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(54) **Appliance for the dispersion of particles in a fluid**

(57) The appliance (1) for the dispersion of particles (P) in a fluid (F) comprises a supporting structure (2), a first disc (3) associated with the supporting structure (2) axially rotatable and a second disc (4) associated with the supporting structure (2), the first disc (3) and the second disc (4) being arranged parallel to one another and substantially closed to define at least an interstice (I), and introduction means (5) for introducing a fluid (F) containing agglomerates of particles (P) to disperse, able to introduce the fluid (F) inside the interstice (I) and in correspondence to a substantially central portion of the first disc (3), the rotation of the first disc (3) being able to submit the fluid (F) inside the interstice (I) to a complex field of forces, with the purpose of producing cutting forces able to separate the agglomerates of particles (P), dispersing the particles (P) inside the fluid (F).

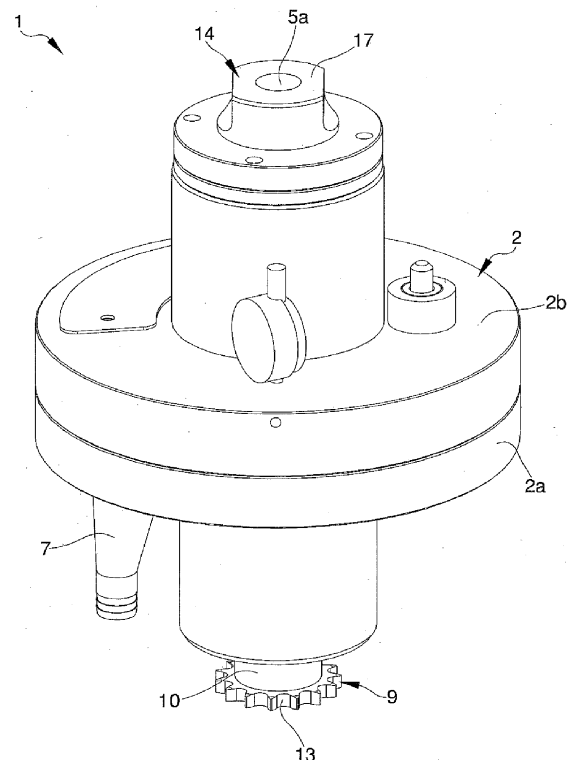


Fig. 1

Description

[0001] The present invention relates to an appliance for the dispersion of particles in a fluid, usable in particular for the dispersion of carbon and graphene nanotubes inside thermosetting polymers.

[0002] The need to save energy together with the need to obtain materials with particular properties and increasingly higher strength/weight ratios is prompting a growing use of composite materials in the aerospace and automotive industries.

[0003] Furthermore, the use of such materials is also growing in the building trade and, more in general, where corrosion phenomena are of primary importance.

[0004] These and other needs have prompted researchers to investigate in detail the properties of nano-engineered composite materials.

[0005] In particular, carbon and graphene nanotubes are considered to be important fillers usable to upgrade the properties of composite materials and, more in general, of polymers.

[0006] The major obstacles to the large-scale diffusion of this new generation of materials are:

- the high cost of carbon and graphene nanotubes;
- the considerable increase in polymer viscosity following the inclusion in same of this category of nanoparticles;
- the lack of a method of dispersion of the nanoparticles in the polymeric matrix which is effective and of low cost.

[0007] More specifically, this latter drawback is mainly due to the high specific surface area of nanoparticles and of the van der Waals forces which tend to keep the particles aggregated to one another.

[0008] Within basic research, the most used method to effectively disperse the nanoparticles is so-called sonication, commonly accompanied by the use of thinners and surfactants which often damage the polymeric matrix.

[0009] In practice, the nanoparticles are dispersed using ultrasonic probes which are soaked inside the preparation.

[0010] This known method however has some drawbacks.

[0011] In particular, sonication permits preparing only small quantities of product at a time, around a few hundred grams, and requires a long time, making the entire process economically unviable.

