inlet-side inner contour

M Heating medium

N Number (of inner tubes 300)

P Product (food product)

R Annular space

S Symmetry axis

PATENT CLAIMS

1. An apparatus for influencing the outflow region of a tube carrier plate of a tube bundle heat exchanger, in particular for the food and beverage industry, with at least one tube bundle (100.1) of the tube bundle heat exchanger (100), which consists of a group of inner tubes (300) connected in parallel and respectively flowed through by the product on the inside, which are arranged in a circular-ring-shaped manner on a single circle (K) and in an outer channel (200*) designed as an annular space and extend in the longitudinal direction thereof and are supported respectively on the end side in a first and a second tube carrier plate (700, 800), with an outer casing (200.1) delimiting the outer channel (200*) from outside and an inner casing (200.2) delimiting it from the inside for a heating medium (M), with a number (N) of inner tubes (300), which together form an inner channel (300*), with a product inlet (E) designed for all inner tubes (300) together, on one side in a first exchanger flange (500) and a common product outlet (A) for the product (P) designed on the other side in a second exchanger flange (600), with a first and a second connection opening (500a, 600a), each of which are arranged centrically in the first and in the second exchanger flange (500, 600) on its flange side facing away from the associated tube carrier plate (700, 800), with the second connection opening (600a), which extends axially symmetrically and radially opposite the direction of flow in the second exchanger flange (600) and continues up to an extended outlet-side passage cross-section (600c) provided on the end side and establishes a fluid-accessible connection to the inner tubes (300), with an axially symmetrical outlet-side displacement body (12) permanently connected coaxially to the second connection opening (600a) and concentrically to the second tube carrier plate (800), which forms an annular space-like outlet channel (600d) together with an outlet-side inner contour (KA) formed by the second connection opening (600a) and its radial extension up to the extended outlet-side passage cross-section (600c),

characterized in that

the annular space-like outlet channel (600d) has a channel passage cross-section (A_S) at least everywhere in its region between a maximum outside diameter (d_{max})

of the outlet-side displacement body (12) and the second connection opening (600a), the channel passage cross-section having a constant passage cross-section over the entire length of the defined region and corresponding in this region with a total passage cross-section (NA_i) of all inner tubes (300) of the number (N) that are flowed through in parallel, each of which has an individual passage cross-section (A_i).

2. The apparatus according to claim 1,

characterized in that

the maximum outside diameter (d_{max}) of the outlet-side displacement body (12) reaches at least up to the diameter of the circle (K).

3. The apparatus according to one of the previous claims,

characterized in that

the inner tubes (300) of the tube bundle (100.1) are arranged in the largest possible circumferential area of the tube carrier plate (700, 800).

4. The apparatus according to one of the previous claims,

characterized in that

the inner tubes (300) of the tube bundle (100.1) are arranged evenly distributed over the perimeter of the circle (K).

5. The apparatus according to one of the previous claims,

characterized in that

the outer channel (200*) designed as an annular space is delimited on the inside by the inner casing (200.2) in the shape of an inner tube (200.2a), which is supported respectively on the end side in the tube carrier plate (700; 800).

6. The apparatus according to one of the previous claims,

characterized in that

the outer channel (200*) designed as an annular space is delimited on the inside by the inner casing (200.2) in the shape of an inner rod (200.2b), which is supported respectively on the end side in the tube carrier plate (700; 800).

7. The apparatus according to one of the previous claims,

characterized in that

the outlet-side displacement body (12) is designed in a mushroom-like manner, in that it ends with a displacement foot (12a) directly at the second tube carrier plate (800), and in that the maximum outside diameter (d_{max}) of the outlet-side displacement body (12) is reduced to an outside diameter (d1) of the displacement foot (12a) in a plane perpendicular to a symmetry axis (S) of the outlet-side displacement body (12).

8. The apparatus according to one of the previous claims,

characterized in that

the annular space-like outlet channel (600d) merges into an annular space (R) at its extended passage cross-section (600c) within the second exchanger flange (600), the annular space being oriented coaxially to the symmetry axis (S), being flush on the radial outside with an inner diameter (D_1) of the extended outlet-side passage cross-section (600c), reaching on the radial inside up to the displacement foot (12a) and being delimited laterally by an annular surface formed between the displacement foot (12a) and the maximum outside diameter (d_{max}) of the outlet-side displacement body (12) and in that the annular space (R) has an axial annular space width (s), which corresponds at least with a fourth of a tube inner diameter (D_i) of the inner tube (300).

