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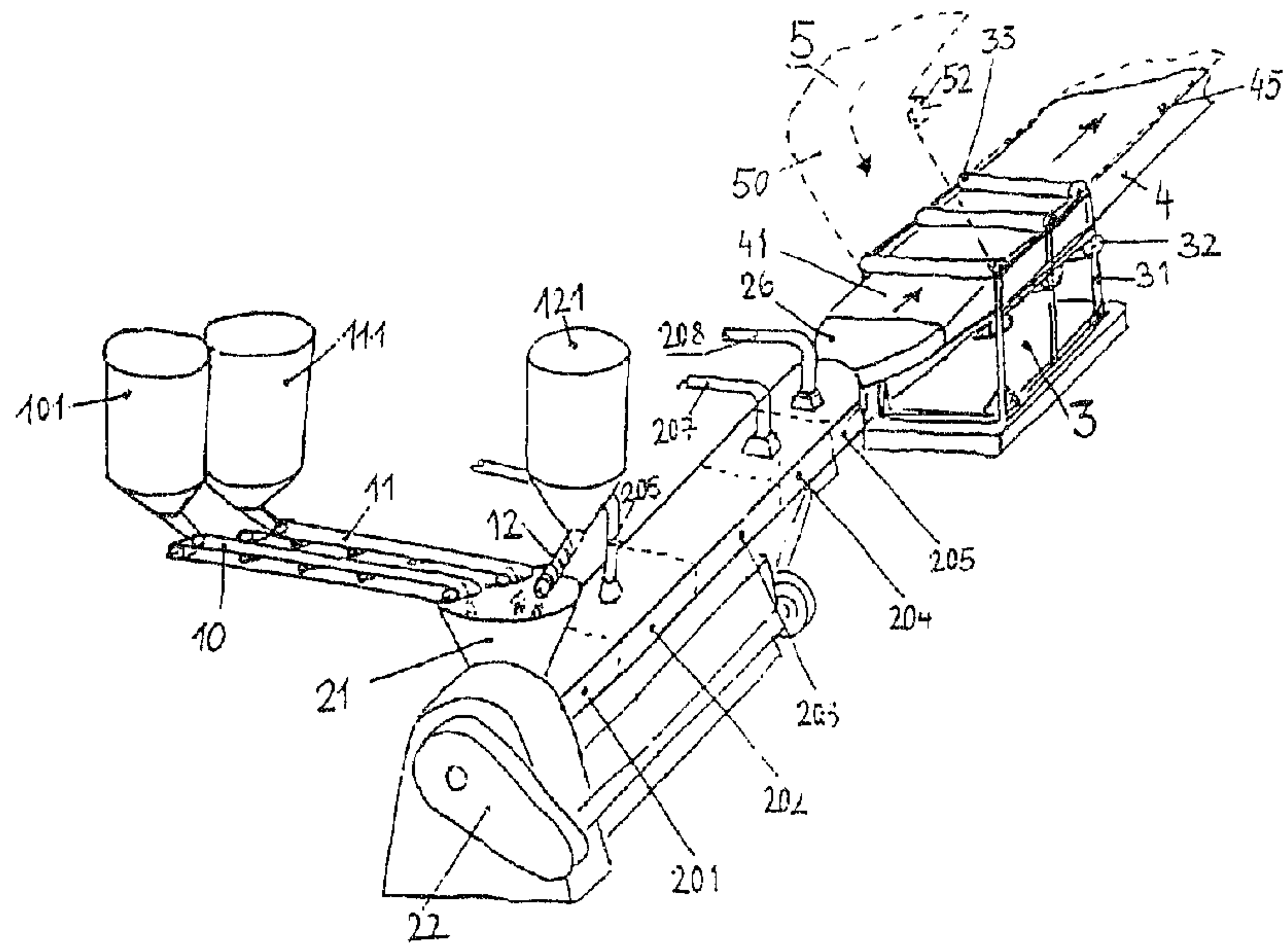
(72) Inventeur/Inventor:
Rettenbacher, Markus, AT

(73) Propriétaire/Owner:
Rettenbacher, Markus, AT

(74) Agent: GOWLING LAFLEUR HENDERSON LLP

(54) Titre : METHODE ET DISPOSITIF POUR L'OBTENTION DE PIECES MOULEES, NOTAMMENT DES ELEMENTS DE CONSTRUCTION, DES REVETEMENTS ISOLANTS ET/OU D'EMBALLAGE; LES PIECES AINSI OBTENUES