[0012] Furthermore, it has been demonstrated that sonication damages carbon nanotubes (see, for example, Lu, K. L. et al. "Mechanical damage of carbon nanotubes by ultrasound" Carbon 34, 814-816 (1996)).

[0013] It is also known that manufacturers of epoxy resins with nano additives use dispersion techniques and machinery previously used in other sectors, like that of cosmetics, inks, paints, the food industry and, more in

general, in all those sectors where micrometric solid particles have to be mixed, dispersed and homogenized inside a substance in liquid state.

[0014] Standard mixers and stirrers used for the production of paints, foodstuffs and in general in the chemical industry become inefficient or even ineffective when the sizes of the particles to be dispersed become nanometric and, in particular, this occurs in the case of carbon or graphene nanotubes.

[0015] The machinery most commonly used for these purposes is currently the so-called Three Roll Mill.

[0016] This machinery is essentially made up of three parallel rollers, between which a predetermined distance is kept which can be adjusted by means of specific devices.

[0017] The first two rollers, i.e., the loading roller and the central roller, turn in opposite directions and at different speeds, so as to produce tangential forces in the material being loaded when this passes between them.

[0018] The third roller, or unloading roller, turns in the opposite direction to the central roller and at a higher speed compared to the latter.

[0019] The speeds of the three rollers are therefore different and increase passing from the loading roller to the unloading roller.

[0020] The unloading roller is kept in contact with a blade integral with an unloading channel. The blade picks up the material from the unloading roller and causes it to flow to the channel, from where it is then picked up.

[0021] This solution too has however some drawbacks.

[0022] In particular, the machinery is heavy and has large overall dimensions and is hazardous for operators due to the presence of the rollers, both during the work phases and during the machine cleaning phases.

[0023] Furthermore, the use of such machinery involves the risk of evaporation, and therefore of inhaling volatile substances inside the work environment.

[0024] Furthermore, the treated preparation does not receive enough energy to obtain a good dispersion by means of a single stroke inside the machine, particularly when nanoparticles are being dealt with such as carbon and graphene nanotubes. This makes it necessary to run the preparation several times inside the machine, thus reducing considerably its productivity.

[0025] A further limit is the fact that, in the event of the machine having to process fluids containing nanoparticles, along with the growth in dimensions of the machine, productivity does not grow linearly and, on the contrary, it can decrease due to the inevitable parallelism errors between the rollers, the eccentricity of same and, therefore, the difficulty in maintaining a constant distance between them.

[0026] Finally, conventionally, production occurs in lots and the machinery is loaded through a hopper that discharges a predefined quantity of preparation between the first two rollers. Once this is processed, the rollers are again loaded.

[0027] The loading and unloading operations do not therefore allow having a machine isolated from the outside environment and, consequently, the openings for the loading and unloading of the fluid convey volatile substances inside the environment.

[0028] The main aim of the present invention is to provide an appliance for the dispersion of particles in a fluid able to ensure effective dispersion.

[0029] Another object of the present invention is to provide an appliance for the dispersion of particles in a fluid which allows to overcome the mentioned drawbacks of the prior art within the framework of a simple, rational, easy, effective to use and affordable solution.

[0030] The above mentioned objects are achieved by the present appliance for the dispersion of particles in a fluid according to claim 1.

[0031] Other characteristics and advantages of the present invention will become better evident from the description of a preferred, but not exclusive embodiment, of an appliance for the dispersion of particles in a fluid, illustrated by way of an indicative, but not limitative example in the accompanying drawings wherein:

Figure 1 is an axonometric view of the appliance according to the invention;

Figure 2 is a sectional side view of the appliance according to the invention;

Figure 3 is an axonometric view of the first and second discs of the appliance according to the invention.

[0032] With particular reference to such illustrations, the reference numeral 1 globally designates an appliance for the dispersion of particles P in a fluid F, usable in particular for the dispersion of carbon and graphene nanotubes, inside of thermosetting polymers.

