column 10 from which a bottom fraction 121 and a overhead fraction 30 are obtained. The overhead fraction 30 contains hydrocarbons that are lighter than Pseudocumene, and is substantially free from Pseudocumene. The bottom fraction 121 contains Pseudocumene and heavier aromatic hydrocarbons. The bottom fraction 121 is supplied to the second distillation column 10', from which a bottom fraction 121' that is heavier than the fed mixture 11, and a overhead fraction 23' of substantially pure Pseudocumene are obtained. For instance, the method described in CN100424055C is based on this sequence.

In both cases, the columns 10,10' are associated with respective bottom reboilers 20,20'. The reboilers 20',20' may be heated by vapour, by diathermic oil or even by a directly fired heater. A contribute to the heat balance of the first column is given by the feed enthalpy, as well as by the enthalpy of the reflux stream 16 that flows back into the column once the vapour 12 has been condensed. The condensation heat which must be removed in the condensers 14,14' may be transferred to a cooling water stream, otherwise it may be directly dispersed into the environment by an air-cooler equipment. Alternatively, the condensation heat may be recovered for generating low-pressure steam. A part of the condensed overhead vapour 12,12' form a reflux stream16,16', according to a predetermined reflux ratio. To obtain a substantially quantitative separation of Pseudocumene from lighter / heavier compounds in the first column 10, and from the heavier / lighter compounds in the second column 10' of apparatus 1/2, as well known, a suitable reflux ratio must be used, which is the ratio between the volume of the reflux stream 16,16' and the volume of the distilled stream 13,13', provided that the columns 10,10' have a suitable number of stages.

US 2008161618 describes a process to obtain 1-butene by distillation of a mixture of hydrocarbons with four carbon atoms in a single column comprising two longitudinal chambers that are separated by an inner partition wall. The two chambers serve for corresponding fractional distillation steps, in which the reflux coming from a chamber is used as a feed for the other chamber. ~~Such an apparatus cannot be used to obtain Pseudocumene by consecutive distillation steps of a mixture of aromatic hydrocarbons with nine or more carbon atoms. In fact, such distillation steps are carried out at a temperature remarkably higher than the temperature used for hydrocarbons~~

~~with four carbon atoms. Typically, the separation of Pseudocumene is carried out at a temperature between 170 and 200°C, in the first distillation, and at a temperature between 160 and 180°C in the second distillation, whereas temperatures of 30-40°C and 30-45°C are used in the case of the 1-butene process. For this reason, in the case of the Pseudocumene process, the temperatures, in particular the temperature difference between the walls of the two longitudinal chambers, would be sensibly higher than the corresponding temperatures and temperature difference of the 1-butene process. Such circumstance is particularly relevant in the steps of start-up and shut-down of the process, in which one of the two chambers may be or may attain the room temperature. In the case of the Pseudocumene process, such temperature differences cause local stresses in the walls of the two chambers that are much higher, in particular, in the inner partition wall and in the joints between the inner partition wall and the body of the column, which the column of US 2008016161 could not tolerate without being damaged. In particular, the stability of the temperatures and of the connections could be seriously impaired when starting up and shutting down the process, for a planned maintenance operation or in an emergency circumstance.~~

However, the boiling points of Pseudocumene and of some aromatic hydrocarbons that are contained in the raw mixture are very close to one another, and the relative volatilities of the various components are close to 1. A reference, industrially acceptable Pseudocumene purity degree value is 98,5%. A reference, industrially acceptable Pseudocumene recovery value is 80%. To obtain such results, according to the diagrams of Fig. 1 and 2, the following would be required:

— a column of distillation 10,10' with a very high total number of stages, normally set between 250 and 400;

— very high reflux ratio values, normally set between 15:1 and 30:1. In such super fractionation or super distillation conditions, very large heating and cooling heat amount must be exchanged, and the operating costs would be very high with respect to the value of the separated product. For the same reason, the purchasing costs of the equipment and the construction costs of the fractionation units would be very high, as well as the maintenance costs.

adapted to tolerate without damages a predetermined number of start up and shut down cycles, also in conditions of emergency, of such two consecutive steps. It is also a feature of the invention to provide such an apparatus that is adapted to tolerate in continuous operation without damages the temperature differences typical of such consecutive steps.

It is another feature of the invention to provide such a method and such an apparatus, which allow reducing the energy requirements of the separation of Pseudocumene by distillation, with respect to what possible with the methods and with the apparatus of known type.

These and other objects are achieved by a method, according to an aspect of the invention, for separating and recovering 1,2,4-trimethylbenzene (TMB), i.e. Pseudocumene, from a raw mixture containing, besides 1,2,4 trimethylbenzene (TMB), aromatic hydrocarbons with nine carbon atoms and preferably with more than nine carbon atoms, and preferably hydrocarbons with less than nine carbon atoms, in particular, containing at least one compound heavier than 1,2,4-TMB and a compound lighter than 1,2,4-TMB, the method comprising the steps of:

— prearranging a column, i.e. a vertical elongated container, that is provided with an inner partition wall, the container and the inner partition wall defining a first longitudinal chamber and a second longitudinal chamber within the elongated container;

— arranging a differential expansion compensation means between the elongated container and the inner partition wall for compensating the differential expansion caused by temperature differences between the first chamber and the second chamber, wherein the partition wall is internally fixed to a shell of the vertical elongated container at a short edge portion extension of the partition wall, whereas other edge portions of the partition wall have a relative freedom of movement with respect to the shell, in order to allow the expansion of the partition wall with respect to the shell.

