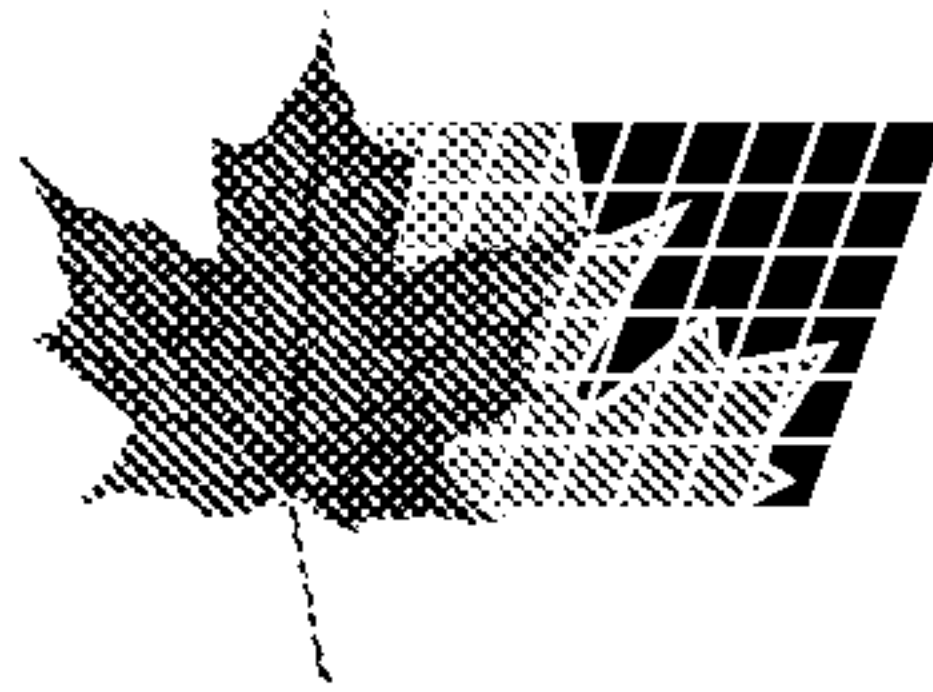




(72) BEER, EKKEHARD, DE

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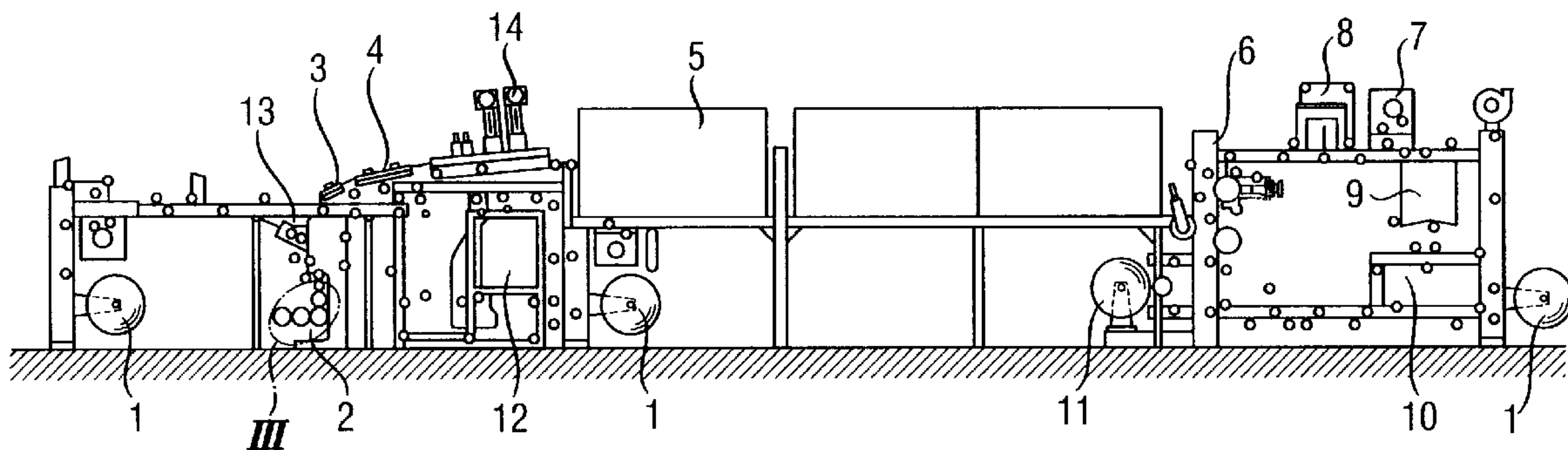
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(30) 1998/06/29 (19828858.1) DE

(54) **FILM MULTICOUCHE THERMOFORMABLE**

(54) **THERMOFORMABLE COMPOSITE FILM**



(57) The present invention relates to a thermoformable composite film comprising at least one film which comprises a cycloolefin copolymer and comprising, laminated to at least one side of this film, a thermoplastic film. The thermoformable film is obtainable by using a solvent-free single-component adhesive to apply the thermoplastic film laminated to the film which comprises cycloolefin copolymer. The film which is laminated is a oPP-containing thermoplastic film. The thickness of the entire film is from 100 to 500 μm , the thickness of the oPP film is from 1 to 150 μm and the thickness of the COC film is from 50 to 400 μm . The thermoformable composite film is used to produce blister packs.

Abstract

The present invention relates to a thermoformable composite film comprising at least one film which comprises a cycloolefin copolymer and comprising, laminated to at least one side of this film, a thermoplastic film. The thermoformable film is obtainable by using a solvent-free single-component adhesive to apply the thermoplastic film laminated to the film which comprises cycloolefin copolymer. The film which is laminated is a oPP-containing thermoplastic film. The thickness of the entire film is from 100 to 500 μm , the thickness of the oPP film is from 1 to 150 μm and the thickness of the COC film is from 50 to 400 μm . The thermoformable composite film is used to produce blister packs.

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Thermoformable composite film

- 5 The present invention relates to a thermoformable composite film, a process for producing a thermoformable composite film and the use of the film as a packaging material.

10 To produce high-performance packaging, flexible films are molded to the shape of a tray or capsule using the action of heat and pressure and a mechanical ram at super- and/or subatmospheric pressures. The film serves firstly to protect the contents. It has to protect the contents from the effects of the environment and must therefore have a high level of barrier properties with respect to water-vapor, gases and UV. It must have
15 mechanical stability to protect the contents from physical effects, and so that it does not itself become damaged by the contents. The quality of the contents must not be impaired by constituents released from within the film.

20 Blister packs are increasingly frequently chosen as packaging for a wide variety of articles, since this type of pack is available in a wide variety of forms and meets the requirements of mechanized packaging processes. The starting materials used for blister packs are thermoformable films. These are plastic films which when heated can be shaped relatively readily by applying super- or subatmospheric pressure pneumatically, or using a
25 ram. Appropriate selection of the molds can thus introduce depressions (blisters) into the film (base film) and these can be matched to the shape of the article to be packed. After this shaping step, the article to be packed is introduced into the resulting blister. Once the blister has been filled, a backing film is applied to the base film and encloses the article to be
30 packed within its blister.

If all of the requirements cannot be covered by a single material, the properties required in a film are achieved by combining more than one film to give a composite film. Films produced from cycloolefin copolymers have
35 very good impermeability to water vapor. However, these films have poor resistance to fats. Environmental-stress-cracking corrosion occurs on exposure to unsaturated fatty acids.

The film most frequently used in blister packs is of polyvinyl chloride (PVC). To increase its barrier properties with respect to gases, in particular water vapor, the PVC base film is frequently coated with PVDC. Films made from unoriented polypropylene (uPP) give better water-vapor barrier properties than PVC films and are less questionable from an environmental point of view. However, the disadvantages are that this material has poorer thermoformability and higher shrinkage.

The COC mono- or multilayer films described in EP-A-570 188 and EP-A-631 864 when used as base films give good processing and good barrier properties.

Relatively new developments in the area of blister packs for pharmaceuticals describe the use of amorphous polyolefins with good processing performance and high levels of water-vapor barrier properties. For example, EP-A-570 188 and EP-A-631 864 describe the use of polyolefins with cyclic olefins as polymeric building block. These applications describe the use of these polyolefins (cycloolefin copolymers, abbreviated to COC) in mono- or multilayer films for blister packs.

