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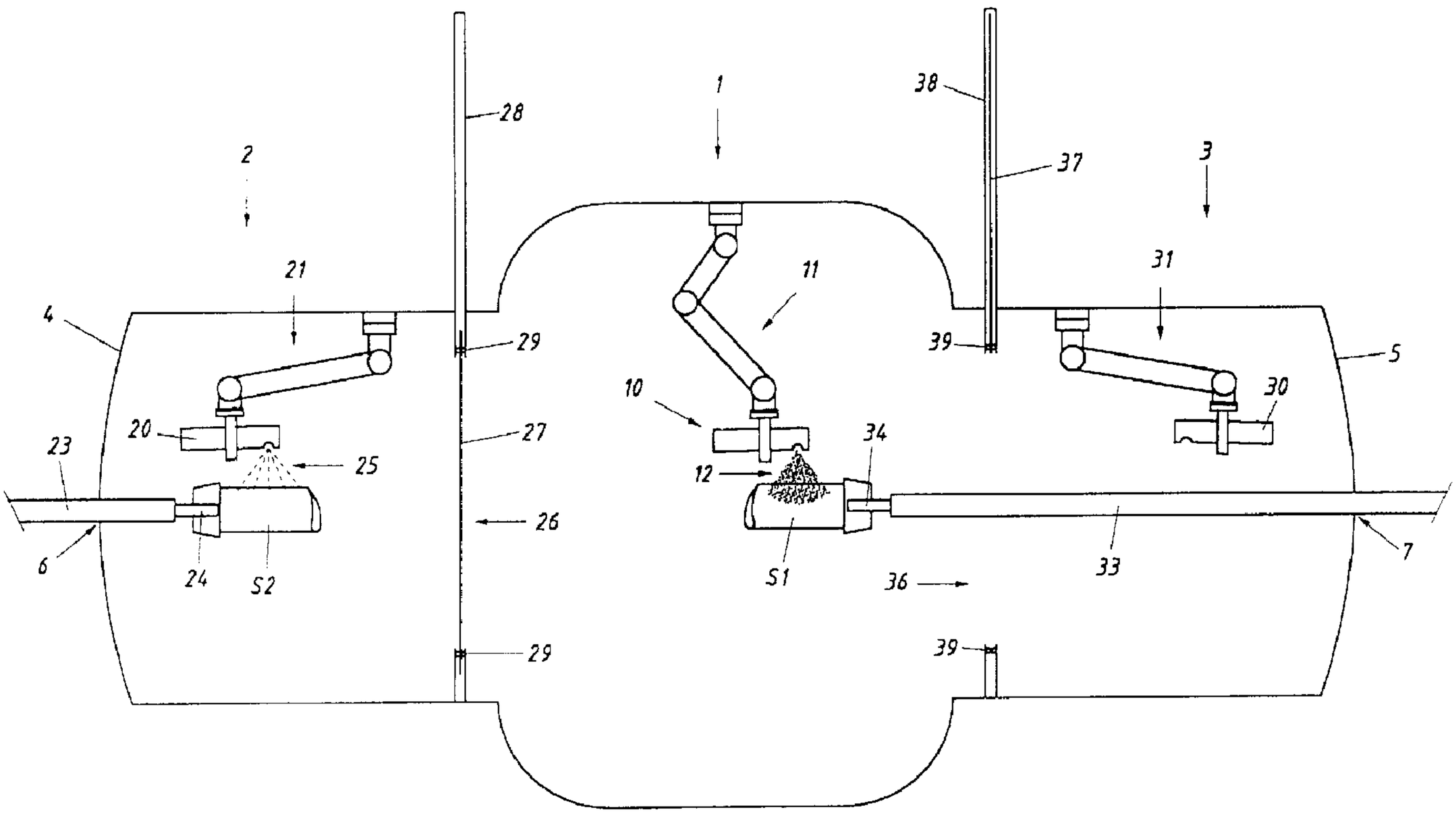
(72) Inventeur/Inventor:
KELLER, SILVANO, CH

(73) Propriétaire/Owner:
SULZER METCO AG, CH

(74) Agent: CASSAN MACLEAN

(54) Titre : UNE METHODE ET UN APPAREIL POUR TRAITER LA SURFACE DE SUBSTRATS AVEC UN PLASMA
(54) Title: A METHOD AND AN APPARATUS FOR PLASMA TREATING THE SURFACE OF SUBSTRATES



(57) Abrégé/Abstract:
An apparatus for plasma surface treating of substrates comprises a treatment chamber that can be evacuated as well as two adjoining pre-treatment chambers that can be evacuated as well. Both of the pre-treatment chambers are provided with a plasmatron. While a first substrate is plasma coated in the treatment chamber, a second substrate to be subsequently plasma coated is simultaneously pre-treated in a pre-treatment chamber by means of the plasmatron received in that chamber. For this purpose, the second substrate is alternately heated and cleaned, whereby the second substrate, during the cleaning operation, is connected as cathode to create an electric arc between the substrate and the plasmatron. By means of such a method and such an apparatus, the throughput can be substantially increased, while the quality of the coating meets the highest requirements.

Abstract of the Disclosure

An apparatus for plasma surface treating of substrates comprises a treatment chamber that can be evacuated as well as two adjoining pre-treatment chambers that can be evacuated as well. Both of the pre-treatment chambers are provided with a plasmatron. While a first substrate is plasma coated in the treatment chamber, a second substrate to be subsequently plasma coated is simultaneously pre-treated in a pre-treatment chamber by means of the plasmatron received in that chamber. For this purpose, the second substrate is alternately heated and cleaned, whereby the second substrate, during the cleaning operation, is connected as cathode to create an electric arc between the substrate and the plasmatron. By means of such a method and such an apparatus, the throughput can be substantially increased, while the quality of the coating meets the highest requirements.