— feeding the raw mixture into the first longitudinal chamber that is maintained within a predetermined first working temperature range and at a predetermined first working pressure;

— extracting a first overhead vapour fraction from the first longitudinal chamber, the first overhead vapour fraction comprising aromatic hydrocarbons that are lighter than Pseudocumene, i.e. aromatic hydrocarbons that have a relative volatility higher than 1, with respect to Pseudocumene;

— extracting a first bottom fraction from the first longitudinal chamber, the first bottom fraction comprising aromatic hydrocarbons that are heavier than Pseudocumene, i.e. aromatic hydrocarbons that have a relative volatility lower than 1, with respect to Pseudocumene;

wherein the first working temperature range and/or the first working pressure are selected in such a way that Pseudocumene is present substantially in only

one fraction selected among the first overhead fraction and the first bottom fraction, such that a Pseudocumene-containing fraction and a substantially Pseudocumene-free mixture are extracted from the first longitudinal chamber,

— feeding at least one part of the Pseudocumene-containing fraction into the second longitudinal chamber, the second longitudinal chamber maintained within a predetermined second working temperature range and at a predetermined second working pressure;

— extracting a second overhead vapour fraction from the second longitudinal chamber;

— extracting a second bottom fraction from the second longitudinal chamber;

wherein the second working temperature range and/or the second working pressure are selected in such a way that Pseudocumene is present substantially pure only in one fraction selected among the second overhead fraction and the second bottom fraction, according to whether the amount of the Pseudocumene-containing fraction, which is extracted from the first longitudinal chamber, and supplied to the second longitudinal chamber is at least one part of the first bottom fraction or at least one part of the first overhead fraction, respectively;

— compensating differential expansions of the inner partition wall due to a temperature difference between the first chamber and the second chamber by the differential expansion compensation means that are between the elongated container and the inner partition wall.

This way, the separation of Pseudocumene from the aromatic C9 or C9+ mixture is carried out in a single container, in particular, in a single divided fractionation column, which reduces the overall construction and operating costs of the fractionation unit.

On the contrary, the apparatus disclosed in US 2008161618, which does not have such a differential expansion compensation means, cannot be used to obtain Pseudocumene by consecutive distillation steps of a mixture of aromatic hydrocarbons with nine or more carbon atoms. In fact, such distillation steps are carried out at a temperature remarkably higher than the temperature used for hydrocarbons with four carbon atoms. Typically, the separation of Pseudocumene is carried out at a temperature between 170 and 200°C, in the first distillation, and at a temperature between 160 and 180°C in the second distillation, whereas temperatures of 30-40°C and 30-45°C are used in the case of the 1-butene process.

For this reason, in the case of the Pseudocumene process, the temperatures, in particular the temperature difference between the walls of the two longitudinal chambers, would be sensibly higher than the corresponding temperatures and temperature difference of the 1-butene process.

Such circumstance is particularly relevant in the steps of start-up and shut-down of the process, in which one of the two chambers may be or may attain the room temperature. In the case of the Pseudocumene process, such temperature differences cause local stresses in the walls of the two chambers that are much higher, in particular, in the inner partition wall and in the joints

between the inner partition wall and the body of the column, which the column of US 2008016161 could not tolerate without being damaged. In particular, the stability of the temperatures and of the connections could be seriously impaired when starting up and shutting down the process, for a planned maintenance operation or in an emergency circumstance.

In an exemplary embodiment, indicated as direct sequence, which is suggested by the composition of the raw mixture, the operating temperature range of the first longitudinal chamber is selected in such a way that the Pseudocumene-containing fraction, which is extracted from the first longitudinal chamber, is the bottom fraction, which forms a feed for the second longitudinal chamber for separating Pseudocumene from the compounds heavier than Pseudocumene, whereas the substantially Pseudocumene-free fraction, which is extracted from the first longitudinal chamber, it is the overhead fraction, and the operating temperature range of the second longitudinal chamber, as well as the composition of the feed of the second longitudinal chamber are such that the substantially pure Pseudocumene-

wherein the maintenance means is adapted to maintain working temperature ranges and/or operating pressures such that:

— Pseudocumene is present substantially in only one fraction selected among the first overhead fraction and the first bottom fraction, and

— substantially pure Pseudocumene is contained only in one fraction selected among the second overhead fraction and the second bottom fraction, according to whether the Pseudocumene-containing fraction that is extracted from the first longitudinal chamber is the first bottom fraction or the first overhead fraction, respectively,

wherein the apparatus comprises an elongated container that is adapted to be arranged vertically, wherein an inner partition wall is arranged within the elongated container, the inner partition wall defining within the elongated container the first chamber and the second chamber,

wherein the main feature of the apparatus is that it comprises a differential expansion compensation means for compensating the differential expansion due to a temperature difference between said first chamber and said second chamber;

wherein the partition wall is internally fixed to a shell of the vertical elongated container at a short edge portion extension of the partition wall, whereas other edge portions of the partition wall have a relative freedom of movement with respect to the shell, in order to allow the expansion of the partition wall with respect to the shell.

Preferably, the inner partition wall is substantially vertical.

The inner partition wall may have a shape selected from the group consisting of:

— a wall comprising at least one portion which extends according to a plane;

— a wall comprising at least one portion having a curvilinear cross section;

— a wall having a curvilinear and/or rectilinear closed cross section.

The position of the inner partition wall may be selected according to the composition of the raw mixture and/or according to the relative difficulty of the separations that are carried out in the first chamber and in the second chamber; In particular, the inner partition wall is a substantially diametrical wall.

In an exemplary embodiment, the inner partition wall has an inner passageway, the passageway extending between a top section of the first chamber and a feed section of the second chamber, the passageway adapted to convey a stream of vapour between the first chamber and the second chamber and/or vice-versa.

chamber 73'; an amount 41' of this fraction is condensed in a heat exchanger or condenser 34' and temporarily stored within a storage tank 43', to be then reintroduced into distillation chamber 73' through an inlet port made at an upper portion of chamber 73', wherein a reflux stream 36 is formed' according to a predetermined reflux ratio. Even in this case, the flow rate of reflux stream 36' may be controlled in a well-known way, typically through a regulation valve 37'.

A stream 38' of a bottom fraction is extracted as a liquid from a bottom section of second chamber 73', an amount 39' of which is supplied to a reboiler 40' where it is caused to boil and preferably heated, receiving enough heat to separate by distillation lighter and heavier products that are contained in stream 33, which takes place in second chamber 73'. Stream 39' of the vaporized bottom fraction is recycled into second distillation chamber 73', where it releases the fractionation heat and allows a predetermined temperature profile to be established, responsive to the chemical-physical properties of the hydrocarbon mixture treated in second distillation chamber 73'.

