

(19) Organisation Mondiale de la Propriété
Intellectuelle
Bureau international



(43) Date de la publication internationale
3 mai 2001 (03.05.2001)

PCT

(10) Numéro de publication internationale
WO 01/31680 A1

(51) Classification internationale des brevets⁷: H01J 37/32,
C23C 16/04

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(21) Numéro de la demande internationale:

PCT/FR00/02941

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(22) Date de dépôt international:

23 octobre 2000 (23.10.2000)

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Industrielle, BP 204, F-76053 Le Havre Cedex (FR).

(25) Langue de dépôt:

français

(26) Langue de publication:

français

(30) Données relatives à la priorité:

99/13638

25 octobre 1999 (25.10.1999)

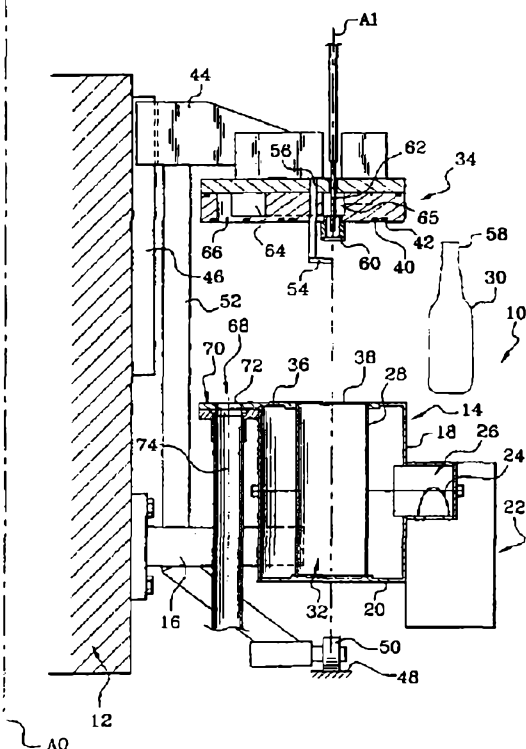
FR

(81) États désignés (national): AE, AG, AL, AM, AT, AU, AZ,
BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE,
DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU,
ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS,
LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO,

[Suite sur la page suivante]

(54) Title: VACUUM CIRCUIT FOR A DEVICE FOR TREATING A RECEPTACLE WITH LOW PRESSURE PLASMA

(54) Titre: CIRCUIT DE VIDE POUR UN DISPOSITIF DE TRAITEMENT D'UN RECIPIENT A L'AIDE D'UN PLASMA A
BASSE PRESSION



(57) Abstract: The invention relates to a device for treating a receptacle (30) with a low pressure plasma, comprising at least one treatment station (14) consisting of a fixed cavity (32) which is connected by a vacuum circuit (74) to a depressurizing source, and wherein said treatment station (14) consists of a moveable cover (34) provided with means for supporting (54) the receptacle (30) in such a way that the receptacle is introduced into the cavity (32) by displacing the cover (34). The invention is characterized in that the cover (34) comprises a connecting channel (64) which enables the cavity (32) to communicate with a fixed end (69) of the vacuum circuit when the cover (34) is in a position in which the cavity is hermetically sealed.

(57) Abrégé: L'invention propose un dispositif pour le traitement d'un récipient (30) à l'aide d'un plasma à basse pression, du type comportant au moins un poste de traitement (14) comprenant une cavité fixe (32) reliée à une source de dépression par l'intermédiaire d'un circuit de vide (74), et du type dans lequel le poste de traitement (14) comporte un couvercle mobile (34) muni de moyens de support (54) du récipient (30) de sorte que l'introduction du récipient dans la cavité (32) soit assurée par déplacement du couvercle (34), caractérisé en ce que le couvercle (34) comporte un canal de liaison (64) qui, lorsque le couvercle (34) est en position de fermeture étanche de la cavité (32), met en communication la cavité (32) avec une extrémité fixe (68) du circuit de vide (74).



NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR,
TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

Publiée:

Avec rapport de recherche internationale.

(84) États désignés (régional): brevet ARIPO (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), brevet eurasien (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), brevet européen (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), brevet OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

En ce qui concerne les codes à deux lettres et autres abréviations, se référer aux "Notes explicatives relatives aux codes et abréviations" figurant au début de chaque numéro ordinaire de la Gazette du PCT.

TRANSLATION FROM FRENCH

**VACUUM CIRCUIT FOR A DEVICE FOR PROCESSING A CONTAINER
USING LOW PRESSURE PLASMA**

5

This invention relates to the field of devices for processing a container using a low-pressure plasma in which the plasma is created by excitation of a gas using electromagnetic waves.

