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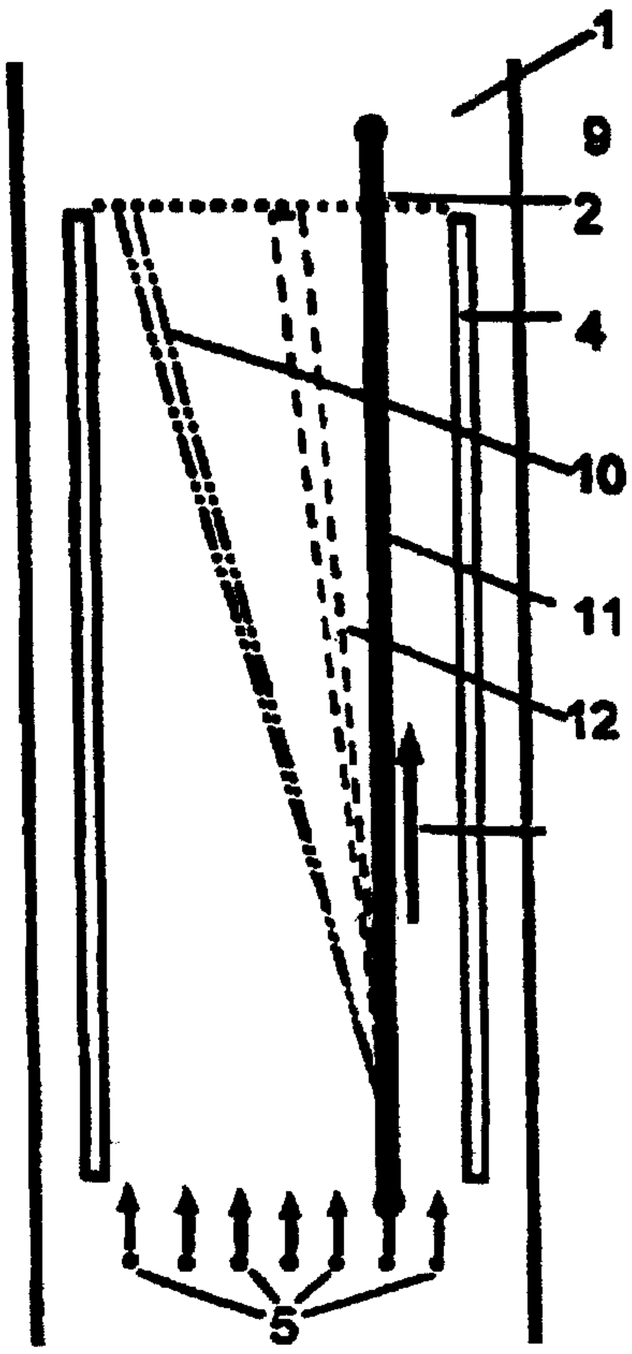

(57) Abrégé/Abstract:
The invention relates to an electrophoresis device comprising a separation chamber that is provided with at least one sample inlet on the inlet side and outlets (9) for the electrophoretically treated sample species on the outlet side. The separation chamber is

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(57) Abrégé(suite)/Abstract(continued):
divided into two chamber parts (7, 8) by at least one separation element (2) which is selectively permeable for specific sample species and has a continuos inner space extending longitudinally, especially a hollow fiber, from the inlet to the outlet side. Electrodes (4) are disposed parallel to the separation element on both sides of the separation chamber.

Abstract

The invention relates to an electrophoresis device comprising a separation chamber that is provided with at least one sample inlet on the inlet side and outlets (9) for the electrophoretically treated sample species on the outlet side. The separation chamber is divided into two chamber parts (7, 8) by at least one separation element (2) which is selectively permeable for specific sample species and has a continuos inner space extending longitudinally, especially a hollow fiber, from the inlet to the outlet side. Electrodes (4) are disposed parallel to the separation element on both sides of the separation chamber.

ELECTROPHORESIS DEVICE, ELECTROPHORESIS METHOD USING AN ELECTROPHORESIS DEVICE AND USE OF THE ELECTROPHORESIS DEVICE

The invention relates to an electrophoresis device, an electrophoresis method using an electrophoresis device and the use of the electrophoresis device.

Electrophoresis devices and electrophoretic separation methods are known in which sample substances are fractionated, at the interface between the liquid phase and the solid phase, into the individual sample species.

An analogous separation method, namely pressure filtration, has already been used in industry on a broad scale and is widely used to separate biopolymers. In comparison, electrophoretic separation, i.e. the so-called electrophoretic filtration process or, in short, electrofiltration is used rarely on the whole, although this process appears to be particularly advantageous since - in contrast to pressure filtration - it is not the entire sample volume but only the ionic species and not the entire volume of the solvent which need to be transported during the electrophoretic transfer via the separation membrane provided in the separation chambers of the corresponding electrophoresis device. The reason for the rare application of the electrofiltration process is based on the fact that problems occur in particular during the separation of biopolymers according to this process, which problems appear to reside inter alia in the irreversible sorption and denaturisation of the biopolymers, the restriction imposed on electrofiltration by technical problems in the optimum dissipation of the heat which arises during the electrophoretic process and in the changes in the

separation characteristics of the material of the solid phase, i.e. the separation membrane.

Irreversible sorption at the interface between the liquid phase and the solid phase, i.e. the separation membrane, can be largely minimised by using biocompatible synthetic resin membranes, though it has so far not been possible to prevent the change in the separating characteristics of the membrane after a prolonged period of contact with the biopolymers to be separated, which is referred to as "fouling".

The problems which occur during the use of electrofiltration as a result of the heat development inherent in this separation process decisively restrict, in practice, both the application range of this process and the quantitative throughput in comparison with pressure filtration. In the case of an unfavourable increased development of heat in the material of the separation membrane, the characteristic separation properties can be significantly altered and, as a result, the material can even be destroyed as a result of overheating.

Moreover, electrophoretic separation methods for separating bioparticles in aqueous solution, which are referred to as carrierless electrophoresis or free flow electrophoresis (FFE), and corresponding electrophoretic separation devices are known. During this electrophoretic separation of bioparticles in aqueous solution, media with a high conductivity need to be used in order to maintain the vitality of the bioparticles during and after separation. For this purpose, it is necessary inter alia to solve the problem of the optimum removal of heat from the separation chamber since rising temperatures in the separation chamber cause a substantial deterioration in the

separation performance. This means that, for an optimisation to be achieved, the temperature gradients at every point in the separation chamber gap as well as the temperature differences at the different points in the separation space need to be minimised. In order to improve the separation performance of FFE, the separation of the bioparticles must also take place with the electrical field strengths being as high as possible which, as a result of the high conductivity of the media, leads to a more than proportional increase in the process heat evolved during the separation process.

The electrophoresis devices available on the market for separating bioparticles, which operate according to the FFE process, have therefore been optimised insofar as, on the one hand, an electrical field strength necessary for the desired separation performance was used and, simultaneously, an optimum elimination of the process heat was achieved by selecting as small as possible a separation chamber gap.

Moreover, from DE 69 029 466 T2, an electrophoresis device with longitudinal hollow fibres is known which are used to pass through a cooling medium.

In comparison, the object on which the invention is based consists of creating a high performance electrophoresis device operating at high speed.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, there is provided an electrophoresis device comprising: a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for electrophoretically treated sample species; at least one separation element selectively permeable to certain

samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into two chamber parts; and electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element, wherein the separation element is formed by a groove-shaped depression in an inside surface of the separation chamber and a facing shut-off device of the separation chamber, and wherein the separation element contains holes between the separation chamber and the groove-shaped depression for introduction and discharge.

The electrophoresis device according to the invention operates according to a combined process of electrofiltration and FFE such that the electrofiltration is carried out under the boundary conditions of an optimised FFE separation process permitting a rapid electrofiltration process and simultaneously avoiding the problems, caused by overheating, of the change in the separation characteristics and a possible destruction of the membrane material.

In accordance with a further aspect of the present invention there is provided an electrophoresis method comprising: the steps of providing an electrophoresis device having a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for electrophoretically treated sample species; at least one separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into two chamber parts; and electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element; applying a direct voltage to the electrodes of said electrophoresis device; and periodically connecting and disconnecting said direct voltage during active electrophoresis.

In accordance with another aspect of the present invention there is provided An electrophoresis method comprising: the steps of providing an electrophoresis device having a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for the electrophoretically treated sample species; at least one separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into two chamber parts; and electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element; and applying a direct voltage, the polarity of which is periodically reversed, to the electrodes of said electrophoresis device, wherein an application period with a polarity of the direct voltage opposite to a polarity of

the direct voltage during active electrophoresis is shorter than a period of the polarity of the direct voltage during active electrophoresis.

