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**Apparatus and process for simultaneous distillation
and extraction**

- 5 The invention concerns an apparatus and a process for the simultaneous distillation and extraction of volatile substances from an aqueous medium to a water-immiscible solvent medium, which may be used in particular for the extraction of volatile flavours under controlled conditions.
- 10
- The process for the simultaneous distillation and extraction of volatile substances is known at the laboratory level. A suitable apparatus known as the "Likens-Nikerson" apparatus is described, for example in Likens, S.T., Nikerson, G.B.
- 15 ASBC proceedings 1964, 5-13. This process and this apparatus enable volatile compounds to be extracted from an aqueous medium to a water-immiscible organic solvent medium, without there being any contact between the organic solvent and the sample treated. Thus, the system prevents the
- 20 extraction of undesirable substances from the treated medium, such as for example lipids, pigments or other substances which do not form part of the desired volatile fraction, which could occur in direct contact with the solvent. This apparatus however does not enable work to be
- 25 carried out on a preparative scale and does not provide the desired flexibility of use, for example the possibility of operating under atmospheric conditions or under reduced pressure in cases where mild conditions are required, in particular mild temperature conditions, so as to preserve
- 30 the heat-sensitive compounds, nor does it enable work to be carried out either in batches or continuously, namely under conditions which can be modified and varied.

The apparatus and the process according to the invention
35 offer means of overcoming the insufficiencies of the known apparatus and process.

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The apparatus according to the invention comprises :

- means for distilling volatile substances by entrainment in steam from a first vessel containing an aqueous dispersion,
- 5 means for condensing the aqueous vapours containing volatile substances,
- means for distilling a water-immiscible organic solvent,
- 10 with a boiling point close to that of water, from a second vessel containing it,
- means for condensing solvent vapours distinct from the means for condensing aqueous vapours,
- 15 means for the liquid/liquid extraction of aqueous vapours by the condensed solvent, connected to means for condensing the aqueous vapours and to means for condensing the solvent,
- 20 means for separating the aqueous extracts and organic extracts enriched in the said volatile substances derived from the means for extraction and
- means for regulating the pressure connected to the means for
- 25 condensing the aqueous vapours.

Preferably, the means for liquid/liquid extraction are provided with means for stirring.

- 30 Advantageously, the second vessel containing the solvent is connected to a distillation column placed between the latter and the means for condensing the solvent.

- In the case of a continuous operation, the first vessel
- 35 containing the aqueous dispersion is advantageously connected to an evaporation system, in particular a

stripping column through which the dispersion is pumped by means of a pump.

The invention also concerns a process for the simultaneous
5 distillation and extraction of volatile substances from an aqueous medium to a water-immiscible solvent medium, characterized in that the solvent and the aqueous medium contained in distinct vessels are distilled separately, that they are condensed separately, that the condensates are put
10 into contact in an extraction cell with stirring and that the aqueous phase depleted in, and the organic phase enriched in the said substances are separated by decanting, in a manner separate from the extraction cell.

15 The water immiscible solvent which can be used in the process of the invention has, if possible, a boiling point at atmospheric pressure if possible relatively close to that of water, of the order of 30 to 180°C. It is, preferably, lower than that of water while being relatively close to it,
20 for example of the order of 0 to 60°C at the working pressure, which is advantageous in as much as this enables heat-sensitive substances to be handled. It may be more or less dense than water. It is, preferably, an aliphatic hydrocarbon, a halogenated aliphatic hydrocarbon, an
25 alicyclic hydrocarbon, an aromatic hydrocarbon or an ether, for example selected from dichloromethane, pentane, iso-octane, toluene, trichloroethane, trichloroethene and diethylether.

30 Since the preceding solvents are not of food quality, it may be advantageous to select a solvent considered as edible, for example a terpene, such as limonene, alpha- and beta-pinene.

35 In as much as the extracted volatile substances have boiling points close to that of the solvent, a distillation column is preferably used for the solvent provided at its base with

a return tube for the solvent, so as to limit redistillation of the said substances with the solvent.

According to a first embodiment, in batches, the apparatus
5 is connected to a vacuum pump enabling work to be carried out under an almost static vacuum, namely at a reduced pressure up to atmospheric pressure, preferably 30 to 760 mbar.

10 According to a second, continuous, embodiment, the vessel containing the aqueous medium may have a large volume and a smaller quantity of aqueous medium may be pumped through a stripping column and only this column is brought to the boiling point and this only for a limited period. In this
15 variant, the aqueous medium may be directly recycled from the stripping column to the vessel. In this variant, it is possible also to work under reduced pressure, with an almost static vacuum, which is achieved with the aid of a valve automatically regulated in relation to a reference value of
20 the pressure.

In the two variants, the extraction cell may be of any known type, operating so as to ensure good contact between the distillates, for example in counter current or with
25 stirring.

Separation of the phases takes place in a manner separate from the extraction cell, by decantation and, according to the operating procedure, the aqueous phase may be recycled
30 to the vessel containing the aqueous medium.

The invention also concerns the use of the process for extracting substances from an aqueous medium, without subjecting them to thermal degradation. In particular, the
35 process applies to cold extraction or to extraction at a moderate temperature, of heat-sensitive flavouring and/or fragrant substances present in a very dilute state in an

aqueous medium such as a solution or a dispersion, or of substances which are very difficult to extract, for example an aqueous residue containing volatile flavours. It is particularly applicable to the extraction of these substances as they are generated, for example during an enzymatic reaction. As particular reactions, reference may be made for example to the isolation of aromatic mixtures from a coffee extract or the extraction of benzaldehyde from water used for treating kernels, for example apricot kernels.

The apparatus will be described in greater detail with reference to the accompanying drawings illustrating two embodiments of the apparatus, given by way of example, in which :

Figure 1 is a diagram of a first embodiment of the apparatus intended to work in batches,
figure 2 is a diagram of a second embodiment of the apparatus intended for continuous extraction which is able to process larger quantities of substrate,
figures 3 and 4 are respectively, a view in elevation and a side view of the means for extracting aromatic substances and condensing aqueous vapours,
figures 5 and 6 are respectively a view in elevation and a side view of means for distilling and condensing the solvent,
figure 7 is a view in elevation of the means for separating aqueous vapours and solvent,
figure 8 is a section through AA of figure 7 and
figure 9 is a section through BB of figure 7.

In figure 1, the aqueous substrate contained in the vessel 1 is entrained in steam and distils through the tube 2 to the extractor 3. The extractor 3 consists at its upper part of a cooled condenser for vapours 4, and at its lower part of a liquid/liquid extraction chamber 5, provided with a magnetic

stirrer 6. The bottom of the extractor 3 is connected via the tube 7 to a separator 8, itself connected to a vessel 1 by the tube 9, for recycling the condensed aqueous medium to the vessel 1. The vessel 10, containing the solvent, is connected to the distillation column 11. The solvent is condensed in the condenser 12 from which it is directed by the tube 14 to the extraction chamber 5. The solvent returns from the separator 8 to the vessel 10 by the tube 15. Outlets 13 and 16 leading to a vacuum device are provided at the tops of the condensers 4 and 12.

In figure 2, the same components are represented by the same numbers as previously. As differences in relation to the preceding embodiment, the larger vessel 1 is connected, via the tube 17 and the pump 18, to a stripping column 19. The pipes 20 and 21 enable the overflow from the aqueous medium coming from the stripping column 19 and the water coming from the separator 8 to be returned respectively to the vessel 1. The pipes 22 and 23 ensure removal of exhausted aqueous media from the stripping column 19 and the separator 8 respectively, to the vessel 24 acting as a waste tank.

The assembly of figure 1 operates in the following manner :

When working in batches at atmospheric pressure, the vessels 1 and 10 are heated to the boiling point of water and of the solvent and are stirred magnetically. The phase separator 8 and the condensers 4 and 13 are cooled to -1°C . The outlets 13 and 16 are open to atmospheric pressure. Solvent and water distil, the vapours are condensed and the condensates are collected in the extractor 5 where they are put into contact by vigorous stirring by means of the magnetic stirrer 6 and from where they flow to the separator 8 in which two phases appear. In the embodiments shown, liquid/liquid extraction takes place by contact between the phases with vigorous stirring. Other means of achieving liquid/liquid extraction could be envisaged, by the use of

any type of extractor, for example a counter-current extractor.