- 10 Such a device is for example described in the same applicant's patent application W099/49991 to which reference can be made for all clarification regarding the processes that can be implemented using the device according to the invention. In the device described in the aforementioned document, it is provided that each container is dealt with in a processing station having a sealed cavity and an external chamber. The
- 15 station is provided with a movable upper cover which makes it possible to open the cavity in order to insert therein a container to be processed. In closed position the cover closes the said cavity in a sealed manner in order to obtain in the cavity the low pressure necessary for creating a "cold" plasma. Advantageously, the cover of the device comprises means for supporting the container in such a way that the
- 20 introduction and removal of the container is assured by movement of the cover between its opening and closing positions.

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- 20 introduction and removal of the container is assured by movement of the cover between its opening and closing positions.

The device described in the document W099/49991 is a device in which the object of processing with low-pressure plasma is to deposit a substance on the container walls.

- 25 For that purpose it is necessary to introduce into the processing cavity a precursor gas which will be ionised to plasma form. Advantageously, the said document thus provides that the means of injecting the precursor gas includes an injector mounted on the cavity cover.

- 30 Further, in order to achieve the low pressure necessary to establish a plasma, the cavity must be connected to pumping means by a circuit referred to as a vacuum circuit. Here again the document referred to above provides that the end of the said vacuum circuit is arranged on the cover to open directly into the cavity.

However, the said document does not specifically describe the means enabling connection of the cover to the vacuum circuit.

Hence, the object of the invention is to provide a specific design for the vacuum circuit
5 which enables the machine incorporating the said device to operate in a fully reliable manner.

With that object, the invention provides a processing device of the type described hereinabove, wherein the cover comprises a connecting channel which, when the cover
10 is in its sealed closure position on the cavity, puts the cavity in communication with a fixed end of the vacuum circuit.

According to other features of the invention:

- 15 - the connecting channel has an end connection, which cooperates with the fixed end of the vacuum circuit, and two endings which open into an internal surface of the cover delimiting the cavity when the cover is in closed position, and support means are provided to hold in a sealed manner an opening of the container to be processed against the said internal surface of the cover, the opening completely surrounding a
20 first of the said endings in such a way that the container delimits within the cavity a first part connected to the vacuum circuit by the first ending and a second part connected to the vacuum circuit by the second of the said endings ;
- one of the two endings has a controlled shutter so as to be able to separate the
25 two parts of the cavity in a sealed manner when the cover is in closed position ;
- the shutter is a controlled valve ;
- the first ending of the connecting channel allows the passage of an injector to
30 bring a reagent gas inside the container; and
- the connecting channel has an air recycling port, which opens out into the open air and which is equipped with a controlled shutter so as to be able to connect the cavity with the outside atmosphere at the end of processing.

Other features and advantages of the invention will appear from a reading of the detailed description hereinbelow as well as from the attached drawings, in which :

- 5 - figure 1 is a schematic view in axial cross section of a machine incorporating a processing device according to the invention, the cover of which is illustrated in open position;
- figure 2 is a view similar to that in figure 1 in which the cover is illustrated in
10 position to close the cavity ;
- figure 3 is a schematic diagram in exploded perspective view of the different components of a processing station according to the invention;
- 15 - figure 4 is a schematic plan view of the cover according to the invention ;
- figure 5 is a schematic sectional view along line 5—5 of figure 4, illustrating the two endings in the connecting channel;
- 20 - figure 6 is a schematic view in cross section illustrating the means of controlling the valve that controls differential pressure between the inside and the outside of the container.

25 Figures 1 and 2 show schematic views in axial cross section of a processing station 10 according to the teachings of the invention. Here station 10 is part of a rotary machine comprising a carousel 12 continuously rotated about a vertical axis A0. The carousel 12 is thus provided to carry on its periphery a series of processing stations 10 identical to the one illustrated. The stations are distributed in a regular manner about axis A0.

30 The processing station 10 has an external chamber 14 which is fastened by a radial support 16 to the periphery of carousel 12. The chamber 14 is made of electrically conductive material, for example of metal, and formed from a tubular cylindrical wall 18 with vertical axis A1. The chamber is closed at its lower end by a lower bottom wall 20.