(54) Title: PROCESS AND DEVICE FOR PRODUCING MOULDINGS, IN PARTICULAR FOR STRUCTURAL ELEMENTS, INSULATIONS AND/OR PACKAGING, AND MOULDINGS SO OBTAINED




(57) Abrégé/Abstract:
In a process for producing mouldings, in particular particle boards, at least one binding agent is mixed with a least one fine-particle basic material extruded at high temperature and pressure. The basic material has, or is brought to, a total content of 6 to 25 wt.%. It is extruded, together with at least one biopolymer, preferably a binding agent containing starch which can be convented to molten and/or gel form at least at the extrusion temperature and pressure, and the fine-particle material. Immediately after extrusion, the pressure is relieved by spontaneous expansion. The device for implementing the process comprises extrusion machines (2, 20) for starting components in lump form. These machines have an extrusion nozzle (26, 260) and an upstream processing region (204) where the basic material to be processed is partially pressure relieved by internal partial expansion. The extruded mouldings have a compact surface and a basic material in which particles of a fine-particle fibrous material are distributed throughout a matrix containing numerous minute voids. The fraction of starch-containing matrix is equal to 5 to 85 wt.%.

**PCT**

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**(71) Anmelder** *(für alle Bestimmungsstaaten ausser US):* M. KAINDL HOLZINDUSTRIE [AT/AT]; Walser Weg 12, A-5071 Wals (AT).

**(72) Erfinder; und**
**(75) Erfinder/Anmelder** *(nur für US)* : RETTENBACHER, Markus [AT/AT]; Parkstraße 1/8, A-5020 Salzburg (AT).

**(74) Anwälte:** BRAUNEISS, Leo usw. ; Strohgasse 10, A-1030 Wien (AT).

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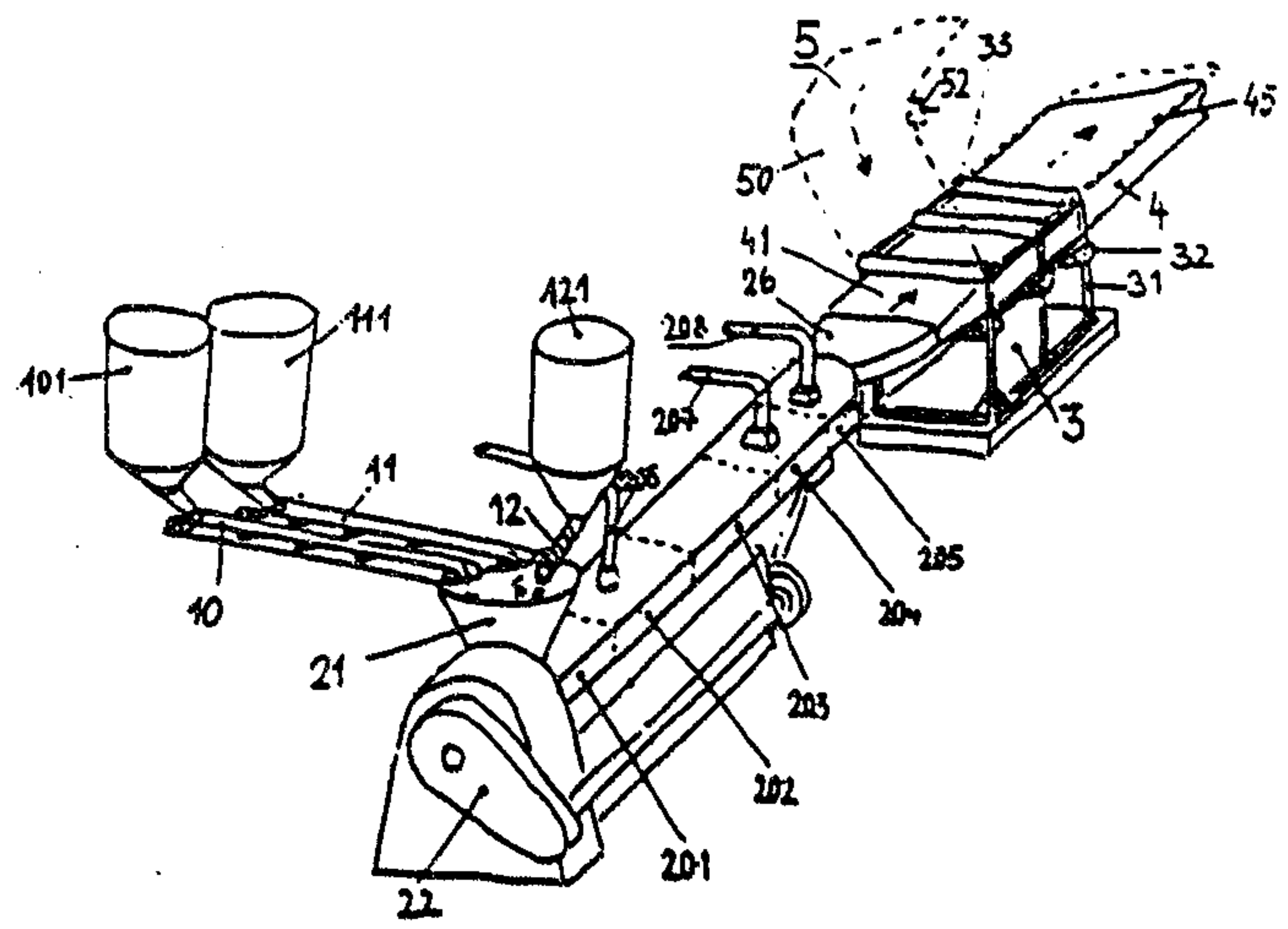
**(54) Title:** PROCESS AND DEVICE FOR PRODUCING MOULDINGS, IN PARTICULAR FOR STRUCTURAL ELEMENTS, INSULATIONS AND/OR PACKAGING, AND MOULDINGS SO OBTAINED