In the case, for example, of a solvent which is less dense than water, as shown in figures 7 to 9, the solvent containing the organic extract returns to the vessel 10 through the mouth of the tube 9 situated above the mouth of the tube 15 through which the exhausted aqueous phase returns to the vessel 1. If it is desired to use a solvent denser than water, it is then sufficient to connect the end of the tube 15 to the vessel 10 containing the solvent, and the end of the tube 9 to the vessel 1 respectively.

It is possible to work with two specific separators/decanters 8 dedicated, either to a solvent less dense than water, or a solvent more dense than water, although, according to the invention, it is preferable to employ a multi-purpose separator as previously explained.

In this way, the volatile fraction containing the fragrant organic compounds is continually extracted without there being direct contact between the matrix and the solvent, which means that only the constituents entrained in steam are selected. The extraction yield by weight at the end of about one hour is frequently >90%.

Advantageously, the tube 2 has a large diameter, which makes possible a high flow rate of steam. As shown in figures 3 and 4, the extractor 3 is cooled by means of fluids circulating respectively between the ends 25 and 26 for the body and the ends 27 and 28 for the coil 29 of the central part of the condensing part 4. As is apparent in figures 5 and 6, the column 12 for condensing solvent is also cooled by means of fluids circulating through a double envelope and through the central coil 30 from the ends 31 and 32. The column 11 prevents, to a large extent, redistillation with the solvent of low boiling point volatile compounds

collected with the latter under the effect of hot steam, in as much as the condensed solvent is introduced through the tube 14 directly to the cold part of the extraction chamber 5. In addition, on account of the fact that the condensers 5 for steam and solvent vapour are distinct, it is possible to operate them at different temperatures. Moreover, as follows from figures 7 to 9, the separator/decanter 8 is provided with a double envelope which ensures its cooling by a fluid circulating between the ends 33 and 34.

10

The atmospheric variant has however the disadvantage of cooking samples at 100°C for a relatively long period, which considerably modifies the qualitative and quantitative composition of the volatile compounds with the appearance of 15 cooked, caramelized and sugary notes.

It may be preferable to work under reduced pressure, for example with the aim of preventing deterioration of aromatic compounds by prolonged cooking. In order to do this, the 20 extractor 3 and the condenser 12 are connected to a vacuum pump from the outlets 13 and 16 via an automatic valve (not shown) for regulating the pressure with respect to a set value. This system provides an almost static vacuum in the extractor. The pressure regulator does not allow continuous 25 pumping through the system, since the valve only opens if the set value of the vacuum is exceeded. Losses of volatile aromatic compounds, which would occur in the case of continuous vacuum pumping, are thus limited. When working under reduced pressure, it may prove particularly 30 advantageous to cool the separator/decanter 8 as previously explained.

In the variant shown in Figure 2, with continuous operation, it is possible to subject only a small part of the sample to 35 distillation by the stripping column 19, the pump 18 providing the stripping column 19 only with the quantity necessary for generating a flow of steam sufficient to feed

the extractor and to achieve entrainment by steam. It is possible, for example, to pass the quantity to be treated through a stripper held, for example, at 140°C. Thus, all the sample contained in the vessel 1, which may be a large capacity reservoir, is not subjected to the distillation temperature for a long period, as was the case with the known Likens-Nikerson apparatus. Moreover, there is additional value in working continuously under reduced pressure, in as much as the latter variant enables a greater quantity of volatile compounds in absolute value to be extracted than in the case of working with batches from a larger sized sample, which may be very dilute.

The following examples illustrate the process according to the invention and certain applications. In these, the parts and percentages are by weight, unless indicated to the contrary.

Example 1

20

Recovery of a mixture of flavours in batches at atmospheric pressure

By applying the batch process at atmospheric pressure and by using the layout of figure 1, volatile organic compounds were extracted from a mixture of flavouring compounds with various solvents. Among the desired compounds, phenyl ethanol and coumarin were selected as representing particularly difficult compounds to extract with an acceptable yield.

In Table 1 below, the operating conditions and the yields obtained (%) are shown, based on an initial concentration of 15 mg/l of each compound, with a 2700 ml sample. The quantities of aromatic compounds collected were determined by gas chromatography (GC), using undecanol as an internal standard.

Table 1

Solvent	Pentane	Ethyl ether	Dichloromethane			
			1h	2h20	19h30	41h30
Duration	1 h	1 h				
Pyridine	24.3	60.2	76.3	95.4	96.9	88.5
Ethyl butyrate	97.1	109.8	96.3	97.5	96.0	95.5
t-2-hexenal	93.2	104.7	93.4	97.7	97.1	98.9
2,6-dimethyl pyrazine	30.9	33.1	53.5	81.3	99.3	100.5
Limonene	99	110.8	93.6	98	97.3	97.8
2-phenylethanol	7.9	17	17.7	34.6	101	103.2
Anethol	71.3	85.4	69.6	75.7	92.4	96.8
Coumarin	< 1	< 1	3.8	8.2	66.8	93.8
Dodecanol	77.5	71.6	75	81.9	92.9	98

The above results show that the extraction efficiency approximately follows the rule : pentane < ether < dichloromethane.

Example 2

Recovery of chicken flavour in batches at atmospheric pressure

10 litres of chicken gravy were extracted by applying a batch process at atmospheric pressure and by using the layout of figure 1 for 3 h, using ethyl ether as solvent. After removing the ethyl ether, the extract had a typical roast chicken flavour. The concentration factor was 60,000 x, which corresponded to 18 ppm (parts per million) of volatile compounds found in the standard chicken gravy by GC after isolation by simultaneous distillation/extraction using conventional laboratory apparatus.

Example 3**Continuous recovery of a mixture of flavours at atmospheric
5 pressure**

The batch process is limited as regards batch size and the fact that the sample must be kept at the boiling point of water during treatment, which produces thermal degradation.
10 With the aim of limiting this degradation, the layout of figure 2 was used, by placing the sample to be treated in the cooled vessel 1 and by pumping a continuous stream of the sample from this vessel through the tube 17 with the aid of the pump 18 to the stripping column 19. Thus, only a
15 fraction of the sample was subjected to a high temperature and this only for a short period.

Starting with the same mixture of aromatic compounds as in example 1, the degree of recovery of volatile substances was
20 evaluated. In a first case, the condensed aqueous distillate was recycled to the vessel 1. In a second case, the distillate was collected in a separate vessel, without recycling it. The operating conditions and the results are shown in Table 2 below, the yields being expressed in %.

25

Table 2

	Solvent	Distillate recycling		Without distillate recycling	
		Ether	CH ₂ Cl ₂	Ether	CH ₂ Cl ₂
5	Duration	23 h	23 h	8h30 (a)	8h30 (a)
	Pyridine	21.9	75.5	5.2	50.5
	Ethyl butyrate	62.4	86.2	61.6	81
	t-2-hexenal	64	86.7	60.7	81
10	2,6-dimethyl pyrazine	32.1	80.1	14.9	55.9
	Limonene	47.2	53.4	26.6	39.4
	2-phenylethanol	56.3	62.5	31.6	34
	Anethol	73	69.9	29.6	32.5
15	Coumarin	32.2	33.2	9.3	11.1
	Dodecanol	65.4	59.5	31.2	39.3

(a) As much as 100 % of the batch of the sample (5 l) had
 20 passed through the stripping column 19.

Example 4

25 Continuous recovery of benzaldehyde at atmospheric pressure from waste water used for treating apricot kernels

The preparation of apricot kernel milk results in waste
 water containing natural benzaldehyde. It is not possible to
 30 recover benzaldehyde from the condensate by stripping and
 decanting on account of its significant solubility in water.

Thus a waste water was treated by using the plant according
 to figure 2; that is 1.5 l of an ultrafiltration permeate of
 35 kernel milk containing 178 mg/kg of natural benzaldehyde and
 proteins, were treated by passing it at a flow rate of
 5 ml/min through the stripping column 19 held at 135°C for

5 hours, without recycling. 50 ml of iso-octane were used for the extraction.

A single passage of the solution through the stripping column enabled 54 % of the benzaldehyde to be recovered.

Example 5

10 Recovery of a mixture of flavours in batches under reduced pressure

Treatment under reduced pressure considerably reduced the artifacts due to the heat treatment. The apparatus according to Figure 1 was put into operation using trichloroethene as solvent, at an almost static pressure of 48 mbar to extract a mixture of volatile aromatic substances.

The operating conditions and yields (%) obtained are shown in Table 3 below.