On the outside of the chamber 14, affixed thereto, there is a housing 22 which comprises means (not shown) for creating inside chamber 14 an electromagnetic field capable of generating a plasma. When this occurs, it may involve means capable of
5 generating electromagnetic radiation in the UHF range, i.e. in the microwave range. In that event, housing 22 can thus contain a magnetron having an antenna 24 which extends into a wave guide 26. The said wave guide 26 may be, for instance, a tunnel of rectangular cross section which extends along a radius with respect to axis A0 and which opens directly into the interior of chamber 14 through the side wall 18.

10 However, the invention may also be implemented in the context of a device equipped with a source of radiation of the radiofrequency type and/or the source might also be arranged otherwise, for example at the lower axial end of chamber 14.

Inside the chamber 14, there is a tube 28 with axis A1 which is made of a material
15 which is transparent to the electromagnetic waves introduced into chamber 14 via the wave guide 26. The said tube 28 could be made of quartz, for example. The tube 28 is intended to receive a container 30 to be processed. Its internal diameter must thus be adapted to the diameter of the container. In addition, it must delimit a cavity 32 in which a vacuum in the order of 10^{-4} bar will be created once the
20 container is inside the enclosure.

As can be seen in figure 1, the chamber 14 is partially closed at its upper end by an upper wall 36 which is provided with a central opening 38 having a diameter essentially equal to the diameter of the tube 28 so that the tube 28 will open fully
25 upward in order to allow the introduction of the container 30 into the cavity 32. On the other hand, it can be seen that the lower metallic wall 20, to which the lower end of tube 28 is connected in a sealed manner, forms the base of the cavity 32.

To re-close chamber 14 and cavity 32, processing station 10 thus has a cover 34 which
30 can be moved axially between a high position shown in figure 1 and a low closing position shown in figure 2. In high position, the cover is sufficiently disengaged to permit the introduction of the container 30 into cavity 32.

In closed position, shown in figure 2, the cover 34 comes to rest in a sealed manner against the upper surface of the upper wall 36 of chamber 14. As the upper end of the tube 28 is connected in a sealed manner to the upper wall 36, the cover 34 is able to close the cavity 32 in a sealed manner. For that purpose a sealing device 40 of the O-ring type is provided on the cover 34, coming to bear against the upper wall 36 of the cavity 14 around the central orifice 38.

Further, the cover 34 also comprises a flexible conductor ring 42, made for example in the form of a metallic braid, which also comes to bear against the wall 36 to ensure an electrical connection between the chamber 14 and the cover 34 when the latter is in closed position. In fact, the cover is made of a conductive material and has the function of closing the chamber 14 in order to allow the establishment inside the same of an electromagnetic field capable of creating a plasma in the cavity 32. Advantageously, the said conductor ring may be made from a flexible material (of the silicon type) loaded with metallic particles in order to be electrically conductive. In fact, a conductor ring of this type may act simultaneously as a sealing device and an electrical connection between the cover and the chamber 14.

In the example illustrated, the cover 34 slides vertically with respect to chamber 14. For that purpose, it is carried by a carriage 44 which slides on a slide 46 which is integral with the carousel 12. However, it is possible to envisage that the cover 34 has another relative movement with respect to cavity 14 between its opening and closing positions, a pivoting movement about a horizontal axis for instance.

In the example illustrated, use is made of the fact that the processing station is mounted on a rotary carousel to control the displacements of the cover using a cam 48 and roller 50 system. In fact, the machine comprises a fixed cam 48 which follows the arc of a circle about axis A0 and of which one upper surface forms a roller track. Naturally, the height of the cam 48 varies with the angular position about axis A0.

30

The roller 50 is connected to the carriage 44, which carries the cover 34 on a post 52, and thus rotates with the carousel 12. When the roller 50 arrives in an angular sector in which the cam 48 rises, the roller thus causes the cover to be raised towards its high position. On the other hand, in other angular sectors the level of the cam lowers and

the roller 50 then allows cover 34 to lower again towards its closed position. Naturally, other means for controlling the movement of the cover 34 can be imagined without departing from the scope of the invention.

- 5 In a particularly advantageous manner, cover 34 does not have the sole function of assuring the sealed closure of cavity 32. In fact, it has supplementary members.