A METHOD AND AN APPARATUS FOR PLASMA TREATING THE SURFACE OF SUBSTRATES

Background of the Invention

The present invention refers to a method and an apparatus for plasma treating the surface of substrates.

In order to get an optimum quality of a coating that has been applied to the surface of a substrate by means of a plasma spraying apparatus, on the one hand, the surface of the substrate must be as clean as possible and, on the other hand, the substrate to be coated has to be heated to a certain temperature. Both of these requirements contribute to a perfect adhesion of the coating to the surface of the substrate.

Prior Art

In most cases, the coating operation of the surface of substrates takes place in a treatment chamber in which usually a subatmospheric pressure is created in order to avoid that the surface of the substrate to be coated oxidizes. In the methods known in the prior art, the substrate to be coated is inserted into the treatment chamber in the interior of which it is first cleaned, then heated and finally coated. The result is that the duration of the entire treatment operation not only depends on the time it takes to coat the surface of the substrate, but that duration is substantially increased by the cleaning and heating steps.

Objects of the Invention

Thus, it is an object of the invention to provide a method for plasma treating the surface of substrates by means of which the duration of the entire treatment operation of the substrate can be substantially decreased and, thereby, the throughput substantially increased without impairing the high quality of the coating applied to the surface of the substrate.

It is a further object of the invention to provide an apparatus for plasma treating the surface of substrates by means of which the duration of the entire treatment operation of the substrate can be substantially decreased and, thereby, the throughput substantially increased without impairing the high quality of the coating applied to the surface of the substrate.

Summary of the Invention

In order to meet these and other objects, the invention provides, according to a first aspect, a method for plasma treating the surface of substrates in which a first substrate is coated by a plasma coating apparatus in the interior of a treatment chamber while, simultaneously, a second substrate to be subsequently coated is pre-treated outside of that treatment chamber.

According to a second aspect, the invention provides an apparatus for plasma treating the surface of substrates, comprising a treatment chamber, a device for creating a subatmospheric pressure in the treatment chamber, and a plasma spraying apparatus located in the interior of the treatment chamber.

The apparatus further comprises at least one pre-treatment chamber, a device for creating a subatmospheric pressure in the pre-treatment chamber, and a plasmatron located in the interior of the pre-treatment chamber.

Due to the fact that the time consuming pre-treatment operation of the substrate, that has to be done before the real coating operation of the surface of the substrate, is performed outside of the treatment chamber, a first substrate can be plasma coated in the interior of the treatment chamber, while simultaneously a second substrate to be subsequently coated can be pre-treated outside of the treatment chamber. The result is that the dwell time of the substrate in the treatment chamber can be shortened and the throughput substantially increased. It should be noted that the expression "simultaneously" shall be understood in a sense that the pre-treatment operation and the coating operation take place simultaneously at least during a portion of the required time, i.e. at least partially overlap. On no account the expression "simultaneously" should be interpreted such that both operations have to be started at the same moment or have to end at the same moment.

Experience has shown that the time required for the pre-treatment, i.e. for cleaning and heating the substrate, can vary between 50% and 200% of the time required to plasma coat the surface of the substrate. In other words, using the method and the apparatus according to the present invention in which the pre-treatment of a substrate is performed outside the treatment chamber, the throughput can be increased by appr. 50% to 100%.

Brief Description of the Drawings

In the following, the method and an embodiment of the apparatus according to the invention will be further described, with reference to the accompanying drawings, in which:

Fig. 1 shows the apparatus in a first phase of operation;

Fig. 2 shows the apparatus in a second phase of operation;

Fig. 3 shows the apparatus in a third phase of operation;

Fig. 4 shows the apparatus in a fourth phase of operation;

Fig. 5 shows the apparatus in a fifth phase of operation.

Detailed Description of the Method and of a preferred Embodiment of the Apparatus

First, the general layout of the apparatus of the invention will be described in more detail with the aid of Figs. 1 and 2 showing the apparatus during two different phases of operation. Since the basic principle of pre-treating and coating of a substrate by means of a plasmatron is well known to any person skilled in the art, in the following, only the characteristics will be further discussed that are essential in connection with the present invention. Moreover, in the present example, it is assumed that the substrates that have to undergo a surface treatment by means of a plasma torch are made of metallic material.

The apparatus according to the invention comprises a central treating chamber 1 in which a plasma spraying apparatus 10 is received. The plasma spraying apparatus 10 is mounted on a first swiveling supporting apparatus 11 that can be moved along three orthogonal axes within a Cartesian coordinate system. At the left side next to the

central treating chamber 1, a first pre-treating chamber 2 is provided, while a second pre-treating chamber 3 is located at the right side next to the central treating chamber 1. The first pre-treating chamber 2 is provided with a first removable cover 4, and the second pre-treating chamber 3 is provided with a second removable cover 5. The covers 4, 5 being removed, a substrate S1 and S2, respectively, can be inserted into the pre-treating chambers 2, 3 and removed therefrom, respectively.

The first pre-treating chamber 2 comprises a plasmatron 20 mounted in its interior by means of a second swiveling supporting apparatus 21, and the second pre-treating chamber 3 comprises a plasmatron 30 mounted in its interior by means of a third swiveling supporting apparatus 31. Moreover, the first pre-treating chamber 2 is provided with a first supporting member 23 adapted to receive the substrate S2, while the second pre-treating chamber 3 is provided with a second supporting member 33 adapted to receive the substrate S1. At the end of the first supporting member 23, a first clamping member 24 is attached by means of which the substrate S2 can be clamped to the supporting member 23, and at the end of the second supporting member 33, a second clamping member 34 is attached by means of which the substrate S1 can be clamped to the supporting member 33. Each of the first and second covers 4 and 5, respectively, is provided with an opening 6 and 7, respectively, through which the first and second supporting members 23 and 33, respectively, extend.