**(54) Bezeichnung:** VERFAHREN ZUR HERSTELLUNG VON NEUEN FORMKÖRPERN, INSBESONDERE FÜR STRUKTURELEMENTE, ISOLIERUNGEN UND/ODER VERPACKUNG, VORRICHTUNG ZUR DURCHFÜHRUNG DES VERFAHRENS SOWIE INSBESONDERE DANACH BZW. DAMIT ERHALTENER FORMKÖRPER



**(57) Abstract**

In a process for producing mouldings, in particular particle boards, at least one binding agent is mixed with a least one fine-particle basic material extruded at high temperature and pressure. The basic material has, or is brought to, a total content of 6 to 25 wt.%. It is extruded, together with at least one biopolymer, preferably a binding agent containing starch which can be converted to molten and/or gel form at least at the extrusion temperature and pressure, and the fine-particle material. Immediately after extrusion, the pressure is relieved by spontaneous expansion. The device for implementing the process comprises extrusion machines (2, 20) for starting components in lump form. These machines have an extrusion nozzle (26, 260) and an upstream processing region (204) where the basic material to be processed is partially pressure relieved by internal partial expansion. The extruded moulcings have a compact surface and a basic mate :ial in which particles of a fine-particle fibrous material are distributed throughout a matrix containing numerous minute voids. The fraction of starch-containing matrix is equal to 5 to 85 wt.%.

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# A Process for the Manufacture of Construction Material, Structural Material or Packaging Material and Equipment for Implementing the Process

The subject of the invention is a process for the production of new shaped parts used for the production of construction material, structural material or packaging material, preferably made from wood chip and/or fibre-based sections and/or boards, also the equipment for producing the parts and the use of the said parts.

Many procedures are known by means of which biopolymeric products may be broken down in order to process them in a separate, second work step into other products, e.g. wood-fibre boards. The biopolymeric products are broken down by the application of steam followed by decompression or mechanical comminution. Usually a combination of these two methods is used. The serious drawbacks of both these processing methods are that they require high inputs of energy and also that the intermediate products obtained can only be processed in batches.

Other processes are known in which a mass consisting of resin and wood chips is extruded to produce structural boards. Specially designed extruders, and especially extruder screws, have to be used for this purpose. In most cases, only semi-finished products are produced and no attempt is ever made to produce the final product in one single operation. The expense involved in having to provide separate machinery for the final products adds to the expense of the boards, wall elements, etc. which are extruded on the known machinery.

Reference is made here to German Patent Application DE-A1 1 653 263 which can stand as an example of the known extrusion processes for producing boards and sections from material containing lignocellulose. According to that Patent Application, wet raw material in the form of chips is first dried in the drying mixer to the desired moisture content then mixed with glue in at least one mixer, and only after a binder - specific materials are mentioned in the Patent Application - is applied in a separate wetting step is the raw material continuously extruded in a screw extruder while continuously adjusting the pressure and while also regulating the temperature, to form the finished product.