9. The apparatus according to one of the previous claims,

characterized in that

the inner tubes (300) lead on the end side respectively into and flush with a floor (800b) of an inlet groove (800a), which engages into the second tube carrier plate (800) from the side of the second exchanger flange (600) in the shape of an

annular recess, and in that the floor (800b) is distanced from the front surface of the second tube carrier plate (800) by an recess (r).

10. The apparatus according to claim 9,

characterized in that

the inlet groove (800a) tapers continuously and symmetrically towards the outside diameter of the respective inner tube (300).

11. The apparatus according to claim 9 or 10,

characterized in that

the respective inner tube (300) is received in a connection bore hole (800d) in the floor (800b), which is countersunk in the shape of an inlet hopper (800c) engaging in the inlet groove (800a) and tapering continuously towards the inner tube (300).

12. The apparatus according to one of claims 9 to 11,

characterized in that

the extended outlet-side passage cross-section (600c) with its inner diameter (D_1) merges flush and continuously into an outside flank and the displacement foot (12a) with its outside diameter (d_1) designed on the end side merges flush and continuously into an inside flank of the inlet groove (800a).

13. The apparatus according to one of the previous claims,

characterized in that

the first connection opening (500a), seen in the direction of flow, extends axially symmetrically and radially in the first exchanger flange (500) and continues up to an extended inlet-side passage cross-section (500c) provided on the end side and establishes a fluid-accessible connection to the inner tubes (300), in that an axially symmetrical inlet-side displacement body (11) is arranged coaxially to the first connection opening (500a) and concentrically to the first tube carrier plate

(700) and is permanently connected with it, and in that the inlet-side displacement body (11) forms an annular space-like inlet channel (500d) together with an inlet-side contour (KE) formed by the first connection opening (500a) and its radial extension up to the extended inlet-side passage cross-section (500c).

14. The apparatus according to claim 13,

characterized in that

the first and the second exchanger flange (500, 600) and the first and the second tube carrier plate (700, 800) are designed identical in shape and dimension.

15. A use of an apparatus according to one of the previous claims for temperature-sensitive and/or viscous products (P) in the dairy industry.