[0033] The use of the appliance 1 cannot however be ruled out for the dispersion in different fluids of different types of particles, whether these are of nanometric or micro metric size.

[0034] For example, the appliance 1 can be used to:

- disperse pigments in paints and inks;
- disperse excipients, active ingredients and other particles in the preparation of creams, cosmetics and pharmacological products.

[0035] The appliance 1 comprises a supporting structure, indicated altogether in the illustrations by the reference 2.

[0036] The appliance 1 also comprises:

- a first disc 3 supported by the supporting structure 2 and axially rotatable around a rotation axis R;
- a second disc 4 supported by the supporting structure 2 and superimposed to the first disc 3.

[0037] Advantageously, the first disc 3 and the second disc 4 are arranged substantially parallel to one another

and close together, so as to define an interstice I between the two respective flat surfaces.

[0038] Conveniently, the second disc 4 is associated axially translatable with the supporting structure 2, along a translation axis T, and is mobile close to/away from the first disc 3.

[0039] The variation in the distance between the first disc 3 and the second disc 4 permits varying the dimensions of the interstice I according to the particular particles P to be dispersed, as well as to the particular fluid F used.

[0040] Preferably, the first disc 3 and the second disc 4 must maintain levelness and not come into contact including for distances close to 0.00001 m.

[0041] With non-exclusive reference to the particular and preferred embodiment of the appliance 1 shown in the illustrations, the first disc 3 is arranged substantially horizontally and has a first flat surface 3a turned upwards.

[0042] Furthermore, the second disc 4 is also arranged substantially horizontally and has a second flat surface 4a turned downwards, facing and parallel to the first flat surface 3a. The interstice I is defined between the first flat surface 3a and the second flat surface 4a.

[0043] Advantageously, the appliance 1 has introduction means 5 of a fluid F containing agglomerates of particles P to disperse. The introduction means I are able to introduce the fluid F inside the interstice I, in correspondence to a substantially central portion of the first disc 3.

[0044] In particular, the introduction means 5 can consist of an introduction channel having a charging mouth 5a of the fluid F and of a dispensing mouth 5b of the fluid F, wherein the dispensing mouth 5b is arranged in correspondence to the central portion of the first disc 3.

[0045] With non-exclusive reference to the embodiment of the appliance 1 shown in the illustrations, the introduction channel 5 consists of a through hole made along a cylindrical support 6 of the second disc 4, through the second disc itself, up to the second flat surface 4a.

[0046] More specifically, the charging mouth 5a is made in correspondence to the upper portion of the cylindrical support 6 of the second disc 4, while the dispensing mouth 5b consists of an opening made on the second flat surface 4a of the second disc 4, in correspondence to the central portions of the first and the second discs 3 and 4.

[0047] The appliance 1, in particular the supporting structure 2, also comprises a collection channel 7 arranged in correspondence to a perimeter portion of the first disc 3 and able to collect the fluid F containing the dispersed particles P. During the operation of the appliance 1, the flow rate and supply pressure of the fluid F introduced through the introduction channel 5, the distance between the opposite first and the second flat surfaces 3a and 4a of the first and second discs 3 and 4 and the rotation speed of the first disc 3 can be varied.

[0048] Advantageously, the fluid F, forced to pass inside the interstice I between the first and the second flat surfaces 3a and 4a of the first and second discs 3 and

4, is submitted to a complex field of forces that produces cutting forces able to separate the agglomerates of nanoparticles P, thus dispersing these inside the fluid F.

[0049] In particular, the fluid F completes a spiral path passing from the central portion of the first and second discs 3 and 4, up to the perimeter portions of the first and second discs 3 and 4 and, then, to the collection channel 7.

[0050] Usefully, the first disc 3 can have, in correspondence to one or more of its perimeter portions, one or more spatulas 8 or similar devices able to push the fluid F towards the collection channel 7.

[0051] The appliance 1 also comprises operation means 9 operatively associated with the first disc 3 and able to produce the rotation of the first disc 3 around the rotation axis R.

