Claims

1. Method for separating gases containing helium, characterized in that
it is carried out in an apparatus which has a feed stream separation stage (1), a retentate separation stage (2) and a permeate separation stage (3), as well as at least one compressor (4) and/or at least one, preferably one or two, vacuum pump(s) (15),
the feed stream separation stage (1) separates a feed stream (5) consisting of helium and at least one other component into a first permeate stream (6) enriched with regard to helium compared to the feed stream (5), and a first retentate stream (7) depleted with regard to helium compared to the feed stream (5),
the retentate separation stage (2) separates the first retentate stream (7) into a second permeate stream (9) enriched with regard to helium compared to the first retentate stream (7), and a second retentate stream (8) depleted with regard to helium compared to the first retentate stream (7),
the permeate separation stage (3) separates the first permeate stream (6) into a third retentate stream (10) depleted with regard to helium compared to the first permeate stream (6), and a third permeate stream (11) enriched with regard to helium compared to the first permeate stream (6),
the third permeate stream (11) is removed as product or processed further
the second permeate stream (9) is fed to feed stream (5), the ~~and optionally the~~ second retentate stream (8) is removed as a first further product or

processed further or discarded,

~~the second permeate stream (9) and~~ the third retentate stream (10) is ~~are~~ fed to the feed stream (5) or discarded,

the first permeate stream (6) is not subjected to a recompression,

upon recycling the second permeate stream (9) and optionally the third retentate stream (10), the control of the gas volume recycled with the second permeate stream (9) and optionally the third retentate stream (10) to the feed stream (5) is adjusted such that, in total, less than 50% by volume, preferably 5 to 40% by volume, very particularly preferably 5 to 30% by volume and especially preferably 10 to 25% by volume, of the volume of the crude gas stream (17) are recycled,

and

upon recycling the second permeate stream (9) and optionally the third retentate stream (10), the helium concentration after the first recycling of the second permeate stream (9) and optionally of the third retentate stream (10) in the feed stream (5) is increased, preferably by at least 2%, particularly preferably by at least 3%, particularly preferably by 4 to 10% and very particularly preferably by 5 to 10%, in each case compared to the concentration in the crude gas stream (17).

2. Method for separating gases containing helium, characterized in that

it is carried out in an apparatus which has a feed stream separation stage (1), a retentate separation

stage (2) and a permeate separation stage (3), as well as at least one compressor (4) and/or at least one, preferably one or two, vacuum pump(s) (15),
the feed stream separation stage (1) separates a feed stream (5) consisting of helium and at least one other component into a first permeate stream (6) enriched with regard to helium compared to the feed stream (5), and a first retentate stream (7) depleted with regard to helium compared to the feed stream (5),
the retentate separation stage (2) separates the first retentate stream (7) into a second permeate stream (9) enriched with regard to helium compared to the first retentate stream (7), and a second retentate stream (8) depleted with regard to helium compared to the first retentate stream (7),
the permeate separation stage (3) separates the first permeate stream (6) into a third retentate stream (10) depleted with regard to helium compared to the first permeate stream (6), and a third permeate stream (11) enriched with regard to helium compared to the first permeate stream (6),
the third permeate stream (11) as product and the second retentate stream (8) as second product are each either removed or further processed,
the second permeate stream (9) is discarded,
the third retentate stream (10) is fed to the feed stream (5) or discarded,
the first permeate stream (6) is not subjected to a recompression,
upon recycling the third retentate stream (10), the control of the gas volume recycled with the third retentate stream (10) to the feed stream (5) is

adjusted such that, in total, less than 50% by volume, preferably 5 to 40% by volume, very particularly preferably 5 to 30% by volume and especially preferably 10 to 25% by volume, of the volume of the crude gas stream (17) are recycled,

and

upon recycling the third retentate stream (10), the helium concentration after the first recycling of the third retentate stream (10) in the feed stream (5) is increased, preferably by at least 2%, particularly preferably by at least 3%, particularly preferably by 4 to 10% and very particularly preferably by 5 to 10%, in each case compared to the concentration in the crude gas stream (17).