In accordance with still another aspect of the present invention there is provided an electrophoresis device comprising: a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for electrophoretically treated sample species; at least one separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into two chamber parts; and electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element, wherein the sample inlet introduces a sample into an interspace between the separation element and the electrodes.

In accordance with yet another aspect of the present invention there is provided an electrophoresis device comprising: a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for the collection of electrophoretically treated sample species; at least one separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into separation spaces; and electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element, wherein the outlets for the collection of electrophoretically treated sample species are outside the separation element.

In accordance with yet a further aspect of the present invention there is provided an electrophoresis device comprising: a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for the collection of electrophoretically treated sample species; a plurality of separation elements, arranged parallel to each other, each separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into separation spaces; and electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element, wherein the outlets for the collection of electrophoretically treated sample species are located in the separation spaces.

In the following, particularly preferred practical examples of the invention are described in further detail by way of the corresponding drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 shows a plan view of a first practical example of the electrophoresis device according to the invention,

- Figure 2 shows a sectional view of the practical example illustrated in Figure 1,

- Figure 3 shows a plan view of the practical example illustrated in Figure 1 with the introduction of the sample substance in the hollow fibre,

- Figure 4 shows a plan view of the practical example illustrated in Figure 1 with the introduction of the sample substance into the separation chamber,

- Figure 5 shows a plan view of the practical example illustrated in Figure 1 during the so-called immunoextraction,

- Figure 6 shows a plan view of a practical example of the electrophoresis device according to the invention, which corresponds to the practical example illustrated in Figure 1 but operates according to a simultaneous multiple process,

- Figure 7 shows a plan view of the practical example illustrated in Figure 1 in combination with FF isoelectric focusing,

- Figures 8A to 8C shows sectional views of further practical examples of the device according to the invention to illustrate the shape of the separation element and,

- Figures 9A to 9C are diagrammatic representations of the method of operation of the electrophoresis device according to the invention.

The practical example of the electrophoresis device according to the invention illustrated in Figure 1 exhibits a horizontally aligned FFE separation chamber with a small gap width of e.g. 0.3 to 1 mm, which is formed between a synthetic resin block 1 and a metal block 3 having an insulating cover. On the inlet side, the separation chamber is provided with at least one sample inlet and several media inlets 5 and on the outlet side with several outlets 9 for the sample species treated by electrophoresis.

In the separation chamber, a hollow fibre 2 passes from the inlet to the outlet side and separates the separation chamber into two separation chamber parts 7 and 8. Electrodes 4 are arranged parallel to the hollow fibre 3 on both sides of the separation chamber from the inlet to the outlet side. By appropriately poling the direct voltage applied to the electrodes, separation chamber part 7 becomes the separation space for anionic species and the separation chamber part 8 the separation space for cationic species. The electrode voltage is preferably selected in such a way that short migration paths of the species are sufficient for separation.

The hollow fibre 2 is provided with an inlet and an outlet and exhibits in its interior a continuous hollow

space leading from the inlet to the outlet. As illustrated in Figure 1, the hollow fibre 2 extends in the longitudinal direction beyond the outlets 9 for the separated species.

Before being introduced into the separation chamber, the hollow fibre 2 used has an outside diameter substantially larger than the width of the separation chamber spacer, the values of the wall thickness of the hollow fibre 2 being distinctly smaller than half of the width of the separation chamber gap. On introduction of the hollow fibre 2 into the separation chamber, the hollow fibre 2 is flattened in terms of its inner cross-section from a circular shape to an oval shape which, nevertheless, allows the unhindered passage of the sample substances to be separated.

The hollow fibre 2 is arranged parallel to the electrodes 4 within the electrophoretic separation chamber such that once the electrophoresis device illustrated in Figure 1 is supplied with an aqueous solution with salts dissolved therein and a direct voltage is applied to the electrodes 4, the ionic species in the liquid externally of and within the hollow fibre 2 are moved in the direction of the electrodes. The anionic and cationic species of the salt used migrate in the aqueous solution from the liquid phase through the hollow fibre 2 in the direction of the electrodes 4. Dissolved ionic polymers which, during the electrophoretic migration, reach the interface between the hollow fibre 2 and the aqueous solution, are retained on this interface if the pore size of the hollow fibre 2, compared with the size or the molecular weight of the ionic polymers, is sufficiently small. This retention of the polymeric species occurs equally in the aqueous phase outside the hollow fibre 2 and in the inner hollow space of

the hollow fibre 2. The material and the pore size of the hollow fibre 2 differ according to the application concerned, i.e. the samples to be treated, and are chosen correspondingly. The position, i.e. the correct placing of the hollow fibre 2 in the separation chamber, is also chosen as a function of the desired separation of the materials. As an example, a retention of an analyte at the phase boundary of the hollow fibre 2 is possible only if, following the addition of the sample, the migration takes place in the direction towards the hollow fibre.

The electrophoresis device illustrated in Figure 1 can be used for different applications, in particular for electrofiltration under FFE conditions without using it as a separation process, for two-stage separation optimised by making use of the possibilities of both separation processes, for electrofiltration as a measure for sample introduction in order to by-pass complex sample conditioning or to at least simplify it, or for a highly selective electrophoretic separation operation in electrofiltration, i.e. as immunoextraction.

For electrofiltration, the sample, which is to be fractionated by electrofiltration, can be introduced either via the inner hollow space of the hollow fibre 2 or into the interspace between an electrode 4 and the hollow fibre 2, which is illustrated respectively in Figures 3 and 4. In the case of the addition of the sample into the interspace between an electrode 4 and the hollow fibre 2, however, it is necessary to ensure that this addition is effected on the correct side since a retention at the phase boundary between the aqueous phase and the hollow fibre 2 can be expected only if the migration of the polymeric substance takes place in the direction towards the hollow fibre 2.

In Figure 3, in which the addition of the sample into the inner hollow space of the hollow fibre 2 is illustrated, the paths of three analytes are marked as 10, 11, and 12. This means, in particular, that the analyte 11 remains in the hollow fibre 2.

In Figure 4, the paths of the analytes starting out from a sample metering site 13 in the interspace between the hollow fibre 2 and an electrode 4 are also marked as 10, 11 and 12. In the case of this type of application, the analyte 11 is consequently retained on the outer surface, i.e. the interface between the liquid phase and the solid phase.

If the medium within the hollow fibre 2 exhibits different salts and different concentrations of the salts, compared with the medium outside the hollow fibre 2, the original salts within the hollow fibre 2 are substituted by the salts outside the hollow fibre and/or their concentrations are levelled; this is also called sample conditioning.

If the sample conditioned in this way is to be separated in a subsequent independent process, it is eluated from the inner hollow space of the hollow fibre 2, for which purpose the pore size of the hollow fibre 2 is selected to be sufficiently small in order to retain the ionic analytes of interest in the interior of the hollow fibre 2.

If simultaneous sample conditioning and electrophoretic separation by FEE are desirable, a hollow fibre 2 with a pore size must be used which allows the analytes to be separated to be conveyed from the inner hollow space of the hollow fibre 2 into the separation chamber.

An extraction of ionic species between two aqueous solutions is also possible via the sharp interface formed within the separation chamber; this, however, is feasible only if the rheological properties of the media forming this interface for the substance transfer are similar and the adjacent media can be transported through the separation chamber at a similar linear speed. In many cases, however, these boundary conditions are not fulfilled. If a hollow fibre 2 is used for the addition of a medium, the media within and outside of the hollow fibre 2 can be conveyed at different linear speeds and it is even possible to use media with extremely different physical and chemical properties such as density, viscosity, surface tension, electrical conductivity etc.

The direction of substance transfer and/or migration of the ionic species to be extracted can in this connection be selected almost at random; possibilities in this respect are illustrated in Figures 3 and 4 and have already been described above. This means that the transfer of substance can take place in the direction of the interspace between the hollow fibre 2 and an electrode 4 and along the hollow fibre 2.

A further application of the electrophoresis device illustrated in Figure 1 is the so-called immunoextraction illustrated in Figure 5. In this application, a component of an immunocomplex to be formed is dissolved in the medium within the hollow fibre 2 in any desired concentration. The molecular weight of this component and/or the separation boundary of the hollow fibre 2 are chosen in such a way that this component remains in the inner hollow space of the hollow fibre 2 even under electrophoresis conditions. As illustrated in detail in Figure 5, analyte 10 is thus

retained in the hollow fibre 2 as immunocomplex, analyte 11 is retained on the outside wall of the hollow fibre 2 and analyte 12 takes the path illustrated in the interspace between the hollow fibre 2 and an electrode 4.