The first and second supporting members 23 and 33, respectively, are movable along their longitudinal axes to such an extent that the particular substrate S2 and S1, respectively, can be fixed to the first and second supporting members 23 and 33, respectively, and clamped by the first and second clamping members 24 and 34, respec-

tively, outside of the first and second pre-treatment chambers 2 and 3, respectively, and that the substrates S2 and S1, respectively, can be displaced into the central treatment chamber 1 by means of the supporting members 23 and 24, respectively. Moreover, the supporting members 23 and 24, respectively, are rotatable around their longitudinal axes such that the substrates S2 and S1, respectively, can be rotated into an optimal position both during the pre-treatment as well as during the coating operation in order to realize an even pre-treatment and coating, respectively.

Between the central treatment chamber 1 and the first pre-treatment chamber 2, a first slide member 27 is provided, and between the central treatment chamber 1 and the second pre-treatment chamber 3, a second slide member 37 is provided. Thus, the central treatment chamber 1 can be tightly closed with regard to the first and second pre-treatment chambers 2 and 3. The first and second slide members 27 and 37, respectively, are of essential circular shape and are received in first and second guide members 28 and 38, respectively.

As can be seen from Figs. 1 and 2, the first slide member 27 is in its closed position such that the central treatment chamber 1 is separated from the first pre-treatment chamber 2. In order to avoid an exchange of gas between the first pre-treatment chamber 2 and the central treatment chamber 1, as well as between the first and second pre-treatment chambers 2 and 3, respectively, and the ambient atmosphere, the first and second guide members 28 and 38, respectively, are provided with sealing members 29 and 39, respectively. It is understood that also the first and second covers 4 and 5, respectively, are provided with sealing members; however, for the sake of clarity, that sealing members are not shown in the drawings.

In order to evacuate the central treatment chamber 1 as well as the first and second pre-treatment chambers 2 and 3, there is provided an evacuation apparatus that is, again for the sake of clarity, not shown in the drawings as well. Moreover, such evacuation apparatuses being well known to every person skilled in the art removes the need to further discuss them here.

In the following, the method of the invention as well as the mode of operation of the apparatus will be further explained with reference to Figs. 1-5.

Fig. 1 shows a first phase of operation; thereby, the second slide member 37 located between the central treatment chamber 1 and the second pre-treatment chamber 3 is in its open position, while the first slide member 27 located between the central treatment chamber 1 and the first pre-treatment chamber 2 is in its closed position. By this measure, both in the central treatment chamber 1 and in the first pre-treatment chamber 2, in each case a gaseous atmosphere can be created that is best suited to the particular operation to be performed; thus, a mutual influencing of or an interference between the different operations, - coating the substrate S1 in the central treatment chamber 1 and pre-treating the substrate S2 in the first pre-treatment chamber 2 -, can be avoided. Anyway, in the present example, both in the central treatment chamber 1 and in the first pre-treatment chamber 2, a subatmospheric pressure in the order of appr. 10 to 50 mbar is maintained.

The first substrate S1 clamped to the second supporting member 33 is coated by means of the plasma spraying apparatus 10 located in the central treatment chamber 1. The coating jet escaping from the plasma spraying apparatus 10 is designated by reference numeral 12. Simultaneously, as the substrate S1 is coated, the second substrate

S2 is pre-treated by means of the plasmatron 20 located in the first pre-treatment chamber 2. The expression "pre-treating" shall be understood, in the present case, as an operation comprising cleaning and heating the substrate S2. In Fig. 1, the heating operation is shown; this is accomplished by means of a plasma torch 25 generated by the plasmatron 20; in Fig. 2, the cleaning operation is illustrated; this is realized by generating an electric arc 25A between the plasmatron 20 and the substrate S2. Due to the fact that the substrate S2 is connected as the cathode, and further by the presence of the electric arc 25A, a flow of electrons takes place from the substrate S2 to the plasmatron 20, with the result that the surface of the substrate S2 is freed from contamination and oxides. That operation is well known to the person skilled in the art under the expression “sputtering”. In certain cases, it may be advantageous that the substrate S2 alternately is cleaned and heated. It is understood that the first substrate S1 has undergone a cleaning and heating process as well in a mode as explained herein before prior to being coated.

Once the first substrate S1 has been coated and the second substrate S2 has been cleaned and heated, the second supporting member 33 is moved to the right. As soon as the first substrate is in the interior of the second pre-treatment chamber 3, the second slide member 37 is moved from its open to its closed position (cf. Fig. 3) and, thereafter, the first slide member 27 is moved from its closed to its open position. In order to enable the second cover 5 of the second pre-treatment chamber 3 to be removed and the finally coated substrate S1 to be removed from the second pre-treatment chamber 3, the second pre-treatment chamber 3 is vented until its pressure corresponds to ambient atmospheric pressure. After the second cover 5 has been removed,

the second supporting member 33 is further moved to the right to such an extent that the finished substrate S1 can be removed from the second clamping member 34 and replaced by another one (cf. Fig. 4). Simultaneously, the second substrate S2 now can be displaced from the first pre-treatment chamber 2 into the central treatment chamber 1. Once the second supporting member 33, together with the new substrate, has been moved into the second pretreatment chamber 3, the second cover 5 is fixed to seal the second pre-treating chamber 3 and the latter one can be evacuated again.