The operating parameters of the column, in particular, the reflux ratio and the amount of heat, may be predetermined in such a way that different temperature profiles may be obtained along the first distillation chamber, and therefore different concentration profiles of each component that is present in stream 33, in particular, with a sufficient number of stages, it is possible to obtain substantially pure Pseudocumene in stream 38' of bottom fraction, and to withdraw a stream 33' of substantially pure Pseudocumene. Even in this case, the flow rate of withdrawn Pseudocumene 131' may be controlled conventionally, typically by a regulation valve 130 that is controlled by the liquid level of a bottom section of chamber 73'.

Fig. ~~5~~2B relates to the case in which Pseudocumene is present as the main component, or substantially alone, in stream 38 of the bottom fraction. Therefore, a stream 47 of the bottom fraction is supplied to second chamber 73' for separating Pseudocumene from heavier aromatic hydrocarbons.

An amount 33 of stream 32 of overhead vapour 41 that is extracted from first distillation chamber 301 and condensed, is withdrawn as light product from fractionation unit 3', and contains aromatic hydrocarbons lighter than

In Figs. 3A to 3E a differential expansion compensation means is shown for compensating the differential expansion caused by the temperature difference between a first chamber 273 and a second chamber 273', of a distillation column 200 where a distillation is carried out of a mixture of hydrocarbons with 9 and more than 9 carbon atoms, to obtain pseudocumene. Chambers 273,273' are separated by a dividing wall 285.

According to a first ~~in the~~ exemplary embodiment of Fig. 3A, dividing wall 285 is internally ~~connected~~fixed to a shell of column 200 at an own short edge portion extension, whereas the other edge portions have a relative freedom of movement, which allows the expansion o dividing wall 285. For example, this edge portion may be welded to the shell, or it may be connected by any suitable ~~connection~~fixed technique.

In the ~~in the~~ exemplary embodiment of Fig. 3B, the dividing wall is internally ~~connected~~fixed to a rounded bottom 218,219 of the column at an own end edge portion, preferably it is welded within lower end portion 218. In this case, a guide means is provided for guiding the longitudinal slide movement of dividing wall 285, the guide means preferably comprising a couple of longitudinal plates 221 that extend along the whole height of column 200. Also longitudinal plates 221 may be internally ~~connected~~fixed with the column, typically within the shell 217, by welding or by any suitable technique. Along the long sides of the longitudinal dividing wall, aligned holes 227 are made parallel to the edges. Similarly, near the edge of each longitudinal plate ~~21~~221 aligned holes 228 are made parallel to the edge. Holes 227 and holes 228 have reciprocal distances according to a same pattern, so that each hole faces a hole during the slide movement of dividing wall 285 with respect to ~~trays~~plates 221. In each couple of reciprocally facing holes 227 and 228 one hole is slotted and the other is circular, or in any case it is adapted to receive a tie-member ~~226~~, in particular, as shown in the picture, to receive stem portion of a screw. A nut 225 is arranged opposite to the screw head 226, and engages with the screw according to a prefixed blocking force. A seal 222 is arranged between longitudinal plate 221 and dividing wall 285, for example a Teflon® seal, which ensures the a fluid-tight contact between chamber 273 and chamber 273'. Materials are known that are well-suited to provide an acceptable seal at a pressure difference up to 1 bar, between the first chamber and the second

chamber. A suitable seal means may be also be arranged at nut 225, as shown in the picture, or at screw head 226 that is located on the maximum pressure side.

The elongated holes may have an increasing length, moving away from the edge portion ~~connected~~fixed to the equipment, in this case away from the bottom of the apparatus, since the average thermal expansion is proportional to the distance from the constrained end. The locking the screws in the nuts, or of other equivalent screw threaded means, must ensure the seal between the chambers the seal provided by the gaskets 222 without hindering the slide movement of dividing wall 222.

Owing to this arrangement, dividing wall 285 can buckle under the action of thermal stress.

In another exemplary embodiment shown in the same picture, expansion compensation means are provided ~~means~~ that are integrated in the dividing wall, and comprise a deformable portion of the dividing wall, to allow an expansion or in any case a thermally induced deformation.

A distillation column 200 is shown which comprises a container 211 having an inner dividing wall or baffle 85, which defines in the column two distinct distillation chambers 273 and 263'. An expansion compensation means is provided for compensating the differential expansion that is caused by the temperature difference between first chamber 73 and second chamber 73'.

In a first exemplary embodiment, the compensation means comprises a longitudinal slide guide 221 in the form of longitudinal plates, which are internally welded to the wall of the equipment. The compensation means comprises an inner dividing wall or baffle 285, in this case a diametrical wall, which is ~~connected~~fixed to a point of the equipment, for example at a lower top of it.

In Fig. 4 an apparatus 4 is diagrammatically shown, according to an alternative exemplary embodiment of the invention, which differs from apparatus 3 of Fig. 3A in that a stream 42 including all the overhead vapour extracted from first distillation chamber 73 is fed to second distillation chamber 73' of column 301. The reflux stream 46 of first distillation chamber 73 is then obtained by combining a stream 44, containing a part of the light aromatic

CLAIMS

1. A method for separating and recovering Pseudocumene from a raw mixture (31,51) containing aromatic hydrocarbons with nine carbon atoms and preferably with more than nine carbon atoms, and preferably hydrocarbons with less than nine carbon atoms, said method comprising the steps of:

— prearranging a vertical elongated container having an inner partition wall (83,85,89), said container and said inner partition wall defining a first longitudinal chamber (73,75,79-79') and a second longitudinal chamber (73',75',79") within said elongated container;

— feeding said raw mixture into said first longitudinal chamber, said first longitudinal chamber maintained within a predetermined first working temperature range and at a predetermined first working pressure;