For the manufacture of a cigarette-like product, the concept is known of compressing a moist mixture of natural fibre-shaped

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material and starch in an extruder until the starch melts to form a gel which is then allowed to expand to give a foam-like product made of biodegradable substances, cf. EP-A 113 595.

Furthermore, it is known from US-A 4 357 194, that a mixture of natural fibre-shaped or fibre-containing material and starch or sugar may be compacted and heated with steam in order to obtain particle boards made from biodegradable substances, without using artificial glue (adhesives).

In addition, US-A 4 627 951 describes processes by means of which natural, sugar-containing, fibre-shaped material may be compressed in heatable board-pressing machines, without steam and without the addition of glue, to obtain particle boards made of biodegradable substances.

The disadvantage of the chipboards produced by the known procedures is that they have a high density which makes them heavy and awkward to handle when they are used, for example, in the construction of small items of furniture; furthermore, they are not very well suited for use in thermal insulation applications, e.g. as floor, wall and ceiling boards, attic lining materials, etc.

Another large area is accounted for by the production of insulation boards - preferably of low density - from foamed plastics, which vary widely in their properties, whose porosity is obtained by gas-generating primary components or additives. The disadvantages of such products are that their mechanical strength declines rapidly at low density, they melt and burn easily, their resistance to chemicals is inadequate and, last but not least, they do not break down readily once they are disposed of as waste. What is more, the above-described fibre boards can also cause environmental problems right at the manufacturing stage, due to the chemicals used, as well as later when they are employed in their intended applications.

The purpose of the invention is to avoid the disadvantages of the already known processes and products in this sector, while using the customary extrusion machinery, but without the separate prior application of glue to the chip or fibre material, and to create a process which permits the products mentioned at the beginning of this application to be produced in essentially one single operation from environmentally friendly raw materials. The aim is to obtain products which exhibit a greater degree of isotropy and thus have more uniform physical properties than the previously known boards, and which also combine lower density with greater mechanical stability.

In the process according to the invention, the new products are obtained in a particularly advantageous manner, as outlined in the characterizing section of Claim 1.

In this connection, it is particularly important to form a genuine molten gel by applying heat and pressure so that the preferably starch-containing materials or other binder materials capable of forming a melt - such materials may also include starch itself - may be fed directly into the extruder, after the desired moisture content has been adjusted, in solid, lump form, such as whole rice grains, possibly together with the husks which serve as the fibre material component, or simply uniformly mixed with the other biogenic chip or fibre material, e.g. wood chips, straw, cardboard, paper and similar. The products can thus be produced in practically one operation. Apart from the chipped, comminuted, defibrated, fibre-like, fibre-containing and fibre-shaped materials referred to above, the biogenic high-molecular materials also include materials such as rubber and similar which also possess fibre-like molecules.

By converting the binder, which is added in solid form, into a molten gel consistency, it is possible, despite the expansion which immediately takes place, to process the material without any difficulty on a wide range of different types of extruder. The product is smoothed by binding the biogenic materials used, e.g. wood chips, into this highly viscous phase. The process is easy to control and yields products having a pleasing surface finish, low density and high strength. The formation of this gel-like consistency can also be promoted by additives, e.g. agents which cause cellulose to swell or dissolve, which do not themselves possess the ability to gel, but which bring it about in one of the other components, e.g. in the wood chips, when the material is intensively worked in the extruder.

The new products obtained by the process according to the invention offer the special advantage that their specific mass can be controlled by varying the degree of expansion, which can be influenced over a wide range via the pressure and heat applied, and in this way a much lighter wood-fibre board can be produced which is only slightly less strong than other fibre boards.

Immediately the product emerges from the extruder, which can be fitted with any desired shape of extrusion nozzle, in particular a flat nozzle, the gel, especially a starch gel, starts to make the transition into a glassy state as it cools, while simultaneously the steam generated by the water vapour trapped in the extrusion mass undergoes expansion. By adjusting the moisture content, starch component, biopolymer content and the operating conditions, these two competing processes can be precisely matched to one another in order to obtain outstanding final products. One last major advantage is that the final product can be made to expand to the desired density without the need for additional gas-generating or gas-releasing chemicals, but simply via the moisture content of the extrusion mass, e.g. of the wood chips and/or the starch.