Table 3

Duration	1 h	2 h	5 h	7 h	23 h
25 Pyridine	35.6	42.1	48.3	49.3	47
Ethyl butyrate	60	64.7	69.9	75.5	72.2
t-2-hexenal	64.7	70.7	76.4	81.5	80.4
2,6-dimethylpyrazine	14.6	23.6	48.6	59.5	65.2
Limonene	66.3	67.6	71.2	75.2	76.3
30 2-phenylethanol	2.6	5.2	13.9	20.6	36.8
Anethol	76.4	84.4	84.6	88.5	87.1
Coumarin	1.3	2.3	6.1	8.2	27.3
Dodecanol	43.2	67.3	93.4	90.7	95.3

The results show that the yield in pyridine was relatively low, which may be explained by its low boiling point, its air/trichloroethene partition coefficient being 0.35 at 48 mbar. The phenomenon of redistillation cannot thus be neglected in as much as the difference between the boiling points of the solvent and the solute is less under reduced pressure than at atmospheric pressure.

10

Example 6Recovery of a mixture of flavours in batches under reduced pressure

15 A mixture of volatile aromatic substances was treated in batches using the plant of figure 1. Limonene was used as solvent and treatment took place at a pressure of 48 mbar, for 2h 20. The yields are shown in Table 4 below.

20

Table 4

	Volatile aromatic substance	Yield (%)
	2-phenylethanol	2.3
25	Anethol	75.4
	Coumarin	1
	Dodecanol	100.3

30 Anethol and dodecanol were isolated with good yields, which shows that it is possible to use food quality solvents to extract aromatic substances with a high boiling point.

Example 7**Recovery of coffee aromas from an extract in batches at**
5 **reduced pressure**

Analysis of aromas often requires fractionation and concentration of volatile substances. Prior to this stage, a sufficient quantity of the volatile fraction must be
10 isolated and the simultaneous distillation/extraction method under reduced pressure makes extraction possible on the preparative scale. It is known that coffee aroma is spoiled if the extract is heated for a long time. Aromas were thus isolated from a coffee extract under 48 mbar at 31-32°C with
15 trichloroethene using the apparatus of Figure 1, and the trichloroethene extract was then analysed by GC. It was thus possible to analyse the complete profile of the unspoiled coffee aroma, which had not been the case with known methods.

20

Example 8**Extraction of natural benzaldehyde in batches under reduced**
25 **pressure**

Natural benzaldehyde may be extracted from apricot kernel press cakes. By applying a temperature of 35-40°C to the sample and by using the apparatus according to Figure 1 at a
30 reduced pressure of 48 mbar, conditions were achieved compatible with enzymatic reactions. Amygdalin was thus hydrolysed by beta-glycosidase. Apricot kernel press cakes were used which contained the glucoside and the endogenous enzyme. Amygdalin was hydrolysed for 6 h in the vessel 1,
35 whereas benzaldehyde was extracted continuously as soon as it was formed using iso-octane as solvent. The yield obtained was 80.4 %.

It is thus seen that the simultaneous preparative distillation/extraction process according to the invention, under reduced pressure, is suitable for generating and recovering bioaromas simultaneously, even when the reaction medium is a dispersion. Under such conditions, solid particles would lead to blocking problems in the case where membranes were used with the aim of recovering the products of the bioreaction continuously.

Example 9

Continuous recovery of a mixture of flavours under reduced pressure

Using the apparatus according to Figure 2, a cocktail of volatile aromatic substances was pumped continuously through a stripping column 19, at a pressure of 48 mbar, with recycling of the distillate. The results are shown in Table 5 below.

Table 5

Compound	Continuous treatment		Batch treatment
	Yield (%)	Quantity (mg)	Quantity (mg)
Pyridine	17	6.8	19
Ethyl butyrate	92	36.8	29.2
t-2-hexenal	32	12.8	32.6
2,6-dimethylpyrazine	29	11.6	26.4
Limonene	79	31.6	30.9
Phenylethanol	30	12	14.9
Anethol	90	36	35.3
Coumarin	46	18.4	11.1
Dodecanol	89	35.6	28.6

A good recovery was obtained after 23 h, with the exception of low boiling point compounds or those which were slowly recovered by the simultaneous distillation/extraction method. It will be noted that the sample volume was larger
5 (4.5 l) than in the case of a batch treatment (2.7 l).
Despite a lower initial concentration in the continuous treatment (8.9 mg/l) than in the batch treatment (15 mg/l), the absolute quantities recovered in the solvent vessel after 23 h were comparable, from the fact that it was
10 possible to treat a larger volume with continuous treatment.

As a consequence, this technique may be used to recover dilute flavours from large sample volumes.



Claims

1. Process for the simultaneous distillation and extraction of volatile substances from an aqueous medium to a water-immiscible solvent medium, which may be used in particular for the extraction of volatile flavours under controlled conditions, characterized in that the solvent and the aqueous medium contained in distinct vessels are distilled separately, that they are condensed separately, that the condensates are put into contact in an extraction cell and that the aqueous phase depleted in, and the organic phase enriched in the said substances are separated by decanting, in a manner separate from the extraction cell.
2. Process according to claim 1, characterized in that the water-immiscible solvent has a boiling point at atmospheric pressure relatively close to that of water, of the order of 30 to 180°C and in particular less than that of water while being relatively close to it, of the order of 0 to 60°C at the working pressure.
3. Process according to claim 1, characterized in that the solvent is more or less dense than water and is an aliphatic hydrocarbon, a halogenated aliphatic hydrocarbon, an alicyclic hydrocarbon, an aromatic hydrocarbon or an ether, in particular selected from dichloromethane, pentane, iso-octane, toluene, trichloroethane, trichloroethene and diethylether.
4. Process according to claim 1, characterized in that the solvent is of food quality, in particular a terpene, such as limonene, alpha- and beta-pinene.
5. Process according to claim 1, characterized in that treatment is in batches and that the apparatus is connected to a vacuum pump enabling work to be carried out under an



almost static vacuum, namely at a reduced pressure up to atmospheric pressure, in particular from 30 to 760 mbar.

6. Process according to claim 1, characterized in that
5 treatment is continuous, that the vessel containing the aqueous medium has a large volume and in that a smaller quantity of aqueous medium is pumped through an evaporation system, in particular a stripping column, and in that only this system is brought to the boiling point, and this only
10 for a short period.

7. Process according to claim 6, characterized in that the aqueous medium may be recycled directly from the stripping column to the vessel, and that it is possible also to work
15 under reduced pressure, with an almost static vacuum, which is achieved with the aid of a valve automatically regulated in relation to a reference value of the pressure.

8. Process according to claim 1, characterized in that
20 extraction takes place in counter-current or with stirring.

9. Apparatus for the simultaneous distillation and extraction of volatile substances, characterized in that it comprises :

25 means for distilling volatile substances by entrainment in steam from a first vessel containing an aqueous dispersion,

means for condensing the aqueous vapours containing volatile
30 substances,

means for distilling a water-immiscible organic solvent, with a boiling point close to that of water, from a second vessel containing it,

35 means for condensing solvent vapours distinct from the means for condensing aqueous vapours,



means for the liquid/liquid extraction of aqueous vapours by the condensed solvent, connected to means for condensing the aqueous vapours and to means for condensing the solvent,

- 5 means for separating the aqueous extracts and organic extracts enriched in the said volatile substances derived from the means of extraction and

means for regulating the pressure connected to the means for
10 condensing the aqueous vapours.

10. Apparatus according to claim 9, characterized in that the means for liquid/liquid extraction are provided with means for stirring.

15

11. Apparatus according to claim 9, characterized in that the second vessel containing the solvent is connected to a distillation column placed between the latter and the means for condensing the solvent.

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12. Apparatus according to claim 9, characterized in that, in the case of a continuous operation, the first vessel containing the aqueous dispersion is connected to an evaporation system, in particular a stripping column,

25 through which the dispersion is pumped by means of a pump.

13. Apparatus according to claim 9, characterized in that it is provided with a distillation column for the solvent provided at its base with a return tube for the solvent, in
30 order to limit redistillation of the said substances with the solvent.

14. Use of the process according to one of claims 1 to 8, for extracting substances from an aqueous medium, without
35 subjecting them to thermal degradation.



15. Use according to claim 14, for extraction cold, or at a moderate temperature, of heat-sensitive aromatic substances present in a very dilute state in an aqueous medium such as a solution or a dispersion, or of substances which are very
5 difficult to extract, for example an aqueous residue containing volatile flavours.
16. Use according to claim 14, for the extraction of substances as they are generated, for example during an
10 enzymatic reaction.
17. Use according to claim 14, for the isolation of flavouring substances from a coffee extract or the extraction of benzaldehyde from water for the treatment of
15 kernels, in particular apricot kernels.