~~2.~~3. Apparatus for separating gases containing helium, characterized in that

it has a feed stream separation stage (1), a retentate separation stage (2) and a permeate separation stage

(3), as well as at least one compressor (4) and/or at least one, preferably one or two, vacuum pump(s) (15), the feed stream separation stage (1) is designed such that it separates a feed stream (5) consisting of helium and at least one other component into a first permeate stream (6) enriched with regard to helium compared to the feed stream (5), and a first retentate stream (7) depleted with regard to helium compared to the feed stream (5),
the retentate separation stage (2) is designed such that it separates the first retentate stream (7) into a second permeate stream (9) enriched with regard to helium compared to the first retentate stream (7), and a second retentate stream (8) depleted with regard to helium compared to the first retentate stream (7),
the permeate separation stage (3) is designed in such a way that it separates the first permeate stream (6) into a third retentate stream (10) depleted with regard to helium compared to the first permeate stream (6), and a third permeate stream (11) enriched with regard to helium compared to the first permeate stream (6),
the apparatus is designed such that the third permeate stream (11) can be removed as a product or processed further,
the apparatus is designed such that the second permeate stream (9) is fed to the feed stream (5),
the apparatus is designed such that ~~and optionally~~ the second retentate stream (8) can be removed as a further product or processed further or discarded,
the apparatus is designed such that ~~the second permeate stream (9) and~~ the third retentate stream (10) can be fed to the feed stream (5) or be discarded,
the apparatus is designed in such a way that the first

permeate stream (6) is not subjected to a recompression,

the apparatus is designed such that upon recycling the second permeate stream (9) and optionally the third retentate stream (10), the recycling of the gas volume recycled with the second permeate stream (9) and optionally with the third retentate stream (10) to the feed stream (5) is regulated in such a way that, in total, less than 50% by volume, preferably 5 to 40% by volume, very particularly preferably 5 to 30% by volume and especially preferably 10 to 25% by volume, of the volume of the crude gas stream (17) are recycled,

and

the apparatus is designed such that upon recycling the second permeate stream (9) and optionally the third retentate stream (10), the recycling of the second permeate stream (9) and optionally of the third retentate stream (10) is regulated such that the helium concentration after the first recycling of the second permeate stream (9) and of the third retentate stream (10) in the feed stream (5) is increased, preferably by at least 2%, particularly preferably by at least 3%, particularly preferably by 4 to 10% and very particularly preferably by 5 to 10%, in each case compared to the concentration in the crude gas stream (17).

4. Apparatus for separating gases containing helium, characterized in that

it has a feed stream separation stage (1), a retentate separation stage (2) and a permeate separation stage (3), as well as at least one compressor (4) and/or at least one, preferably one or two, vacuum pump(s) (15),

the feed stream separation stage (1) is designed such that it separates a feed stream (5) consisting of helium and at least one other component into a first permeate stream (6) enriched with regard to helium compared to the feed stream (5), and a first retentate stream (7) depleted with regard to helium compared to the feed stream (5),

the retentate separation stage (2) is designed such that it separates the first retentate stream (7) into a second permeate stream (9) enriched with regard to helium compared to the first retentate stream (7), and a second retentate stream (8) depleted with regard to helium compared to the first retentate stream (7),

the permeate separation stage (3) is designed in such a way that it separates the first permeate stream (6) into a third retentate stream (10) depleted with regard to helium compared to the first permeate stream (6), and a third permeate stream (11) enriched with regard to helium compared to the first permeate stream (6),

the apparatus is designed such that the third permeate stream (11) and the second retentate stream (8) as second product each can be removed or further processed,

the apparatus is designed such that the second permeate stream (9) is discarded and that the third retentate stream (10) can be fed to the feed stream (5) or be discarded,

the apparatus is designed in such a way that the first permeate stream (6) is not subjected to a recompression,

the apparatus is designed such that upon recycling the third retentate stream (10), the recycling of the third

