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(54) **REGENERATIVE HEAT EXCHANGER AND A METHOD FOR OPERATING A REGENERATIVE HEAT EXCHANGER**

REGENERATIVER WÄRMETAUSCHER UND VERFAHREN ZUM BETREIBEN EINES REGENERATIVEN WÄRMETAUSCHERS

ECHANGEUR THERMIQUE A REGENERATION ET PROCEDE D'EXPLOITATION D'UN ECHANGEUR THERMIQUE A REGENERATION

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(73) Proprietor: **ABB AIR PREHEATER, INC.**
Wellsville, NY 14895-0372 (US)

(72) Inventors:
- **HASSELSTRÖM, Rolf**
  S-115 23 Stockholm (SE)
- **WESTERLUND, Dag**
  S-175 73 Järfälla (SE)

(74) Representative: **Waldinger, Ake**
Svenska Rotor Maskiner AB
Box 15085
104 65 Stockholm (SE)

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- **PATENT ABSTRACTS OF JAPAN, Vol. 5, No. 83, M-71; & JP,A,56 030 588, (NISSAN JIDOSHA K.K.), 27 March 1981.**

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Description

[0001] The present invention in a first aspect relates to a regenerative heat exchanger of the kind specified in the preamble of claim 1 and in a second aspect to a method for operating a regenerative heat exchanger as specified in the preamble of claim 8.

[0002] Such a heat exchanger is known e.g. through SE 176 375, disclosing a support in the form of rolling bodies, mounted in the outer ends of sector-shaped plates closed to both ends of the rotating part and rolling on a flange along the periphery at the top and bottom end of the rotor.

[0003] It was therethrough intended that a constant clearance should be possible to be maintained between the ends of the sector-shaped plates and the top and bottom end, respectively. The environment for the rollers, however, was found to be to severe. The bearings of the rollers were worn out rapidly and dirt and particles were by the rolling adhered on the flanges and the surfaces of the roller with break downs as a consequence.

[0004] It has been suggested to replace the rollers by sliding shoes as disclosed in JP, A, 63-315 891. These sliding shoes are made of ceramics in order to attain a high wear resistance. However, problems will occur if the sliding shoe becomes somewhat slanting due to mounting inaccuracy and/or thermal deformations. There will in such cases be a risk that the sliding shoe will contact the flange by only a small part of its sliding surface with unacceptable high contact pressure as a consequence. Furthermore some kind of external lubrication of the sliding surfaces is required or considerable friction losses has to be accepted.

[0005] In WO94/01730 an improvement is disclosed by using sliding shoes of carbon or graphite instead of ceramic sliding shoes. Such a sliding shoe eliminates the drawbacks with a sliding shoe of ceramics. In particular graphite has excellent lubrication properties and like carbon has an ability to maintain the flanges of the rotating body clean when adhering a lubricating layer of carbon or graphite on the flanges. The abrasion of the sliding shoe also secures a correct contact with parallel contact surfaces so that the contact takes place on the complete sliding shoe surface. Carbon and graphite also have a good acceptance of the high temperature and the acid environment that are present. By the abrasion of the sliding shoes they will gradually be consumed and have to be replaced. The degree of abrasion, however, will vary widely, so that one or more sliding shoes might be worn down so much that the clearance reaches zero, whereas other sliding shoes will be almost unaffected. Each sliding shoe therefore is adjustable in a direction perpendicular to the contact surface. A similar solution is disclosed in W095/00809, in which there is provided a measuring rod adjacent to the sliding shoe, which measuring rod is directed parallel to the adjustment direction. The measuring rod from a resting position can be momentary brought in contact with the related flange and indicates when the size of the clearance requires advancement of the sliding shoe a distance so that the initial clearance is restored.

[0006] Another solution is disclosed in WO-A-9 501 541 in which the abrasion problems are overcome in that the sliding shoe is sliding on a gas cushion created by the supply of pressure gas between the sliding shoe and a flange on the rotor. Abrasion thereby is avoided in that there will be no contact between the sliding shoe and the flange.

[0007] This, however, requires the presence of a pressure gas source or makes it necessary to provide the plant with a compressor for producing the pressure gas. This represents a considerable cost increase both for the manufacture of the heat exchanger and for the production of the pressure gas.