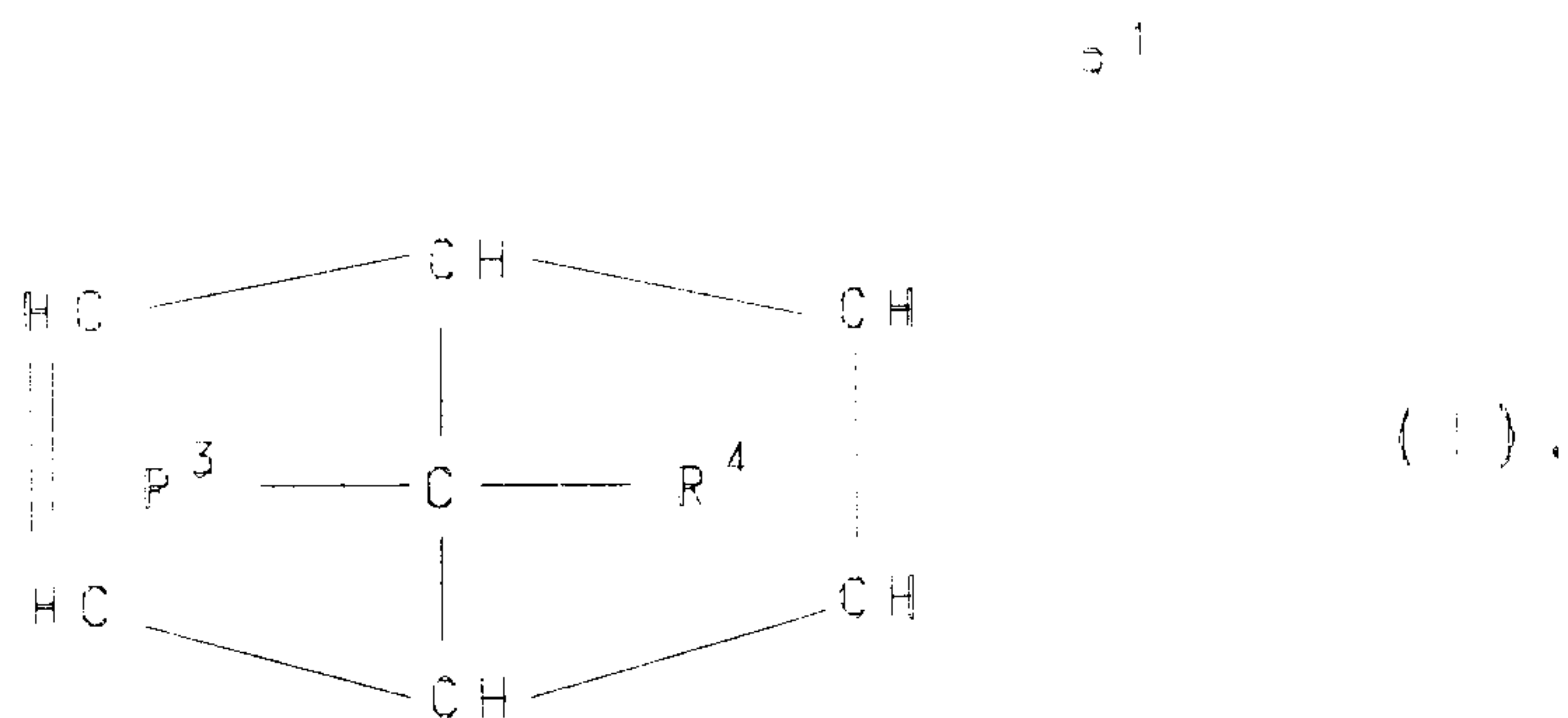
Besides facilitating automated packing and the presentation of the product protected within the blister, for example pharmaceuticals in the form of tablets, capsules or the like, the blister pack can markedly reduce exposure to atmospheric moisture and oxygen and thus increase shelf life.

The object of the present invention is to provide a composite film with a high level of barrier properties, very good thermoformability and good resistance to fats, together with a cost-effective and environmentally friendly process for its production, and the use of the film for producing blister packs.

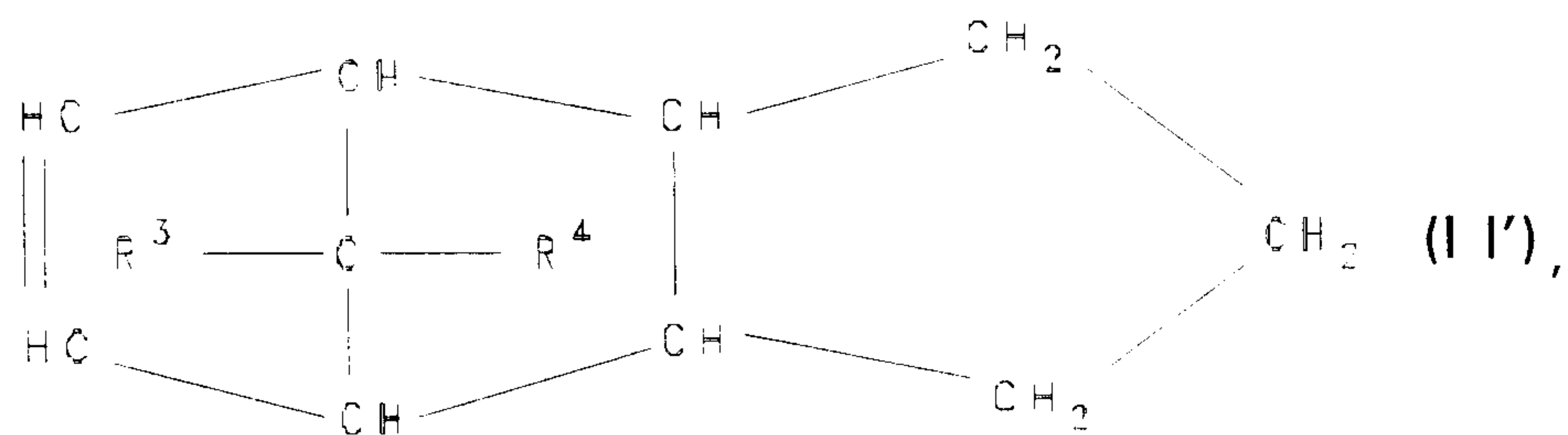
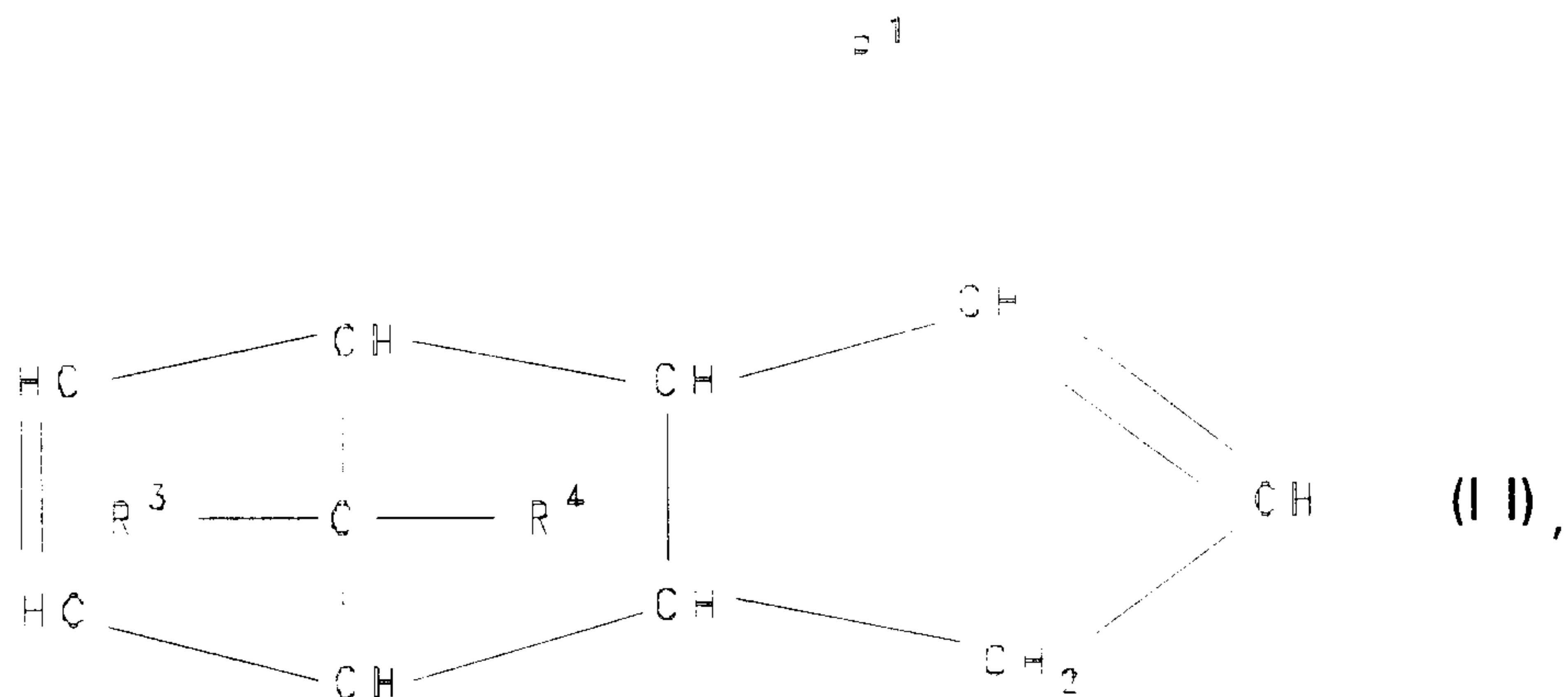
The object of the present invention is achieved by means of a thermoformable composite film comprising at least one film which comprises cycloolefin copolymer and comprising, laminated to at least one side of this film, a thermoplastic PP film.