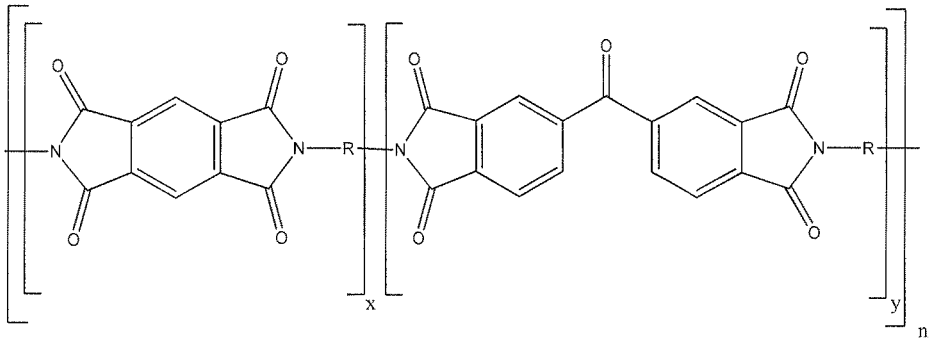
retentate stream (10) to the feed stream (5) is regulated in such a way that, in total, less than 50% by volume, preferably 5 to 40% by volume, very particularly preferably 5 to 30% by volume and especially preferably 10 to 25% by volume, of the volume of the crude gas stream (17) are recycled, and

the apparatus is designed such that upon recycling the third retentate stream (10), the recycling of the third retentate stream (10) is regulated such that the helium concentration after the first recycling of the second permeate stream (9) and of the third retentate stream (10) in the feed stream (5) is increased, preferably by at least 2%, particularly preferably by at least 3%, particularly preferably by 4 to 10% and very particularly preferably by 5 to 10%, in each case compared to the concentration in the crude gas stream (17).

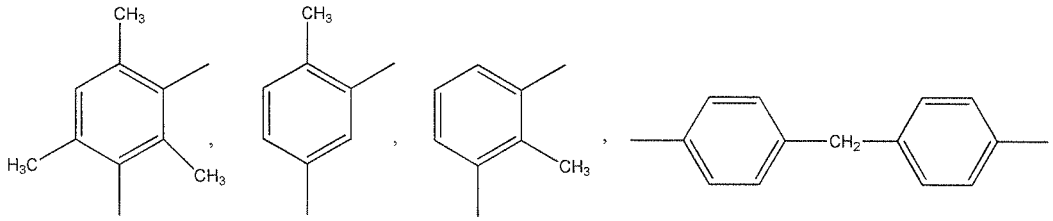
~~3.~~5. Method according to Claim 1 or 2 or apparatus according to Claim ~~2~~3 or 4, characterized in that, at least in the feed stream separation stage (1), but preferably in the feed stream separation stage (1), the retentate separation stage

(2) and the permeate separation stage (3), gas separation membrane modules with a mixed-gas selectivity for helium/methane or for helium/nitrogen of at least 40, preferably 50 to 400, particularly preferably 150 to 300, are used.

~~4.~~6. Method or apparatus according to Claim ~~3~~5, characterized in that
the material used for the separation-active layer of the membranes is a polyimide of the general formula



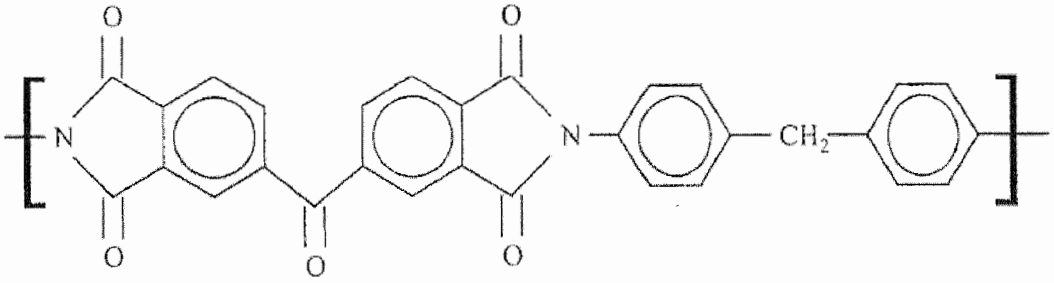
R is selected from the group consisting of