[0008] The object of the present invention is to attain a regenerative heat exchanger of the kind in question having contact-free support means without the drawbacks entailing earlier known constructions.

[0009] This has according to the present invention been attained in that a rotary heat exchanger of the kind specified in the preamble of claim 1 has got the features specified in the characterizing portion of that claim and in another aspect in that a method as specified in the preamble of claim 8 includes the measures specified in the characterizing portion of that claim.

[0010] By achieving the contact-free co-operation between the guided surface and the circumferentially continuous guiding surface, e.g. a flange by the supply of water under pressure, there will be no need to provide for pressure gas production, which is much more circumstantial and costly than supplying the water.

[0011] The invention is particularly but not exclusively suitable for such heat exchangers where the plates are sector shaped plates located closed to the end surfaces of the rotor so that the support means are axially directed.

[0012] Preferably the water supply means includes a plurality of channels through said distance element.

[0013] These and other advantageous embodiments of the invention are specified in the dependent claims.

[0014] The invention will be further explained through the following detailed description of advantageous embodiments thereof and with reference to the accompanying drawings, of which

- fig. 1 is a partial axial section through a first preferred embodiment of a heat exchanger according to the invention,
- fig. 2 is an axial section through the support means along line II-II of fig. 1,
- fig. 3 is a section corresponding to that of fig. 1 but illustrating a second embodiment of the invention,
- fig. 4 is a partial axial section through the support means according to a third embodiment of the invention, and

fig. 5 is a section corresponding to that of fig. 4 but illustrating a fourth embodiment of the invention.

[0015] The heat exchanger illustrated in fig. 1 is of conventional type having a stationary casing 1 and a cylindrical rotor 2 containing the regenerative mass 3. The rotor has a hub 4 and an upper fixed sector shaped centre plate 5 with a movable sector plate 6 pivotally connected thereto and corresponding lower fixed centre plate 7 and movable sector plate 8. The two sets of plates 5, 6 and 7, 8 have the function to seal against the upper and lower ends of the rotor 2 as tight as possible and thereby separate the heat exchanging media flowing to and from the rotor through axial openings connected to media ducts (not shown).

[0016] For that purpose the radially outer ends of the movable sector plates 6, 8 are provided with two devices 10 each, which devices form support means for maintaining a certain clearance between the ends of the sector plates 6, 8 and an upper and lower annular edge flange 12 attached to the rotor along its upper and lower peripheries, each flange having an outer circumferentially continuous guiding surface 61 for co-operation with a guided surface connected to each of the devices 10.

[0017] Fig. 2 illustrates a part of the casing and the upper edge flange 12 of the rotor and the upper movable sector plate 6. In a hole in the sector plate 6 one of the devices 10 is fixed by screws. The device includes an outer sleeve 15 with a mounting flange 16, which with an intermediate sealing ring 17 is attached to the sector plate 6 by means of screws 18.

[0018] At its upper end the outer sleeve 15 has an internal thread 19 and within the outer sleeve 15 there is an inner sleeve 20 having an upper part with an external thread, partly screwed into the thread 19. At its lower end the inner sleeve is provided with a packing 22, which sealingly contacts the inside of the outer sleeve 15. The upper end of the inner sleeve 20 is provided with a nut 23 welded thereto and its lower end is provided with a bottom plate 24 welded thereto. On the underside of the bottom plate 24 a circular sliding shoe 25 of graphite or carbon is exchangeable attached by means of a recessed screw 26 screwed into the bottom plate 24. The sliding shoe 25 has a front surface 62 facing and being parallel to the circumferentially continuous guiding surface 61 of the flange 12.

[0019] The upper end of the outer sleeve 15 is provided with an external annular flange 27 to which the upper end of a sealing bellow 28 of metal is screwed by means of a mounting ring 29, an annular packing 30 and screws 31.

[0020] The lower end of the bellow 28 is provided with a mounting ring 32, which by means of screws 33 and an intermediate packing 34 is attached in a circular hole in the casing 1 so that a predetermined axial force will be applied downwards on the plate 6 due to the spring effect of the bellow 28.