— extracting a first overhead vapour fraction (32,42,52) from said first longitudinal chamber, said first overhead vapour fraction comprising aromatic hydrocarbons that are lighter than said Pseudocumene;

— extracting from said first longitudinal chamber a first bottom fraction (38,98) comprising aromatic hydrocarbons that are heavier than said Pseudocumene;

wherein said first working temperature range and/or said first working pressure are selected in such a way that Pseudocumene is present substantially in only one fraction selected between said first overhead fraction and said first bottom fraction, such that a Pseudocumene-containing fraction and a substantially Pseudocumene-free mixture are extracted from said first longitudinal chamber,

— feeding at least one part (33,42,47,52) of said Pseudocumene-containing fraction into said second longitudinal chamber, which is maintained within a predetermined second working temperature range and at a predetermined second working pressure;

— extracting a second overhead vapour fraction from said second longitudinal chamber (32',92');

— extracting a second bottom fraction from said second longitudinal chamber (38',98',131');

wherein said second working temperature range and/or said second working pressure are selected in such a way that Pseudocumene is present substantially pure only in one fraction selected between said second overhead fraction and said second bottom fraction, according to whether said amount (33,42,47,52) of said Pseudocumene-containing fraction (32,42,47,52,52-65), which is extracted from said first longitudinal chamber and supplied to said second longitudinal chamber, is respectively, at least one part (47) of said first bottom fraction (38,98) or at least one part (33,42,52) of said first overhead fraction (32,42,5252-65),

wherein, in particular, said raw mixture of aromatic hydrocarbons is obtained by a catalytic reforming treatment of a crude-oil distillation fraction, in particular, by a catalytic reforming of a virgin naphtha,

wherein said step of prearranging said inner longitudinal partition wall that is adapted to define said first chamber (73) and said second chamber (73') within said elongated container, is carried out so that differential expansions of said inner partition wall are compensated, said differential expansions due to a temperature difference between said first chamber (73) and said second chamber (73').

2. A method according to claim 1, also comprising the steps of:

— compressing at least one portion (65,65') of said first overhead vapour fraction and/or of said second overhead vapour fraction, a compressed overhead vapour (66,66') being obtained from said compression at a pressure higher than the first/second working pressure, respectively, said compression increasing the condensation temperature of said overhead vapour up to a value that is higher than a boiling temperature of a bottom fraction (38,38',98,98') selected between said first bottom fraction and/or of said second bottom fraction;

— condensing said compressed overhead vapour, said condensation occurring with a release of a condensation latent heat of said compressed overhead vapour;

— heating and reboiling at least one part of said first bottom fraction and/or of said second bottom fraction (38,38',98,98'), said heating and/or boiling occurring with an absorption of a required heat, wherein at least

one part of said required heat is obtained from said condensation latent heat,

wherein, in particular, said step of compression is carried out at a compression ratio set between 1,5:1 and 5:1, more in particular, at a compression ratio set between 1,5:1 and 3:1,

3. A method according to claim 1, wherein said first overhead vapour fraction (42,52) is completely supplied to said second longitudinal chamber, and the method also comprises the steps of introducing a liquid stream (46) into said first longitudinal chamber (73,75,79) as a distillation reflux, said liquid stream obtained from:

– a condensate of at least one part (44) of said second overhead vapour fraction (32',92'), and/or

– at least one part (45) of said second bottom fraction (98',131').

4. A method for separating and recovering Pseudocumene from a raw mixture (21) containing aromatic hydrocarbons with nine carbon atoms and preferably with more than nine carbon atoms, and preferably hydrocarbons with less than nine carbon atoms, said method comprising the steps of:

— prearranging a first vertical elongated container (210) and a second vertical elongated container (210'), said first vertical elongated container and said second vertical elongated container defining a first chamber (72) and a second chamber (72'), respectively;

— feeding said raw mixture into said first chamber, said first chamber maintained within a predetermined first working temperature range and at a predetermined first working pressure;

— extracting from said first chamber a first overhead vapour fraction (22) comprising aromatic hydrocarbons that are lighter than said Pseudocumene;

— extracting from said first chamber a first bottom fraction (28) comprising aromatic hydrocarbons that are heavier than said Pseudocumene;

wherein said first working temperature range and/or said first working pressure are selected in such a way that Pseudocumene is present substantially in only one fraction selected between said first overhead

fraction and said first bottom fraction, such that from said first chamber a Pseudocumene-containing fraction and a substantially Pseudocumene-free fraction are extracted,

— feeding at least one part (23,27) of said Pseudocumene-containing fraction into said second chamber, which is maintained within a predetermined second working temperature range and at a predetermined second working pressure;

— extracting a second overhead vapour fraction (22') from said second chamber;

— extracting a second bottom fraction (28')from said second chamber;

wherein said second working temperature range and/or said second working pressure are selected in such a way that Pseudocumene is present substantially pure only in one fraction selected between said second overhead fraction and said second bottom fraction, according to whether said fraction (23,27) extracted from said first chamber and supplied to the second chamber is, respectively, said first bottom fraction or said first overhead fraction,

characterised in that it comprises the steps of:

— compressing at least one portion (22,22') of said first overhead vapour fraction and/or of said second overhead vapour fraction, a compressed overhead vapour (25,25') being obtained from said compression at a pressure that is higher than the first/second working pressure, respectively, said compression increasing the condensation temperature of said overhead vapour up to a value that is higher than a boiling temperature of a bottom fraction (28,28') selected between said first and/or said second bottom fraction;

— condensation of said compressed overhead vapour, said condensation occurring with a release of a condensation latent heat of said compressed overhead vapour;

— heating and reboiling at least one part (29,29') of said first bottom fraction and/or of said second bottom fraction (28,28'), said heating and/or boiling occurring with an absorption of a required heat, wherein at least one part of said required heat is obtained from said condensation latent heat,

wherein, in particular, said step of compression is carried out at a compression ratio set between 1,5:1 and 5:1, more in particular, at a compression ratio set between 1,5:1 and 3:1.