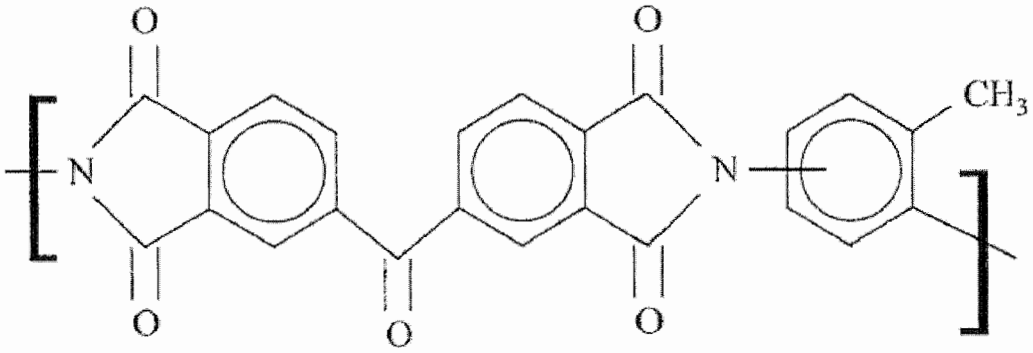
x, y: mole fraction where $0 < x < 0.5$ and $1 > y > 0.5$.

~~5.~~7. Method or apparatus according to Claim ~~4~~6, characterized in that
the material used for the separation-active layer of the membranes is a polyimide comprising 10 to 90% by

weight, preferably 15 to 25% by weight and very particularly preferably 20% by weight of



and 90 to 10% by weight, preferably 85 to 75% by weight and very particularly preferably 80% by weight of



~~6.~~ 8. Method or apparatus according to one of the preceding claims, characterized in that the second permeate stream (9) and/or the third retentate stream (10) on the suction side of the compressor (4) are passed for reprocessing.

~~7.~~ 9. Method or apparatus according to one of the preceding

claims,
characterized in that
a multistage compressor (4) is used.

~~8.~~10. Method or apparatus according to Claim ~~7~~9, characterized in that the second permeate stream (9) and/or the third retentate stream (10) is/are introduced into the compressor (4) between two compression stages.

~~9.~~11. Method or apparatus according to one of the preceding claims, characterized in that the first retentate stream (7) and/or the second retentate stream (8) and/or the third retentate stream (10) are passed through a pressure relief valve.

~~10.~~12. Method or apparatus according to one of the preceding claims, characterized in that at least one of the membrane separation stages (1) to (3) comprises more than one gas separation membrane module which are connected in parallel and/or in series.

~~11.~~13. Method or apparatus according to one of the preceding claims, characterized in that the gas separation membrane module(s) consist(s) of hollow fibre membranes and/or flat membranes.

~~12. Method or apparatus according to one of the preceding claims,~~
~~characterized in that~~
~~at least 95%, preferably at least 97%, particularly preferably at least 99% and very particularly preferably at least 99.5%, of the helium introduced into the apparatus with the crude gas stream (17) are removed from the system via the third permeate stream (11).~~

~~13.~~14. Method or apparatus according to one of the preceding claims,
characterized in that
the pressure of the permeate side (6) of the feed stream separation stage (1) is adjusted preferably by means of a pressure relief valve (14) on the retentate side of the permeate separation stage (3) to 1 to 30 bar, preferably to 2 to 20 bar and particularly preferably to 2 to 10 bar.

~~14.~~15. Method or apparatus according to one of the preceding claims,
characterized in that
the pressure of the first and second retentate stream (7) and (8) is adjusted preferably by means of a pressure relief valve (13) in the second retentate stream (8) to 1 to 100 bar, preferably to 5 to 80 bar and particularly preferably to 10 to 70 bar.

~~15.~~16. Method or apparatus according to one of the preceding claims,
characterized in that
the driving force used for the separation task is a partial pressure difference between the retentate side and the permeate side in the respective membrane separation stages, the partial pressure difference being generated by a compressor in the feed stream (5) and/or by a vacuum pump (15) in the second and/or third permeate stream (9) and/or (11) and/or by a permeate-side flushing-gas stream.

~~16.~~17. Method or apparatus according to one of the preceding claims~~Claims 14 or 15~~,
characterized in that
the pressure of the permeate of the feed stream separation stage (1) is identical or increased compared with the ambient pressure, meaning that there is still a partial pressure difference between retentate and permeate of the permeate separation stage (3) and therefore a driving force is present for the case when the permeate of the permeate separation stage (3) is at ambient pressure or subatmospheric pressure is applied.