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Abstract

The apparatus for the simultaneous distillation and
5 extraction of volatile substances from an aqueous medium to
a water-immiscible solvent medium, comprises :

separate means for mixing and decanting the phases,

10 a distillation column for the solvent,

an extraction cell provided with means for stirring,

separate condensers for steam and solvent and

15

a multi-purpose configuration permitting continuous or batch
operations to be carried out at reduced pressure or at
atmospheric pressure.

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Figure 2.

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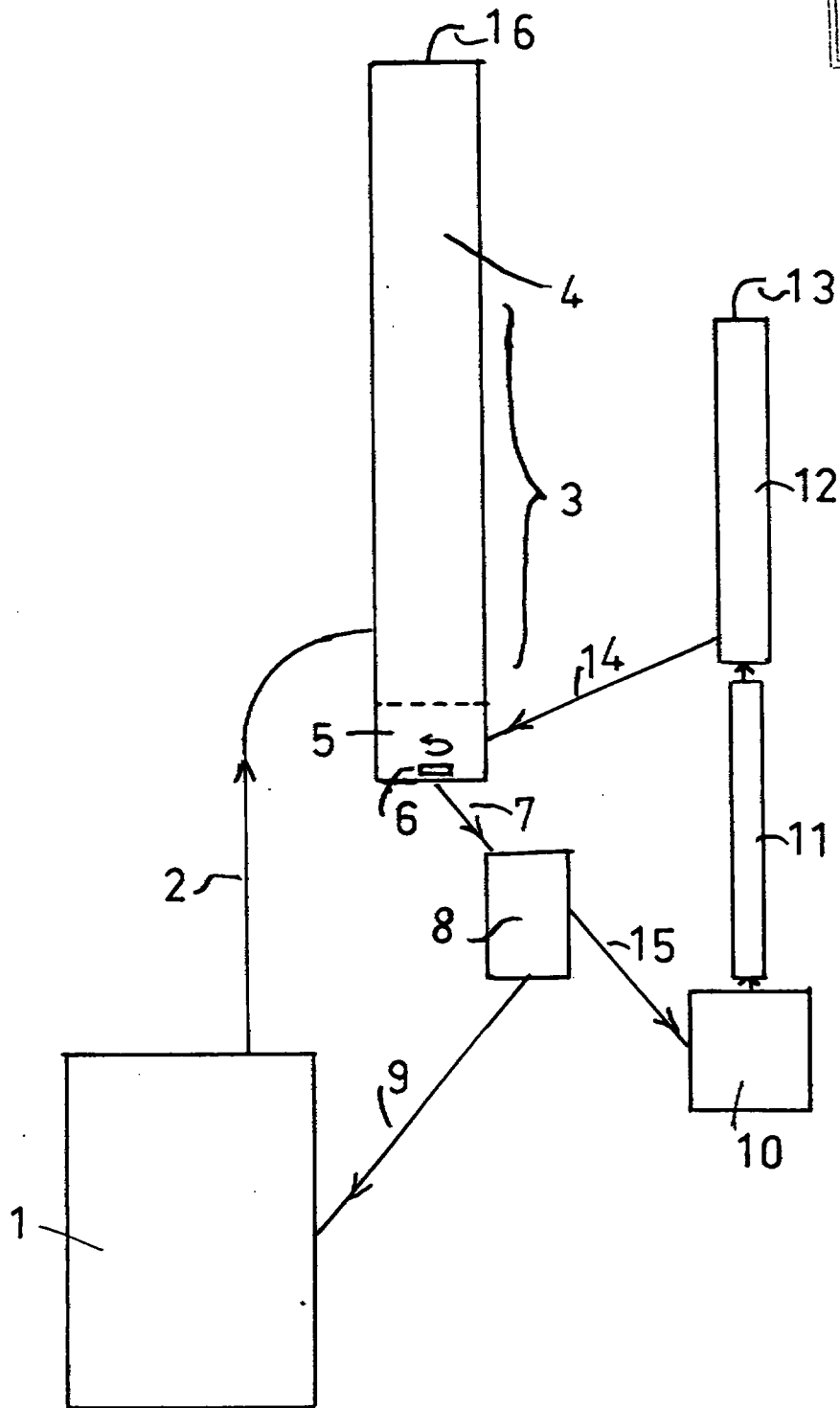