5. A method according to claim 1 or 4, wherein said step of compression is carried out by compressing at least one portion (65) of said first overhead vapour fraction (52-65), said compression increasing the condensation temperature of said overhead vapour up to a value that, advantageously, is higher than a boiling temperature of said second bottom fraction (38'), and said step of heating and reboiling is carried out on at least one part (39') of said bottom fraction that is extracted from said second chamber (75').

6. An apparatus (3,3',4,5,6,7,7',8,9) for separating and recovering Pseudocumene from a raw mixture (31,51) containing aromatic hydrocarbons with nine carbon atoms, and preferably hydrocarbons with more than nine carbon atoms, and preferably hydrocarbons with less than nine carbon atoms, said apparatus comprising:

— a first chamber (73) and a second chamber (75), said first chamber adapted to receive said raw mixture;

— a first feed means for feeding said first chamber (73) with said raw mixture;

— a first top extraction means for extracting a first overhead vapour fraction (52) from said first chamber (73);

— a first bottom extraction means for extracting a first bottom fraction (38) from said first chamber (73);

— a second feed means for feeding said second chamber (75) with a stream (33,42,47,52) selected between a portion of said first overhead vapour fraction and a portion of said first bottom fraction;

— a second top extraction means for extracting a second overhead vapour fraction (32') from said second chamber (75);

— a second bottom extraction means for extracting a second bottom fraction (38',98',131') from said second chamber (75);

— a maintenance means for maintaining said first chamber and said second chamber within predetermined working temperature ranges and at predetermined respective operating pressures;

wherein said maintenance means is adapted to maintain working temperature range and/or operating pressures such that:

— said Pseudocumene is present substantially in only one fraction selected between said first overhead fraction and said first bottom fraction, and

— a substantially pure Pseudocumene is contained only in one fraction selected between said second overhead fraction and said second bottom fraction, according to whether said Pseudocumene-containing fraction that is extracted from said first longitudinal chamber is said first bottom fraction or said first overhead fraction, respectively,

wherein said apparatus comprises an elongated container that is adapted to be arranged vertically,

characterised in that an inner longitudinal partition wall (83,85,89) is arranged within said elongated container, said inner longitudinal partition wall (83,85,89) defining said first chamber (73) and said second chamber (73') within said elongated container, and in that

said apparatus comprises a differential expansion compensation means for compensating differential expansion due to a temperature difference between said first chamber (73) and said second chamber (73').

7. An apparatus (5,7',8,9) according to claim 6, wherein said inner longitudinal partition wall (85,89) has an inner passageway (86,90,90'), said passageway extending between a top section of said first chamber (75) and a feed section (59) of said second chamber (75'),

said passageway adapted to convey a stream of vapour (52,92) from said first chamber to said second chamber and/or vice-versa.

8. An apparatus (9) according to claim 6, wherein

— a transverse inner partition wall is provided within said container (89), which defines along with said inner longitudinal partition wall (89') said first longitudinal chamber and said second longitudinal chamber (79"), such that a continuation portion (79') of said first longitudinal chamber is arranged on the same side of said second longitudinal chamber (79") with respect to said inner longitudinal partition wall (89), and such that said inner longitudinal partition wall (89) fluidically separate

said continuation portion (79") of said first chamber from a main portion (79) of said first chamber;

— said first bottom extraction means is arranged on said continuation portion (79") of said first chamber;

— said main part (79) of said first chamber comprises a bottom feed means;

— said container also comprises:

— a top feed means for feeding a liquid stream into an upper portion of said third chamber;

— a third top extraction means for extracting a third overhead vapour fraction (32,42,52) from said third chamber;

— a third bottom extraction means for extracting a third bottom fraction (38,98) from said third chamber;

and wherein

— a pneumatic connection is provided (90') of said top feed means of said continuation portion (79") of said first chamber with said first extraction means of said first chamber, and

— said third top extraction means is pneumatically connected with said bottom feed means of said main part (79) of said first chamber,

in order to provide a continuous fractionation path of said stream of vapour (92) between said main part (79) and said continuation portion (79") of said first chamber (79'), at opposite sides of said inner longitudinal partition wall (89).

9. An apparatus according to claim 8, wherein said second chamber (79') and said continuation portion (79") together comprise a number of separation stages that is substantially the same as the number of stages of said main part (79) of said first chamber, in particular, said second chamber (79') and said continuation portion (79"), on the one hand, and said main part (79), on the other hand, comprise the same number of trays or substantially the same packed bed height.

10. An apparatus according to claim 8, wherein said pneumatic connection comprises a further passageway (90) that is defined within said inner longitudinal partition wall (89) between said top feed means of said continuation portion (79') of said first chamber and said first extraction

means said first chamber.

11. An apparatus (6,7,7',9) according to claim 6, comprising:

— a compression means for compressing (64,64') at least one portion (65) of said first overhead vapour fraction and/or at least one portion (65') of said second overhead vapour fraction, said compression means (64,64') adapted to provide a compressed overhead vapour (66,66') at a compressed vapour pressure such that said compressed overhead vapour has a condensation temperature that exceeds a boiling temperature of said first bottom fraction and/or it has at a condensation temperature that exceeds a boiling temperature of said second bottom fraction;

— an indirect heat exchange means (70,70',100') between said compressed overhead vapour (66,66') and at least one part (39) of said first bottom fraction (38) and/or at least one part (39',99') of said second bottom fraction (98'), said heat exchange means adapted to cause a boiling of said at least one part of said first bottom fraction and/or a boiling of said at least one part of said second bottom fraction,

12. An apparatus (6,7,7',9) according to claim 11, wherein said compression means can be operated by an expansion means (764) for expanding an aeriform substance (761), in particular by a turbine, and said apparatus comprises a means for generating said aeriform substance,

13. An apparatus (6,7,7',9) according to claim 12, wherein said means for generating an aeriform substance comprise a steam generator (71) that is associated with a heating means (70) of said first bottom fraction and/or of said second bottom fraction.

14. An apparatus according to claim 11, wherein said first chamber and/or said second chamber comprises a fractionation means selected from the group consisting of:

— distillation trays, in particular, sieve trays;

— a packed bed, in particular, a structured packed bed;

— a combination thereof.