Thereafter, the second substrate S2 now located in the central treatment chamber 1 can be coated by means of the plasma spraying apparatus 10, while the further substrate S3 is cleaned and heated by means of the plasmatron 30 located in the second pre-treatment chamber 3 in a kind as has been explained herein before.

Due to the fact that not only the first and second pre-treatment chambers 2 and 3, respectively, but also the central treatment chamber 1 can be evacuated, a particular substrate can be transported, after having been pre-treated, from the particular pre-treatment chamber 2 and 3, respectively, into the central treatment chamber 1 without the danger that the cleaned surface of the substrate is oxidizing again.

It is understood that the example described herein before represents only one of the possible variants of the method of the invention and of the apparatus of the invention, respectively. Particularly, within the scope of the appended claims, modified methods and apparatuses could be used as well. For example, instead of providing two pre-treatment chambers, onle one thereof or even three or more of them could be provided. Similarly, also the design and the arrangement of the supporting members could be constructed in a different manner.

WHAT IS CLAIMED IS:

1. A method for plasma treating the surface of substrates in which:
   - a first substrate is coated by a plasma coating means in the interior of a treatment chamber means while, simultaneously, a second substrate to be subsequently coated is pre-treated by means of a first plasmatron means in the interior of a first pre-treating chamber means;
   - removing said coated first substrate from said treatment chamber means and displacing said pre-treated second substrate from said pre-treatment chamber means into said treatment chamber means and plasma coating said second substrate in said treatment chamber means;
   - pre-treating a third substrate by means of an additional plasmatron in a second pre-treatment chamber means, while, simultaneously, said second substrate is coated in said treatment chamber means.

2. A method according to claim 1 in which said second substrate is connected to serve as a cathode whereby an electric arc is generated between said plasmatron means and said second substrate

3. A method according to claim 1 in which a subatmospheric pressure is generated in said treatment chamber means at least during said coating operation.

4. A method according to claim 1 in which a subatmospheric pressure is generated in said pre-treatment chamber means at least during said pre-treating operation.

5. A method according to claim 1 in which substrates to be subsequently coated are alternately pre-treated in the first pre-treatment chamber means and in the second pre-treatment chamber means, respectively.

6. A method according to claim 1 in which one of said first and second pre-treatment chamber means, in which a pre-treatment of the substrate is in progress, is tightly closed both with regard to the ambient atmosphere and with regard to said treatment chamber means.

7. A method according to claim 1 in which said first substrate and/or said plasma coating means is/are moved relative to each other during said coating operation.

8. A method according to claim 1 in which said second substrate and/or said plasmatron is/are moved relative to each other during the pretreatment operation.

9. An apparatus for plasma treating the surface of substrates, comprising:

- a treatment chamber means;
- a means for creating a subatmospheric pressure in said treatment chamber means;
- a plasma spraying means located in said treatment chamber means;
- two pre-treatment chamber means for pre-treating substrates to be subsequently displaced into said treatment chamber means,

characterized in that,

- the interiors of both a first pre-treatment chamber means and a second pre-treatment chamber means are connected to the interior of said treatment chamber means of a first and a second opening, respectively, whereby first means are provided to tightly close said first opening, and whereby second means are provided to tightly close said second opening and that a plasmatron means is located in each pre-treatment chamber means for pre-treating substrates to be subsequently coated in said treatment chamber means and that the first and the second pre-treatment chamber means each are provided with elongate supporting means adapted for holding substrates.

10. An apparatus according to claim 9, comprising a single pre-treatment

chamber means.

11. An apparatus according to claim 10 in which the interior of said pre-treatment chamber means is connected to the interior of said treatment chamber means by means of the opening, whereby means are provided to tightly close said opening.

12. An apparatus according to claim 9 in which said first and a second means, respectively, to tightly close said first and second openings, respectively, are designed as slide member means.

13. An apparatus according to claim 9 in which said first and second pre-treatment chamber means each are provided with a removable cover means, whereby each of said cover means comprises an opening through which said supporting means extend.

14. An apparatus according to claim 9 in which each of said supporting means is movable along its longitudinal axis, whereby the path of movement corresponds at least to the lengths of said pre-treatment chamber means.

15. An apparatus according to claim 9 in which each of said elongate supporting means is provided with a clamping means fixed to the free end thereof.

16. An apparatus according to claim 15 in which at least said clamping means is rotatable.

17. An apparatus according to claim 9 in which said first and second pre-treatment chamber means are located on diametrically opposite sides of said treatment chamber means.

18. An apparatus according to claim 14 in which said path of movement is such that said substrate held by said supporting means is displaceable from said pre-treatment chamber means into said treatment chamber means and vice versa.