FIG .1



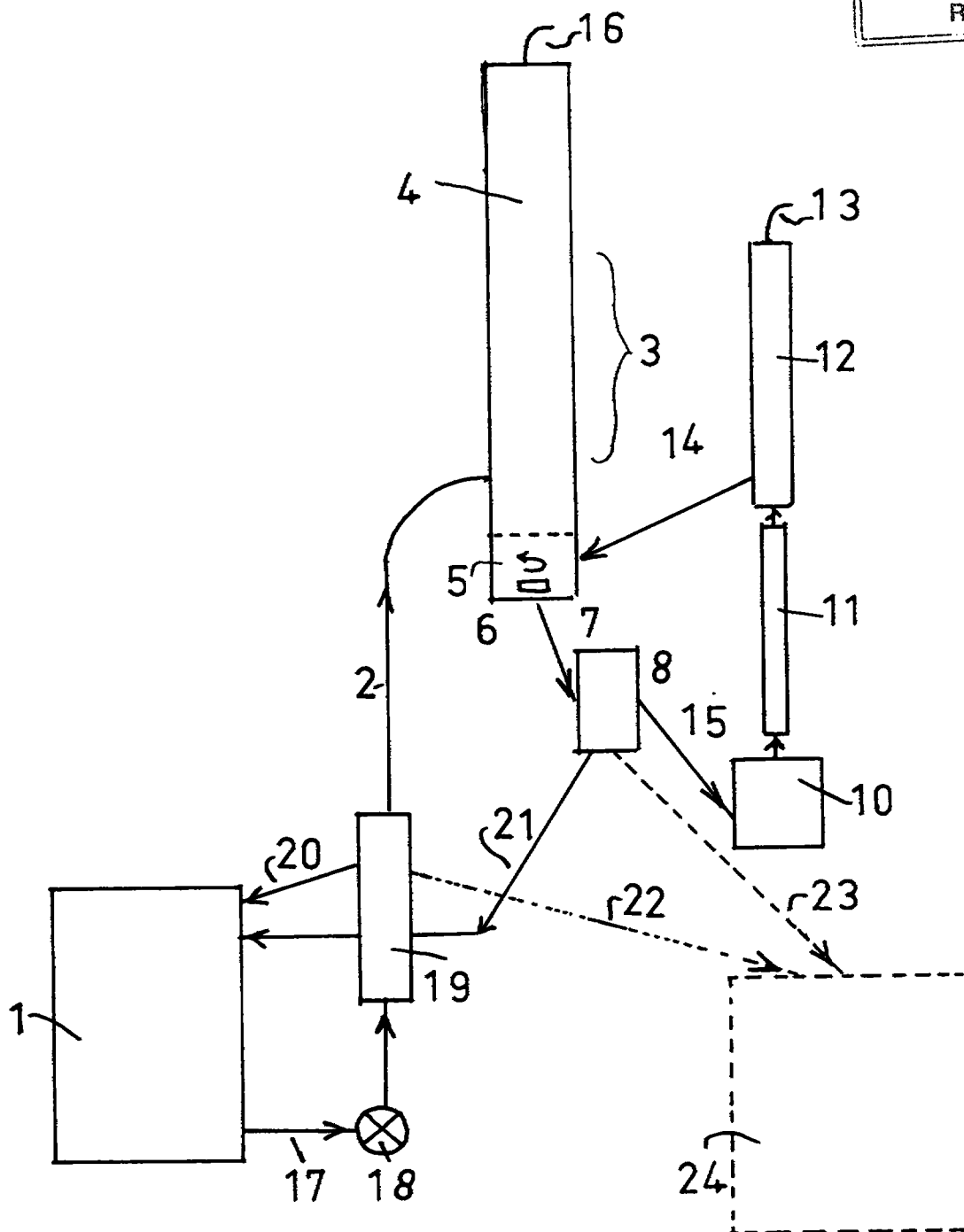
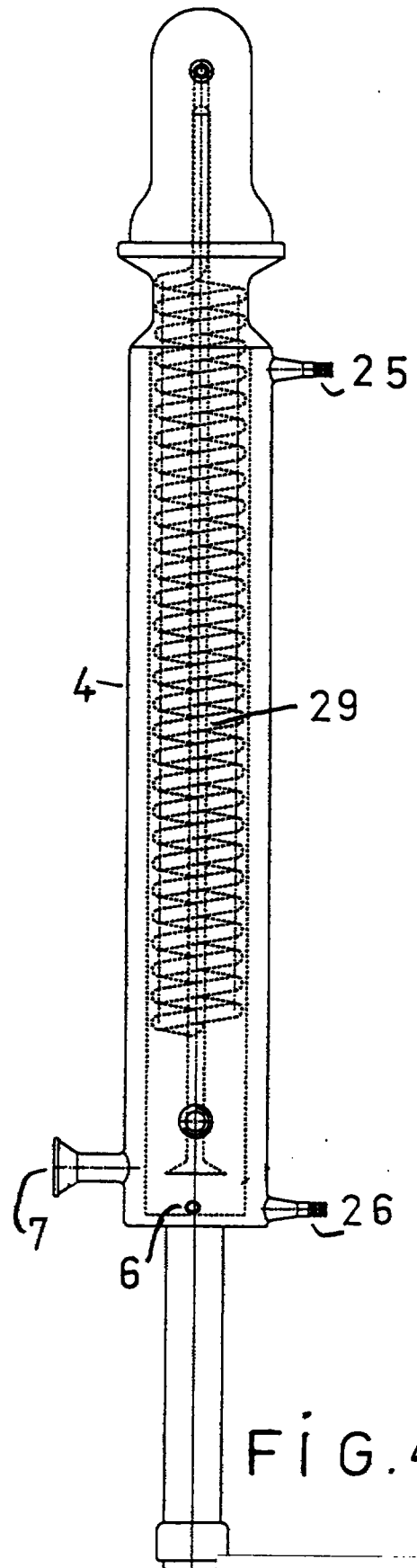
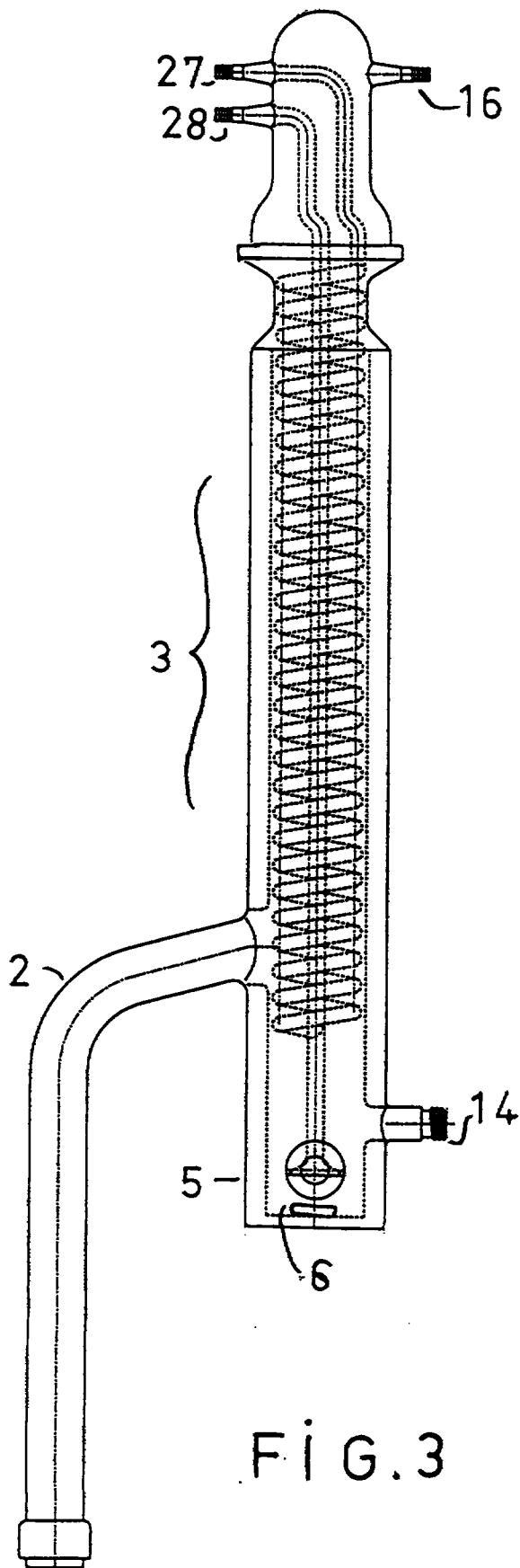
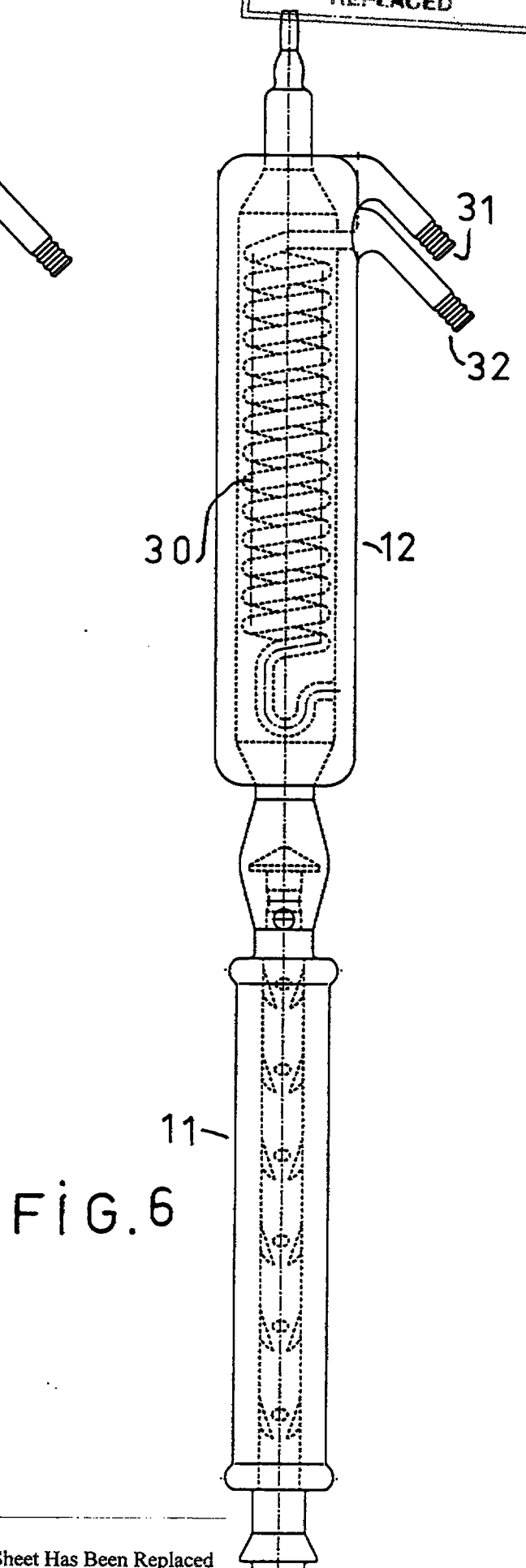
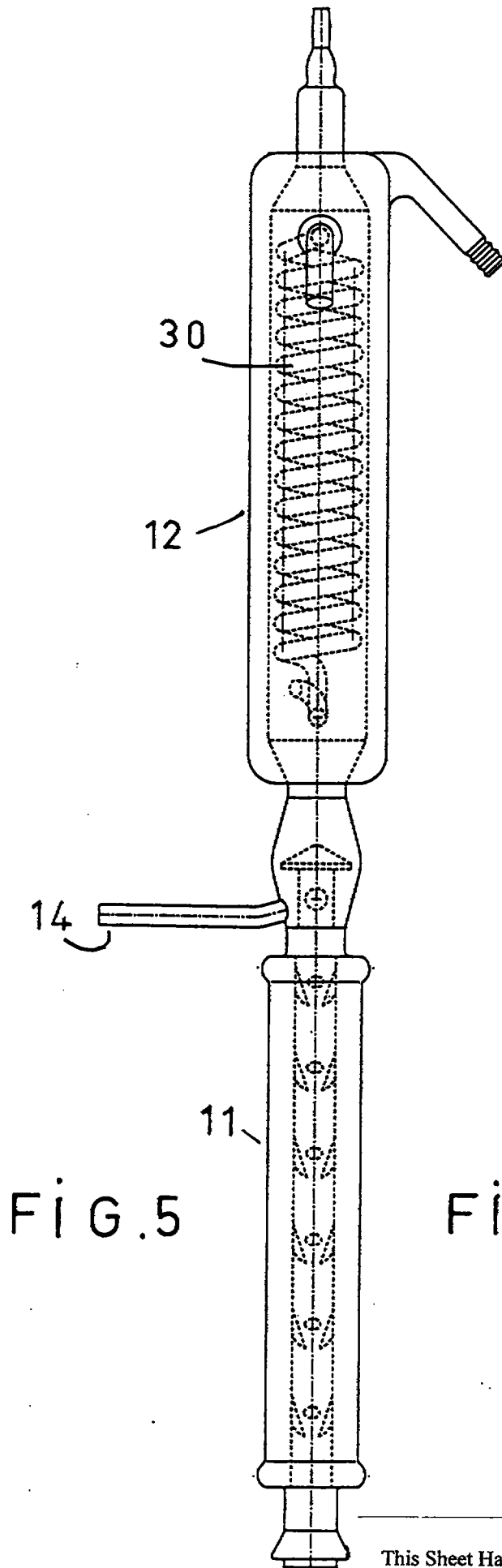