15. An apparatus according to claim 11, wherein a part of said fractionation means corresponding to a real fractionation stage is adapted to cause, in an operating condition of said first chamber and of said second chamber, a pressure drop lower than 20 millibar, in particular, lower than 10

millibar, preferably lower than 2,5 millibar.

16. An apparatus (8) according to claim 6, wherein said first chamber comprises a catalytic fractionation means that is arranged at a height above a feed port (815) of said first longitudinal chamber (75), said catalytic fractionation means adapted to promote an alkylation reaction of said aromatic hydrocarbons with olefins that are contained in said raw mixture (51), bringing said olefins from a feed concentration to a residual concentration that is lower than 4 ppm, in particular, lower than 1 ppm, starting from a feed concentration that is normally set between 100 ppm and 300 ppm.

17. An apparatus according to claim 16, wherein said catalytic fractionation means comprises a catalytic material in the form of a packing material (803), said catalytic material selected from the group consisting of:

— acid earths;
— zeolites;
— a combination thereof.

18. An apparatus according to claim 16, wherein said maintenance means for maintaining said first chamber within a predetermined temperature range is adapted to maintain said catalytic fractionation means (803) at an alkylation temperature set between 160°C and 190°C, and

19. An apparatus according to claim 17, wherein said packing material comprises a catalytic material has a height such that the spatial speed of the liquid phase of the mixture being distilled is set between 1,0 h^{-1} and 10 h^{-1}, preferably it is set between 2,0 h^{-1} and 5,0 h^{-1}

20. An apparatus according to claim 6, wherein said first chamber and said second chamber are made within a column (310,320,330,360) of exchange comprising:

— a vertical elongated container (311) that has a longitudinal dividing wall (385) within said container (311), said container (311) defining with said dividing wall (385) said first chamber (375) and said second chamber (376,377);

— a means (301) for feeding said raw mixture (324) into said first chamber;

— a means (302) for extracting a first fluid stream (324) from said second chamber;

— a source (303) of a second stream;

— an means (304) for extracting said second stream,

— a contact means (363,383) for causing a contact between said first stream (324,364) and said second stream, said contact means (363) arranged within said first chamber (375) and/or within said second chamber (376,377);

— a longitudinal passageway (386,390) that extends between an outlet port (312) of said first chamber (375) and an inlet port (313) of said second chamber (376,377), said passageway made in a proximity (315) of said dividing wall (385), for conveying said first stream (324,64) from said first chamber (375) into said second chamber (376,377);

wherein said contact means (363) and/or said passageway (386,390) are such that in said passageway (386,390) said first stream (324,364) comprises an amount of a substance in said second fluid phase,

comprising furthermore:

— along said passageway (386,390), a phase separation means (340) that is adapted to receive said first stream (324) and to form a main portion (327) of said first stream (324) and a secondary portion (327') of said first stream (324), said secondary portion (327') comprising at least a part of said amount of substance in said second fluid phase;

— a feed means (347,348) of said main portion (327) of said first stream (324) at a predetermined feed height of said second chamber (376,377),

in order to remove said amount of substance in said second fluid phase from said first stream upstream of or at most at said inlet port (313) of said second chamber (376,377).

21. A exchange column (360) according to claim 20, wherein said phase separation means (340) comprise a means for feeding said secondary portion (327') of said first stream (324) to a further predetermined feed height of said second chamber (376,377).

22. A exchange column (360) according to claim 20', wherein said phase separation means (340) comprise a decantation chamber (340') made within said passageway (386).

23. An exchange column (360) according to claim 22, wherein said decantation chamber (340') has a height greater than or equal to twice the height of a theoretical separation stage of said second chamber

24. A exchange column (360) according to claim 22, wherein said decantation chamber (340') has a height (H) higher or identical of 1000 mm, in particular, a height greater than or equal to 1200 mm.

25. A exchange column (360) according to claim 22, wherein said decantation chamber (340') has a transverse dimension (L) that is higher or about 1/3 of an equivalent inner diameter of said column (360).

26. A exchange column (360) according to claim 22, wherein said decantation chamber (340') has a second transverse dimension (W), defined perpendicularly to said first transverse dimension (L), and that is greater than or equal to twice an equivalent diameter of an outlet port (343') of said main portion (327) of said first stream (324).

27. A exchange column (360) according to claim 22, wherein the decantation chamber (340') has a connection means for a level sensor for measuring a level formed by said amount of substance in said second fluid phase within said decantation chamber.

CLAIMS

1. A method for separating and recovering Pseudocumene from a raw mixture (31,51) containing aromatic hydrocarbons with at least nine carbon comprising the steps of:

— prearranging a vertical elongated container having an inner partition wall (83,85,89,93',285,385), said container and said inner partition wall (83,85,89,93',285,385) defining a first longitudinal chamber (73,75,79-79',273,96,375) and a second longitudinal chamber (73',75',79", 273',96',376) within said elongated container;

— arranging a differential expansion compensation means between said elongated container and said inner partition wall (83,85,89,93',285,385) for compensating the differential expansion caused by temperature differences between said first chamber (273) and said second chamber (273'), wherein said partition wall (285) is internally fixed to a shell (217) of said vertical elongated container (200) at a short edge portion extension of said partition wall (285), whereas other edge portions of said partition wall (285) have a relative freedom of movement with respect to said shell (217), in order to allow the expansion of said partition wall (285) with respect to said shell (217),

— feeding said raw mixture (31,51) into said first longitudinal chamber (73,75,79-79',273,96,375), and maintaining first longitudinal chamber (73,75,79-79',273,96,375) within a predetermined first working temperature range and at a predetermined first working pressure;

— extracting a first overhead vapour fraction (32,42,52) from said first longitudinal chamber (73,75,79-79',273,96,375), a first overhead vapour fraction (32,42,52) comprising aromatic hydrocarbons that are lighter than said Pseudocumene;