CASSAN MACLEAN
Suite 401, 80 Aberdeen Street
Ottawa, Ontario
K1S 5R5

Agents for the Applicant

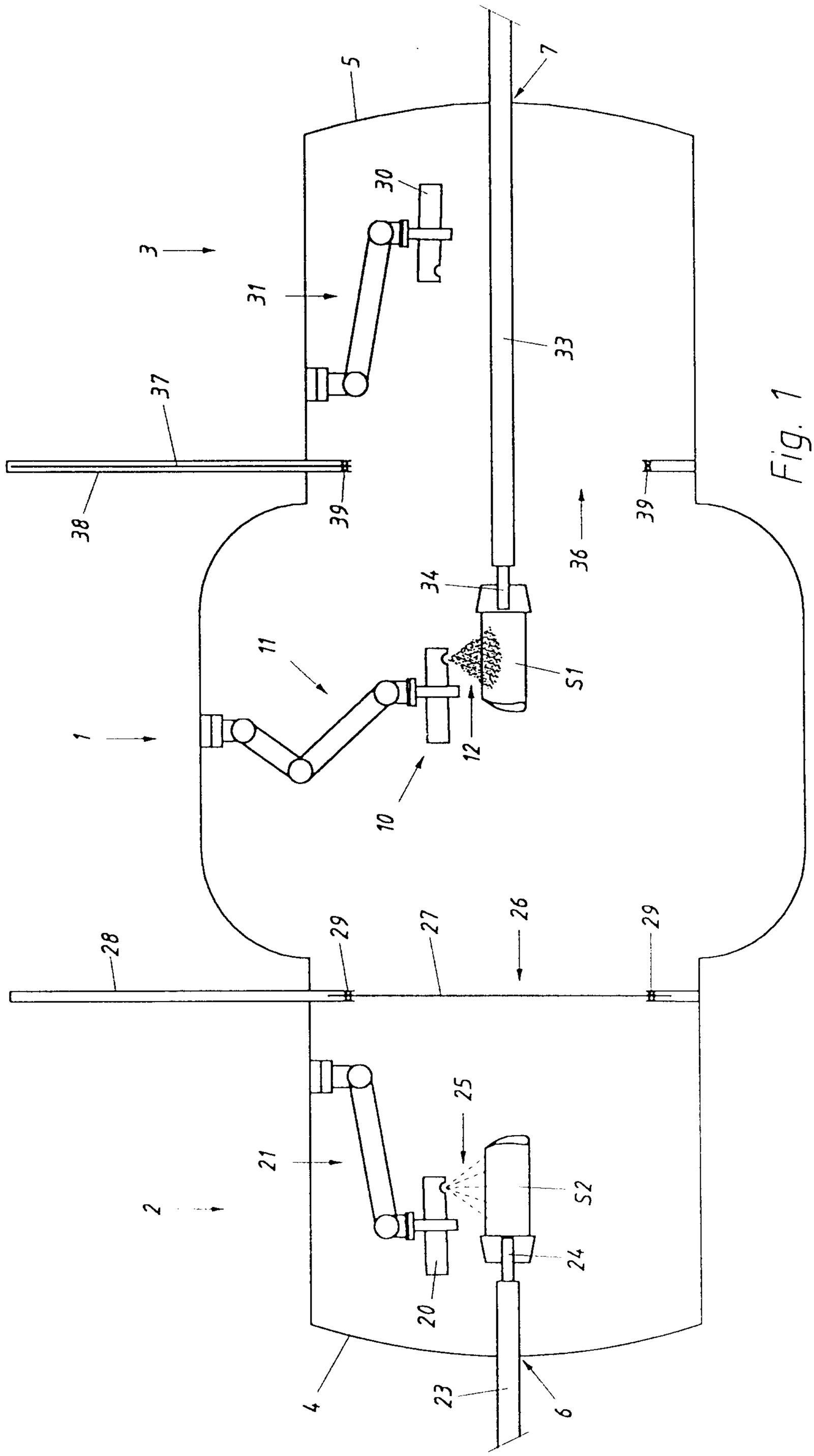

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Fig. 1

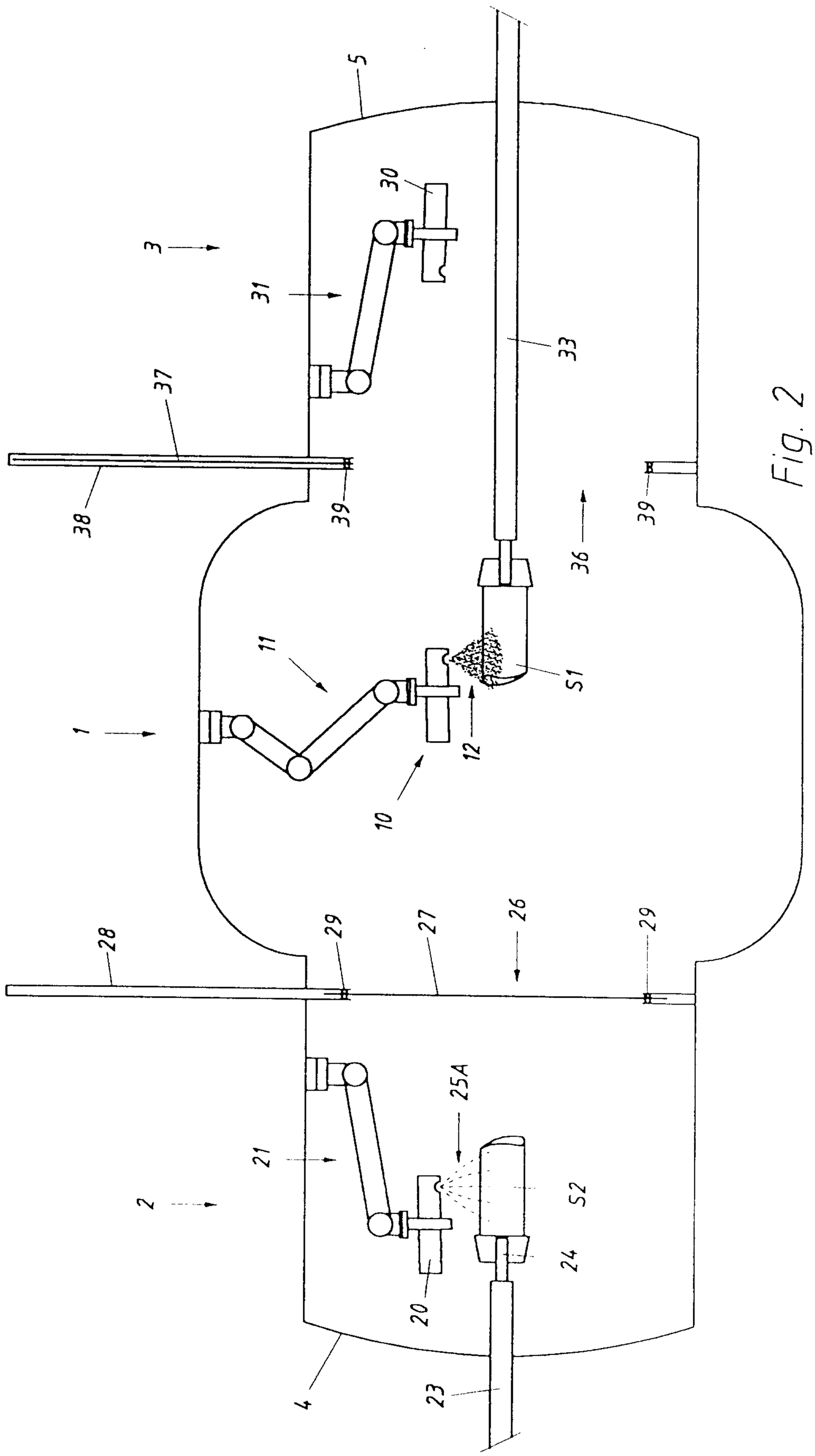
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Fig. 2