At relative humidity of about 85% and at a temperature of about 23°C the film has water-vapor permeability of ≤ 0.05 g/m²d, puncture resistance of ≤ 20 N and thickness of ≤ 100 μ m.

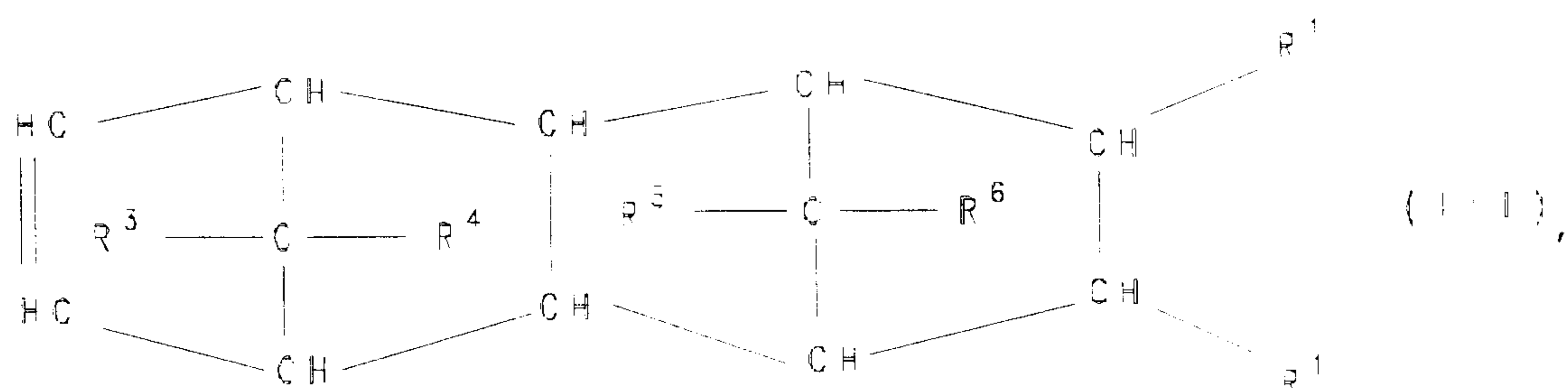
The films suitable for the purposes of the invention comprise at least one cycloolefin polymer selected from the class consisting of polymers containing from 0.1 to 100% by weight, preferably from 10 to 90% by weight, based on the total weight of the cycloolefin polymer, of polymerized units of at least one cyclic olefin of the formulae I, II, II', III, IV, V or VI



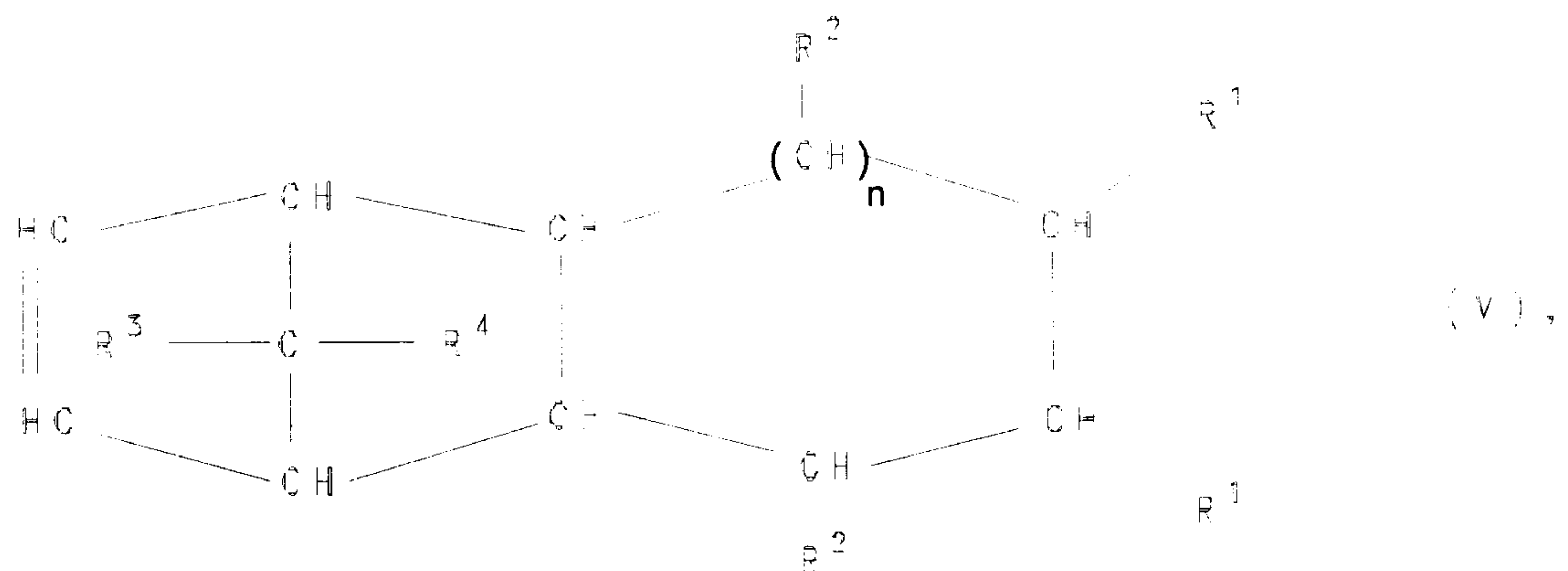
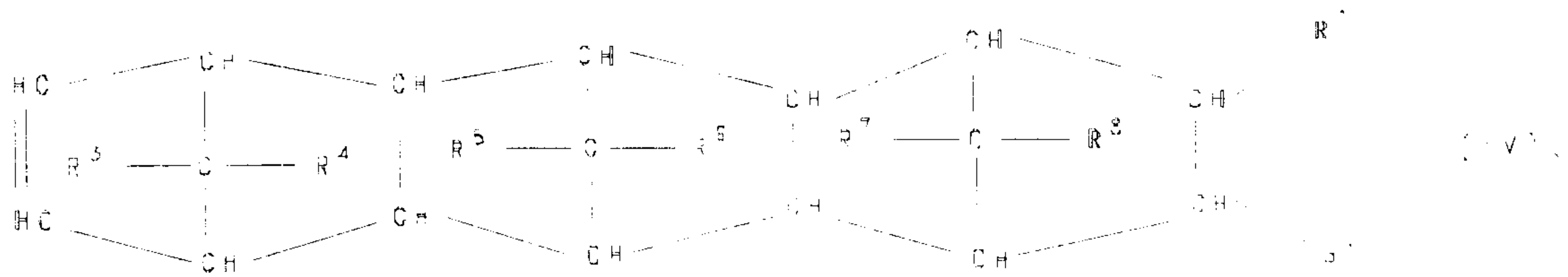
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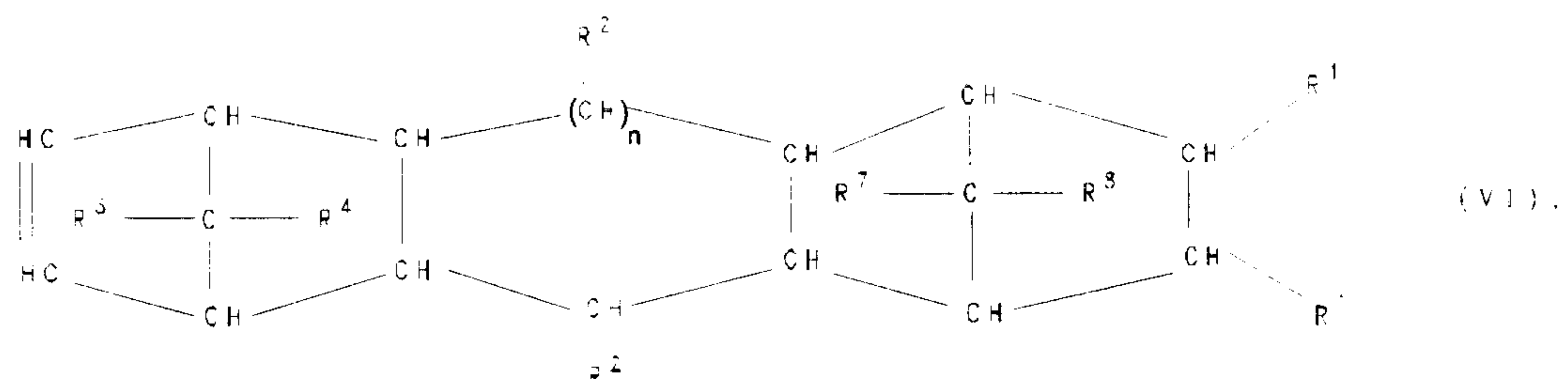
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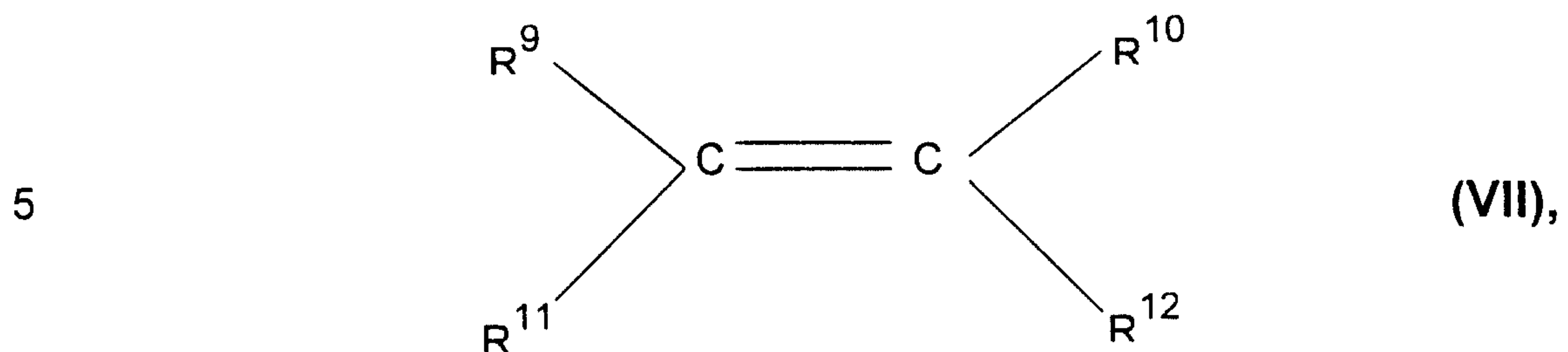