The invention can also be particularly advantageously used for the manufacture of packaging filler materials and throw-away thermal insulating containers, e.g. for snack foods, etc. The products obtained by this process are characterized by their pleasing appearance to the consumer; they also possess good shock-absorbing and elastic properties, which are particularly important when the products are used as fillers, e.g. chips or spheres, in packages, or also when they are used as wrapping elements or foils. Another advantage is their "crisp" consistency, which makes it much easier to comminute them, e.g. for waste disposal purposes, and thus also enhances their biodegradability.

When an advantageous processing method according to Claim 2 is used, together with the binders mentioned in that Claim, and when processing is carried out according to Claim 3, using the plant fibre materials referred to in that Claim, on the one hand high-grade chip or fibre products are obtained, and on the other hand a great deal of flexibility is possible in the choice of starting components and in the quality of the expanded finished products, whereby in particular economic advantages are also achieved.

If the process temperatures are adjusted as provided for in Claim 4, the amount of internal energy needed to permit a controlled expansion, coupled with the competing solidification of the mass to the desired density, can be applied in a favourable manner to the moisture content. When the pressures are maintained as outlined in this Claim, controlled expansion can be very easily and advantageously attained.

In another preferred processing method according to Claim 5, no separate device is needed to heat the mass in the extruder; in addition, because the edges, corners and projections on the lumpy, fibre-containing material are rounded-off, the mass takes on a "smooth" consistency, to which reference has already briefly been made, at the nozzle, and this minimizes the problems of extruding masses of melt-like consistency containing coarse filler materials.

"Lightweight" but structurally rigid boards and sections can be advantageously obtained by performing decompression in order to obtain the preferred values in the expansion index according to Claim 6.

When the biopolymeric binder is used in the preferred quantity ranges quoted in Claim 7, a wide range of chip and fibre-containing materials can be used while still attaining the necessary workability of the extrusion mass along with adequate mechanical properties of the lightweight structural elements which are produced.

In order to ensure that the expansion process can be advantageously controlled in a wide variety of ways, as described in Claim 8, the substances referred to in that Claim may also be added to support the expansion effect of the moisture content in the extrusion mass itself.

If shaped parts such as boards and sections are produced, in a preferred manner, with water-repellent and thus also anti-microbial modifiers in accordance with Claim 9, the products will have a long lifetime but they can still be disposed of at a later date as waste without any problem. For example, by incorporating rubber or silicon molecules, it is possible to produce shaped parts of low density and having a soft but dimensionally stable and even an elastic consistency.

The same holds true for the advantageous process described in Claim 10 according to which the lifetime of the products can be extended, but also in a preferred matter the appearance of the new shaped parts can be modified, by directly incorporating the modifying agents into the molecular structure of the binder.

Preferably, the agent is selected from a least one of the groups of short-chained di-or polycarboxylic acids, di- or poly(thi)ols and their derivatives, molecules containing tertiary amino acid groups, and polyphosphoric acids. The molecules of the biopolymeric binder are starch molecules.

The agent is also referred to as a "bifunctional" agent which means that the agent has two chemical reactive groups as it acts as a linking agent.

When the similarly advantageous process according to Claim 11 is used, shaped parts are obtained which differ from the basic parts in that they have, for example, a tough, elastic or other kind of "rind", "skin" or surface layer.

The process of applying an adhesive, such as hot cross-linking resins, or similar, which is also referred to in this Claim, may be advantageous if any coating is to be applied after extrusion, as is done in the case of chipboards and structural boards.

Boards, sections, etc. provided with surface finishes - e.g. for decorative purposes - can be advantageously produced in the manner described in Claim 14, the advantage being that the extrusion device does not have to be modified to permit the addition of a coating mass before the extrusion mass has left the extruder.

Using a working method as described in Claim 13, dimensionally accurate shaped parts may be obtained in an advantageous way, even if unavoidable fluctuations occur in the raw materials used, e.g. their particle size or grain size or the moisture content, etc.

If coated boards and sections are produced in the matter described in Claim 4, the desired dimensional accuracy of the extrusions is reliably combined in a technically simple and costsaving manner with the advantages of a surface finish which is exactly matched to the later uses to which the products will be put.

A further important and preferred subject of the invention is a machine for manufacturing the aforementioned shaped parts, with devices for comminuting and/or conditioning and/or pre-mixing the starting components, which are preferably supplied in solid form as lumps or small pieces, along with other devices for feeding these components into an extrusion machine, especially a multi-screw extruder possibly having screws with alternating leads and/or a conical configuration, and having also at least one shape-imparting, preferably rectangular extrusion opening.