FIG. 2





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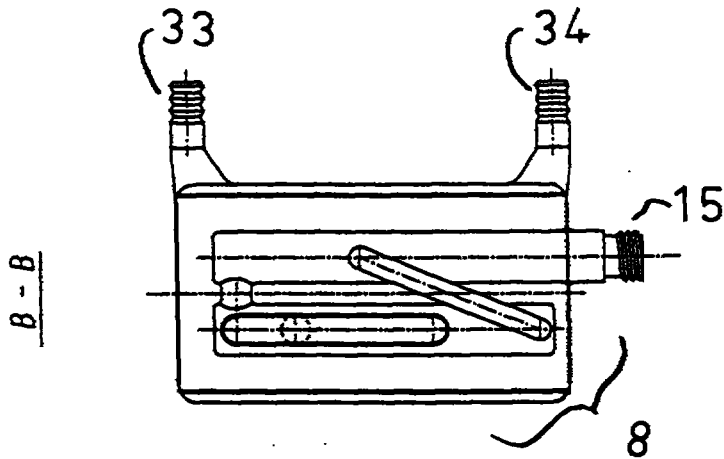


FIG. 9

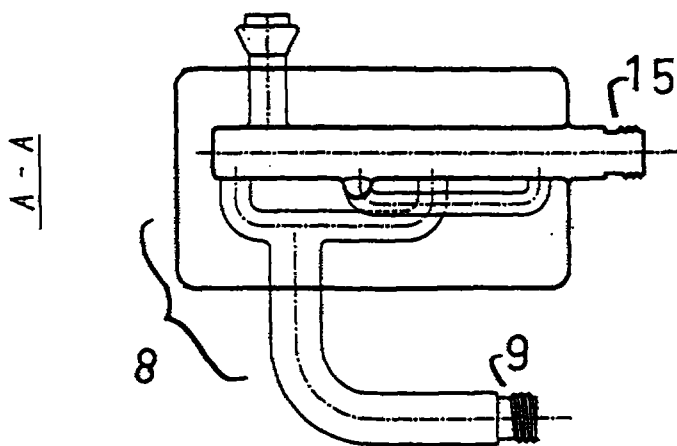


FIG. 8

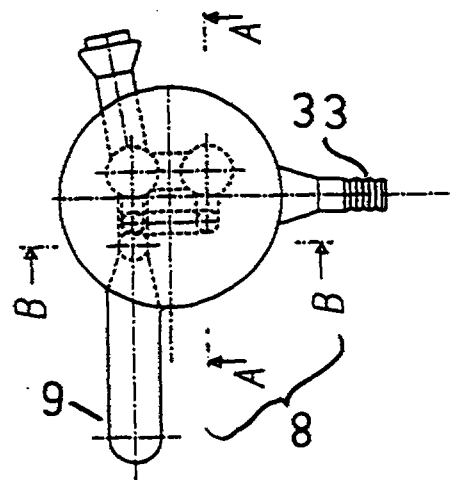


FIG. 7



APPARATUS AND PROCESS FOR SIMULTANEOUS DISTILLATION AND
EXTRACTION

Abstract

The apparatus for the simultaneous distillation and
5 extraction of volatile substances from an aqueous medium to
a water-immiscible solvent medium, comprises :

separate means for mixing and decanting the phases,

10 a distillation column for the solvent,

an extraction cell provided with means for stirring,

separate condensers for steam and solvent and

15

a multi-purpose configuration permitting continuous or batch
operations to be carried out at reduced pressure or at
atmospheric pressure.

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Figure 2.

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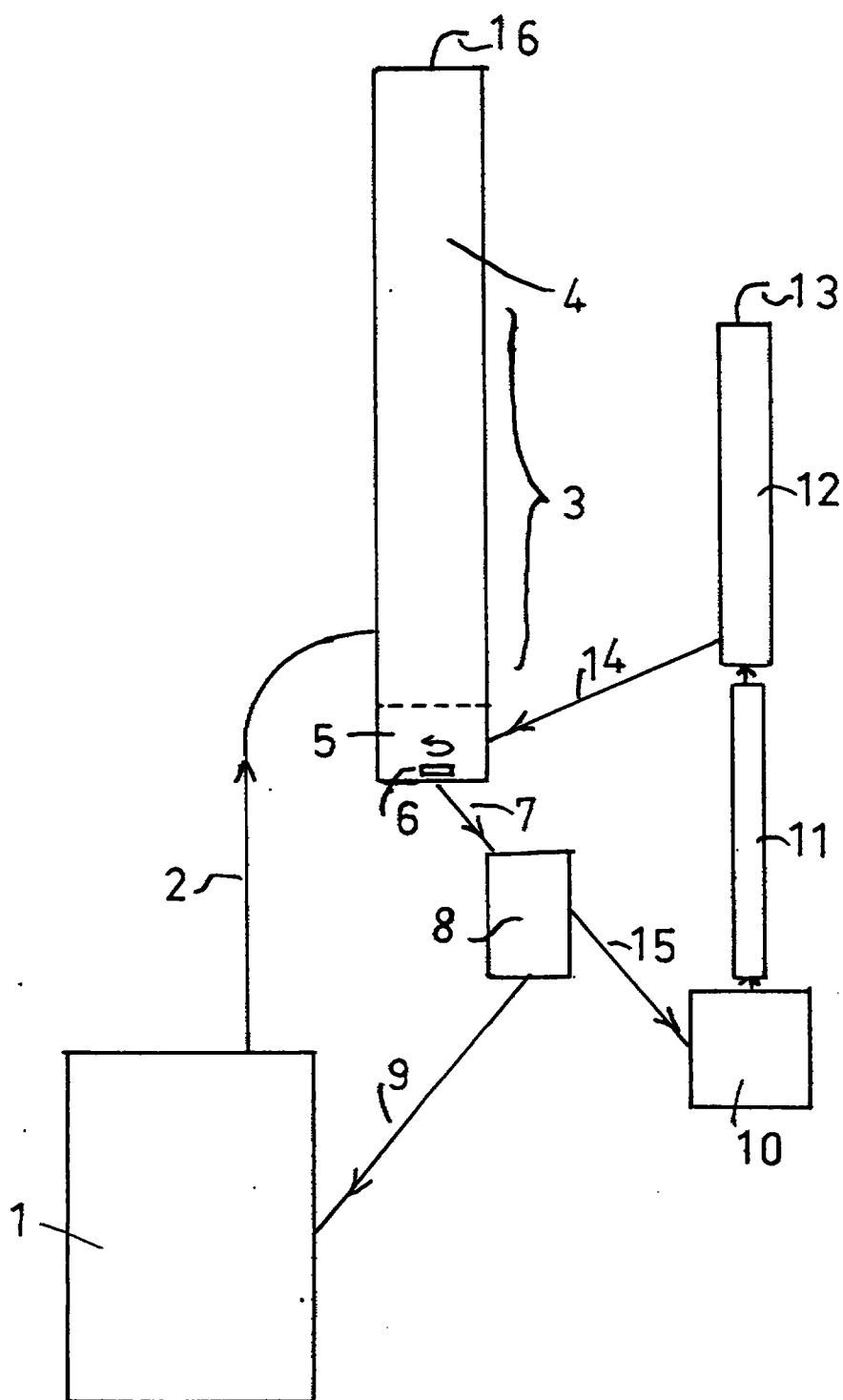