5



- where R^1 , R^2 , R^3 , R^4 , R^5 , R^6 , R^7 and R^8 are identical or different and are
 10 a hydrogen atom or a C_1 - C_{20} -hydrocarbon radical, such as a linear or
 branched C_1 - C_8 -alkyl radical or C_6 - C_{18} -aryl radical or C_7 - C_{20} -alkylenearyl
 radical, or a cyclic or acyclic C_2 - C_{20} -alkenyl radical, or form a saturated,
 unsaturated or aromatic ring, where the same radicals R^1 to R^8 in the
 different formulae I to VI may have different meanings, and n may be from
 15 0 to 5, and
 from 0 to 99.9 mol%, based on the total composition of the cycloolefin
 copolymer, of polymerized units which derive from one or more acyclic
 olefins of the formula VII

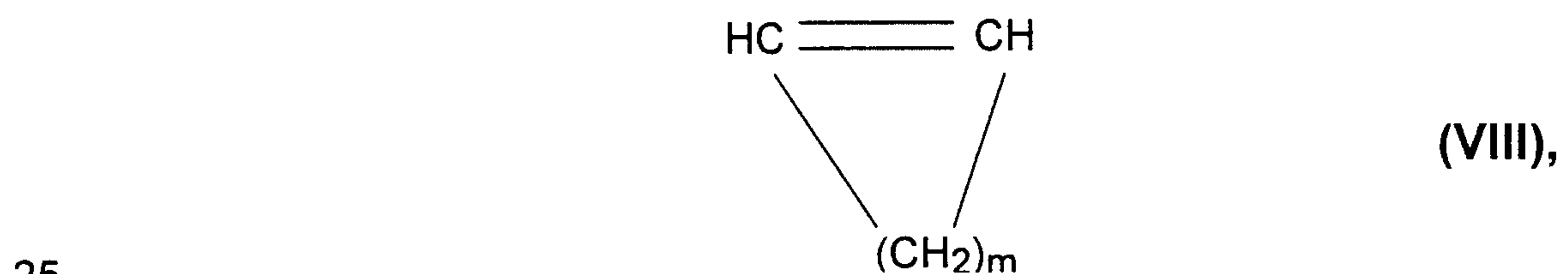
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10 where R^9 , R^{10} , R^{11} and R^{12} are identical or different and are a hydrogen atom, a linear or branched, saturated or unsaturated C_1 - C_{20} -hydrocarbon radical, such as a C_1 - C_8 -alkyl radical, or a C_6 - C_{18} -aryl radical.

15 The cycloolefin copolymers may also be obtained by ring-opening polymerization of at least one of the monomers with the formulae I to VI, followed by hydrogenation of the products obtained.

20 The novel elastomeric cycloolefin copolymer may also contain from 0 to 45 mol%, based on the total composition of the cycloolefin copolymer, of polymerized units which derive from one or more monocyclic olefins of the formula VIII



where m is a number from 2 to 10.

30 The proportion of the polymerized units which derive from cyclic, in particular polycyclic, olefins, is preferably from 3 to 75 mol%, based on the total composition of the cycloolefin copolymer. The proportion of the polymerized units which derive from acyclic olefins is preferably from 5 to 80 mol%, based on the total composition of the cycloolefin copolymer.

35 The cycloolefin copolymers are preferably composed of polymerized units which derive from one or more polycyclic olefins, in particular from polycyclic olefins of the formulae I or III, and polymerized units which derive from one or more acyclic olefins of the formula VII, in particular α -olefins having from 2 to 20 carbon atoms. Particular preference is given to cycloolefin copolymers which are composed of polymerized units which

derive from a polycyclic olefin of the formula I or III and from an acyclic olefin of the formula VII. Preference is also given to terpolymers which are composed of polymerized units which derive from a polycyclic monoolefin of the formula I or III, from an acyclic monoolefin of the formula VII and
5 from a cyclic or acyclic olefin which contains at least two double bonds (polyene), in particular cyclic, preferably polycyclic, dienes, such as norbornadiene, or cyclic, particularly preferably polycyclic, alkenes with a C₂-C₂₀-alkenyl radical, such as vinylnorbornene.

10 The novel elastomeric cycloolefin copolymers preferably comprise olefins with a fundamental norbornene structure, particularly preferably norbornene, tetracyclododecene and, if desired, vinylnorbornene or norbornadiene. Preference is also given to cycloolefin copolymers which contain polymerized units which derive from acyclic olefins with terminal
15 double bonds, such as α -olefins having from 2 to 20 carbon atoms, particularly preferably ethylene or propylene. Particular preference is given to norbornene-ethylene and tetracyclododecene-ethylene copolymers.