[0021] In parallel with the device 10 and closed at the side thereof a measuring device 13 is provided for measuring the clearance between the plate 6 and the flange 12. It includes a tube 40, attached with its lower end in a hole 41 in the sector plate 6 and with its upper end in a hole 42 in the flange 27, and thus extends within the bellow 28. Inside the tube there is a measuring rod 43, the upper end of which is fixed in the shown position to a sleeve 44 by means of a not shown spring and an external flange on the rod, which sleeve 44 is screwed on to the tube 40. In that position a scaled part 45 of the upper end of the rod 43 projects out through the sleeve 44, and the bottom end of the rod 43 is aligned with the underside of the sector plate 6.

[0022] Eventually, as shown, a measuring clock 50 having a measure probe 51 contacting the top end of the scaled part 45 can be provided.

[0023] Support of the movable sector plate 6 for maintaining a clearance between the plate 6 and the flange 12 is attained through contact-free co-operation between a guiding surface 61 being the outer end surface of the rotating flange 12 and a stationary guided surface 62, being the front surface of the sliding shoe 25. To attain this contact-free co-operation, means are provided for establishing a cushion of water steam between these surfaces 61, 62. These means includes a source 64 of water under pressure, connected through a pipe 63 to the interior 65 of the sleeve 20 in which the sliding shoe 25 is mounted. Through the sliding shoe 25 channels 66 communicate the interior 65 of the sleeve 20 with the end surface 62 of the sliding shoe 25. Water thereby is supplied from the water source 64 to the guiding surface 61 of the flange 12. The temperature of the flange is about 350° C, which will result in complete or partial vaporization of the water that comes into contact therewith. The pressure of the water is sufficient to force the water to continuously flow from the channels 66 and escape between the guided surface 62 and the guiding surface 61, which thereby are pressed away from each other. In that way a cushion of the vaporized water is formed between these surfaces 61, 62, having an axial thickness of a fraction of a mm. Since there will be no contact between the surfaces 61, 62 no wear of the sliding shoe will occur. Sufficient water pressure in some applications will be attained by the ordinary line pressure, but in other applications a pump for raising the pressure might be necessary.

[0024] Fig. 3 illustrates an alternative embodiment of the invention according to which there is also or alternatively provided sealing plates 70 closed to the cylindrical surface of the rotor 2. These plates 70 are vaulted to correspond to the cylindrical surface and are substantially rectangular. The plates are radially movable by means not shown and co-operate with axially directed edge flanges 71 at the upper and lower ends of the rotor 2.

[0025] Between each movable plate 70 and the flanges 71 a certain clearance should be maintained which

is accomplished by devices 10' of the same kind as the supports 10 used to maintain the clearance between the sector plates 6, 8 and the ends of the rotor 2. When using both the sector-shaped sealing plates 6, 8 and the vaulted plates 70 it is possible to provide both with the support means according to the invention or to provide either of the sector plates or the vaulted plates with such and have a more simple mounting of the other plates.

[0026] How the channels through the sliding shoe are arranged affects the creation of the steam cushion. Figs. 4 and 5 illustrate two preferred alternatives in which these channel 66 are arranged to promote the creation of the steam cushion. In fig. 4 the channels 66 at the bottom side ends in a cavity 67 facing the guiding surface 61 of the flange 12, and the walls 68 of the cavity 68 are preferably tapered. In fig. 5 the channels 66 are inclined relative to the axial direction and meet centrally at the guided surface 62 of the sliding shoe 25.

Claims

1. Regenerative heat exchanger with a substantially cylindrical rotor (2) mounted in a casing (1), which casing (1) is provided with at least one movable plate (6, 8) arranged closed to said rotor (2) which movable plate (6, 8) is affected by a resultant force towards said rotor (2), the heat exchanger being provided with support means (10, 61, 62) for maintaining a certain clearance between said rotor (2) and said movable plate (6, 8), said support means (10, 61, 62) including a circumferentially continuous guiding surface (61) on said rotor (2) and at least one guided surface (62) connected to said movable plate (6, 8), said guided surface (62) being parallel to and facing said guiding surface (61), characterized in that
said movable plate (6, 8) is provided with water conduit means (63, 65, 66; 67) ending in said guided surface (62) and being connected to a water source (64) of a pressure sufficient to establish a gap between said guided surface (62) and said guiding surface (61) against the action of said resultant force, thereby establishing a cushion of at least partly vaporized water between said surfaces (61, 62) as said water at least partly vaporizes by contact with said guiding surface (61) and escapes from said conduit means (63, 65, 66; 67) through said gap.