FIG .1

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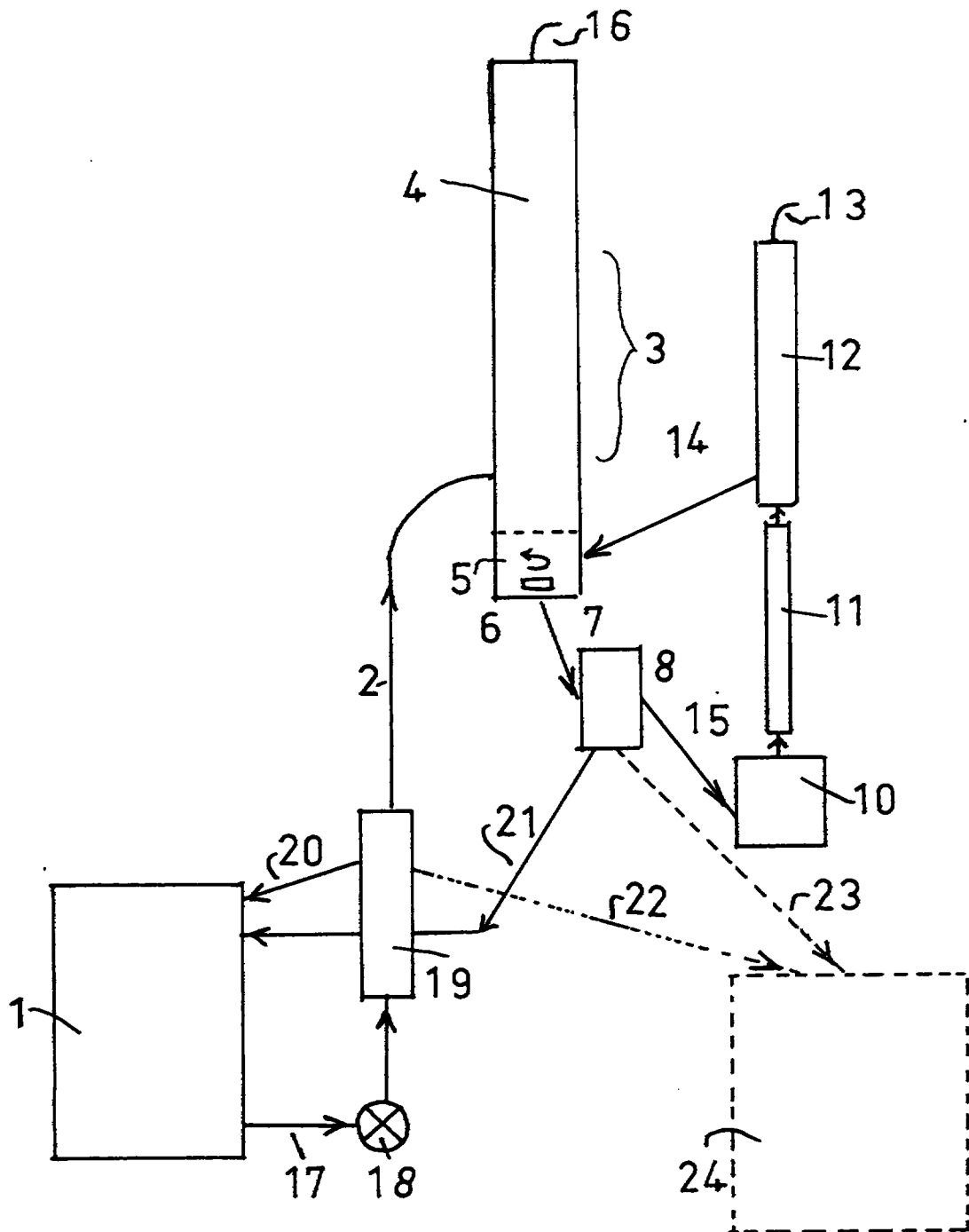
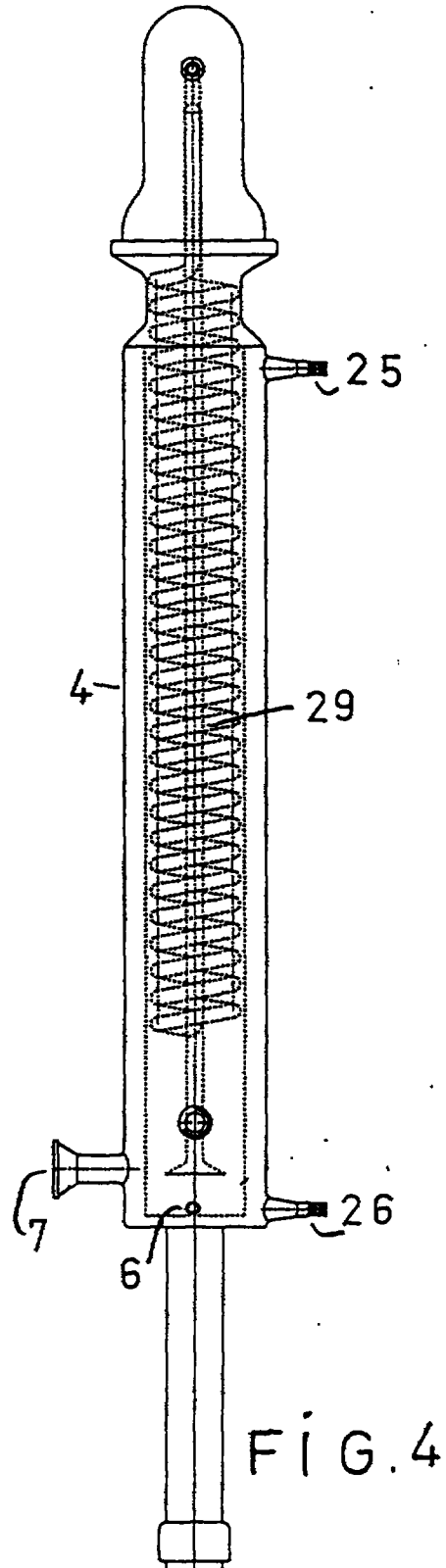
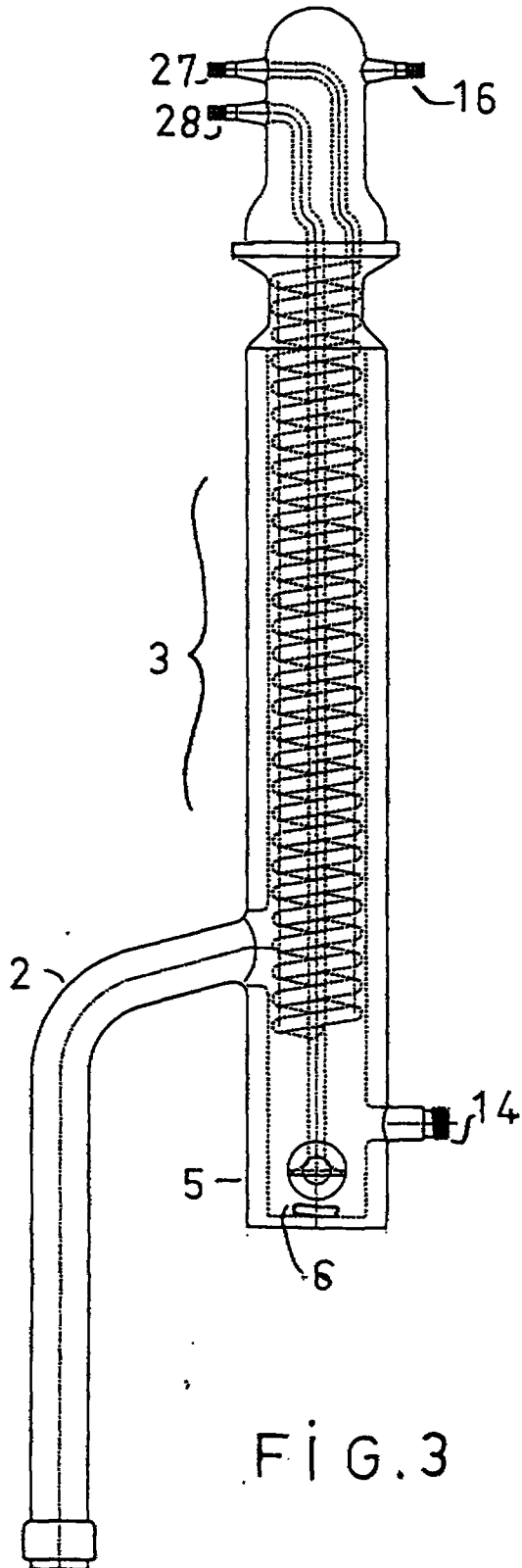
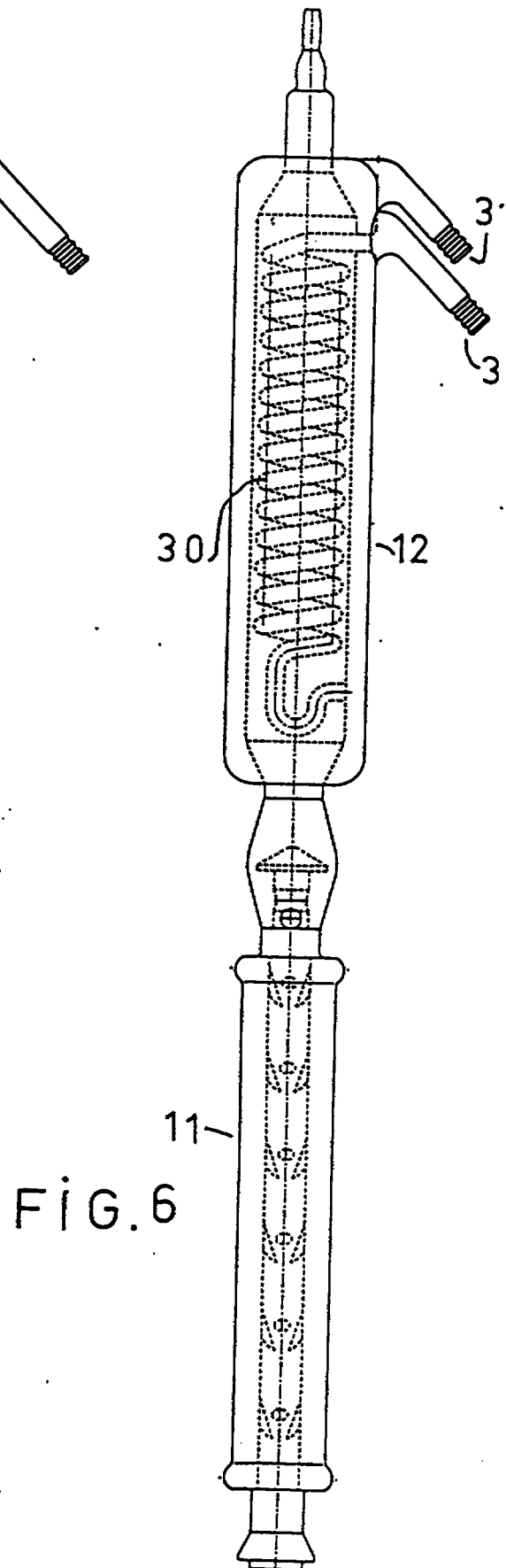
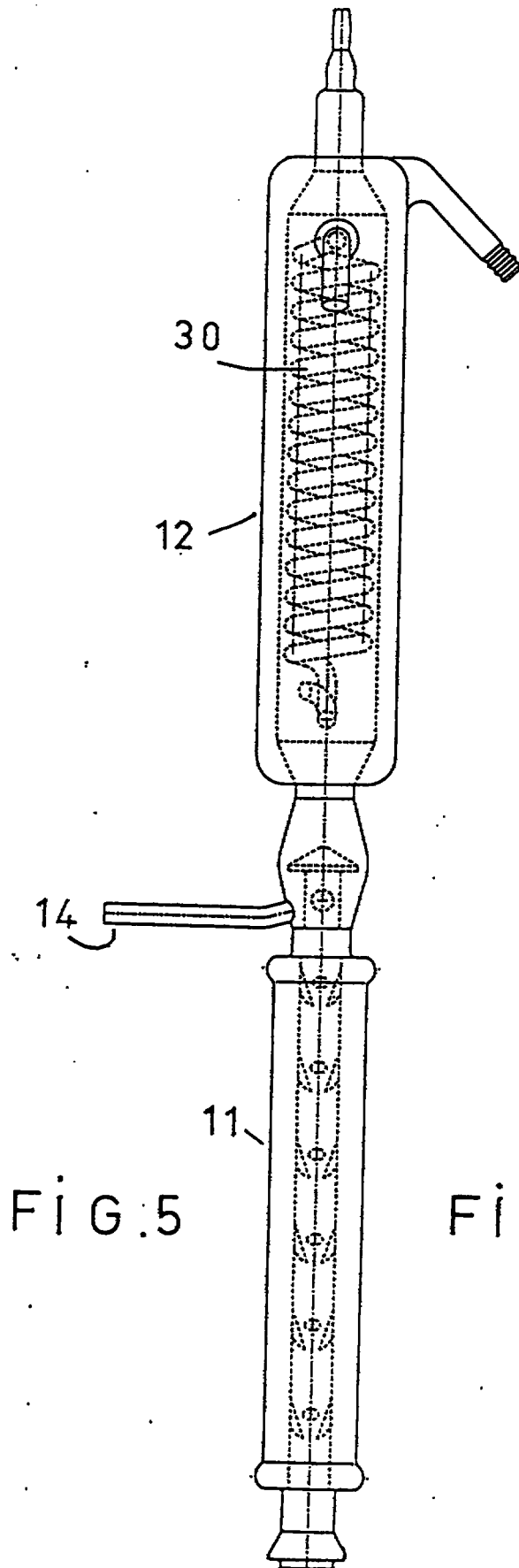