In the case of the combined application of electrofiltration and FFE, conditioning of the sample, which is otherwise frequently necessary before FFE separation, can be omitted and in this way a dilution of the sample is avoidable which can negatively affect or diminish a successful separation and/or the desired sample throughput. The introduction of a sample, which is unsuitable for FFE a priori, into the separation chamber via the hollow fibre 2 in the way illustrated in Figure 3, enlarges the field of application of FFE, simplifies the preparation of the sample and handling of the device during routine use and increases the chances of automating the entire separation process.

All FFE separation techniques, i.e. FF zone electrophoresis, FF isotachophoresis, FF isoelectric focusing and FF field jump electrophoresis can be combined with the process of electrofiltration. In this respect, the combination with focusing FF separation techniques is particularly advantageous.

The combination of the separation technique of FF field jump electrophoresis with electrofiltration, in particular, provides the possibility of effecting the separation in a parallel simultaneous multiple process with an increased sample throughput. This combination in the form of a triple parallel simultaneous multiple process is illustrated in Figure 6 in which the interface of the media 6 (concentration of the ionic analytes) and the conductivity profile 7 are illustrated.

The combination of electrofiltration with the focusing FFE separation technique of FF isoelectric focusing and FF isotachophoresis provides an even better separation performance than the above-mentioned combination, although the execution of a simultaneous parallel process is not possible within the separation chamber.

Figure 7 shows the combination of electrofiltration with the separation technique of FF isoelectric focusing, whereby it is possible to transfer the substances to be separated alternatively from the hollow fibre 2 into the interspace between the hollow fibre 2 and the electrodes 4 or from this interspace into the hollow fibre 2, as has already been illustrated in Figures 3 and 4. The paths of the analytes are marked by 10 and 12, analyte 11 remains in the hollow fibre 2.

In Figures 8B and 8C, the alternative designs regarding the arrangement of a hollow fibre 2 are illustrated; they are shown once more in Figure 8A for comparison. Here, the migration of the anions and cations is marked as 14 and 15.

Figure 8B shows a practical example in which a flat membrane 16 is bonded to the inside surface of blocks 1 or 3, preferably to the inside surface of the synthetic resin block 1 such that a hollow space is formed between the inside surface of the synthetic resin block 1 and the flat membrane 16, the height of this hollow space being greater than the width of the separation chamber gap. Consequently, the flat membrane 16 divides the separation chamber in the same way as can be achieved by the hollow fibre 2 in the practical example illustrated in Figure 8A.

The introduction and discharge of the medium into or out of the hollow space in the flat membrane 16 takes

place, in this case, via holes in the synthetic resin block 1.

In the practical example illustrated in Figure 8C, a groove-type depression 19 is formed in the inner surface of preferably the synthetic resin block 1, instead of a premanufactured hollow fibre 2, and the holes for the introduction and discharge are covered with a flat membrane. In this way, a channel is formed which is filled with the sample to be separated. By shut-off 18 of the flow transport in the separation chamber above the flat membrane, the electrophoretic conveying of substance is deflected via the flat membrane and the depression 19 in the synthetic resin block 1 and the ionic species are transferred from the depression 19 via the flat membrane into the separation chamber. If necessary, the liquid of the depression 19 can be thermostabilised by means of external cooling.

As mentioned already at the beginning, the permeability of the filter membrane decreases during pressure filtration with an increasing duration of filtration and all the more rapidly the higher the content of polymers in the solution to be filtered is, this decrease in the permeability of the filter membrane being referred to as fouling in the membrane.

In the case of electrofiltration, on the other hand, the significance of fouling is considerably less pronounced since not the entire sample volume but only the ionic species in the sample are conveyed in the direction of the separation membrane; however, the influence of fouling is no longer negligible with high contents of ionic polymeric species which need to be retained on the separation membrane during a prolonged duration of filtration.

In contrast to pressure filtration in the case of which filtration with a cross-flow is known as a suitable counter-measure to reduce fouling, a cross-flow is achieved in the case of electrofiltration by the flow rate of the sample in the hollow fibre, but the flow rate is optimised not with regard to reducing fouling but to optimise the mass transfer via the membrane. In other words, this means that the cross-flow existing during electrofiltration is insufficient to effectively reduce or eliminate fouling.

A measure for reducing fouling further involves the selection of a pH of the solution to be filtered at which the charge on the polymers is reduced. In the case of biopolymers with amphoteric properties, a pH of the solution is selected which corresponds to the pH of the biopolymer or its main components. This means that the polymer remains unaffected by the electrical field strength.

The following modified electrofiltration process is considerably more effective in eliminating fouling:

In the case of the standard process of electrofiltration, a certain direct voltage or a certain electrical field strength is applied throughout the entire period of electrofiltration. With an increasing duration of electrofiltration, the inside surface of the hollow fibre and the space in the pores of the separation membrane are increasingly taken up by ionic polymers, possibly leading to the complete coverage of the inside surface of the separation membrane. As shown in Figure 9A, this results in a substantial reduction in the mass transfer via the membrane.

By periodically connecting and disconnecting the effective direct voltage, fouling can be reduced

substantially since a major portion of the polymer attached to the membrane during the electrofiltration period is conveyed further in the hollow fibre during the period of disconnected direct voltage and can be eluated from the hollow fibre after many periodic alternating connection and disconnection operations. This is illustrated in Figure 9B.

As a result of the unfavourable flow profile of the laminar flow in the inner space of the hollow fibre, polymers which are in the direct vicinity of the surface of the membrane are eluated only very slowly and the polymers in the pores remain unaffected by the measures of periodic connecting and disconnecting of the direct voltage. If, however, a process is used in the case of which, after a certain period of active electrofiltration, the polarity of the direct voltage is changed, though for a much shorter period, the polymers that have migrated into the pores are drawn in the direction of the opposite inside wall of the hollow fibre. If the duration of the reverse direct voltage is chosen such that a major proportion of the polymers is moved, during this period of the separation process, from the peripheral area and/or the pores into the centre of the hollow fibre, the polymers get into the area of maximum flow rate and, as a result, the polymers are highly effectively conveyed further within the hollow fibre and eluated following a few electrofiltration cycles and the effect of the changed polarity. This is illustrated in Figure 9C.

Active flushing of the wall surfaces and the pores by means of electrophoresis can additionally be enhanced by periodically changing the pressure within the hollow fibre such that, during the period of active electrophoretic flushing, the inside pressure in the hollow fibre is also

reduced in comparison with the outside space. In this way, flushing is enhanced by simultaneous pressure flushing in the same direction.

CLAIMS

1. An electrophoresis device comprising:

a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for electrophoretically treated sample species;

at least one separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into two chamber parts; and

electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element, wherein the separation element is formed by a groove-shaped depression in an inside surface of the separation chamber and a facing shut-off device of the separation chamber, and wherein the separation element contains holes between the separation chamber and the groove-shaped depression for introduction and discharge.

2. The electrophoresis device according to claim 1, wherein the holes are covered by a flat membrane.

3. The electrophoresis device according to claim 1, wherein the sample inlet leads into the inner hollow space of the separation element.

4. The electrophoresis device according to claim 1, wherein the sample inlet introduces a sample into an interspace between the separation element and the electrodes.

5. The electrophoresis device according to claim 1, wherein a plurality of separation elements are provided parallel to each other and capable of carrying out a simultaneous multiple electrophoresis in the separation chamber.

6. An electrophoresis method comprising:

the steps of providing an electrophoresis device having a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for electrophoretically treated sample species;

at least one separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into two chamber parts; and

electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element; applying a direct voltage to the electrodes of said electrophoresis device; and periodically connecting and disconnecting said direct voltage during active electrophoresis.

7. The electrophoresis method according to claim 6, wherein a temperature gradient in the separation chamber is maintained as low as possible.

8. An electrophoresis method comprising:

the steps of providing an electrophoresis device having a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for the electrophoretically treated sample species;

at least one separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into two chamber parts; and

electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element; and applying a direct voltage, the polarity of which is periodically reversed, to the electrodes of said electrophoresis device, wherein an application period with a polarity of the direct voltage opposite to a polarity of the direct voltage during active electrophoresis is shorter than a period of the polarity of the direct voltage during active electrophoresis.