Among the terpolymers, particular preference is given to norbornene-
20 vinylnorbornene-ethylene, norbornene-norbornadiene-ethylene, tetracyclododecene-vinylnorbornene-ethylene and tetracyclododecene-vinyltetracyclododecene-ethylene terpolymers. The proportion of the polymerized units which derive from a polyene, preferably vinylnorbornene or norbornadiene, is from 0.1 to 50 mol%, preferably from 0.1 to 20 mol%,
25 and the proportion of the acyclic monoolefin of the formula VII is from 0 to 99.9 mol%, preferably from 5 to 80 mol%, based on the total composition of the cycloolefin copolymer. In the terpolymers described, the proportion of the polycyclic monoolefin is from 0.1 to 99.9 mol%, preferably from 3 to 75%, based on the total composition of the cycloolefin copolymer.

30

The cycloolefin copolymer according to the invention preferably comprises at least one cycloolefin copolymer containing polymerized units which derive from polycyclic olefins of the formula I and containing polymerized units which derive from acyclic olefins of the formula VII.

35

The cycloolefin copolymers according to the invention may be prepared at temperatures of from -78 to 200°C and at a pressure of from 0.01 to 200 bar, in the presence of one or more catalyst systems which comprise at least one transition metal compound and, if desired, a

cocatalyst and, if desired, a support. Suitable transition metal compounds are metallocenes, in particular stereorigid metallocenes. Examples of catalyst systems suitable for preparing the elastomeric cycloolefin copolymers according to the invention are described in EP-A-407 870, 5 EP-A-485 893 and EP-A-503 422. These publications are expressly incorporated herein by way of reference.

Examples of transition metal compounds used are:

- rac-dimethylsilylbis(1-indenyl)zirconium dichloride,
- 10 rac-dimethylgermylbis(1-indenyl)zirconium dichloride,
- rac-phenylmethylsilylbis(1-indenyl)zirconium dichloride,
- rac-phenylvinylsilylbis(1-indenyl)zirconium dichloride,
- 1-silacyclobutylbis(1-indenyl)zirconium dichloride,
- rac-diphenylsilylbis(1-indenyl)hafnium dichloride,
- 15 rac-phenylmethylsilylbis(1-indenyl)hafnium dichloride,
- rac-diphenylsilylbis(1-indenyl)zirconium dichloride,
- rac-ethylene-1,2-bis(1-indenyl)zirconium dichloride,
- dimethylsilyl(9-fluorenyl)(cyclopentadienyl)zirconium dichloride,
- diphenylsilyl(9-fluorenyl)(cyclopentadienyl)zirconium dichloride,
- 20 bis(1-indenyl)zirconium dichloride,
- diphenylmethylen(9-fluorenyl)cyclopentadienylzirconium dichloride,
- isopropylene(9-fluorenyl)cyclopentadienylzirconium dichloride,
- rac-isopropylidenebis(1-indenyl)zirconium dichloride,
- phenylmethylen(9-fluorenyl)cyclopentadienylzirconium dichloride,
- 25 isopropylene(9-fluorenyl)(1-(3-isopropyl)cyclopentadienyl)zirconium dichloride,
- isopropylene(9-fluorenyl)(1-(3-methyl)cyclopentadienyl)zirconium dichloride,
- diphenylmethylen(9-fluorenyl)(1-(3-methyl)cyclopentadienyl)zirconium
- 30 dichloride,
- methylphenylmethylen(9-fluorenyl)(1-(3-methyl)cyclopentadienyl)-zirconium dichloride,
- dimethylsilyl(9-fluorenyl)(1-(3-methyl)cyclopentadienyl)zirconium dichloride,
- diphenylsilyl(9-fluorenyl)(1-(3-methyl)cyclopentadienyl)zirconium dichloride,
- 35 diphenylmethylen(9-fluorenyl)(1-(3-tert-butyl)cyclopentadienyl)zirconium dichloride,
- isopropylene(9-fluorenyl)(1-(3-tert-butyl)cyclopentadienyl)zirconium dichloride,
- isopropylene(cyclopentadienyl)(1-indenyl)zirconium dichloride,

- diphenylcarbonyl(cyclopentadienyl)(1-indenyl)zirconium dichloride,
 dimethylsilyl(cyclopentadienyl)(1-indenyl)zirconium dichloride,
 isopropylene(methylcyclopentadienyl)(1-indenyl)zirconium dichloride,
 [4-(η^5 -cyclopentadienyl)-4,7,7-trimethyl(η^5 -4,5,6,7-tetrahydroindenyl)]-
 5 zirconium dichloride,
 [4-(η^5 -cyclopentadienyl)-4,7,7-triphenyl(η^5 -4,5,6,7-tetrahydroindenyl)]-
 zirconium dichloride,
 [4-(η^5 -cyclopentadienyl)-4,7-dimethyl-7-phenyl(η^5 -4,5,6,7-tetrahydro-
 indenyl)]zirconium dichloride,
 10 [4-(η^5 -3'-tert-butylcyclopentadienyl)-4,7,7-triphenyl(η^5 -4,5,6,7-tetrahydro-
 indenyl)]zirconium dichloride,
 [4-(η^5 -3'-tert-butylcyclopentadienyl)-4,7-dimethyl-7-phenyl(η^5 -
 4,5,6,7-tetrahydroindenyl)]zirconium dichloride,
 [4-(η^5 -3'-methylcyclopentadienyl)-4,7,7-trimethyl(η^5 -4,5,6,7-tetrahydro-
 15 indenyl)]zirconium dichloride,
 [4-(η^5 -3'-methylcyclopentadienyl)-4,7,7-triphenyl(η^5 -4,5,6,7-tetrahydro-
 indenyl)]zirconium dichloride,
 [4-(η^5 -3'-methylcyclopentadienyl)-4,7-dimethyl-7-phenyl(η^5 -4,5,6,7-tetra-
 hydroindenyl)]zirconium dichloride,
 20 [4-(η^5 -3'-isopropylcyclopentadienyl)-4,7,7-trimethyl(η^5 -4,5,6,7-tetrahydro-
 indenyl)]zirconium dichloride,
 [4-(η^5 -3'-isopropylcyclopentadienyl)-4,7,7-triphenyl(η^5 -4,5,6,7-tetrahydro-
 indenyl)]zirconium dichloride,
 [4-(η^5 -3'-isopropylcyclopentadienyl)-4,7-dimethyl-7-phenyl(η^5 -
 25 4,5,6,7-tetrahydroindenyl)]zirconium dichloride,
 [4-(η^5 -cyclopentadienyl)(η^5 -4,5-tetrahydropentalene)]zirconium dichloride,
 [4-(η^5 -cyclopentadienyl)-4-methyl(η^5 -4,5-tetrahydropentalene)]zirconium
 dichloride,
 [4-(η^5 -cyclopentadienyl)-4-phenyl(η^5 -4,5-tetrahydropentalene)]zirconium
 30 dichloride,
 [4-(η^5 -3'-methylcyclopentadienyl)(η^5 -4,5-tetrahydropentalene)]zirconium
 dichloride,
 [4-(η^5 -3'-isopropylcyclopentadienyl)(η^5 -4,5-tetrahydropentalene)]-
 zirconium dichloride,
 35 [4-(η^5 -3'-benzylcyclopentadienyl)(η^5 -4,5-tetrahydropentalene)]zirconium
 dichloride,
 [2,2,4-trimethyl-4-(η^5 -cyclopentadienyl)(η^5 -4,5-tetrahydropentalene)]-
 zirconium dichloride,

[2,2,4-trimethyl-4-(η^5 -(3,4-diisopropyl)cyclopentadienyl)(η^5 -4,5-tetrahydropentalene)]zirconium dichloride.

5 The COC films used according to the invention have specific mechanical properties. The films can be processed on the machinery used and also have low puncture resistance and a high level of barrier properties, especially to water vapor. Suitable COC films of this type are unoriented. They may be monolayer films or have more than one layer. The films may comprise organic or inorganic fillers in order to reduce light transmission so
10 as to render the contents invisible (childproof packaging) or in order to improve printability or sealing properties.

The cycloolefin copolymers are prepared by heterogeneous or homogeneous catalysis with organometallic compounds as described in
15 many patents. Catalyst systems based on mixed catalysts made from titanium salts and organoaluminum compounds are described in DD-A-109 224 and DD-A-237 070. EP-A-156 464 describes the preparation using catalysts based on vanadium. EP-A-283 164, EP-A-407 870, EP-A-485 893 and EP-A-503 422 describe the preparation of cycloolefin
20 polymers using catalysts based on soluble metallocene complexes. The preparation processes described and the catalyst systems used in these patents for preparing COCs are expressly incorporated herein by way of reference.