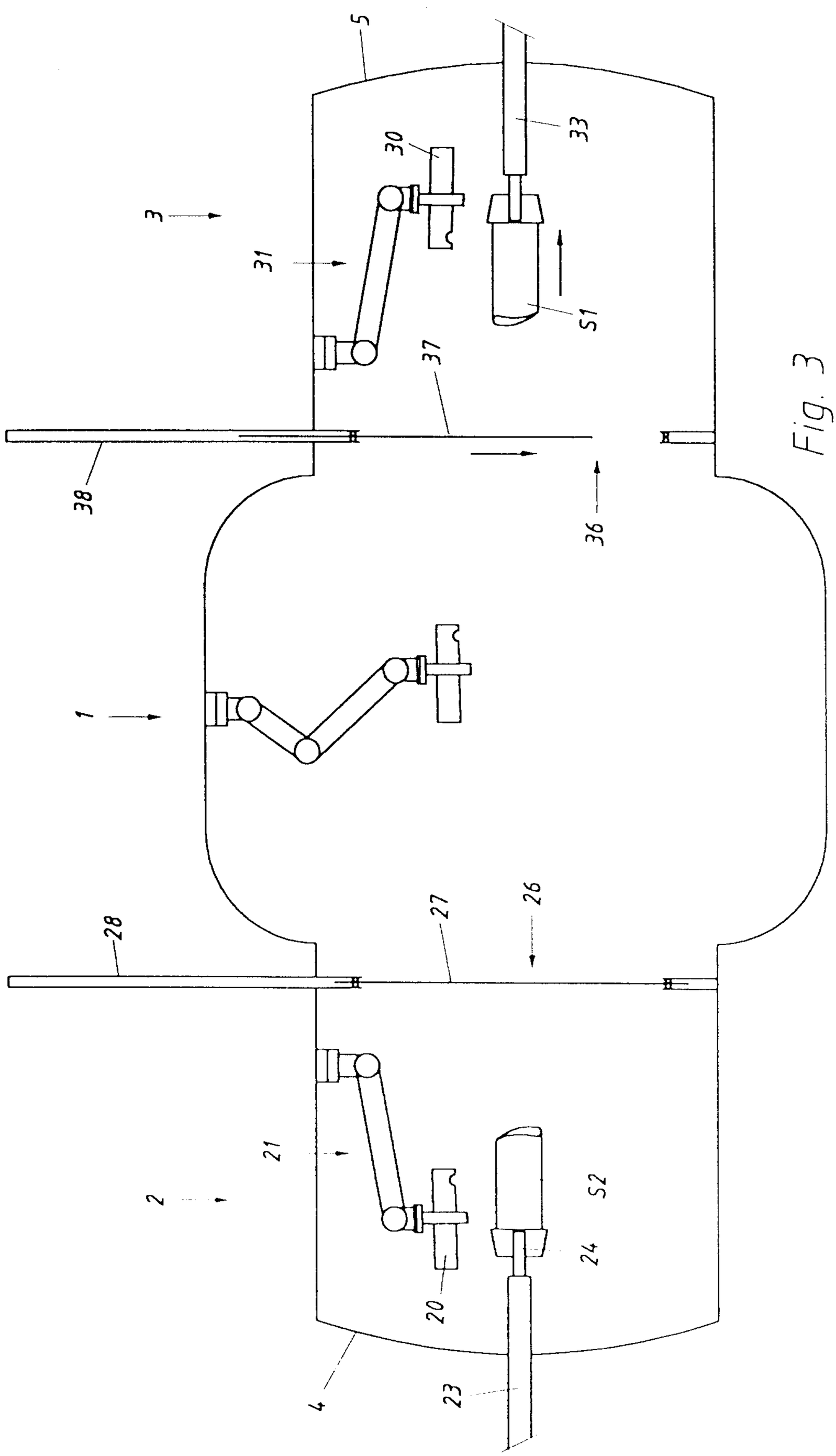


Fig. 3

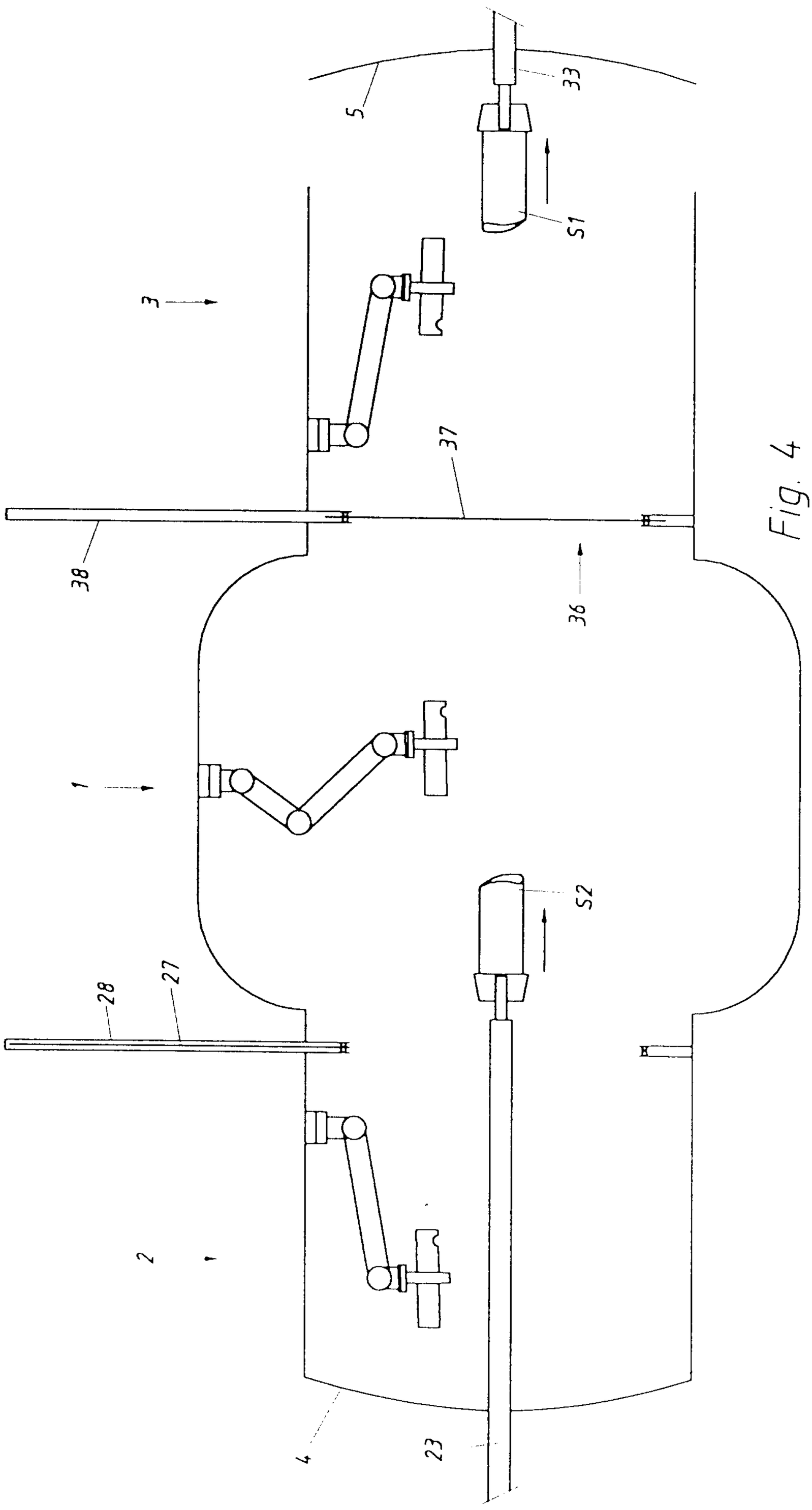