[0052] With reference to the preferred embodiment shown in the illustrations, the operation means 9 comprise a shaft 10 supported axially rotatable by the supporting structure 2 which extends, integral with it, from the lower face of the first disc 3.

[0053] The shaft 10 is connected to the lower face of the first disc 3 and is supported by the supporting structure 2 through specific bearings 11. The preloading of the bearings 11 can be done through a ring nut 12 or other device, for the purpose of cancelling the play.

[0054] The shaft 10, e.g., can be connected to motor means, not shown in the illustrations, by means of a specific pinion 13.

[0055] Different embodiments of the operation means 9 cannot however be ruled out, wherein the first disc 3 is made to rotate by means of different movement systems.

[0056] The appliance 1 also comprises adjustment means 14 suitable for adjusting the distance of the second disc 4 with respect to the first disc 3.

[0057] In particular, with reference to the preferred embodiment shown in the illustrations, the adjustment means 14 comprise a screw micrometer adjusting mechanism 15.

[0058] More specifically, the adjustment means 14 comprise a bush 16 and the adjustment of its distance from the first disc 3 is allowed by specific devices 15, 16, 17, 18 and 19 which enable its micrometric adjustment.

[0059] In the preferred embodiment, this is done by means of an adjustment ring nut 17, and the possible play between screw and nut screw of the screw micrometer adjusting mechanism 15 is eliminated by elastic means 18.

[0060] More specifically, the elastic means 18 preferably consist of a spring that works by pushing the second disc 4 in the direction of the pressure applied by the fluid F between the discs 3 and 4. This way, the pressure applied by the incoming fluid F will not change the distance between the discs 3 and 4.

[0061] In particular, with reference to the embodiment shown in the illustrations, this occurs by compressing the spring 18 between the bush 16 and a contrasting bearing

ring 19 integral with the second disc 4.

[0062] The force applied by the spring 17 must be greater than the weight of the second disc 4, including the weight of all the accessories needed and integral with it, and the spring 17 must be able to overcome any friction between the second disc 4, the bush 16, the contrasting bearing ring 18 and all the accessories of the adjustment means 14 that come into contact with these.

[0063] The distance between the first and the second discs 3 and 4 can be easily measured indirectly, e.g. by means of a micrometer 20 with sensor located on the upper surface of the second disc 4.

[0064] The thicknesses of the first and second discs 3 and 4 are designed for maximum operating pressure and the maximum allowed load in correspondence to the maximum diameter is 1/10 the operating distance envisaged between the discs themselves.

[0065] The work surfaces of the first and second discs 3 and 4, made up of the first and second flat surfaces 3a and 4a, have a surface hardening treatment and are ground or rumbled.

[0066] The perfect parallelism of the discs can furthermore be achieved by means of a ball joint or precision constant-velocity joint in the connection between the first disc 3 and its shaft 10. This way, the pressure of the fluid F itself, perpendicular to the surface of the first and second discs 3 and 4, will ensure its parallelism. In order to obtain a more or less constant operating temperature, cooling circuits can be envisaged on the covers of the supporting structure 2, on the discs and on the shafts.

[0067] Conveniently, the supporting structure 2 comprises suitable means for covering the first and the second discs 3 and 4.

[0068] In particular, the covering means consist of a lower monobloc 2a and of an upper monobloc 2b fastened together to define a compartment V for housing the first and second discs 3 and 4.

[0069] Different types and/or shapes of the supporting structure 2 and of the covering means cannot however be ruled out.

[0070] It has in fact been ascertained how the described invention achieves the proposed objects.

[0071] In particular, the appliance according to the invention, more specifically the rotation of the first disc with respect to the second disc, permits subjecting the fluid to a complex force field, in order to produce cutting forces able to break apart the agglomerates of particles, thereby dispersing the particles themselves inside the fluid.