In the first place cover 34 has means for supporting the container. In the example illustrated, the containers to be processed are thermoplastic bottles, made for example
10 of polyethylene terephthalate (PET). The said bottles have a neck ring with a radial protuberance at the base of their neck 58 so that that it is possible to grip them using a fork 54 which engages or locks around the neck, below the neck ring. The said fork 54 is thus mounted on the lower end of a rod 56 that passes through cover 34. The said rod 56 can be moved vertically with respect to the cover in such a way that bottle
15 30 may be engaged on the fork while being slightly downwardly offset with respect to the cover (figure 1). Upon being held by the fork 54, the bottle 30 may be pressed upward against an abutment surface 60 of cover 34. Preferably, the said abutment is sealed so that when the cover is in the closed position, the interior space of cavity 32 is separated by the container wall into two parts: the inside and the outside of the
20 container.

The said arrangement makes it possible to process only one of the two surfaces (interior or exterior) of the container wall. In the example illustrated, it is sought to treat only the internal surface of the container wall.

25

The said internal processing thus requires the ability to control simultaneously the pressure and the composition of the gases present inside the container. For that purpose it must be possible for the interior of the container to put in communication with a vacuum source and a gas distribution circuit. The cover 34 therefore comprises an
30 injector 62 which is arranged along axis A1 and which is also movable with respect to the cover 34 between a high retracted position for which the container 30 may be delivered radially onto the fork 54 (figure 1) and a low position in which injector 62 is inserted into the interior of the container 30 (figure 2).

In order for the gas injected by injector 62 to be ionised and form a plasma under the influence of the electromagnetic field created in the chamber, the pressure in the container must be in the order of 10^{-4} bar. To place the interior of the container in communication with a vacuum source (for example, a pump), the cover 34 comprises
5 an internal channel 64 one main ending 65 of which opens into the inside surface of the cover, more specifically into the centre of the abutment surface 60 against which the neck of bottle 30 is held.

Note that in the proposed embodiment the abutment surface 60 is not formed directly
10 on the inside surface of the cover but on the lower annular end of a tubular insert 61 with axis A1 which is fixed beneath the cover 34. The internal bore of the said tubular insert 61 constitutes in this case the extension of the main ending 65. Hence, when the upper end of the container neck abuts against the abutment surface 60 the opening of container 30, which is delimited by the said upper end, completely surrounds the
15 orifice through which the main ending 65 opens into the lower surface of the cover 34.

According to the invention, the said main ending 65 is not connected directly to the pumping means. In fact, because of the mobility of cover 34, it would be necessary to provide flexible conduits between the cover and the pumping circuit. Now, such
20 conduits are not well suited to a vacuum circuit since a flexible conduit would have a tendency to collapse under the effect of atmospheric pressure.

Hence, according to the invention the internal channel 64 of the cover 24 comprises a connecting end 66 and the vacuum circuit of the machine has a fixed end 68 which is
25 arranged in such a way that the two ends 66, 68 are facing each other when the cover is in closed position.

In the example illustrated, the upper wall 36 of the chamber 14 has an extension 70 which extends in the same horizontal plane, radially inward with respect to axis A0.
30 The said extension 70 has an orifice 72 cut through it, and has means enabling the connection of a conduit 74 in the vacuum circuit. The said conduit 74 is, for example, connected to one or more pumps (not shown). The said pumps are preferably

arranged on the outside of the machine and in that case are connected to the conduit 74 by means of a rotating union (not shown) in such a way as not to hinder the rotation of the carousel.

- 5 In that way, given that the chamber 14 is fixed with respect to the carousel 12, the conduit 74 may be rigid or very slightly flexible.

As can be seen in fig. 3, cover 34 displays when viewed from above the same shape as the upper wall of the chamber 14 and the connecting end 66 thus opens into the lower
10 surface of cover 34, exactly in line with the orifice 72 at which the conduit 74 is connected.

In order to simplify the production of the internal channel 64, the cover 34 is made in two parts: a lower base 76 and an upper cap 78. The internal channel 64 is hollowed
15 out of the upper surface of base 76, only the connecting end 66 and the main ending 65 opening into the lower surface. Hence, when the cap 78 is placed in a sealed manner on the base, the only communication possible is between the connecting end 66 and the said ending, with the effect that the channel 64 assures a sealed connection between the conduit 74 and the cavity 32.

20

The machine illustrated in the diagrams is provided for processing the internal surface of the containers which are of a relatively deformable material. Such containers could not stand up to an overpressure of the order of 1 bar between the outside and the inside of the bottle. Hence, in order to obtain a pressure of the order of 10^{-4} bar inside the
25 bottle without deforming it, that part of the cavity 32 which is outside the bottle must also be at least partially depressurised. Therefore the internal channel 64 in the cover 34 comprises in addition to the main ending 65 an auxiliary ending 80 which also opens through the lower surface of the cover, but radially to the exterior of the annular abutment surface 60 against which the neck 58 of the container is brought to bear.