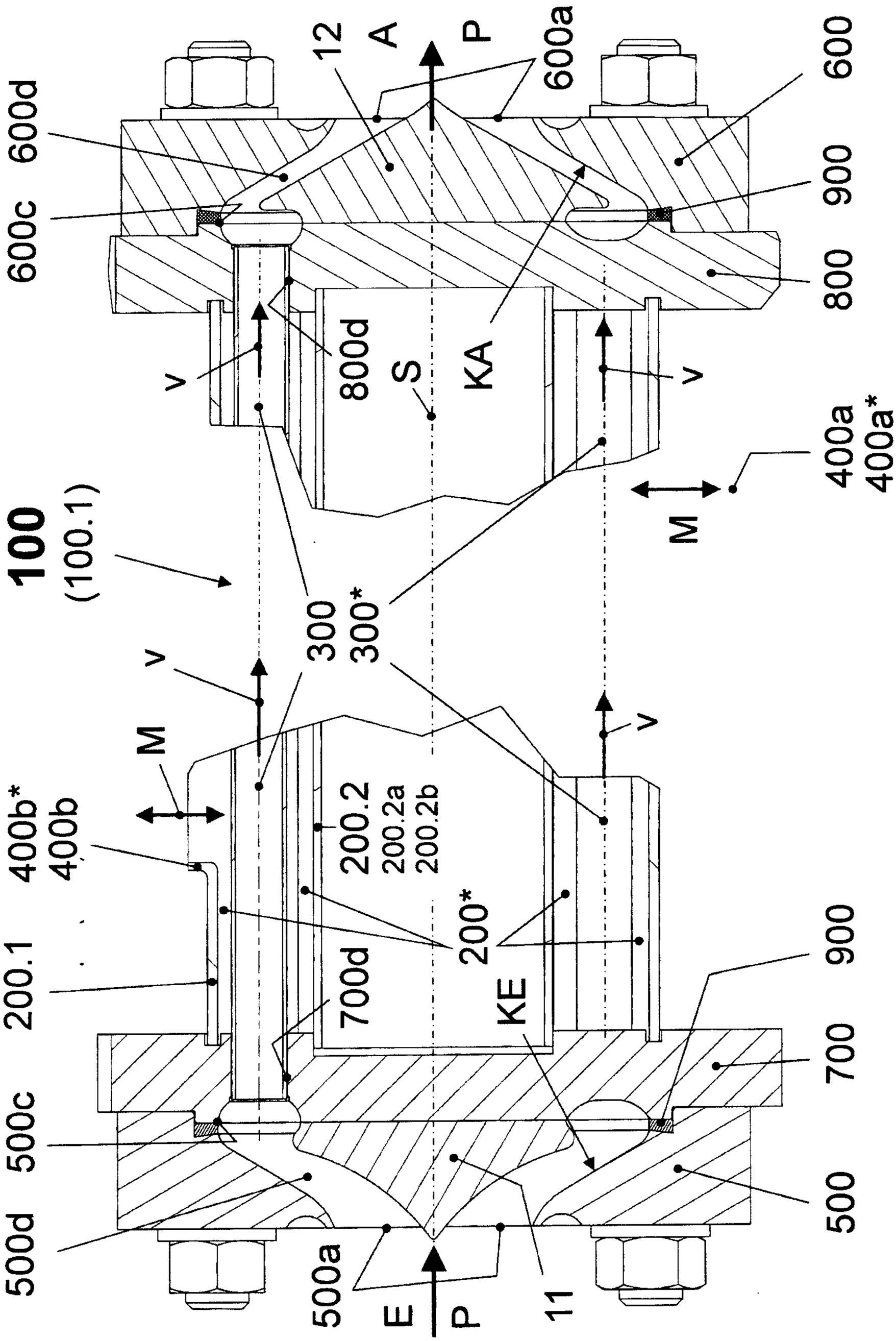

100
(100.1)
600d
600c
600a
600
12
A
P
900
800
800d
S
KA
v
M
400a
400a*
400b*
400b
200.1
200.2
200.2a
200.2b
200*
700d
KE
500d
500c
500a
E
11
700
500