This machine possesses the combination of characteristics grouped together in the characterizing section of Claim 15. An extrusion machine of this type offers the advantage that the dimensions of the expanded parts can be controlled with great accuracy and the whole process runs more "smoothly". The partial decompression is achieved by providing appropriate areas in the screw where the lead of the screw is increased, or by providing larger "free" transportation volumes between the rotating screw and the wall of the extruder.

Another preferred type of device according to Claim 16 offers the advantage that it is simple in design and construction but is capable of guaranteeing the dimensional stability of the product which is dimensionally not very easy to control during the production process.

The advantage of the special embodiment according to Claim 17 is that while the device is simple in design and construction, it is not necessary to provide a separate drive mechanism for moving dimension-limiting elements at a speed conforming to that of the extruded product.

If the surface smoothness or similar of the product has to meet stricter requirements, then a more complex embodiment of the production system as per Claim 18 may be used with advantage.

A significant reduction in the technical effort which would otherwise be needed for applying a foil coating to the shaped part may be achieved with a variant of the design according to Claim 19, which permits a high degree of dimensional precision to be combined with the surface-finishing technique.

The application of a surface finish other than a foil coating, e.g. a coating mass or a similar kind of powder, precisely at the moment after the product has left the extruder nozzle and the expansion commences and continues, is problematical but the problems involved can be avoided when the machine according to the invention is designed as outlined in Claim 20.

The invention, and in particular the preferred types of devices needed to accomplish it, will now be described on the basis of the drawing:

Fig. 1 shows an oblique-angled view of the most important parts of an installation according to the invention for the production of expanded fibre boards; the installation is equipped with a device consisting of rollers for limiting the cross-sectional profile of the products. Fig. 2 depicts a section of an installation, also according to the invention, in which the profile-limiting elements consist of wall elements in the form of continuous belts.

According to Fig. 1, wood chips, starch-containing binder and "additives" - all in solid lump form or as small particles - are fed in that order from storage hoppers 101, 111,and 121 via feed belts 10 and 11 and also feed screw 12 into the storage hopper 21 of the extrusion machine 2. From here, the mass is continuously fed into the work chamber of a two-screw extrusion press 2 equipped with drive 22, and premixing of the starting components takes place in the entry zone 201 of the extruder, right after storage hopper 21. In the immediately following sealing zone 202, on the one hand the moisture content is temporarily prevented from converting back into steam, and on the other hand preliminary compaction of the extrusion mass is carried out. Through a pipe 206 leading into this zone 202, water for example can be fed to adjust the desired total moisture content of the mass. In the following extruder zone 203 - referred to here as the "shear zone" - the screw is shaped in such a way that it imparts a large amount of energy to the mass while simultaneously greatly increasing the pressure and temperature. The further processing zone 204 which follows after shear zone 203 is equipped with a pipe 207 through which, for example, a hydrophobic agent for the binder is supplied; in this zone the now melted mass is stabilized, binder-modifying agents are added or, however, in this zone the leads of the screw are increased or the number of spirals on the screw is reduced in the case of a multi-spiral screw, with the result that partial, preliminary expansion and also "smoothing" of the extrusion mass takes place here. A further pipe 208 leads into the ejection zone 205 adjoining downstream in the material flow; materials such as a hot cross-linking plastic for applying an outer coating to the extruded boards can be added via this pipe to the mass while it is still in its "melt-gel state" in order to modify its surface finish. Finally, the mass is extruded through the - in this case rectangular - heatable extruder nozzle 26 and, as a result of the ensuing decompression, the flat extrusion 4 immediately starts to expand spontaneously as part of the moisture which it contains turns to steam, and the extrusion increases gradually in thickness while the density is reduced in zone 41 after the product leaves the flat nozzle 26.

An extrusion cross-section limiting device 3 is provided to limit the thickness of the boards. The frame 31 in which this device is mounted is advantageously equipped with oppositely arranged, precisely positionable, upper and lower rollers 33 and 32 which can be moved towards each other. The extruded product, which is expanding extremely slowly due to the increase in viscosity brought about by the cooling process, is passed between these rollers and its cross sectional profile is exactly shaped and maintained so that finally an "endless board" of the desired thickness is obtained. The boards are then cut up into portions of the desired size and any necessary finishing, for example the surface application of a hydrophobic agent, or similar, is carried out.