Fig. 4

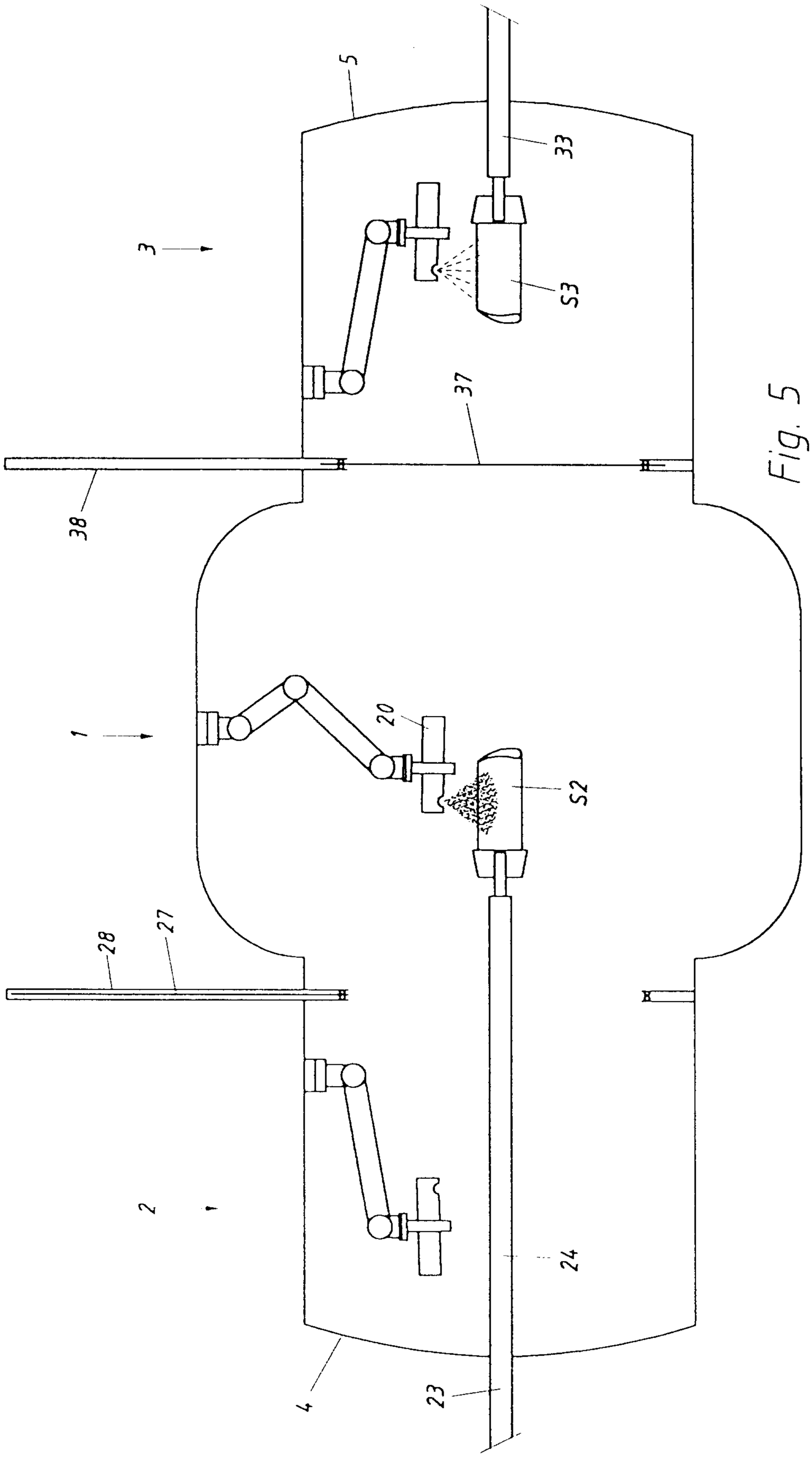