[0072] Furthermore, the fact is underlined that the advantages with respect to the state of the art are:

- specifically conceived and sized for the nanotechnology sector;
- possibility of acting on several variables (distance between discs, supply pressure, supply flow rate, disc rotation speed) in order to achieve the desired result;
- high energy transmitted to fluid which permits ob-

taining effective dispersions with a single stroke of the preparation inside the machine;

- continuous production;
- appliance isolated from the outside environment so as not to allow the introduction of volatile substances into the environment;
- appliance also suitable in applications where micro-metric particles have to be dispersed.

[0073] The fact is also underlined that the presence of disc covering means, together with the particular structure of the appliance, makes the appliance itself safer for operators with respect to solutions of known type.

[0074] Furthermore, together with the increase in disc diameters, the working area also increases by a ratio equal to its square.

Claims

1. Appliance (1) for the dispersion of particles (P) in a fluid (F), **characterized by** the fact that it comprises a supporting structure (2), at least a first disc (3) associated with said supporting structure (2) axially rotatable and at least a second disc (4) associated with said supporting structure (2), said first disc (3) and said second disc (4) being arranged parallel to one another and substantially closed to define at least an interstice (I), and introduction means (5) for introducing a fluid (F) containing agglomerates of particles (P) to disperse, able to introduce said fluid (F) inside said interstice (I) and in correspondence to a substantially central portion of said first disc (3), the rotation of said first disc (3) being able to submit said fluid (F) inside said interstice (I) to a complex field of forces, with the purpose of producing cutting forces able to separate said agglomerates of particles (P), dispersing the particles (P) inside said fluid (F).
2. Appliance (1) according to claim 1, **characterized by** the fact that at least one of said first and second discs (3, 4) is mobile close to/away from the other of said first and second discs (3, 4), the variation in the distance between said first disc (3) and said second disc (4) being able to vary the dimensions of said interstice (I).
3. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that said second disc (4) is associated axially translatable with said supporting structure (2) along a translation axis (T).
4. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that at least one of said first and second discs (3, 4) comprises a first flat surface (3a), while the other of said first and second discs (3, 4) comprises a second flat sur-

face (4a), facing and parallel to said first flat surface (3a), said interstice (I) being defined between said first flat surface (3a) and said second flat surface (4a).

5. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that said introduction means (5) comprise at least an introduction channel (5) having at least a charging mouth (5a) of said fluid (F) and at least a dispensing mouth (5b) of said fluid (F) arranged in correspondence to said substantially central portion of the first disc (3).
6. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that at least a section of said introduction channel (5) is composed of at least a through hole made along at least a portion of said first disc (3) and/or of said second disc (4).
7. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that said dispensing mouth (5b) comprises at least an opening made on a surface of said first disc (3) and/or of said second disc (4) facing towards said interstice (I), in correspondence to said substantially central portion of the first disc (3).
8. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that it comprises at least a collection channel (7) arranged in correspondence to at least a perimeter portion of said first disc (3) and able to collect said fluid (F) containing dispersed particles (P).
9. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that it comprises operation means (9) operatively associated with said first disc (3) and able to make said first disc (3) to rotate around said rotation axis.
10. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that said operation means (9) comprise at least a shaft (10) associated axially rotatable with said supporting structure (2), integrally associated with said first disc (3) and associable with motor means.
11. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that it comprises adjustment means (14) for adjusting the distance of at least one of said first and second discs (3, 4) with respect to the other of said first and second discs (3, 4).
12. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that said adjustment means (14) comprise a screw microme-

ter adjusting mechanism (15) associated with at least one of said first and second discs (3, 4).

13. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that it comprises elastic means (18) for pushing at least one of said first and second discs (3, 4) in the direction of the pressure applied by said fluid (F) between the discs themselves, said elastic means (18) being able to eliminate the possible play between screw and nut screw of the screw micrometer adjusting mechanism (15).
14. Appliance (1) according to one or more of the preceding claims, **characterized by** the fact that said supporting structure (2) comprises covering means (2a, 2b) of said first and second discs (3, 4).