When the surfaces of the preferably silicone-coated or teflon-coated rollers 32 and 33 are appropriately formed, boards with any desired surface structure may be produced.

The broken lines in Fig. 1 also show how a coating foil 50 is passed over a deflection roller 52 of a foil-coating device 5, which is not shown here in any further detail, at the end of the expansion zone 41, then brought into contact with the upper surface of the extruded product 4, and then deflected once more around the first of the upper rollers 33 of the roller frame 3 of the dimension-control device. An "adhesive layer" can be applied to the surface of the extrusion 4 by injecting an adhesive under pressure via the supply line 208 ahead of nozzle 26 into zone 205 of the extruder, e.g. via an annular duct arranged on the inside of the cylinder and opening towards the screws. This adhesive layer serves to bond the foil 50 running through the roller frame 3 firmly to the surface of the board 40, thereby forming a foil coating 45.

A device similar to that shown for feeding foil 50 can, of course, also be provided for coating the underside of the extruded board.

The dimension-control device 30 shown in Fig. 2, which is used to limit the cross sectional dimensions of the product, consists of rollers 311 mounted in a frame 310 to guide upper and lower continuous belts 330 and 320 which form an upper and lower "wall element" respectively running continuously in the same direction of travel (see arrow) and at the same speed as the extruded product 4. The belts 330 and 320 may be provided with separate drives to move them at a speed matched to that of the speed of the extrusion or, also, they may be designed as non-driven belts. A surface-coating medium can be supplied via a pipe 280 in the exit area 250 of the cylinder - not shown in detail here -of the extruder 20, close to the flat nozzle 260. Because this coating medium is then extruded together with the extrusion mass it forms an extremely integral bond with the extrusion 40.

The broken lines denote another surface-coating device 50 which is arranged transversely across zone 410 of the extrusion 40 just as it leaves the nozzle 260 and starts to undergo expansion. The lower surface of this device is provided with outlet openings for uniformly distributing a surface-coating medium supplied via feed pipe 510. A similar type of system can, of course, be provided to apply a coating medium to the underside of the extrusion.

It goes without saying that, if the expanded lightweight board 40 is desired to have a structured surface, the continuous belts 330 and 320 may be designed with appropriate surface-texturing elements which should be advantageously coated with a non-stick release agent, as mentioned above.

Finally, the new use of shaped parts for the production of structural elements, e.g. in furniture and structures, and for insulation and/or packaging purposes, is also an important subject of the present invention. These parts are preferably made from fibre-based sections and/or boards in turn obtained from the components described above. Shaped parts which possess the combination of characteristics listed in the characterizing section of Claim 21 are advantageously used for this purpose. They possess excellent mechanical strength, are resistant, "lightweight" and easy to manipulate, e.g. they can be cut and sanded without any problem, they may also exist in granulate form, and they have a pleasing outer appearance. They are long-lasting and have an unlimited range of applications extending from construction via interior decor, automobile and other vehicular uses, all the way through to efficient lightweight packaging.

The shaped parts described in Claim 22 or 23 possess the advantages already described when discussing the variants of the process.

The use of shaped parts which are textured in accordance with Claim 24 has the advantage that the parts are highly resistant to penetration by fluids, in particular water, and they can therefore be used in areas of elevated relative humidity, e.g. in the tropics, in cellars and basements, or also they are suitable as packaging materials for fresh fruit or meat, especially when they are additionally treated with a hydrophobic agent according to Claim 9. With their foam-like structure, the new shaped parts exhibit especially high strength and a high degree of isotropy as regards their mechanical properties and workability. Shaped parts having the densities mentioned in this Claim are preferred because of their "lightweight" characteristics while still retaining adequate mechanical stability.

The advantages which can be obtained by using shaped parts having a reduced density and coated in accordance with Claim 25 exceed the advantages already described. In addition to the enhanced surface finish provided by the coating layer, a sandwich effect is also achieved which additionally improves the stability and distortion resistance of the product.

Using in particular board-shaped, expanded, shaped products having strength values in accordance with Claim 26 offers the advantage that they can be used without any problem in place of the hitherto customarily used particle boards of the same thickness.

The invention will now be explained in more detail on the basis of the following examples:

and then expanded,subject to the conditions quoted in Claim 26, with special preference being given to the conditions and characteristics summarized in Claim 27.