25 Unoriented extruded COC films are brittle, making it difficult to find appropriate processing conditions, and their processing performance is poor (cf. DE-A-4304309). They readily split or break during winding-up and/or unwinding under tension. For this reason their mechanical strength has to be increased. This may be achieved by orientation (mono- or biaxial
30 stretching) of the films. The films oriented in this way are significantly easier to handle and do not have the disadvantages described in DE-A-4304309. The puncture resistance of oriented films was studied in accordance with DIN 53373. One measure of puncture resistance is penetration energy. It has now been established that orientation increases the puncture
35 resistance of the films. Without exception, the values found were larger than those of unoriented films of comparable thickness. DE-A-4414669 states that 450 N/mm is excessively high for a film to be useful as a backing film for blister packs. Significantly lower values are desirable on blister packing machinery for fragile pharmaceuticals. The puncture

resistances of aluminium foils can be taken as a preliminary guide: that of a (16 μm) aluminum foil is 90 N/mm. When oriented COC films are used, therefore, it is not possible to ensure easy removal of the pharmaceutical from the blister pack.

5

Alongside ideal, but not excessively low, puncture resistance the blister film must have relatively high toughness. Careful balancing of mechanical strength (hardness), flexibility and the force required to compress the compartment is required to enable the contents, such as a tablet, capsule
10 suppository or dragee, to be released from the pack without damage and without unreasonable expenditure of effort. Low expenditure of effort is a particular requirement when elderly people use the product, and also in the clinical sector where medical personnel are continually using pressure to remove tablets and can suffer from fatigue or muscular aching in the
15 fingers.

The water-vapor barrier effectiveness of the films is comparable with that observed for unoriented COC films, i.e. the orientation has no marked effect on the barrier effectiveness of the films. The thickness of the backing
20 films based on COC films should therefore be within the range of the thicknesses of the films in the blister after forming. The resultant thickness for the backing films is from 20 to 150 μm , preferably from 40 to 100 μm .

The water-vapor barrier effectiveness is not significantly affected by organic
25 or inorganic additives. It is from 0.2 to 0.4 $\text{g}/\text{m}^2\cdot\text{d}$ for a film thickness of 100 μm . The polarity of the surface can be increased by corona-treating the film.

The additives may be organic polymers, such as polypropylene or
30 polyethylene in the form of homo- or copolymers, polyesters, polyamides, polycarbonate, polyacetals, or acrylate or methacrylate polymers. Inorganic pigments which may be used are titanium dioxide, barium sulfate, calcium sulfate, calcium carbonate and barium carbonate.

35 One or both sides of the COC film may be laminated with a film which comprises polymers such as unoriented or oriented polyethylene, polypropylene or polyvinyl chloride. The thickness of the film laminated to the COC film is from 1 to 150 μm , preferably from 1 to 100 μm , particularly preferably from 5 to 50 μm . A solvent-free adhesive is preferably used in

the lamination, particularly preferably a solvent-free single-component adhesive.

5 COC is preferably laminated with PVC, and particularly preferably with oriented polypropylene (oPP) on one or both sides. Oriented polypropylene can be used to produce films substantially thinner than those using COC. COC and oPP in the form of a laminate give a flexible, puncture-resistant composite film of good appearance.

10 The thickness of the entire film is from 50 to 550 μm , preferably from 150 to 400 μm and particularly preferably from 200 to 350 μm . The thickness of the oPP film is from 1 to 150 μm , preferably from 2 to 50 μm and particularly preferably from 4 to 10 μm . The thickness of the COC film is from 50 to 400 μm , preferably from 150 to 350 μm , particularly preferably
15 from 175 to 300 μm .

The novel thermoformable composite film is used for producing blister packs. Blister packs or PTP (push-through packaging) produced therefrom have very good water-vapor barrier properties, thus increasing the value of
20 the packaged item. They can be used to pack contents such as pharmaceuticals and foodstuffs, in particular pelletized or encapsulated pharmaceuticals, foods containing rice, cookies, snacks, and also hygroscopic items, such as cigarettes and teabags.

25 The invention is described in more detail using a drawing and examples.

Drawing

The drawing comprises Figures 1 to 3.
30

Fig. 1 shows the coating plant

Fig. 2 shows the set-up of the coating plant

Fig. 3 shows the application device in the coating plant.

35 The coating plant of Fig. 1 comprises an unwind (1), application device (2), short-wavelength infrared source (3), medium-wavelength infrared source (4), flotation drier (5), dry-lamination unit (6), corona system (7), web edge-guiding system (8), remoistening equipment (9), cooling unit (10), wind up (11), electron-beam unit (12), wet-lamination unit (13) and UV source (14).

Fig. 2 shows the set-up of the coating plant for the following procedures:

- A) thermal drying or UV curing
- B) thermal drying with shock cooling
- 5 C) thermal drying with remoistening
- D) thermal drying with dry lamination
- E) thermal drying with UV curing.

10 Fig. 3 shows the application device in the coating plant with application by smooth rollers using four rollers (wet). G here indicates a rubber roller and S a steel roller. The rollers here are heated and cooled. Application using smooth rollers is particularly suitable for the lamination of COC with PVC or oPP.

15 **Example**

A COC film of thickness $190\ \mu\text{m}$ ($194\ \text{g/m}^2$) was, laminated on both sides with an oriented polypropylene film of thickness $5\ \mu\text{m}$ ($4.6\ \text{g/m}^2$) using Herberts GmbH 1K-LF 190X3 solvent-free single-component adhesive.
20 Application was at $1.50\ \text{g/m}^2$. Corona treatment at 48 kW. For lamination a width of 810 mm was used with a speed of 50 m/min, and a smooth-roller application system with four rollers and one pass for each laminated side. The thickness of the thermoformable composite film was $260\ \mu\text{m}$. The bond strength of the composite film was high, and when this strength was
25 measured it was the composite film which fractured.

Comparative Example

30 The procedure of the example was followed except that both sides of the COC film were laminated with an unoriented polypropylene film. The thickness of the thermoformable composite film was $210\ \mu\text{m}$.

What is claimed is:

1. A thermoformable composite film comprising at least one film which comprises cycloolefin copolymer and comprising, laminated to at least one side of this film, a thermoplastic film.
5
2. A thermoformable composite film as claimed in claim 1 obtainable by using a solvent-free adhesive to apply the thermoplastic film laminated to the film which comprises cycloolefin copolymer.
10
3. A thermoformable composite film as claimed in claim 1 or 2 obtainable by using a solvent-free single-component adhesive to apply the thermoplastic film laminated to the film which comprises cycloolefin copolymer.
15
4. A thermoformable composite film as claimed in one or more of claims 1 to 3, comprising at least one film which comprises cycloolefin copolymer and comprising, laminated to at least one side of this film, an oPP-containing thermoplastic film.
20
5. A thermoformable composite film as claimed in one or more of claims 1 to 4, where the thickness of the oPP film is from 1 to 150 μm and the thickness of the COC film is from 50 to 400 μm .
25
6. A thermoformable composite film as claimed in one or more of claims 1 to 5, where the thickness of the oPP film is from 2 to 50 μm and the thickness of the COC film is from 150 to 350 μm .
30
7. A thermoformable composite film as claimed in one or more of claims 1 to 6, where the thickness of the oPP film is from 4 to 10 μm and the thickness of the COC film is from 175 to 300 μm .
35
8. A process for producing a thermoformable composite film as claimed in one or more of claims 1 to 7, where a solvent-free adhesive is used to apply the thermoplastic film laminated to the film which comprises cycloolefin copolymer.

9. A process as claimed in claim 8, where a solvent-free single-component adhesive is used to apply the thermoplastic film laminated to the film which comprises cycloolefin copolymer.
- 5 10. The use of a thermoformable composite film as claimed in one or more of claims 1 to 7 for producing blister packs.