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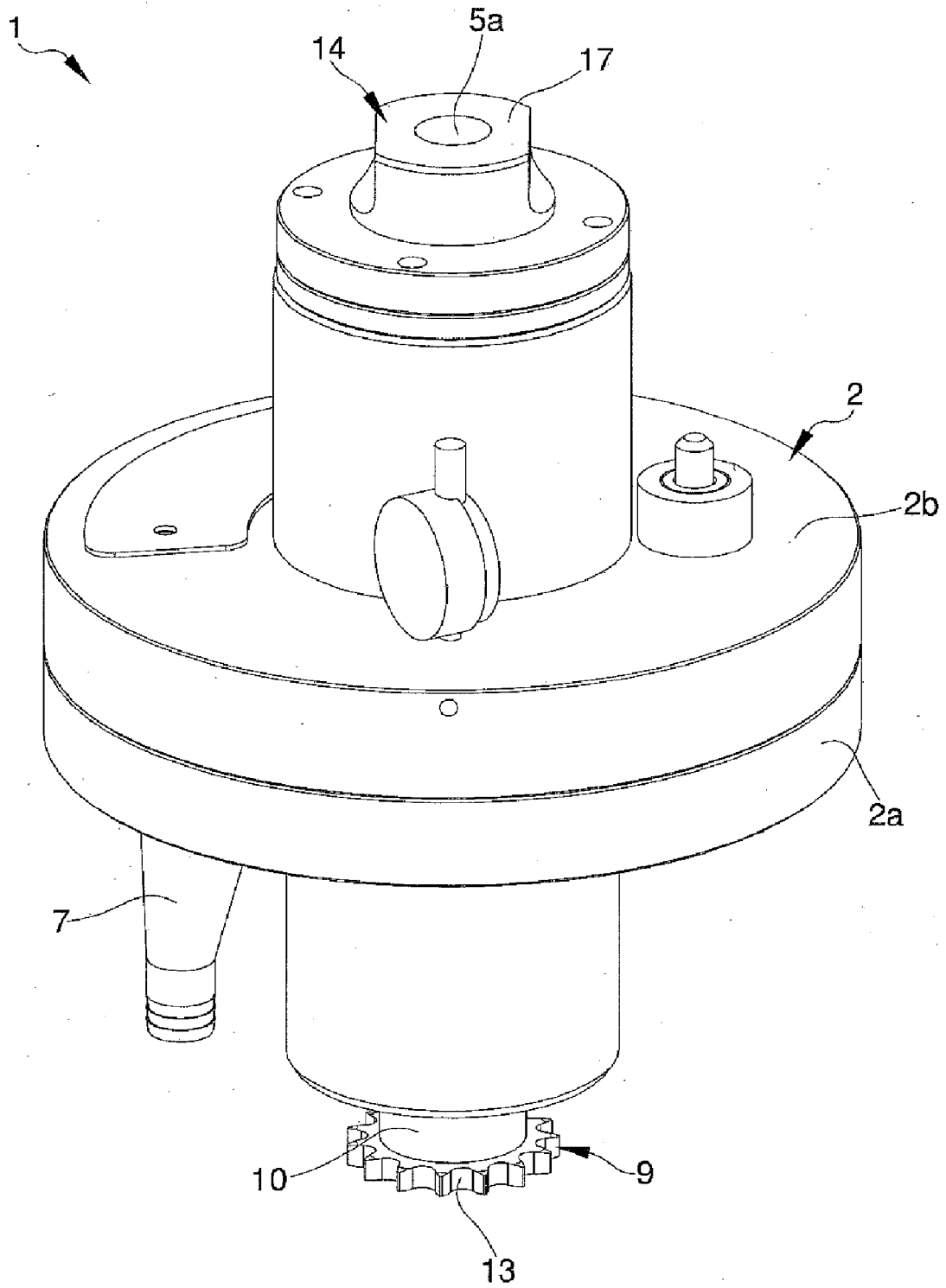