— extracting from said first longitudinal chamber (73,75,79-79',273,96,375) a first bottom fraction (38,98) comprising aromatic hydrocarbons that are heavier than said Pseudocumene;

wherein said first working temperature range and/or said first working pressure are selected in such a way that Pseudocumene is present substantially in only one fraction selected between said first overhead fraction (32,42,52) and said first bottom fraction (38,98), such that a Pseudocumene-containing fraction and

a substantially Pseudocumene-free mixture are extracted from said first longitudinal chamber (73,75,79-79',273,96,375),

— feeding at least one part (33,42,47,52) of said Pseudocumene-containing fraction into said second longitudinal chamber (73',75',79"-79',273',96',376), which is maintained within a predetermined second working temperature range and at a predetermined second working pressure;

— extracting a second overhead vapour fraction (32',92') from said second longitudinal chamber (73',75',79",273',96',376);

— extracting a second bottom fraction (38',98',131') from said second longitudinal chamber (73',75',79",273',96',376);

wherein said second working temperature range and/or said second working pressure are selected in such a way that Pseudocumene is present substantially pure only in one fraction selected between said second overhead fraction (32',92') and said second bottom fraction (38',98',131'), according to whether said amount (33,42,47,52) of said Pseudocumene-containing fraction (32,42,47,52,52), which is extracted from said first longitudinal chamber (73,75,79-79',273,96,375) and is supplied to said second longitudinal chamber (73',75',79",273',96',376), is respectively, at least one part (47) of said first bottom fraction (38,98) or at least one part (33,42,52) of said first overhead fraction (32,42,52),

wherein, in particular, said raw mixture (31,51) of aromatic hydrocarbons is obtained by a catalytic reforming treatment of a crude-oil distillation fraction, in particular, by a catalytic reforming of a virgin naphtha,

- compensating differential expansions of said inner partition wall (83,85,89,93',285,385) due to a temperature difference between said first chamber (73,75,79-79',273,96,375) and said second chamber (73') by said differential expansion compensation means that are between said elongated container and said inner partition wall (83,85,89,93',285,385).

2. A method according to claim 1, also comprising the steps of:

— compressing at least one portion (65,65') of said first overhead vapour fraction (32,42,52) and/or of said second overhead vapour fraction (32',92'), a compressed overhead vapour (66,66') being obtained from said compression at a pressure higher than the first/second working pressure, respectively, said compression increasing the condensation temperature of said overhead vapour

(32,42,52,32',92') up to a value that is higher than a boiling temperature of a bottom fraction (38,38',98,98') selected between said first bottom fraction (38,98) and/or of said second bottom fraction (38',98');

— condensing said compressed overhead vapour (66,66'), said condensation occurring with a release of a condensation latent heat of said compressed overhead vapour (66,66');

— heating and reboiling at least one part of said first bottom fraction (38,98) and/or of said second bottom fraction (38',98'), said heating and/or boiling occurring with an absorption of a required heat, wherein at least one part of said required heat is obtained from said condensation latent heat,

wherein, in particular, said step of compression is carried out at a compression ratio set between 1,5:1 and 5:1, more in particular, at a compression ratio set between 1,5:1 and 3:1,

3. A method according to claim 1, wherein said first overhead vapour fraction (42,52) is completely supplied to said second longitudinal chamber, and the method also comprises the steps of introducing a liquid stream (46) into said first longitudinal chamber (73,75,79) as a distillation reflux, said liquid stream (46) obtained from:

– a condensate of at least one part (44) of said second overhead vapour fraction (32',92'), and/or

– at least one part (45) of said second bottom fraction (98',131').

4. A method according to claim 2, wherein said step of compression is carried out by compressing at least one portion (65) of said first overhead vapour fraction (52-65), said compression increasing the condensation temperature of said overhead vapour up to a value that is higher than a boiling temperature of said second bottom fraction (38'), and said step of heating and reboiling is carried out on at least one part (39') of said bottom fraction that is extracted from said second chamber (75').

5. An apparatus (3,3',4,5,6,7,7',8,9) for separating and recovering Pseudocumene from a raw mixture (31,51) containing aromatic hydrocarbons with at least nine carbon atoms, said apparatus comprising:

— a first chamber (73,75,79-79',273,96,375) and a second chamber (73',75',79",273',96,376), said first chamber adapted to receive said raw mixture (31,51);

— a first feed means for feeding said first chamber (73,75,79-79',273,96,375) with said raw mixture (31,51);

— a first top extraction means for extracting a first overhead vapour fraction (32,42,52) from said first chamber (73,75,79-79',273,96,375);

— a first bottom extraction means for extracting a first bottom fraction (38,98) from said first chamber (73,75,79-79',273,96,375);

— a second feed means for feeding said second chamber (73',75,79",273',96',376) with a stream (33,42,47,52) selected between a portion (33,42,52) of said first overhead vapour fraction and a portion (47) of said first bottom fraction (38,98);

— a second top extraction means for extracting a second overhead vapour fraction (32',92') from said second chamber (73',75 ,79",273',96',376);

— a second bottom extraction means for extracting a second bottom fraction (38',98',131') from said second chamber (73',75,79",273',96',376);

— a maintenance means for maintaining said first chamber (73,75,79-79',273,96,375) and said second chamber (73',75,79",273',96',376) within predetermined working temperature ranges and at predetermined respective operating pressures;

wherein said maintenance means is arranged to maintain a working temperature range and/or operating pressures such that:

— said Pseudocumene is present substantially in only one fraction selected between said first overhead fraction (32,42,52) and said first bottom fraction (38,98), and

— a substantially pure Pseudocumene is contained only in one fraction selected between said second overhead fraction (32',92') and said second bottom fraction (38',98',131'), according to whether said Pseudocumene-containing fraction that is extracted from said first longitudinal chamber (73,75,79-79',273,96,375) is said first bottom fraction (38,98) or said first overhead fraction (32,42,52), respectively,

wherein said apparatus comprises an elongated container (200) that is adapted to be arranged vertically,

wherein an inner longitudinal partition wall (83,85,89,93',285,385) is arranged within said elongated container, said inner longitudinal partition wall

(83,85,89,93',285,385) defining said first chamber (73,75,79",273',96',376) and said second chamber (73',75,79",273',96',376) within said elongated container,

characterised in that

said apparatus (3,3',4,5,6,7,7',8,9) comprises a differential expansion compensation means that is arranged between said elongated container and said inner partition wall (83,85,89,93',285,385) for compensating differential expansion due to a temperature difference between said first chamber (273) and said second chamber (273'), wherein said partition wall (285) is internally fixed to a shell (217) of said vertical elongated container at a short edge portion extension of said partition wall (285), whereas other edge portions of said partition wall (285) have a relative freedom of movement with respect to said shell (217), in order to allow the expansion of said partition wall (285) with respect to said shell (217).