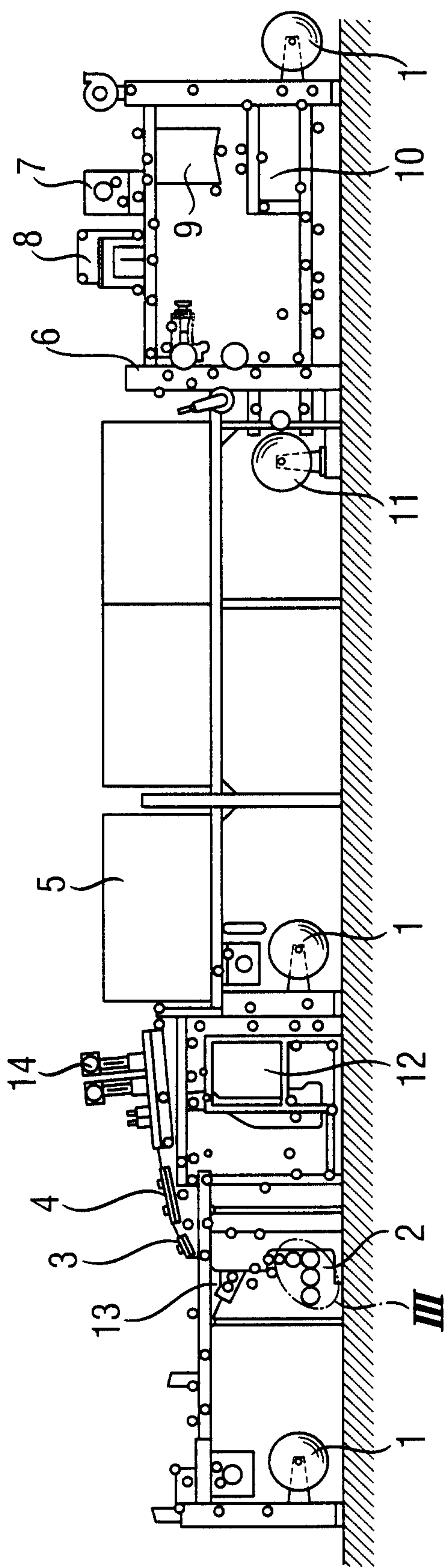


Fig. 1

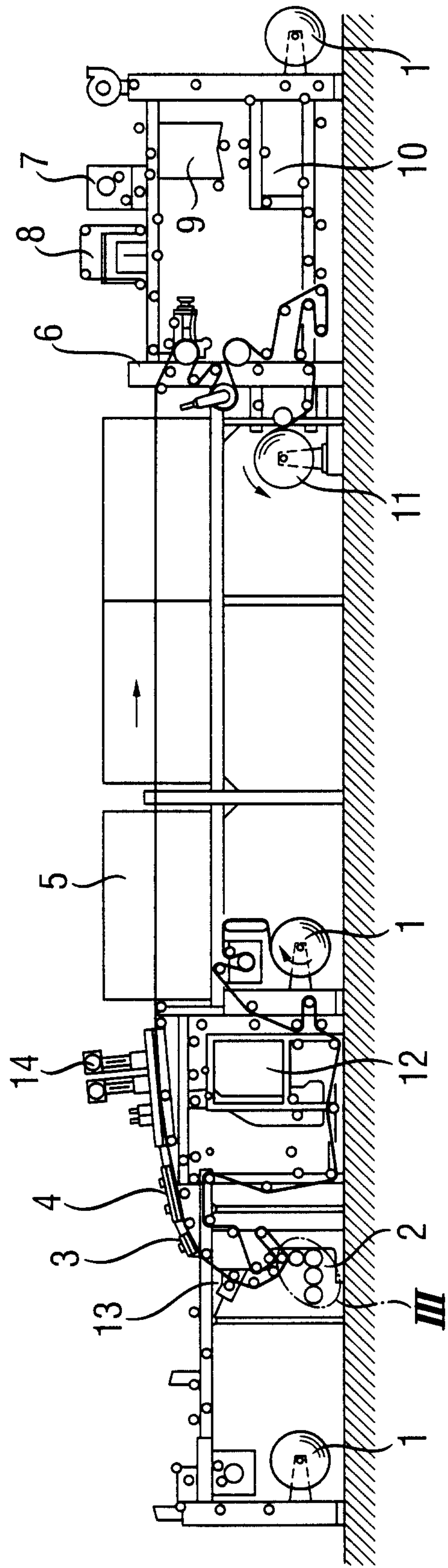


Fig. 2A

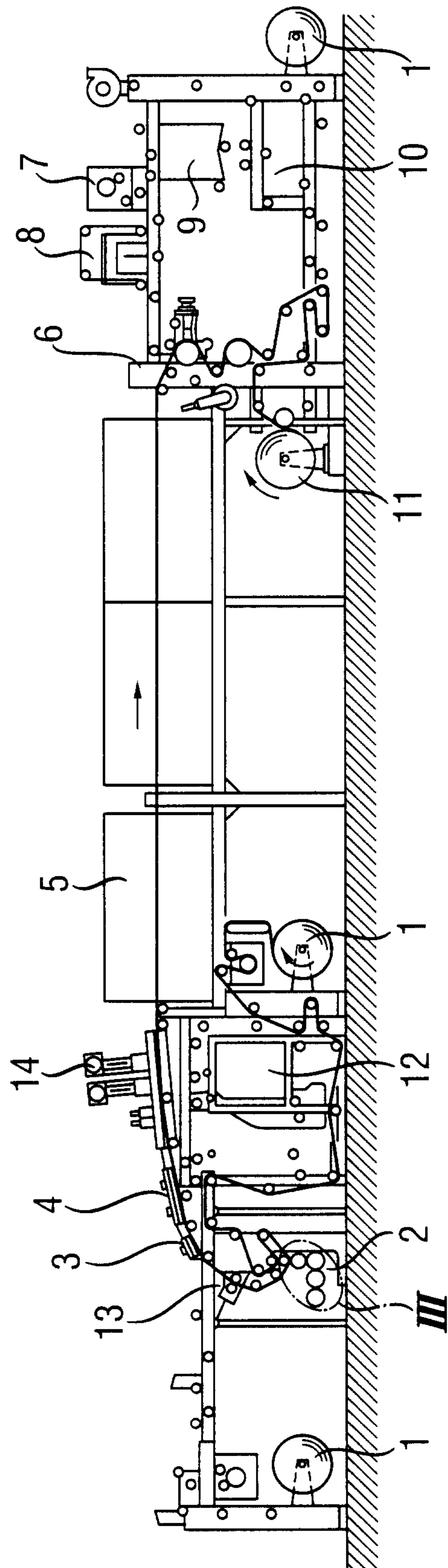


Fig. 2B

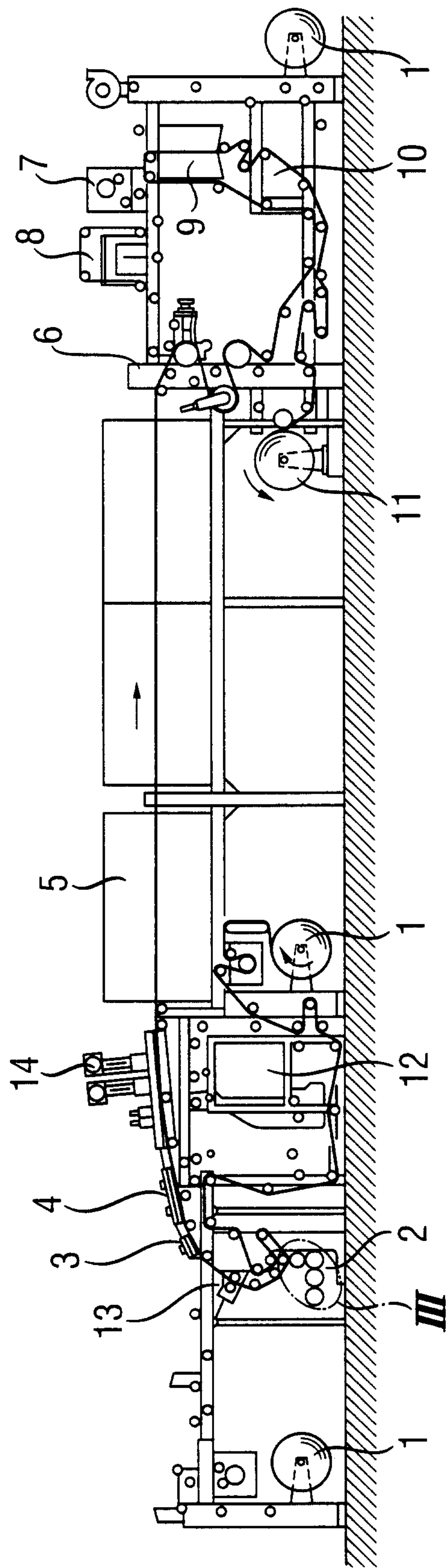