2. Heat exchanger according to claim 1, wherein said movable plate (6, 8) is located closed to one of the ends of said rotor (2) in an orientation substantially perpendicular to the axis of said rotor (2) and separating axially directed openings communicating with ducts for heat transferring media, said guiding surface (61) being located on an edge flange (12) at the periphery of the related end of said rotor (2) and being perpendicular to the axis of said rotor (2).

3. Heat exchanger according to claim 2, wherein said movable plate (6, 8) is sector-shaped and having a radially outer end adjacent to said edge flange (12) and a radially inner end pivotally connected to a centre plate (5, 7) rigidly fixed to said casing (1) said movable plate (6, 8) being provided with two said guided surfaces (62), which are peripherally distributed and being individually axially adjustable in relation to said movable plate (6, 8).

4. Heat exchanger according to any of claims 1 to 3, wherein each said guided surface (62) is a surface on a sliding shoe (25) and said water conduit means includes a plurality of channels (66) through said sliding shoe (25) and ending through a plurality of openings in said guided surface (62).

5. Heat exchanger according to any of claims 1 to 3, wherein said guided surface (62) is a surface on a sliding shoe (25) and said water conduit means includes at least one channel (66) through said sliding shoe and a recess (67) in said guided surface (62), said channel (66) ending in said recess (67), and said recess (67) having a larger cross-flow area than said channel (66).

6. Heat exchanger according to claim 5, wherein said recess (67) has a conical wall (68), widening towards said guided surface (62).

7. Heat exchanger according to claim 4, wherein at least some of said channels (66) are inclined relative the axis of said rotor (2).

8. A method for operating a regenerative heat exchanger to maintain a certain clearance between a substantially cylindrical rotor (2) of the heat exchanger and a movable plate (6, 8) arranged close to said rotor and being connected to a casing (1) of the heat exchanger, said rotor (2) having a circumferentially continuous guiding surface (61) co-operating with a guided surface (62) connected to said movable plate (6, 8) said guided surface (62) being parallel to and facing said guiding surface (61), characterized by supplying water through water conduit means (63, 65, 66; 67) ending in said guided surface (62), said water having a pressure sufficient to establish a gap between said guided surface (62) and said guiding surface (61) against the action of said resultant force, thereby establishing a cushion of at least partly vaporized water between said surfaces (61, 62) as said water at least partly vaporizes by contact with said guiding surface (61) and escapes from said conduit means (63, 65, 66, 67) through said gap.

Patentansprüche

1. Regenerativer Wärmetauscher mit einem im wesentlichen zylindrischen Rotor (2), der in einem Gehäuse (1) montiert ist, das mit wenigstens einer nahe dem Rotor (2) angeordneten beweglichen Platte (6, 8) versehen ist, die mit einer resultierenden Kraft in Richtung des Rotors (2) beaufschlagt ist, wobei der Wärmetauscher zur Aufrechterhaltung eines bestimmten Spiels zwischen dem Rotor (2) und der beweglichen Platte (6, 8) mit Stützmitteln (10, 61, 62) versehen ist, die eine über den Umfang durchgängige Führungsfläche (61) an dem Rotor (2) und wenigstens eine geführte Fläche (62) umfassen, die mit der beweglichen Platte (6, 8) verbunden und parallel liegend der Führungsfläche (61) zugewandt ist, **dadurch gekennzeichnet,** daß die bewegliche Platte (6, 8) mit Wasserleitungsmitteln (63, 65, 66; 67) versehen ist, die in der geführten Fläche (62) enden und an eine Wasserquelle (64) mit einem bestimmten Druck angeschlossen sind, um gegen die Wirkung der resultierenden Kraft einen Spalt zwischen der geführten Fläche (62) und der Führungsfläche (61) auszubilden und dadurch ein Kissen aus wenigstens teilweise verdampftem Wasser zwischen den Flächen (61, 62) aufzubauen, da das Wasser durch Kontakt mit der Führungsfläche (61) wenigstens teilweise verdampft und aus den Leitungsmitteln (63, 65, 66; 67) durch den Spalt austritt.