6. An apparatus according to claim 5, wherein said partition wall (285) is internally fixed to said shell (217) of said column at an own short end edge portion, whereas other edge portions of said partition wall (285) have a relative freedom of movement, in order to allow an expansion of said partition wall (285),

in particular said partition wall (285) is internally fixed to a rounded bottom portion (218,219) of said shell (217).

7. An apparatus according to claim 6, wherein said edge portion of said partition wall (285) is welded to said shell (217),

in particular said partition wall (285) is welded within said bottom portion (218,219) of said column.

8. An apparatus according to claim 7, wherein a guide means is provided for guiding a longitudinal slide movement of said partition wall (285).

9. An apparatus according to claim 8, wherein said guide means comprises a couple of longitudinal plates (221) that extend along the whole height of said column (200), wherein said longitudinal plates (221) are fixed to said column, within said shell (217), by welding or by a suitable technique.

10. An apparatus according to claim 9, wherein aligned holes (227) are made parallel to said edges along long sides of said longitudinal partition wall (285), and

aligned holes (228) are made near an edge of each of said longitudinal plate (221) parallel to said edge,

wherein holes (227) and holes (228) have reciprocal distances according to a same pattern, so that each hole (227) faces a hole (228) during said slide movement of said partition wall (285) with respect to plates (221),

wherein in each couple of reciprocally facing holes (227,228) one hole is slotted and the other hole is adapted to receive a tie-member,

in particular said other hole (228) is a circular hole,

in particular said other hole (228) is adapted to receive a stem portion of a screw as said tie member, and a nut (225) is arranged opposite to a head of said screw, and engages with said screw according to a prefixed blocking force.

11. An apparatus according to claim 10, wherein a seal (222) is arranged between said longitudinal plate (221) and said dividing wall (285) in order to ensure a fluid-tight contact between said first chamber (273) and said second chamber (273'),

in particular, a further seal means is arranged at nut (225) or at screw head (226), whichever is located on a higher pressure side of said column.

12. An apparatus according to claim 10, wherein said slotted holes (227) have an increasing length, moving away from said edge portion fixed to said shell (217), in particular away from said bottom portion (218,219) of said shell (217).

13. An apparatus (5,7',8,9) according to claim 5, wherein said inner longitudinal partition wall (85,89) has an inner passageway (86,90,90',386), said passageway extending between a top section of said first chamber (75,79) and a feed section (59) of said second chamber (75',79'),

said passageway arranged to convey a stream of vapour (52,92) from said first chamber to said second chamber (75',79') and/or vice-versa.

14. An apparatus (6,7, 9) according to claim 5, comprising:

— a compression means (64,64') for compressing at least one portion (65) of said first overhead vapour fraction (32,42,52) and/or at least one portion (65') of said second overhead vapour fraction (32',92'), said compression means (64,64') adapted to provide a compressed overhead vapour (66,66') at a compressed vapour pressure such that said compressed overhead vapour (66,66') has a condensation temperature that exceeds a boiling temperature of said first bottom fraction (38) and/or it has at a condensation temperature that exceeds a boiling temperature of said second bottom fraction (38',98');

— an indirect heat exchange means (70,70',100') between said compressed overhead vapour (66,66') and at least one part (39) of said first bottom fraction

(38) and/or at least one part (39',99') of said second bottom fraction (38',98'), said heat exchange means (70,70',100') adapted to cause a boiling of said at least one part (39) of said first bottom fraction (38) and/or a boiling of said at least one part (39',99) of said second bottom fraction (38',98),

in particular, said compression means (64,64') are operated by an expansion means (764) for expanding an aeriform substance (761), in particular by a turbine, and said apparatus comprises a means for generating said aeriform substance, in particular, said means for generating an aeriform substance comprise a steam generator (71) that is associated with a heating means (70) of said first bottom fraction (38) and/or of said second bottom fraction (38',98'),

in particular said first chamber (73,79) and/or said second chamber (73',79') comprises a fractionation means selected from the group consisting of:

— distillation trays, in particular, sieve trays;
— a packed bed, in particular, a structured packed bed;
— a combination thereof.

15. An apparatus (8) according to claim 5, wherein said first chamber comprises a catalytic fractionation means (803) that is arranged at a height above a feed port (815) of said first longitudinal chamber (75), said catalytic fractionation means (803) adapted to promote an alkylation reaction of said aromatic hydrocarbons with olefins that are contained in said raw mixture (51), bringing said olefins from a feed concentration to a residual concentration that is lower than 4 ppm, in particular, lower than 1 ppm, starting from a feed concentration that is normally set between 100 ppm and 300 ppm,

in particular, said catalytic fractionation means comprises a catalytic material in the form of a packing material (803), said catalytic material selected from the group consisting of:

— acid earths;
— zeolites;
— a combination thereof,

in particular, said maintenance means for maintaining said first chamber (75) within a predetermined temperature range is adapted to maintain said catalytic fractionation means (803) at an alkylation temperature set between 160°C and 190°C,

in particular, said packing material (803) comprises a catalytic material that has a height such that the spatial speed of the liquid phase of the mixture being

distilled is set between 1,0 h^{-1} and 10 h^{-1}, preferably it is set between 2,0 h^{-1} and 5,0 h^{-1}.