9. The electrophoresis method according to claim 8, wherein a temperature gradient in the separation chamber is maintained as low as possible.

10. The electrophoresis method according to claim 8, comprising the further step of periodically altering the inside pressure of the separation element, as compared to the surrounding external space.

11. An electrophoresis device comprising:

a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for electrophoretically treated sample species;

at least one separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into two chamber parts; and

electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element, wherein the sample inlet introduces a sample into an interspace between the separation element and the electrodes.

12. An electrophoresis device comprising:

a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for the collection of electrophoretically treated sample species;

at least one separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into separation spaces; and

electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element,

wherein the outlets for the collection of electrophoretically treated sample species are outside the separation element.

13. An electrophoresis device comprising:

a separation chamber having an inlet side with at least one sample inlet and an outlet side having outlets for the collection of electrophoretically treated sample species;

a plurality of separation elements, arranged parallel to each other, each separation element selectively permeable to certain samples species, having a longitudinally extending continuous inner hollow space, which is arranged in the separation chamber from the inlet side to the outlet side and divides the separation chamber into separation spaces; and

electrodes which are arranged on opposing sides of the separation chamber parallel to the separation element, wherein the outlets for the collection of electrophoretically treated sample species are located in the separation spaces.

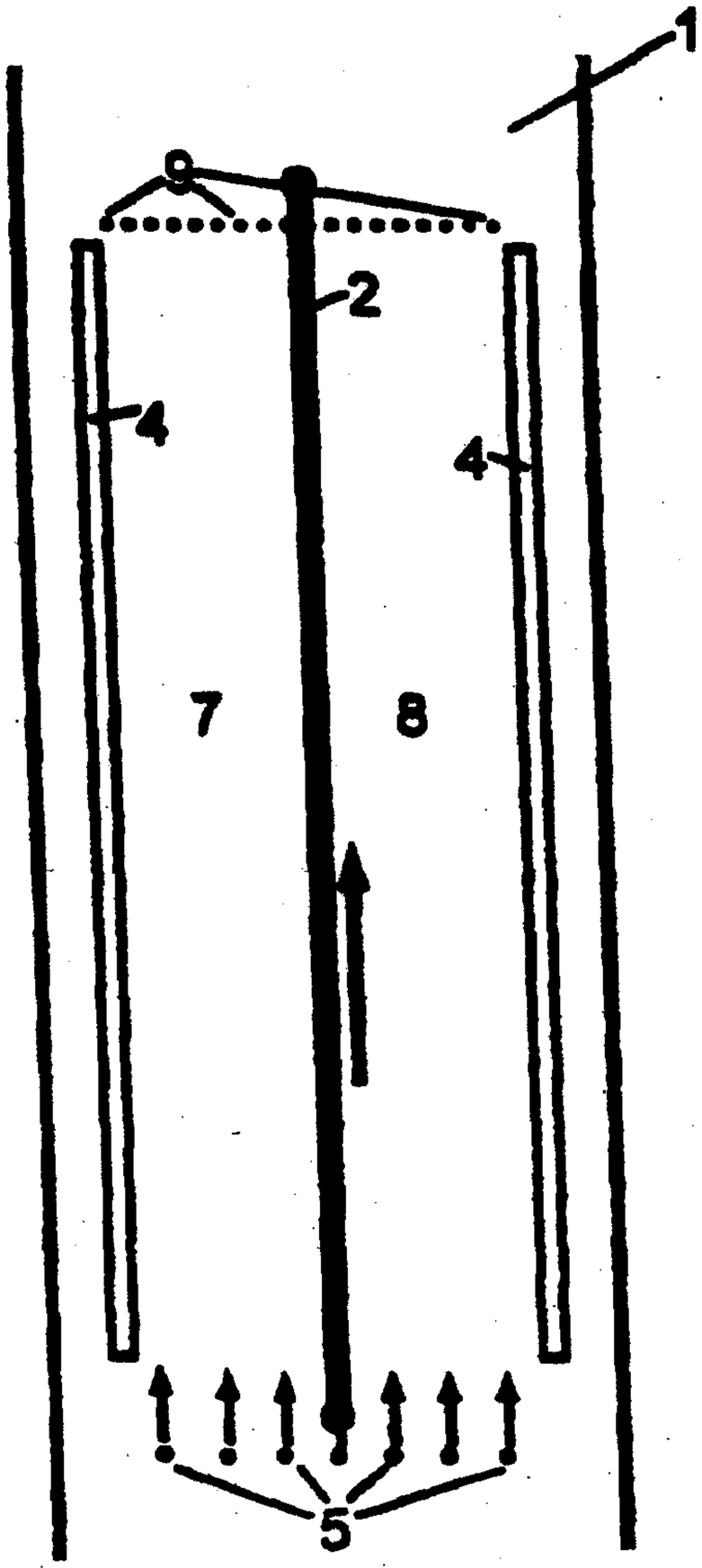


Fig. 1

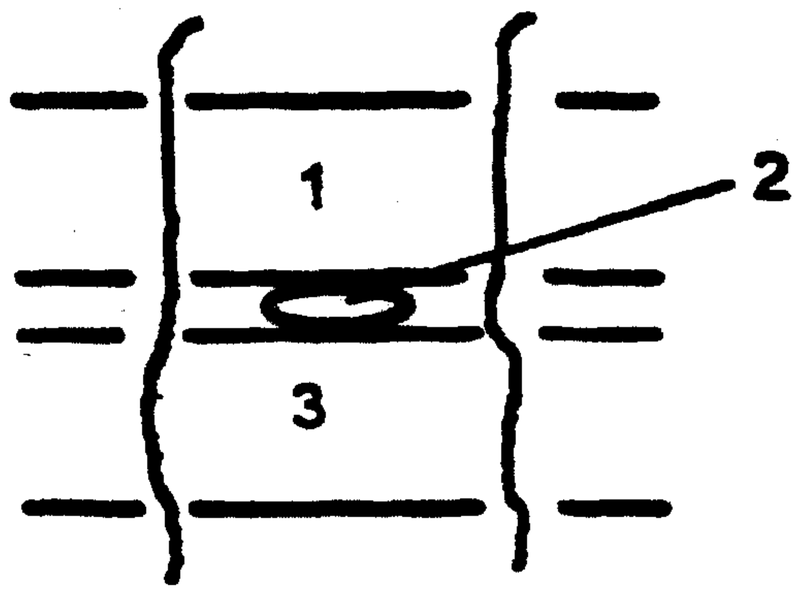


Fig. 2

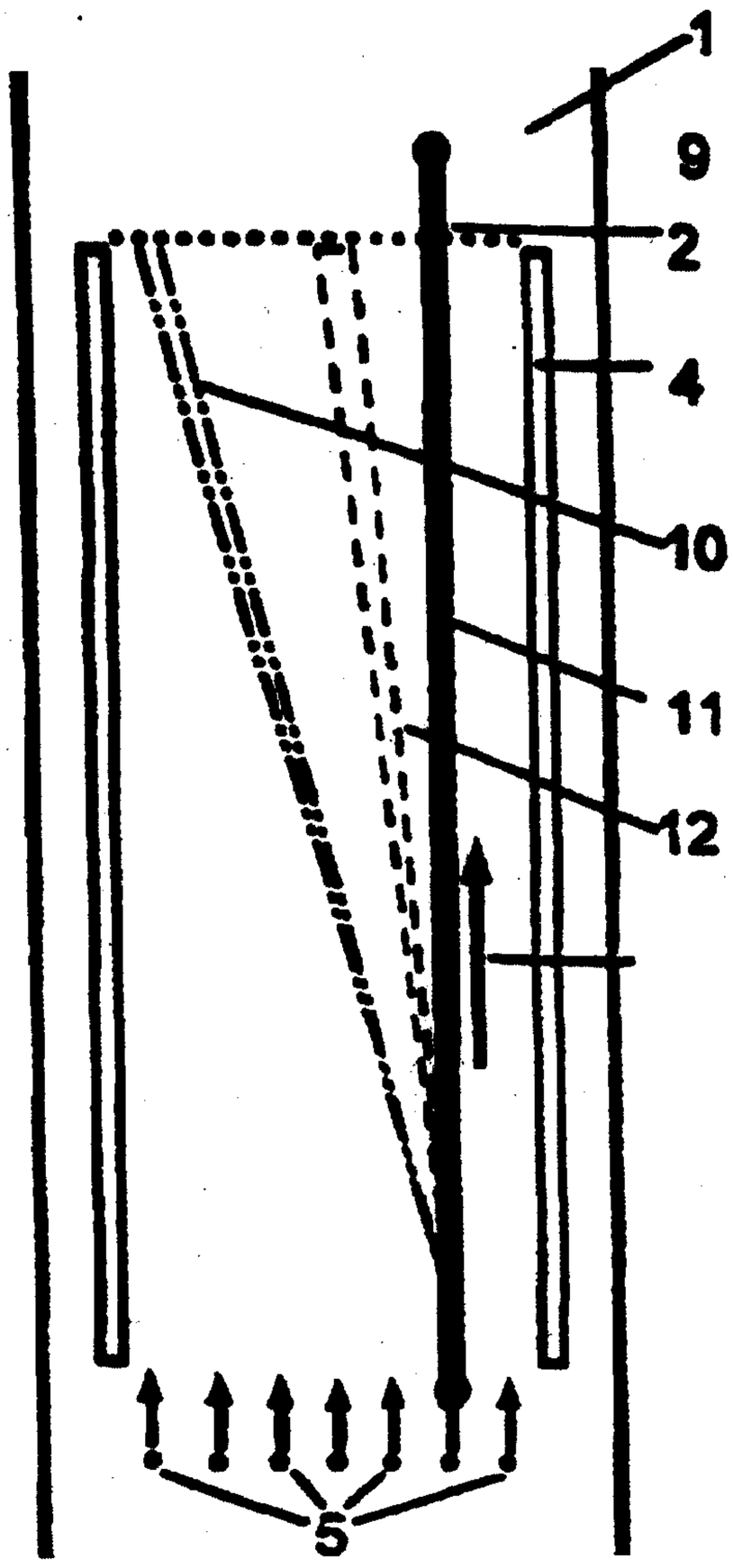


Fig. 3

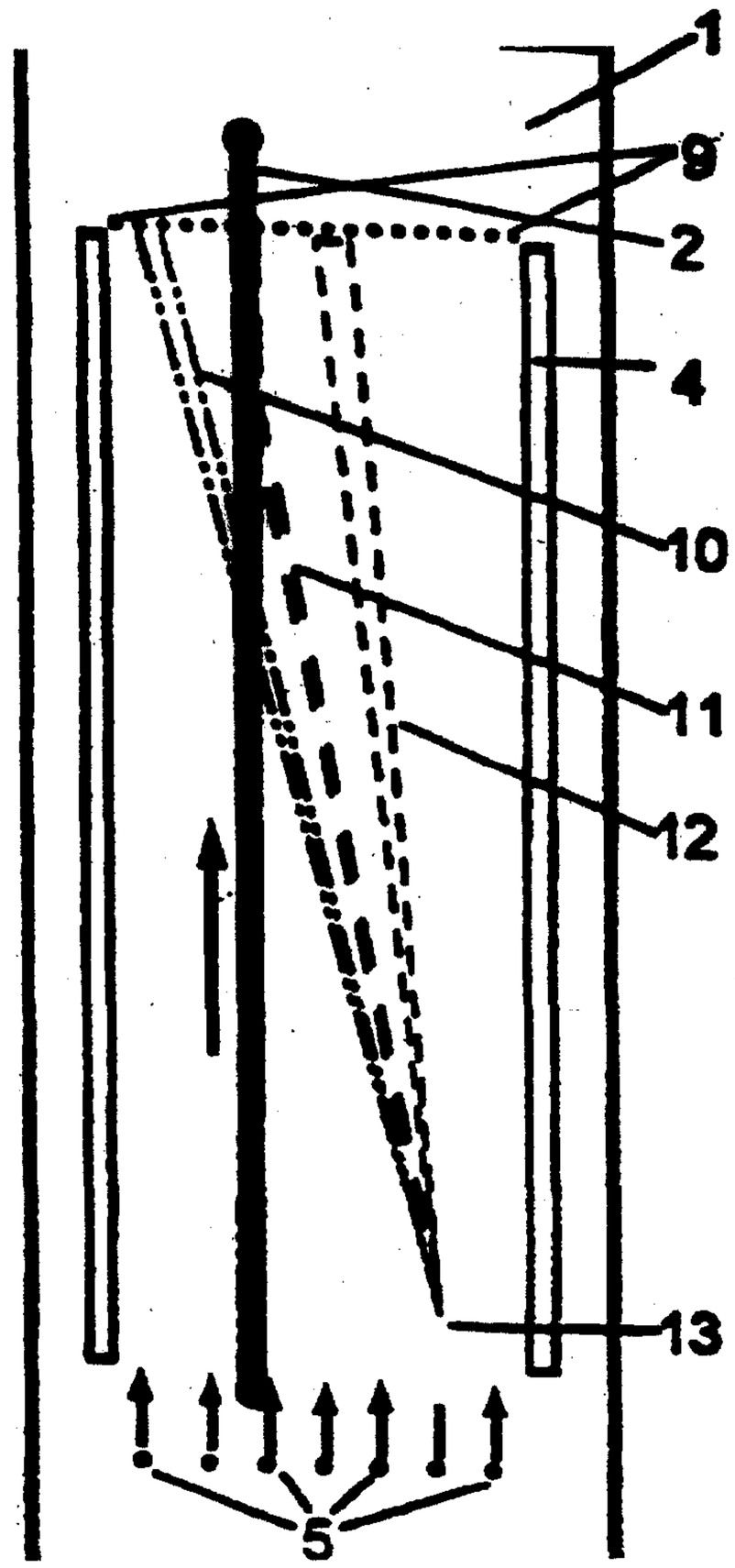


Fig. 4