30

Hence, the same pumping means simultaneously creates the vacuum inside and outside the container.

In order to limit the pumping volume and to avoid an unwanted plasma appearing outside the bottle, it is preferable for the outside pressure not to drop below 0.05 to 0.1 bar, against an internal pressure of 10^{-4} bar. Further, it has been observed that even thin-walled bottles can stand up to the said pressure-difference without being
5 subject to noticeable deformation. For that reason, the cover is to be provided with a controlled valve 82 capable of shutting off the auxiliary ending 80.

As can be seen in figures 4 and 5, valve 82 is trapped within the cover 34, between the base 76 and the cap 78, and is of the normally closed type. The valve 82 is connected
10 to the lower end of a valve stem 84 which moves¹ upward through the cap 78 of the cover 34.

As can be seen in greater detail in figure 6, valve stem 84 is controlled by a roller system 86 which is designed to cooperate with a fixed cam 88 on the machine. At a
15 given point in the carousel's rotation the cam 88 causes roller 86, which is integral with a lever 90 hinged about a horizontal axis A2 on the cover 34, to rise. The roller thus causes lever 90 to pivot, which in turn causes stem 84 to be raised through means of a control nut 92. When cam 88 allows the roller to come down again, a return spring 94 acting between the cover 34 and the lever 90, urges the valve stem 84 downward to
20 press valve 82 against a valve seat 96 formed around auxiliary ending 80.

Naturally, other control means for valve 82 could be provided without departing from the scope of the invention. An actuator or solenoid could also be used, for example.

25 The device that has just been described could operate as follows:

At a given point in the carousel's rotation, the cover 34 is in high position. The fork 54 is in low position, and the injector is in high retracted position as illustrated in figure 1. A container 30 may then be brought to this point on the fork 54, for example using a
30 notched transfer wheel. Such wheels are generally known and used in machines for manufacturing and filling PET bottles. The said wheel will thus be tangential to the carousel at the bottle loading point.

¹ Translator's note : There appears to be a verb missing in the original ; but something like "moves" seems to be intended.

Once the container is loaded on fork 54, the carousel 12 continuing its rotational movement, the cover lowers towards its closed position. At the same time, the rod 56 holding fork 54 is activated to press the container in a sealed manner against the abutment surface 58 of cover 34 and injector 62 is lowered for insertion inside the container. Note that the injector lowers through the main ending 65 of channel 64 but does not block it off.

Once the cover is in the closed position, it is possible to evacuate the air contained in the cavity 32 which is connected to the vacuum circuit by the internal channel 64 of the cover 34.

As a first step, the valve 82 is actuated to open with the result that the pressure drops in cavity 32 both outside and inside the container simultaneously. When the carousel 12 arrives at a predetermined angular position, the vacuum outside the container is considered to have reached a sufficient level and the cam 88 and roller 86 system controls the closing of the valve 82. It is then possible to continue the pumping exclusively inside the container 30.

Once the processing pressure has been reached, the processing can start. The said processing may consist, for example, of depositing an internal coating, the deposit in question being obtained through plasma ionisation of a precursor gas injected into the container using the injector 62.

Once the processing has been completed, the cavity is advantageously returned to atmospheric pressure through the internal channel 64 in the cover. The choice can then be made to do that by connecting the conduit 74 to atmospheric pressure or else one could choose to provide channel 64 with a controlled opening (not shown) enabling direct connection of the channel to the atmosphere. In both cases, care must first be taken to actuate the opening of valve 82 so that atmospheric pressure is re-established simultaneously outside and inside the container.

Once pressure equilibrium is achieved between the outside and the inside of the container, it is possible to actuate the cover towards its high position, retract the

injector and offset the fork 54 downward with respect to the cover 34 to enable removal of the processed container.

By virtue of this invention, the machine's vacuum circuit can be given an economical
5 and reliable design because it does not call for the cover to have flexible systems,
which might break under the repetitive stress they would be subjected to.

CLAIMS

1. A device for processing a container (30) using a low pressure plasma which is
5 created by excitation of a gas by electromagnetic waves, of the type having at least one
processing station (14) comprising a fixed cavity (32), provided to receive the
container (30) to be processed, the cavity (32) being intended to be connected to a
vacuum source by way of a vacuum circuit (74), of the type in which the processing
station (14) has a movable cover (34) which makes it possible to close the cavity (32)
10 in a sealed manner and of the type in which the introduction of the container into the
cavity (32) before processing and its removal after processing are assured by
displacement of the cover (34) with respect to the cavity (32),

wherein the cover (34) comprises a connecting channel (64) which, when the
cover (34) is in its sealed closure position on the cavity (32), puts the cavity (32) in
15 communication with a fixed end (68) of the vacuum circuit (74).