FIG. 2

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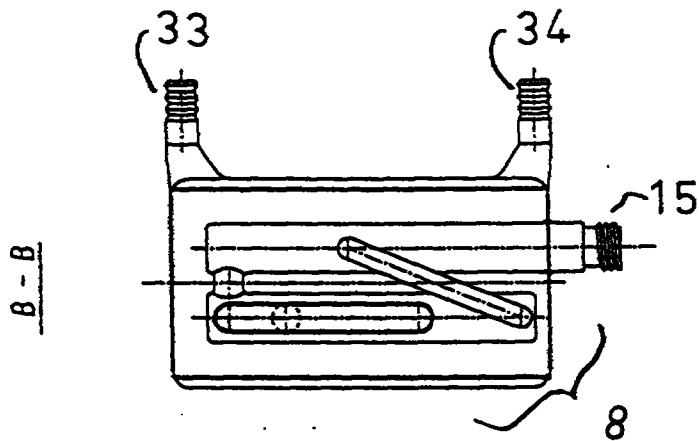


FIG. 9

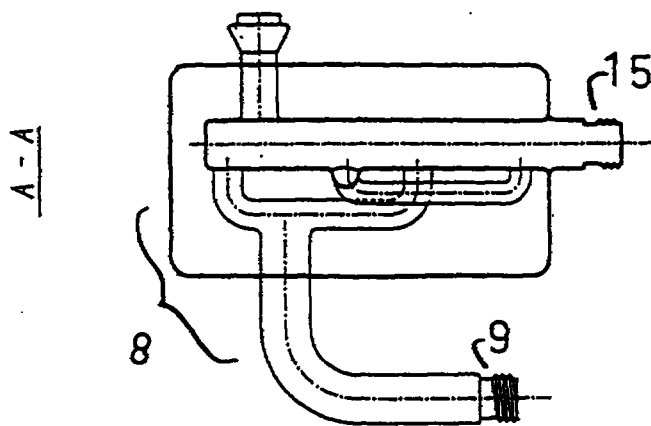


FIG. 8

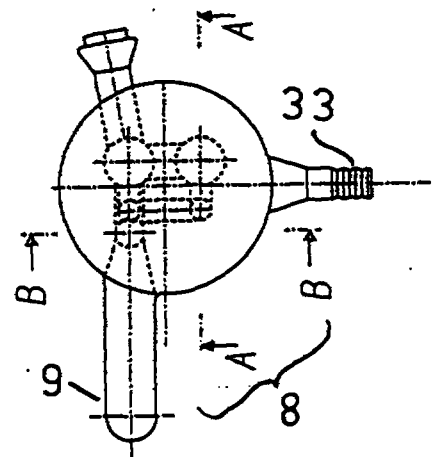


FIG. 7