Figure 1

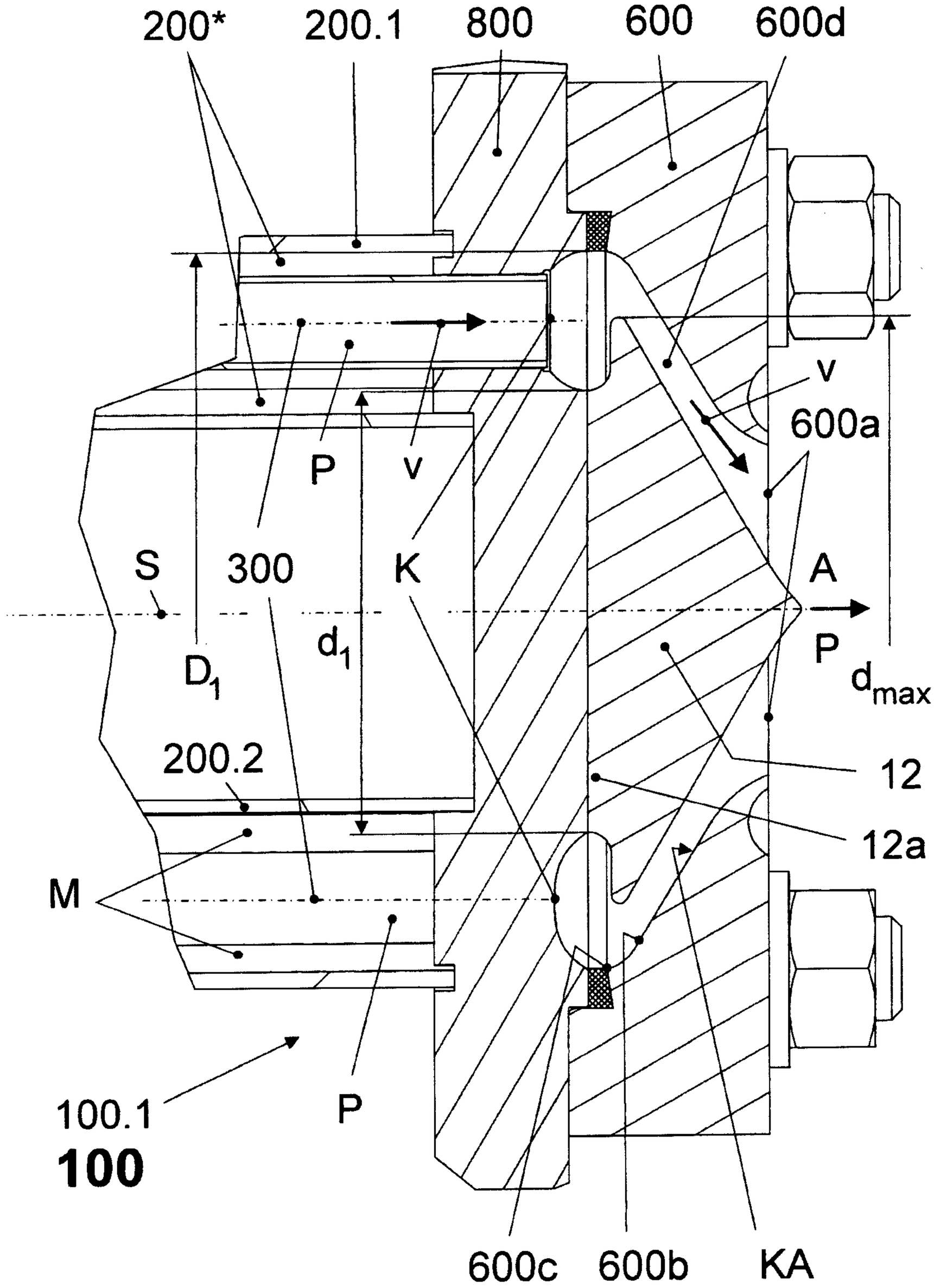

200*
200.1
800
600
600d
V
600a
P
V
S
300
K
A
D_1
d_1
P
d_{max}
200.2
12
12a
M
100.1
P
100
600c
600b
KA