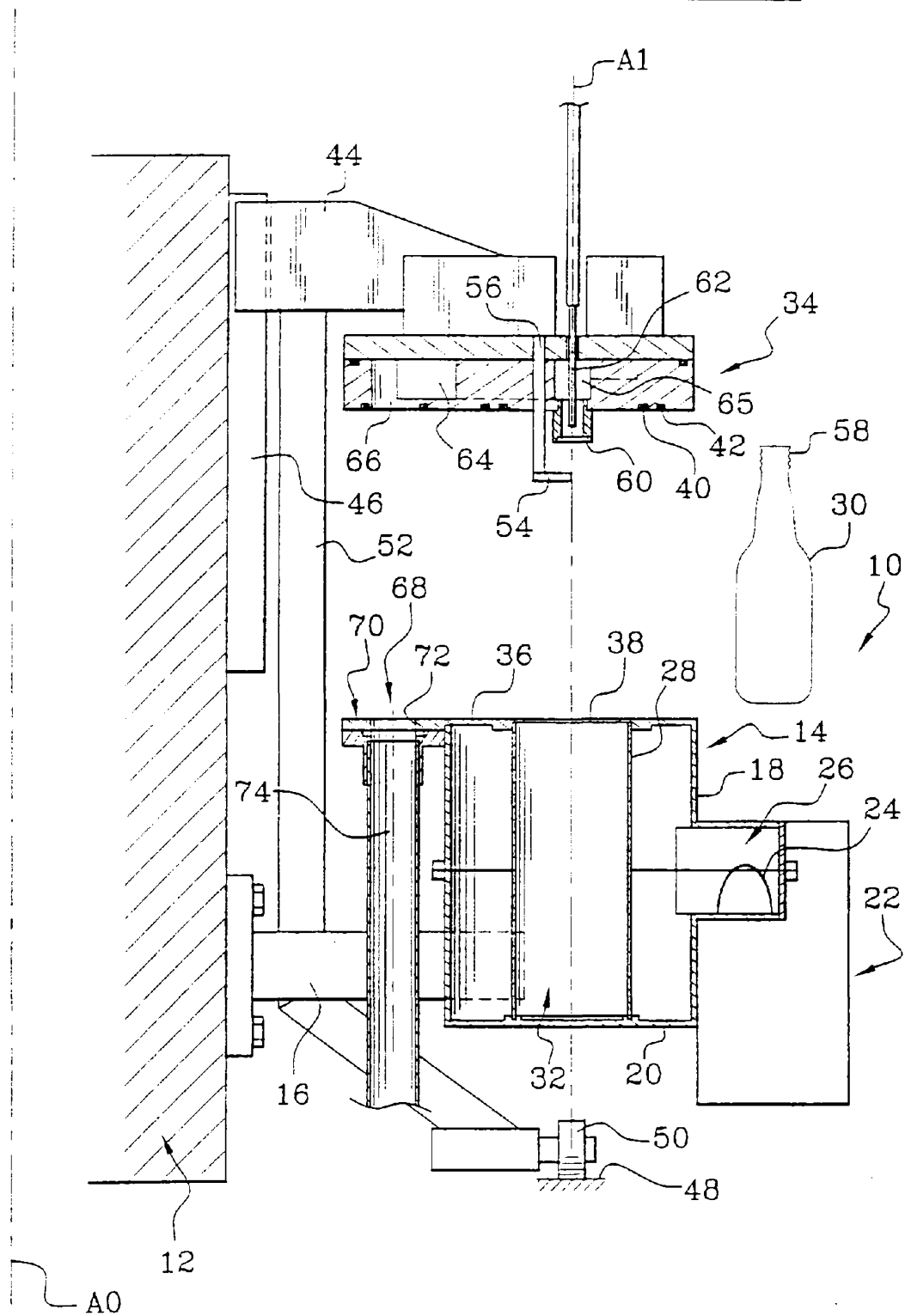
2. A device according to claim 1, wherein the connecting channel (64) has an end
connection (66), which cooperates with the fixed end (68) of the vacuum circuit, and
20 two endings (65,80) which open into an internal surface of the cover (34) delimiting
the cavity when the cover is in closed position, and wherein support means (54) are
provided to hold in a sealed manner an opening of the container to be processed
(58,30) against the said internal surface (60) of the cover (34), the opening completely
surrounding a first of the said endings in such a way that the container (30) delimits
25 within the cavity (32) a first part connected to the vacuum circuit by the first ending
(65) and a second part connected to the vacuum circuit by the second (80) of the said
endings.