Fig. 2C

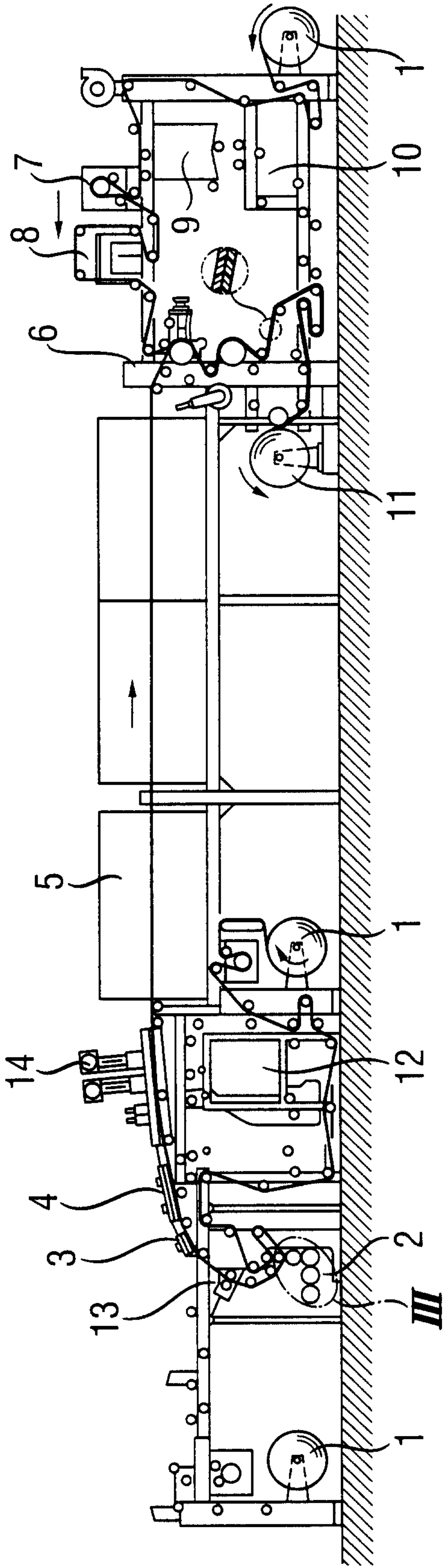


Fig. 2D

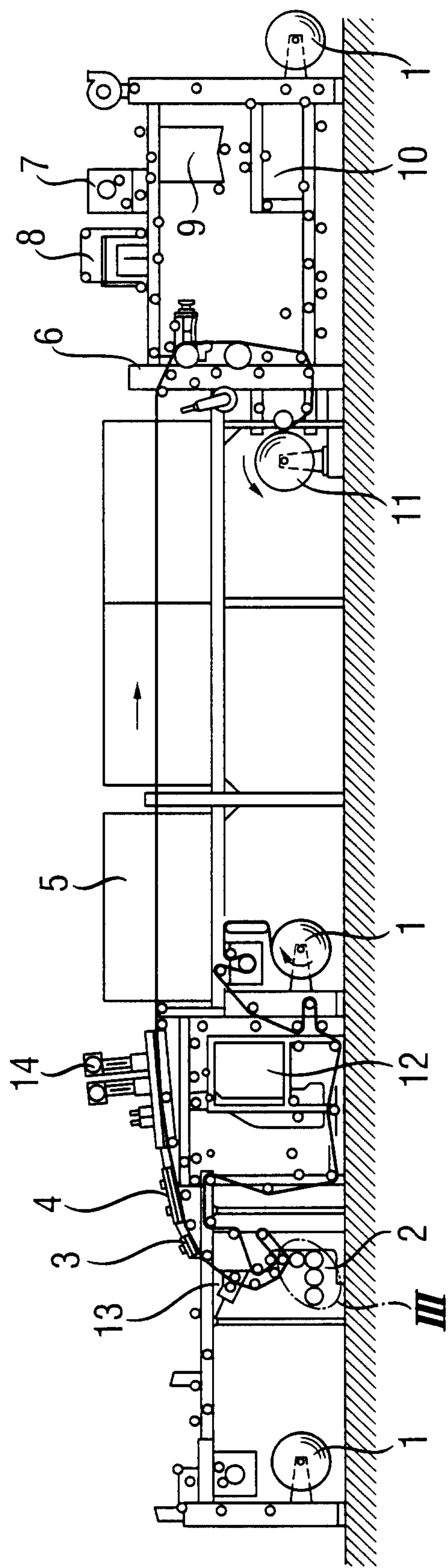


Fig. 2E

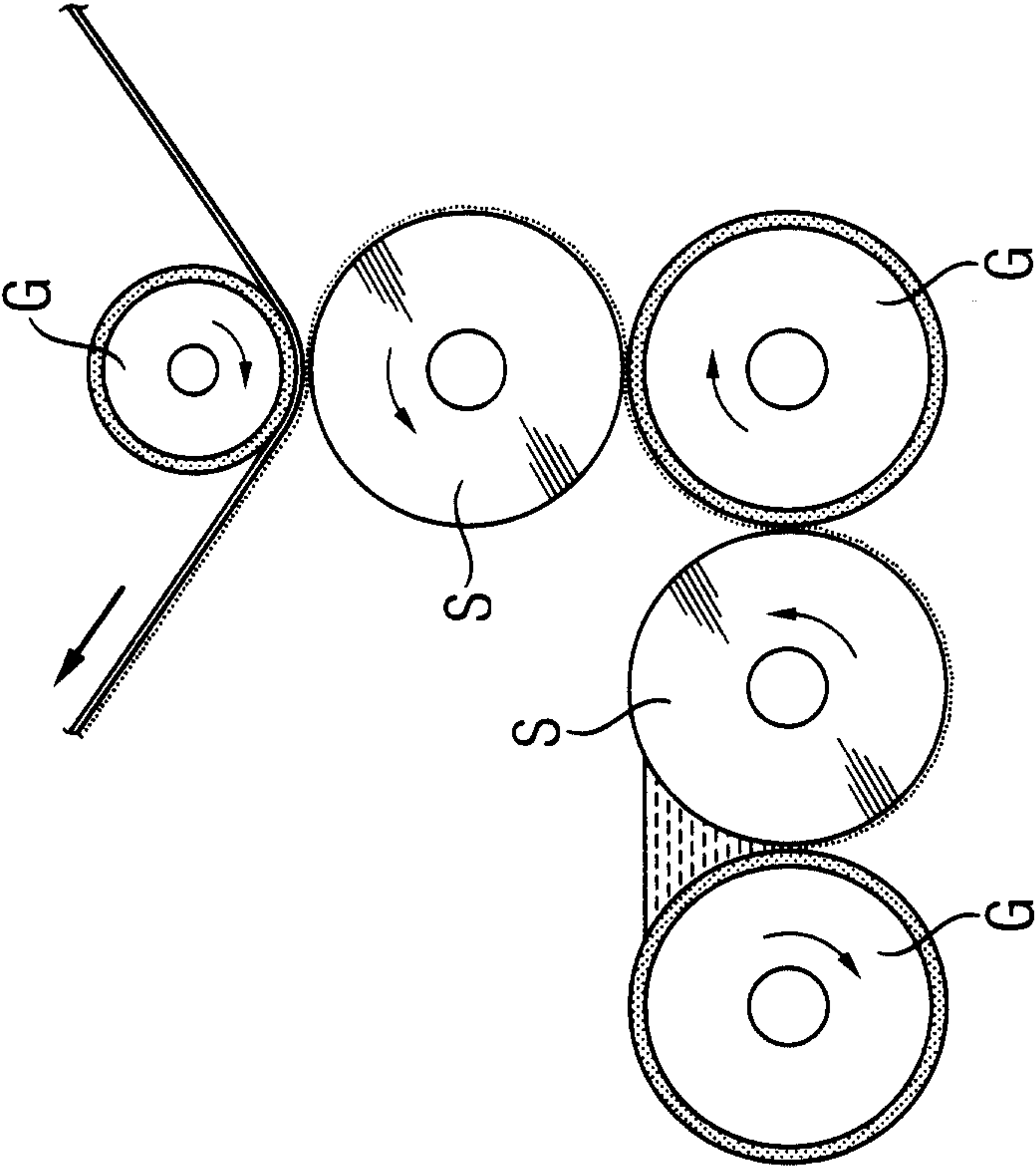


Fig. 3