Figure 2

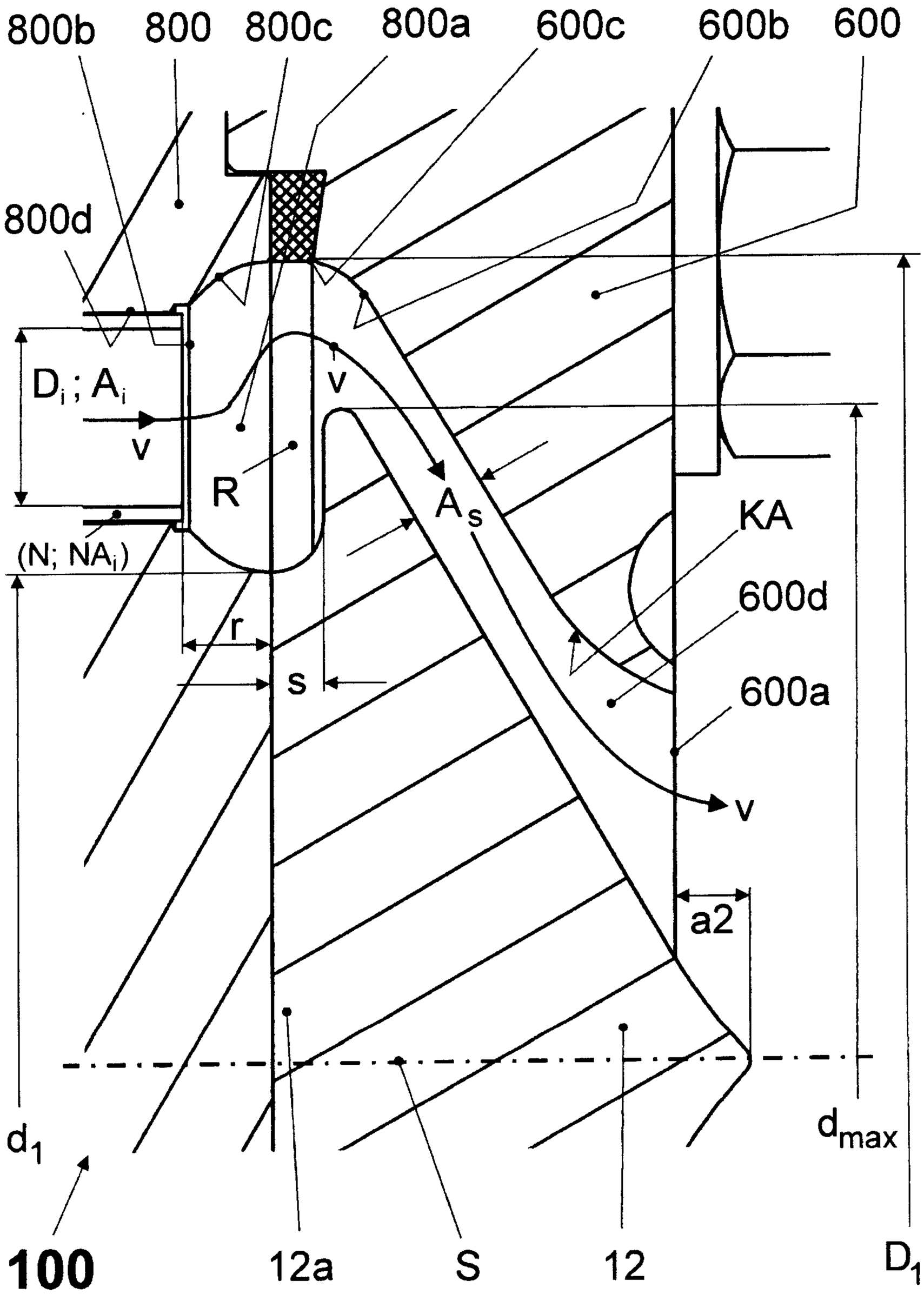

800b
800
800c
800a
600c
600b
600
800d
D_i ; A_i
v
R
v
A_s
KA
600d
600a
(N; NA_i)
r
s
a2
d_1
d_{max}
100
12a
S
12
D_1