3. A device according to claim 2, wherein one of the two endings (65,80) has a
30 controlled shutter (82) so as to be able to separate the two parts of the cavity in a
sealed manner when the cover (34) is in the closed position.

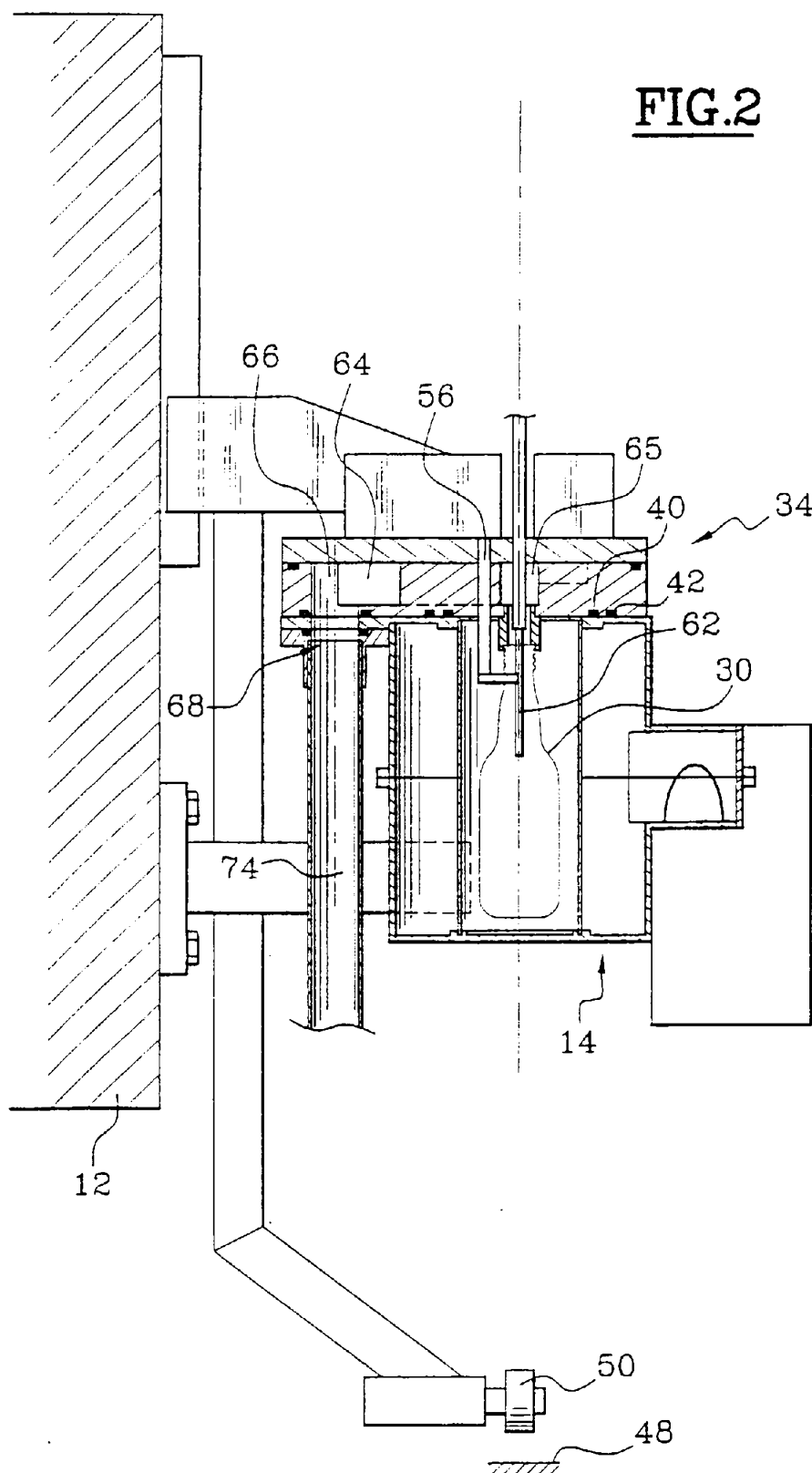
4. A device according to claim 3, wherein the shutter is a controlled valve (82).