2. Wärmetauscher nach Anspruch 1, **dadurch gekennzeichnet**, daß die wenigstens eine bewegliche Platte (6, 8) nahe eines der Enden des Rotors (2) in einer Ausrichtung im wesentlichen senkrecht zu der Achse des Rotors (2) angeordnet ist und axial ausgerichtete Öffnungen trennt, die mit Leitungen für wärmeübertragende Medien in Verbindung stehen, wobei die Führungsfläche (61) an einem Eckflansch (12) am Umfang des zugehörigen Endes des Rotors (2) angeordnet ist und senkrecht zur Achse des Rotors (2) liegt.

3. Wärmetauscher nach Anspruch 2, **dadurch gekennzeichnet,** daß die wenigstens eine bewegliche Platte (6, 8) sektorförmig ist und ein radial äußeres Ende nahe dem Eckflansch (12) und ein radial inneres Ende besitzt, das schwenkbar mit einer Mittelplatte (5, 7) verbunden ist, die starr mit dem Gehäuse (1) verbunden ist, wobei die bewegliche Platte (6, 8) mit zwei geführten Flächen (62) versehen ist, die am Umfang verteilt und mit Bezug auf die bewegliche Platte (6, 8) individuell axial einstellbar sind.

4. Wärmetauscher nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet,** daß jede geführte Fläche (62) eine Fläche an einem Gleitschuh (25) ist und die Wasserleitungsmittel eine Mehrzahl von Kanälen (66) umfassen und durch eine Mehrzahl von Öffnungen in der geführten Fläche (62) enden.

5. Wärmetauscher nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet,** daß die geführte Fläche (62) eine Fläche an einem Gleitschuh (25) ist und die Wasserleitungsmittel wenigstens einen Kanal (66) durch den Gleitschuh und eine Ausnehmung (67) in der geführten Fläche (62) umfassen, wobei der Kanal (66) in der Ausnehmung (67) endet und diese einen größeren Durchströmbereich als der Kanal (66) besitzt.

6. Wärmetauscher nach Anspruch 5, **dadurch gekennzeichnet,** daß die Ausnehmung (67) eine konische Wandung (68) besitzt, die sich in Richtung der geführten Fläche (62) aufweitet.

7. Wärmetauscher nach Anspruch 4, **dadurch gekennzeichnet,** daß wenigstens einige der Kanäle (66) bezüglich der Achse des Rotors (2) geneigt sind.

8. Verfahren zum Betreiben eines regenerativen Wärmetauschers zur Aufrechterhaltung eines bestimmten Spiels zwischen einem im wesentlichen zylindrischen Rotor (2) des Wärmetauschers und einer beweglichen Platte (6, 8), die nahe dem Rotor angeordnet und mit einem Gehäuse (1) des Wärmetauschers verbunden ist, wobei der Rotor (2) eine über den Umfang durchgängige Führungsfläche (61) besitzt, die mit einer geführten Fläche (62) zusammenwirkt, die mit der beweglichen Platte (6, 8) verbunden und parallel liegend der Führungsfläche (61) zugewandt ist, **dadurch gekennzeichnet**, daß Wasser durch Wasserleitungsmittel (63, 65, 66; 67), die in der geführten Fläche (62) enden, zugeführt wird, wobei das Wasser einen hinreichenden Druck besitzt, um zwischen der geführten Fläche (62) und der Führungsfläche (61) gegen die Wirkung der resultierenden Kraft einen Spalt auszubilden und dadurch ein Kissen aus wenigstens teilweise verdampftem Wasser zwischen den Flächen (61, 62) aufzubauen, da das Wasser wenigstens teilweise durch Kontakt mit der Führungsfläche (61) verdampft und aus den Leitungsmitteln (63, 65, 66; 67) durch den Spalt austritt.