Figure 2a

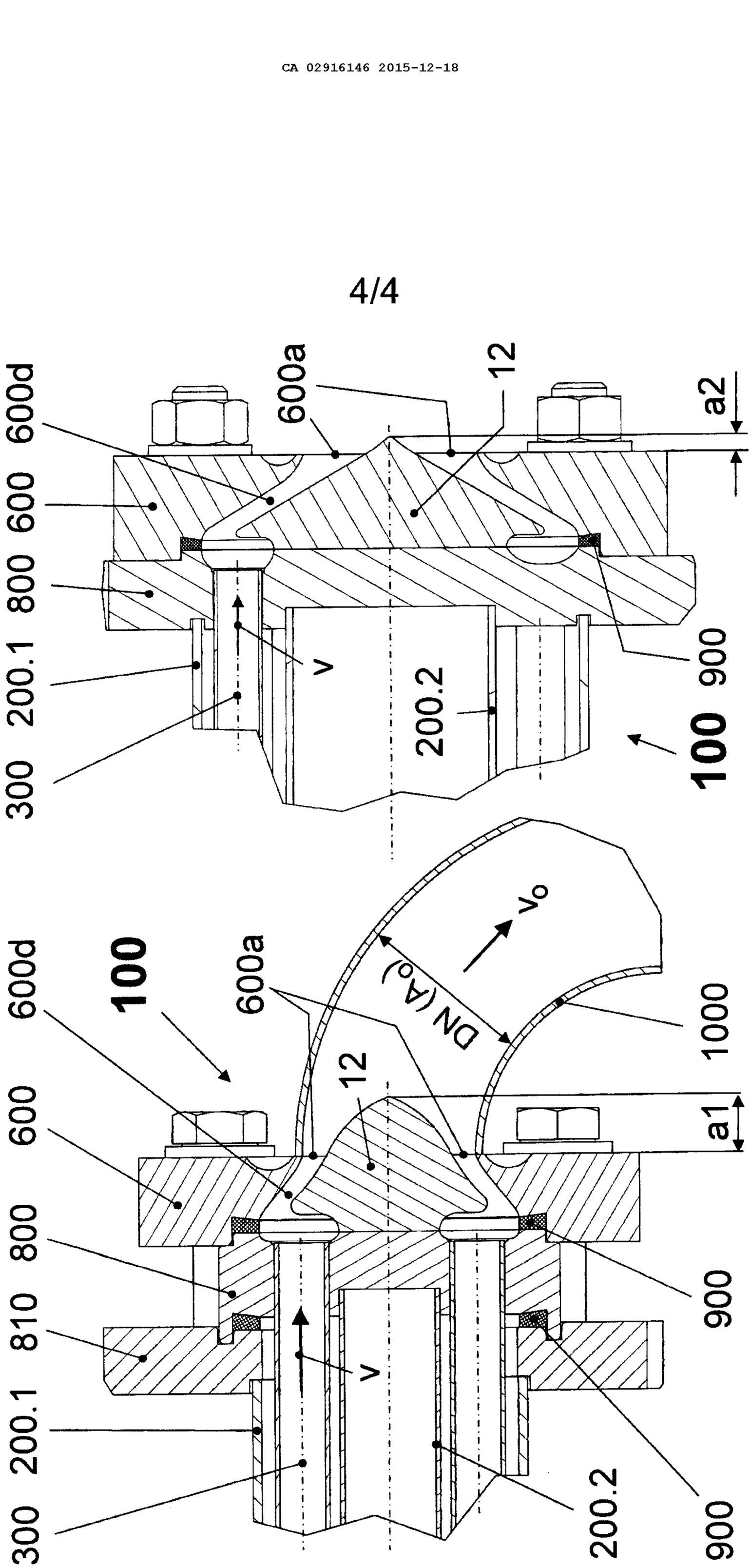
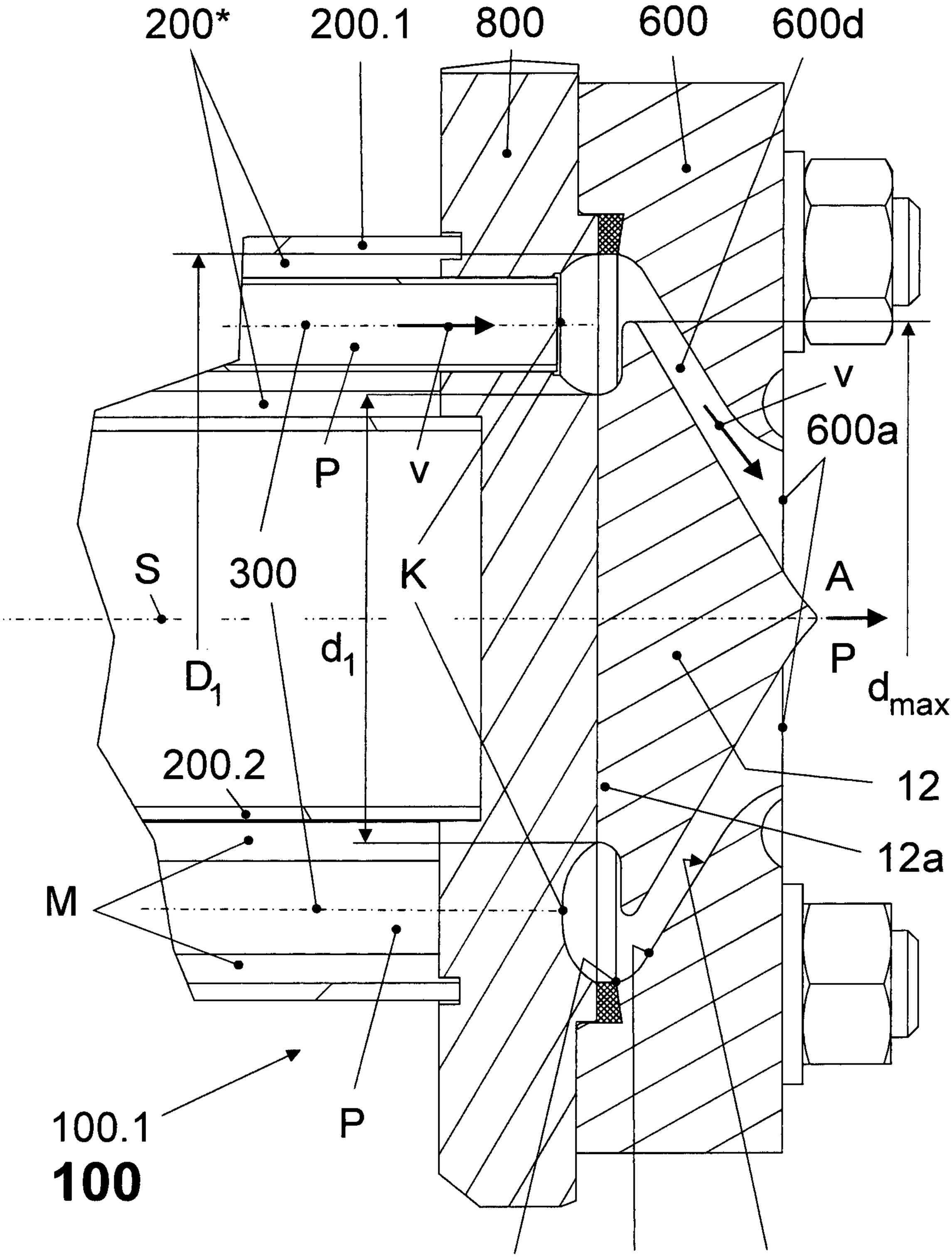


Figure 3

Figure 4


200*
200.1
800
600
600d
v
600a
P
v
S
300
K
A
P
d_{max}
D_1
d_1
200.2
12
12a
M
100.1
100
P
600c
600b
KA

Figur 2