5. A device according to any of claims 2 to 4, wherein the first ending (65) of the connecting channel (64) allows the passage of an injector (62) to bring a reagent gas inside the container (30).
- 5 6. A device according to any of the foregoing claims, wherein the connecting channel has an air recycling port, which opens out into the open air and which is equipped with a controlled shutter so as to be able to connect the cavity (32) with the outside atmosphere at the end of processing
- 10 7. A device according to any of the foregoing claims, wherein the cover (34) comprises support means (54) for the container (30).

FIG.1

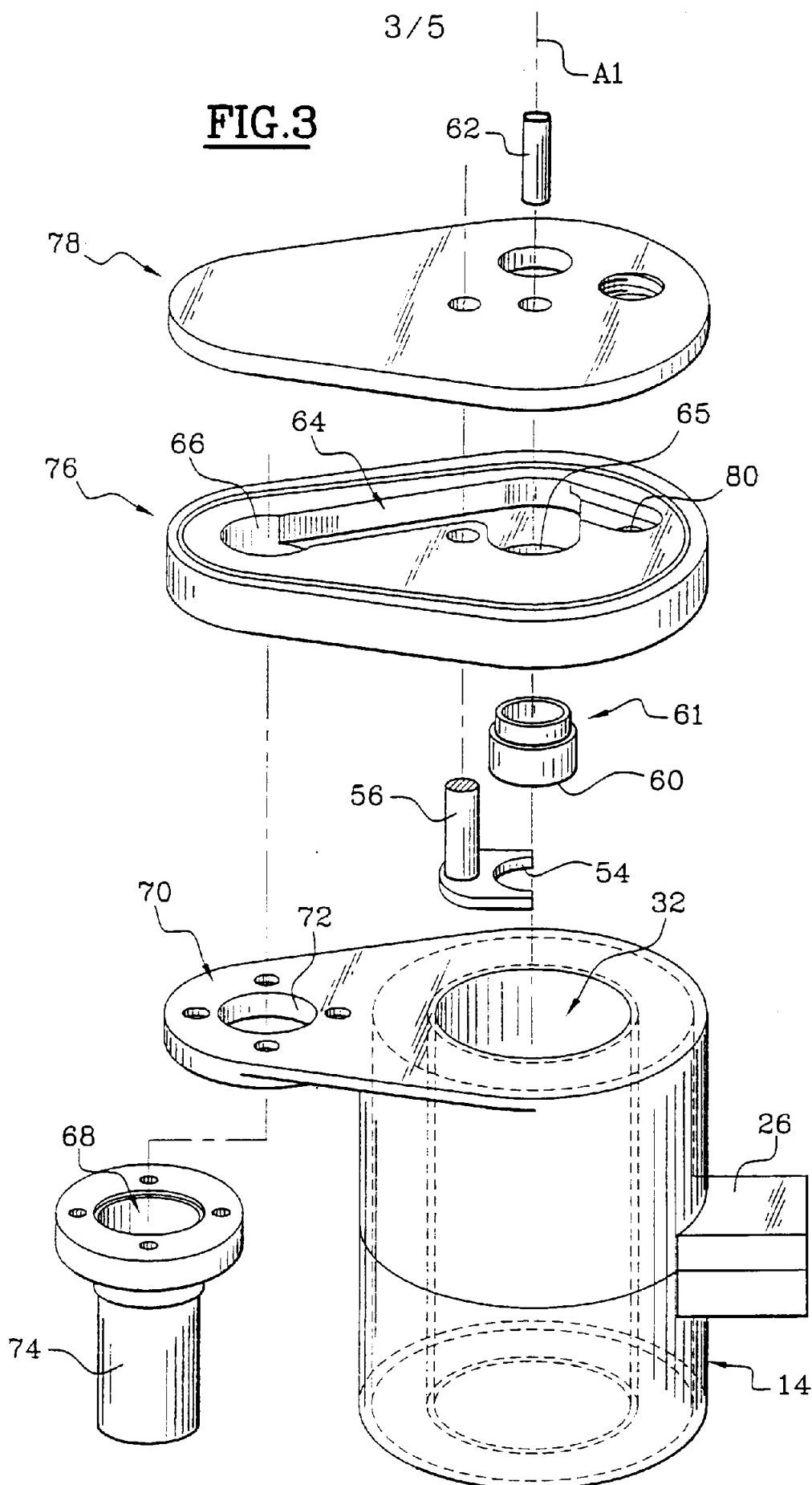


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FIG.2

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FIG.3



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