Revendications

1. Echangeur de chaleur à régénération avec un rotor sensiblement cylindrique (2) monté dans un carter (1), lequel carter (1) est pourvu d'au moins une plaque mobile (6, 8) disposée près dudit rotor (2), laquelle plaque mobile (6, 8) est affectée par une force résultante vers ledit rotor (2), l'échangeur de cha-

leur étant pourvu de moyens de support (10, 61, 62) destinés à maintenir un certain jeu entre ledit rotor (2) et ladite plaque mobile (6, 8), lesdits moyens de support (10, 61, 62) comprenant une surface de guidage circonférentiellement continue (61) sur ledit rotor (2) et au moins une surface guidée (62) reliée à ladite plaque mobile (6, 8), ladite surface guidée (62) étant parallèle et face à ladite surface de guidage (61), caractérisé en ce que ladite plaque mobile (6, 8) est pourvue de moyens de conduite d'eau (63, 65, 66; 67) qui se terminent dans ladite surface guidée (62) et qui sont reliés à une source d'eau (64) d'une pression suffisante pour établir un espace entre ladite surface guidée (62) et ladite surface de guidage (61) à l'encontre de l'action de ladite force résultante, établissant ainsi un coussin d'eau au moins partiellement vaporisée entre lesdites surfaces (61, 62) lorsque ladite eau se vaporise au moins partiellement par contact avec ladite surface de guidage (61) et s'échappe desdits moyens de conduite (63, 65, 66; 67) à travers ledit espace.

2. Echangeur de chaleur selon la revendication 1, dans lequel ladite plaque mobile (6, 8) est disposée près d'une des extrémités dudit rotor (2) dans une orientation sensiblement perpendiculaire à l'axe dudit rotor (2) et séparant des ouvertures orientées axialement qui communiquent avec des conduits pour les milieux de transfert de chaleur, ladite surface de guidage (61) étant disposée sur une bride à bord (12) au niveau de la périphérie de l'extrémité liée dudit rotor (2) et étant perpendiculaire à l'axe dudit rotor (2).

3. Echangeur de chaleur selon la revendication 2, dans lequel ladite plaque mobile (6, 8) est en forme de secteur et possède une extrémité radialement extérieure adjacente à ladite bride à bord (12) et une extrémité radialement intérieure reliée de façon pivotante à une plaque centrale (5, 7) fixée rigidement sur ledit carter (1), ladite plaque mobile (6, 8) étant pourvue des deux dites surfaces guidées (62), qui sont réparties de manière périphérique et qui sont réglables axialement de manière individuelle par rapport à ladite plaque mobile (6, 8).

4. Echangeur de chaleur selon l'une quelconque des revendications 1 à 3, dans lequel chaque dite surface guidée (62) est une surface sur un patin de glissement (25) et lesdits moyens de conduite d'eau comprennent plusieurs canaux (66) à travers ledit patin de glissement (25) et se terminant à travers plusieurs ouvertures dans ladite surface guidée (62).

5. Echangeur de chaleur selon l'une quelconque des revendications 1 à 3, dans lequel ladite surface guidée (62) est une surface sur un patin de glissement (25) et lesdits moyens de conduite d'eau comprennent au moins un canal (66) à travers ledit patin de glissement et un renfoncement (67) dans ladite surface guidée (62), ledit canal (66) se terminant dans ledit renfoncement (67), et ledit renfoncement (67) ayant une section d'écoulement plus grande que ledit canal (66).

6. Echangeur de chaleur selon la revendication 5, dans lequel ledit renfoncement (67) possède une paroi conique (68), qui s'élargit vers ladite surface guidée (62).

7. Echangeur de chaleur selon la revendication 4, dans lequel au moins certains desdits canaux (66) sont inclinés par rapport à l'axe dudit rotor (2).

8. Procédé de mise en oeuvre d'un échangeur de chaleur à régénération destiné à maintenir un certain jeu entre un rotor sensiblement cylindrique (2) de l'échangeur de chaleur et une plaque mobile (6, 8) disposée près dudit rotor et qui est reliée à un carter (1) dudit échangeur de chaleur, ledit rotor (2) ayant une surface de guidage circonférentiellement continue (61) qui coopère avec une surface guidée (62) reliée à ladite plaque mobile (6, 8), ladite surface guidée (62) étant parallèle et face à ladite surface de guidage (61), caractérisé par le fait de délivrer de l'eau par l'intermédiaire de moyens de conduite d'eau (63, 65, 66; 67) qui se terminent dans ladite surface guidée (62), ladite eau ayant une pression suffisante pour établir un espace entre ladite surface guidée (62) et ladite surface de guidage (61) à l'encontre de l'action de ladite force résultante, établissant ainsi un coussin d'eau au moins partiellement vaporisée entre lesdites surfaces (61, 62) lorsque ladite eau se vaporise au moins partiellement par le contact avec ladite surface de guidage (61) et s'échappe desdits moyens de conduite (63, 65, 66; 67) à travers ledit espace.