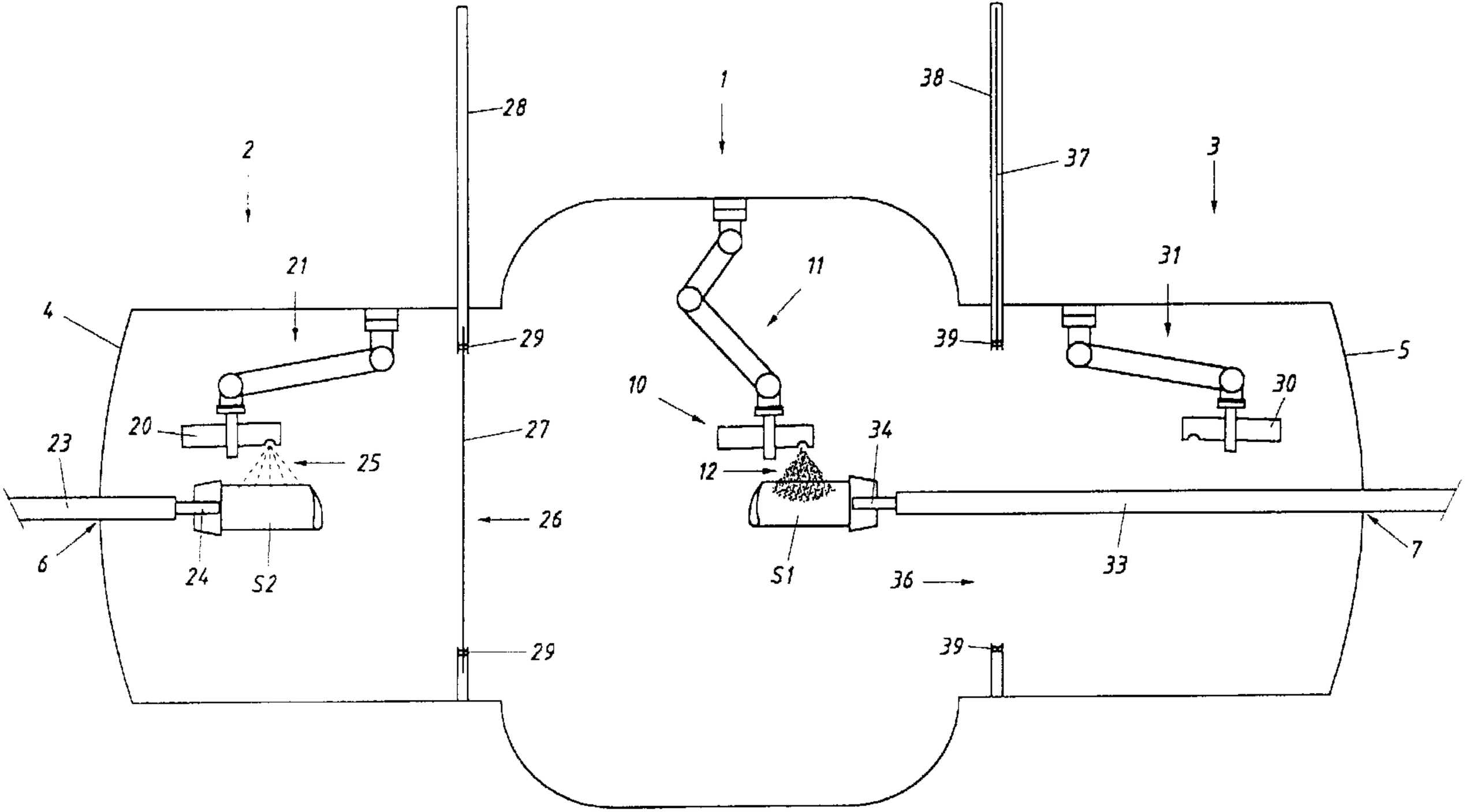


Fig. 5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