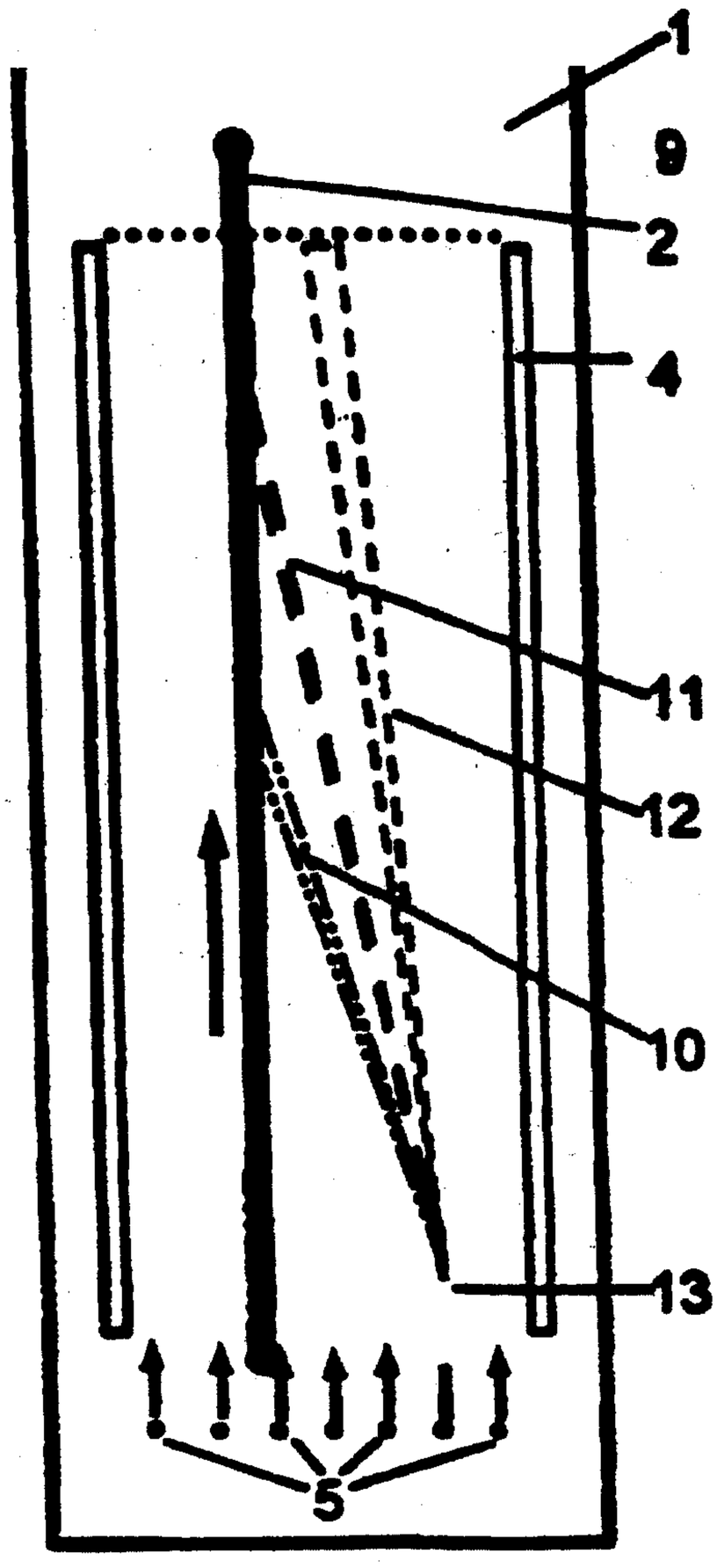


Fig. 5

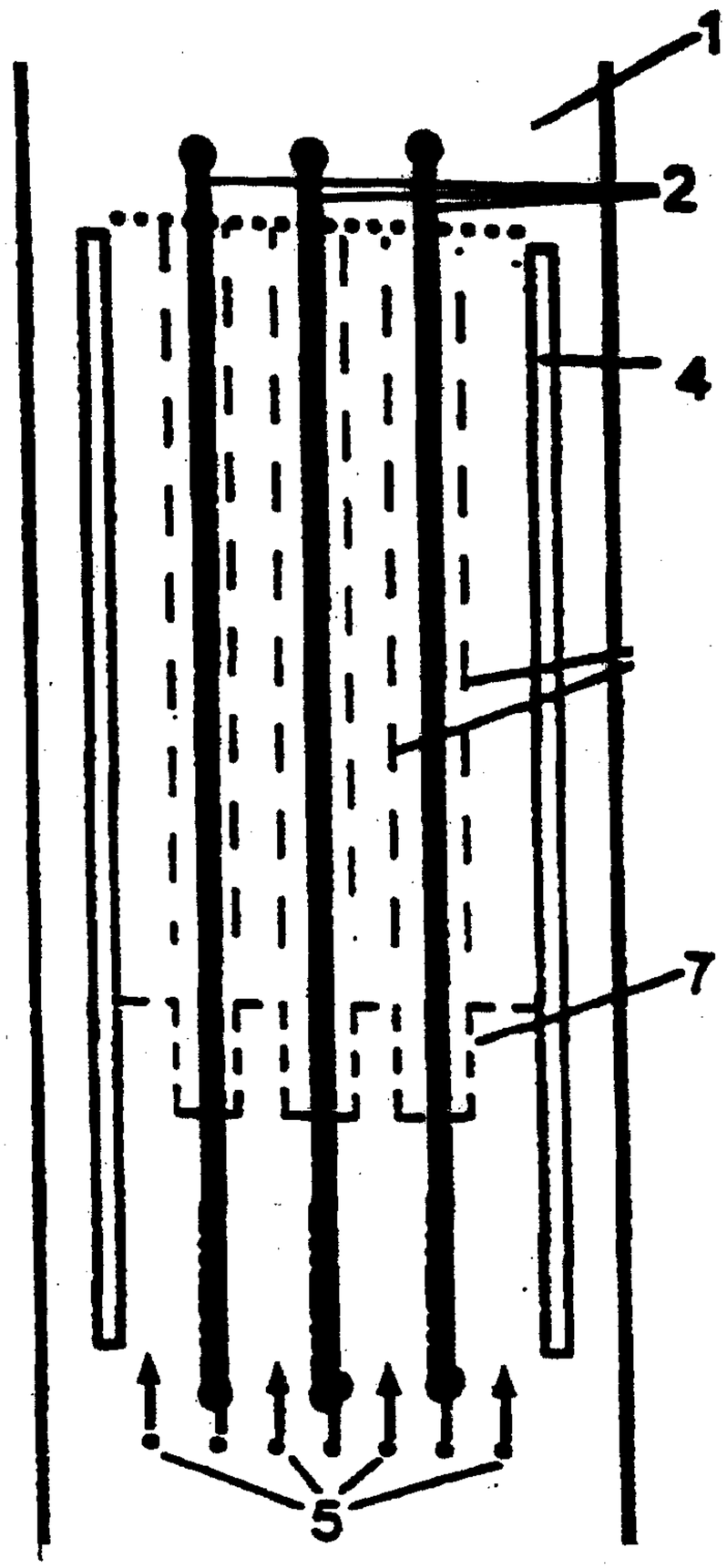


Fig. 6

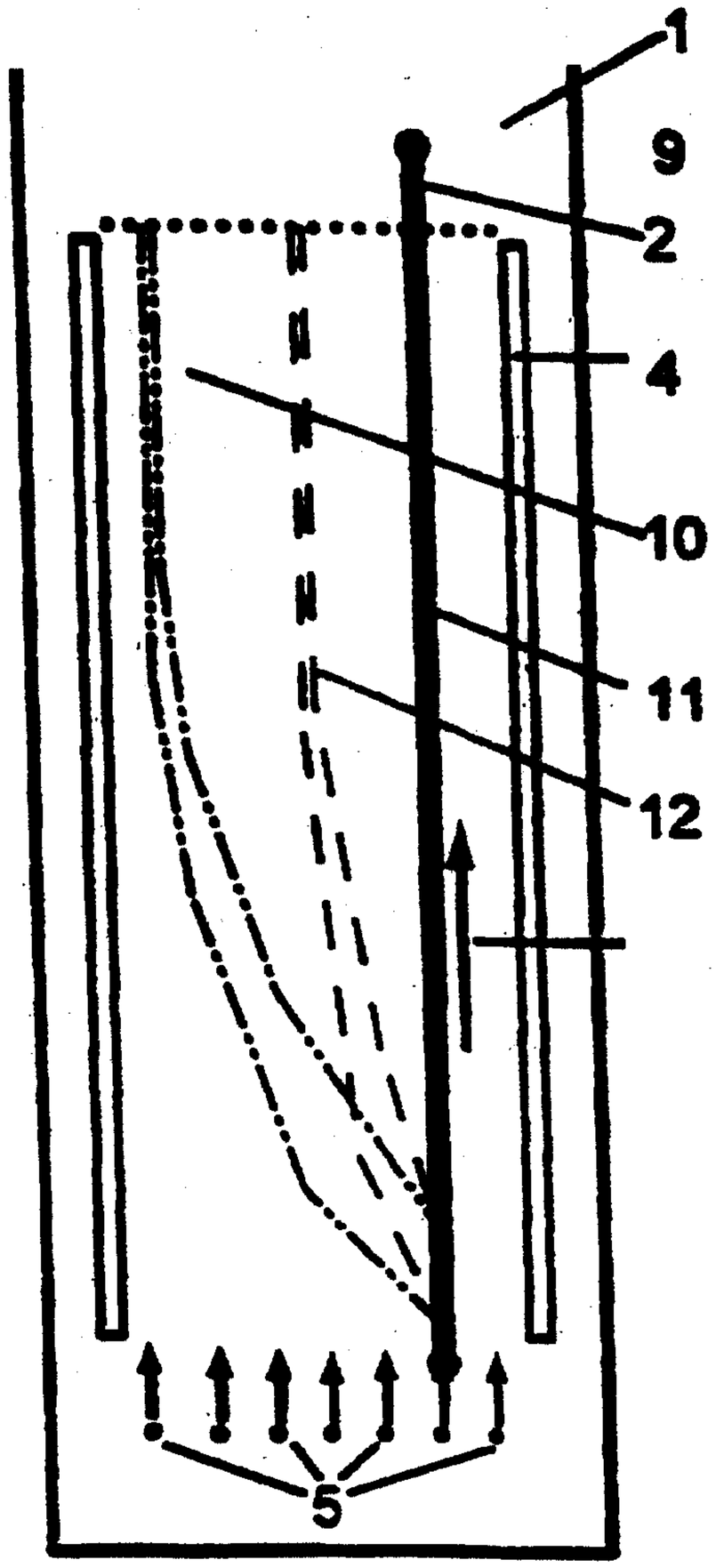


Fig. 7

Fig. 8A

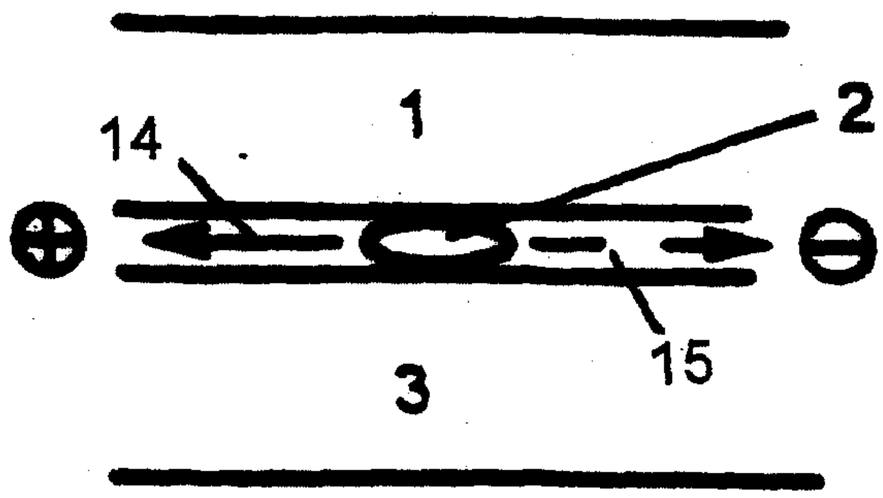


Fig. 8B

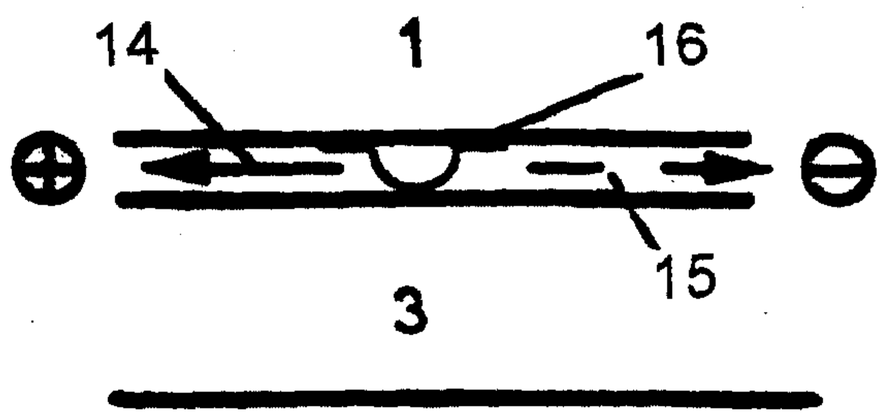


Fig. 8C

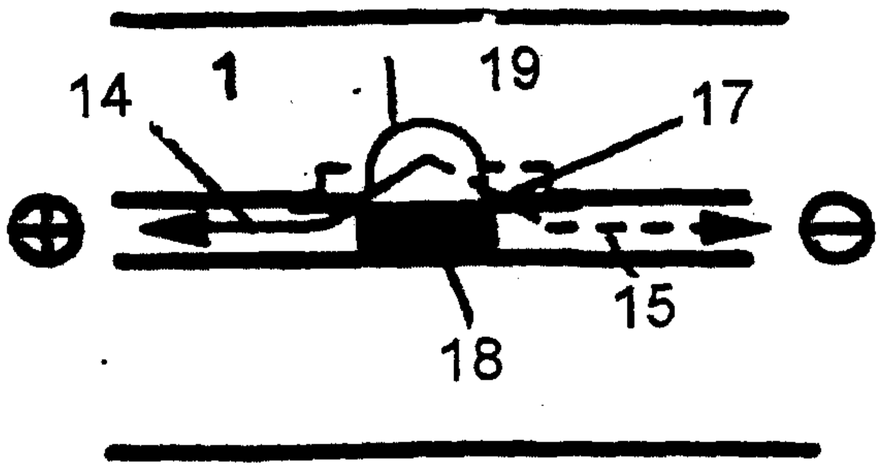


Fig. 9A

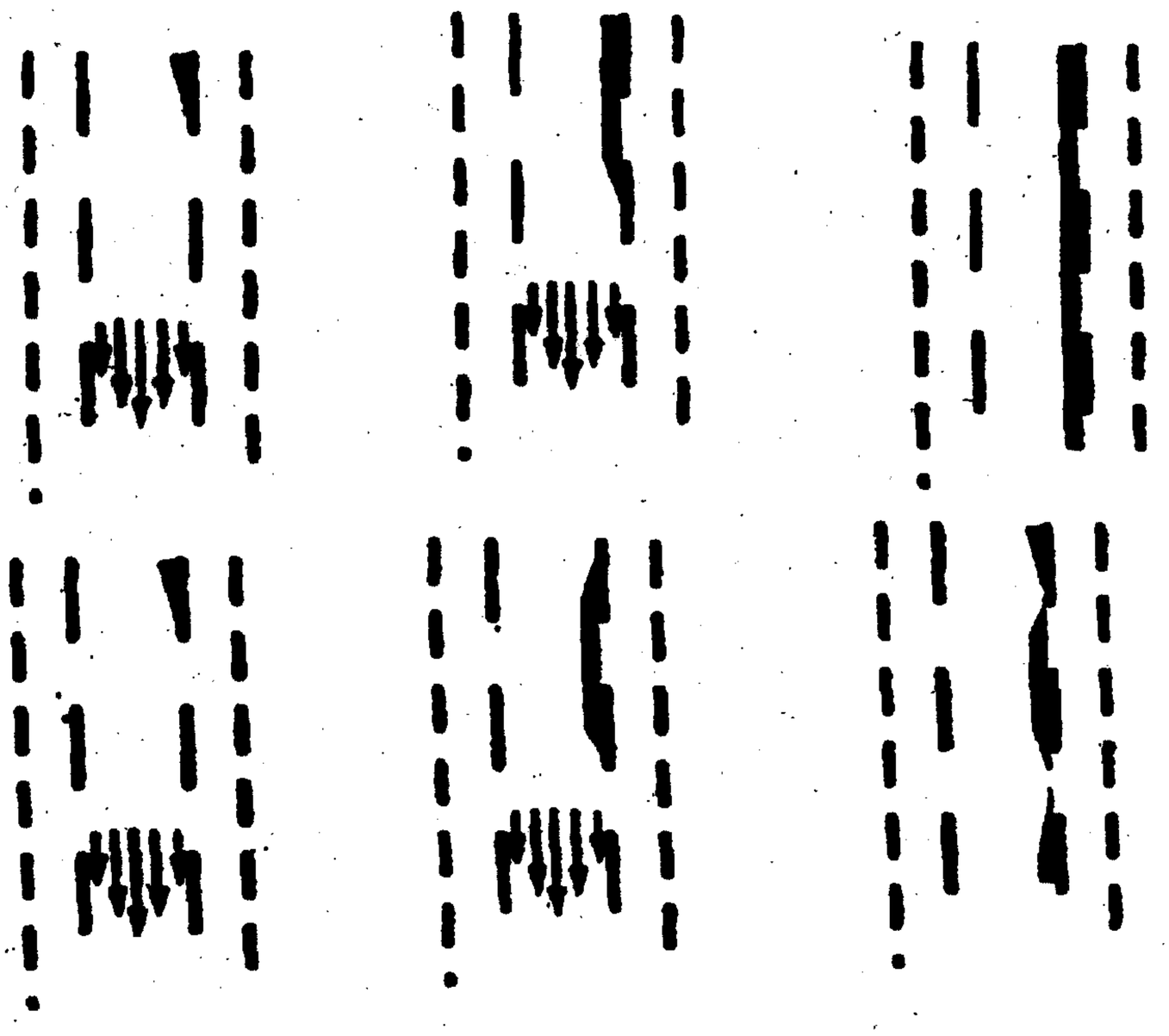


Fig. 9B

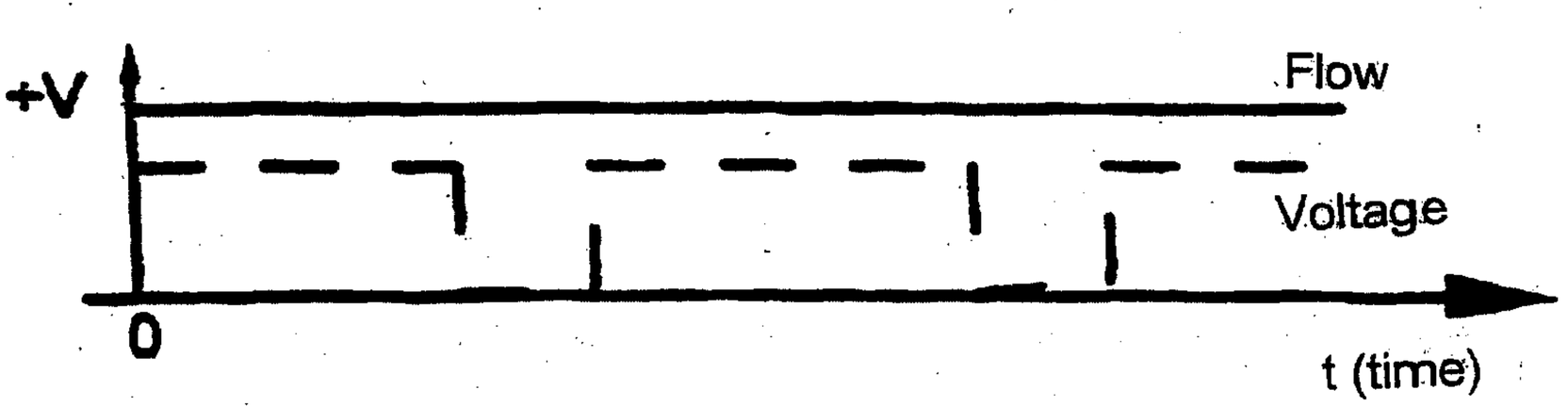
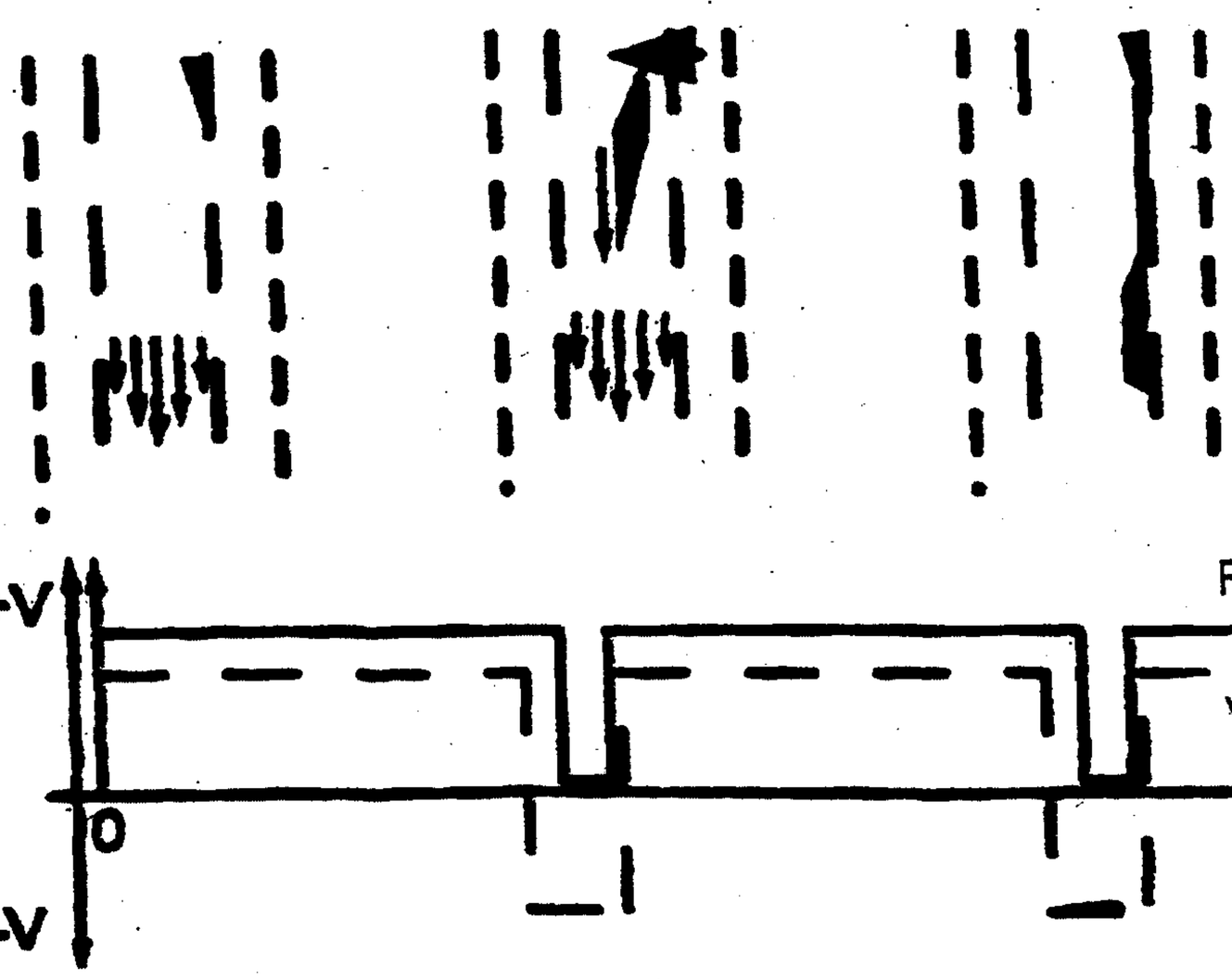
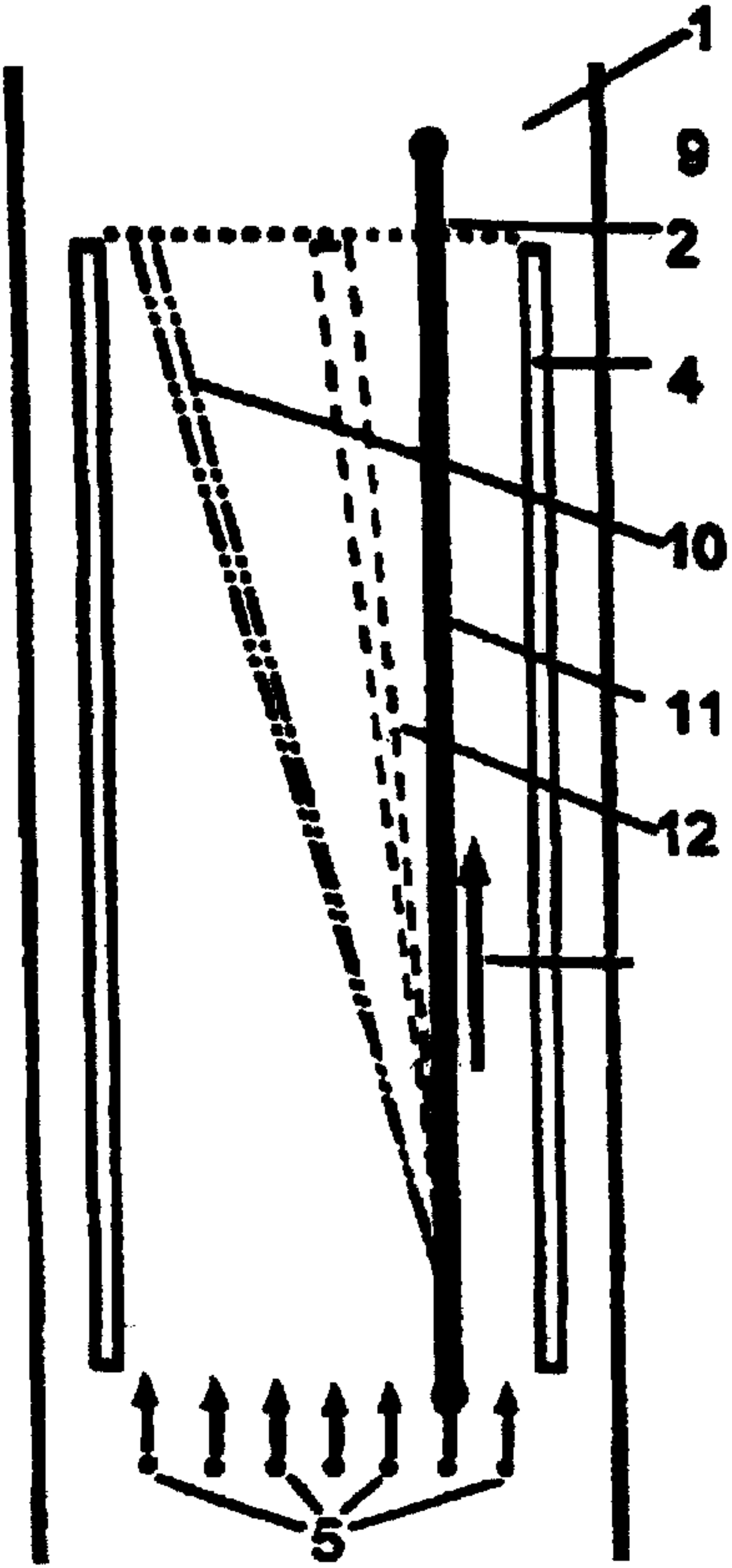


Fig. 9C

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