Fig.1

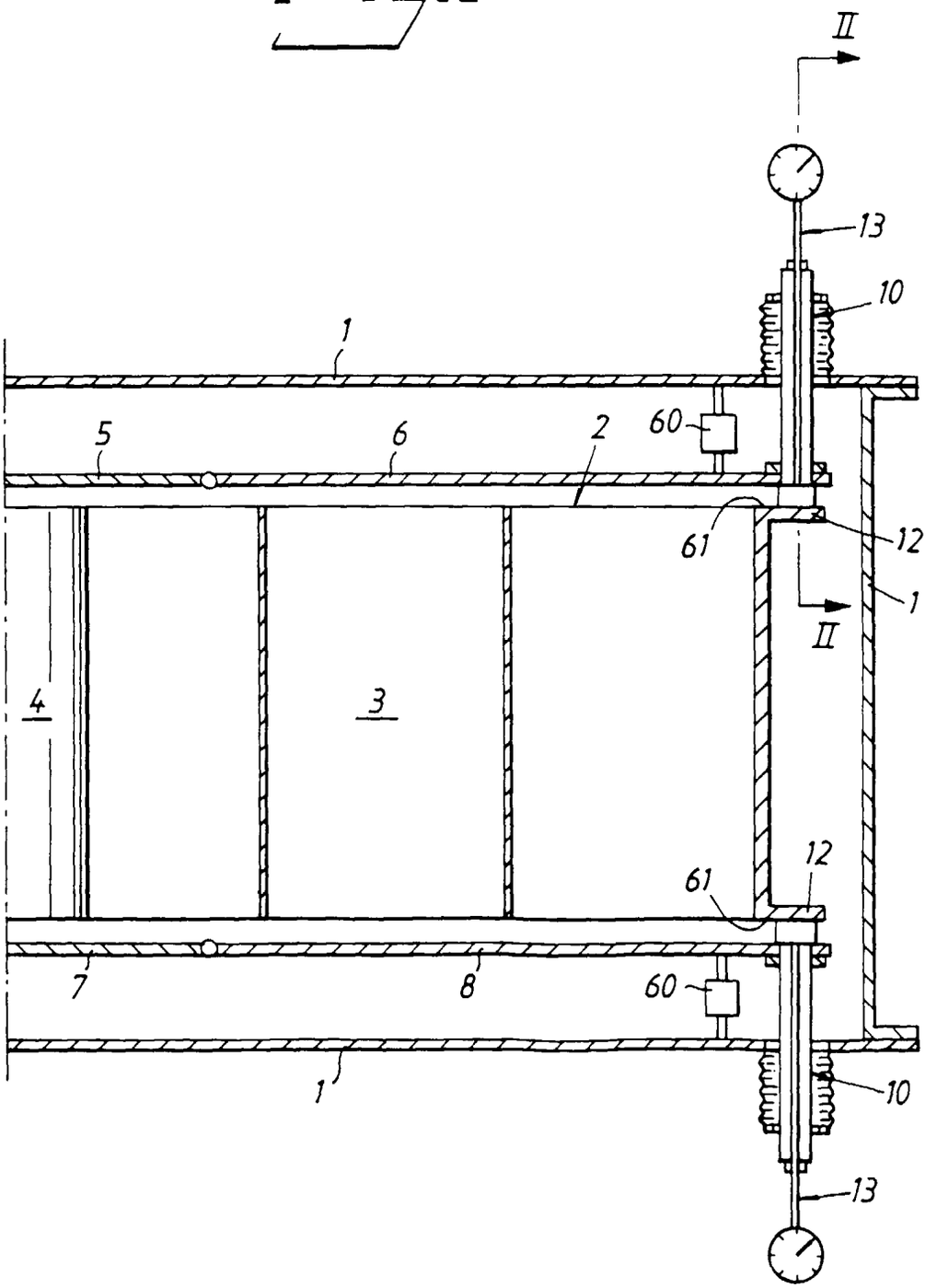
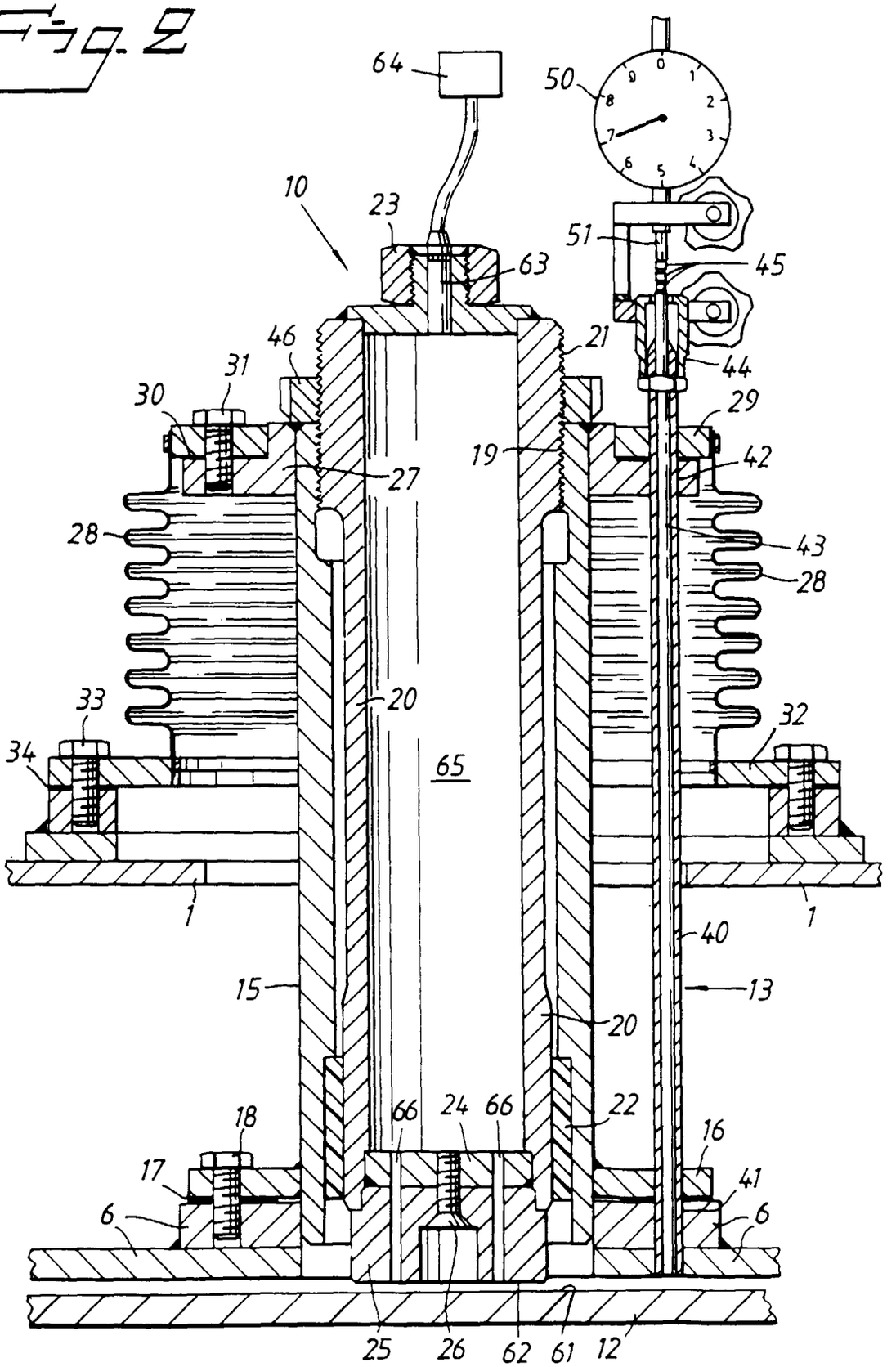


Fig. 2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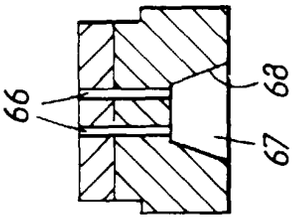
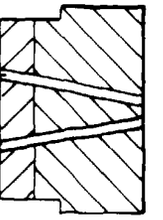
Фиг. 4



Фиг. 5



Фиг. 3