Fig. 1

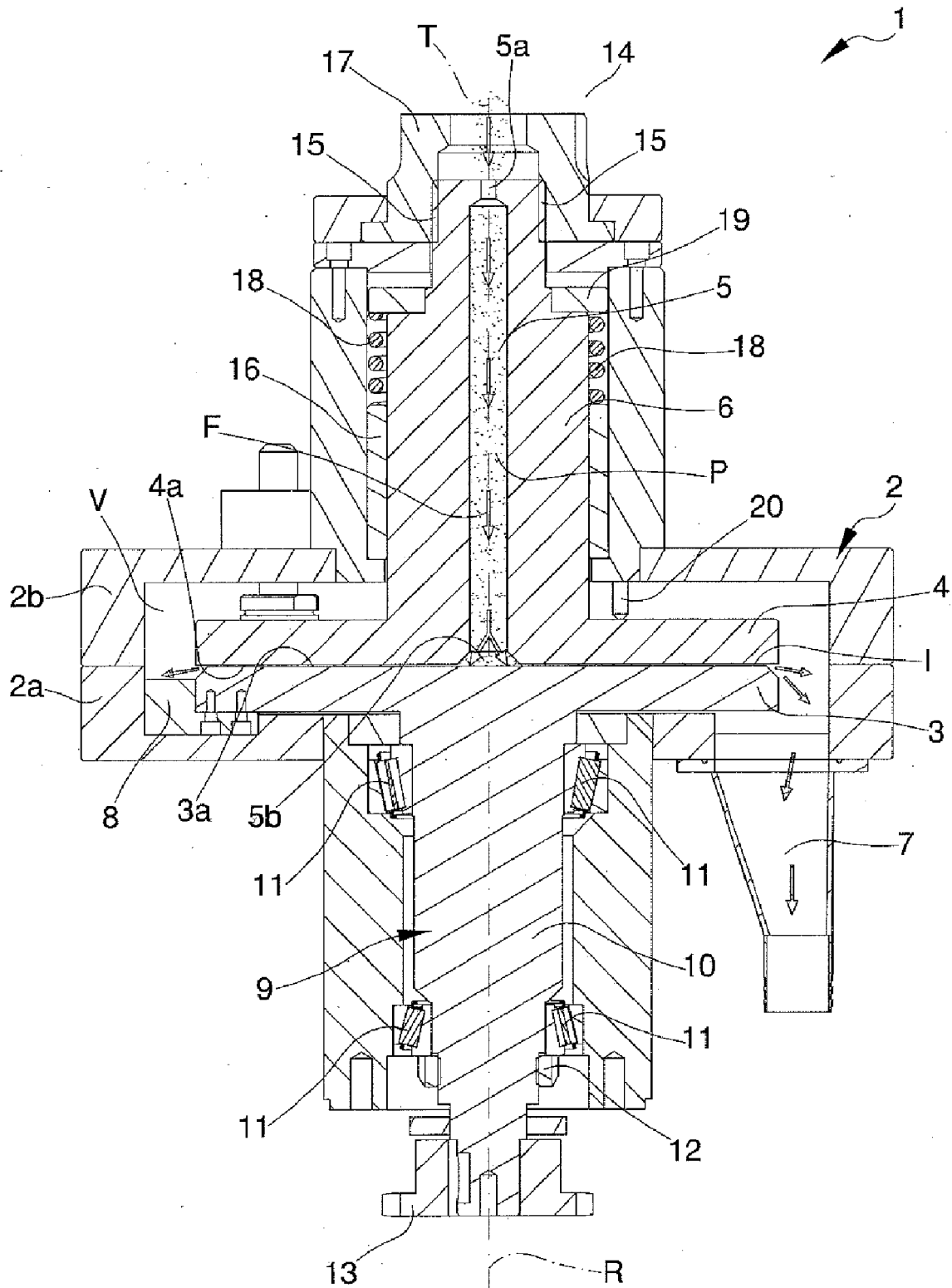
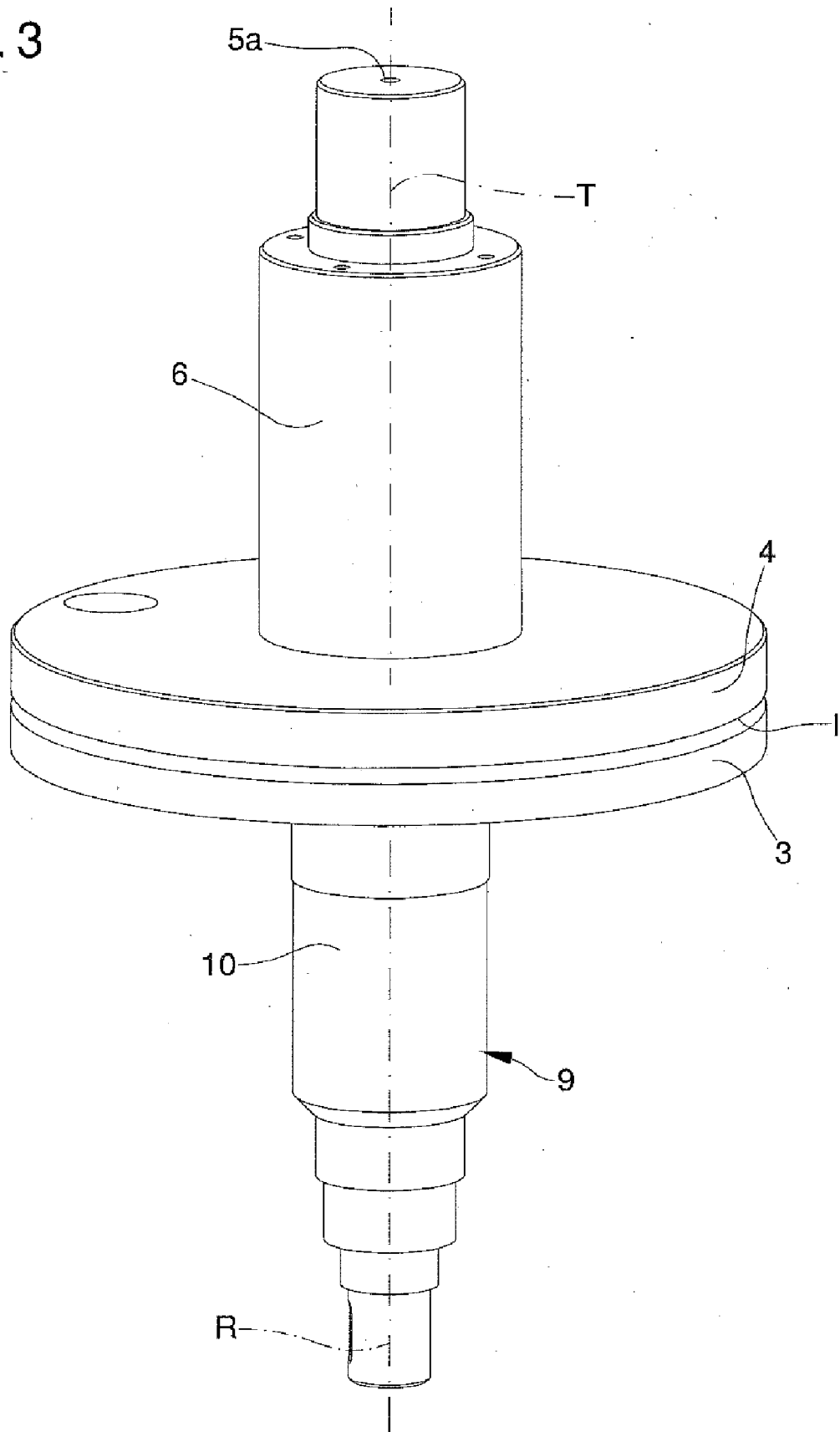


Fig. 2

Fig. 3





EUROPEAN SEARCH REPORT

Application Number
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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	* figures 1-3,6,7 * * paragraph [0037] - paragraph [0040] * -----	13	
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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		13 March 2015	Krasenbrink, B
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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13-03-2015

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