The invention will now be explained in more detail on the basis of the following examples:

Example 1:
Manufacture of an expanded wood fibre board
60 wt.% wood chips between 0 and 3 mm in size having a residual moisture content of 12%, 35 wt.% cassava meal having a residual moisture content of 12% and 5 wt.% tall resin, are fed as solids into a conical double-screw extruder whose operation is adjusted in such a way that the temperature in the mass is 160°C and the pressure in the mass is 150 bar close to the nozzle. The plastic, gel-like molten mass is extruded through a heatable flat nozzle and converted into a continuous board product by carrying out sudden decompression and adjusting the expansion index to 3, and the product is then transported to other areas of the plant for further processing.

The board product had a dense surface, a thickness of 20 mm, a density of 0.48 $t/m^3$, and a bending strength of 14.2 $N/mm^2$.

Example 2
Crushed rice and natural rubber in proportions of 70 wt.% to 29 wt.% were fed continuously into a twin-screw extruder via separate fed mechanisms.

In the area of the sealing zone, water was continuously supplied to the extruder via a feed pipe in such quantities (approximately in the range from 2 to 10 wt.% relative to 99% starting materials) that an extrusion mass having a uniform water content of 14 wt.% was transported into the compression zone of the extruder. Through another feed pipe 1 wt.%, relative to the solid starting components, of a 60% aqueous paraffin emulsion was fed into the "further processing zone" of the extruder. During stable, continuous operation the temperature in the mass was 165°C and the pressure was 200 bar. Products of round cross section were continuously extruded through two circular openings each 1.5 cm in diameter while adjusting the expansion index to 6; then, while the extrusions were still slowly expanding, they were cut up into small spherical granulates using a rotating knife. The pleasant-looking packaging filler obtained in this way was waterproof, and elastic but exhibited high shape-restoring forces and, lastly, possessed good biodegradability when disposed of as waste.

Example 3:
The same procedure as described in Example 2 was used, the only

difference being that apart from crushed rice, up to 70 wt.% less natural rubber than in Example 2, namely 24 wt.%, and an additional 5 wt.% of cellulose as a biogenic fibre material were added to the extruder and a packaging foil material approximately 1.5 mm thick was extruded through a flat nozzle.

An elastic, dimensionally stable, low-density non-woven product was obtained which exhibited increasing shape-restoring properties and high tear strength in proportion to increasing application of pressure.

Example 4:

The following components and conditions were selected for the extrusion process:

| | |
|---|---|
| Potato starch: | 67.5 wt.% |
| Phthalic acid anhydride: | 2.5 wt.% |
| pH value | 8 to 11 (adjusted with 30% strength NaOH) |
| Cellulose (from the paper industry) | 30% |
| Water content of overall mixture adjusted to | 16 wt.% |

Operating conditions:

| | |
|---|---|
| Expansion index | 4.5 |
| Density | 0.25 $t/m^3$ |
| Temperature of the mass | 150°C |
| Pressure in the mass | 120 bar |

Boards 3.5 mm thick were obtained and these are ideally suitable for packaging fruit, producing thermal insulating containers for fresh snack foods, etc., but they are still brittle enough to be broken up into smaller pieces when disposed of as waste.

Example 5:
An extrusion mass having the composition

| | |
|---|---|
| Corn semolina | 37 wt.% |
| Polyethylene | 10 wt.% |
| Softwood chips | 50 wt.% (particle size 1-10 mm) |
| Linseed oil | 3 wt.% |

was extruded in a single-screw extruder to give a lightweight chipboard 24 mm thick. The degree of expansion was 3.0 and the density of the board obtained was 0.3 $t/m^3$.

The operating conditions were as follows:

| | |
|---|---|
| Temperature in the mass | 145°C |
| Pressure in the mass | 90 bar |

The wood chipboard product obtained in this way was waterproof also under tropical conditions; it possessed a bending strength of 13.8 and was a pleasant yellow-brown in colour.

## CLAIMS

1. A process for the manufacture of materials for use in the construction industry, or as structural or packaging materials, made by producing shaped parts from moist, natural, fibre-containing or fibre-shaped material and a binder, which are mixed and compacted in a screw extruder having a shape-imparting nozzle attached, characterized in that:

a) at least one biopolymeric, natural material is used from at least one of the following groups: starches, dextrins, pectins, collagens, proteins or caseins,

b) the water content of the mixture, relative to the total mass, is adjusted to 6 - 25%,

c) through the effects of compaction and shear forces applied in the screw extruder, the pressure and temperature of the mixture is increased until the binder melts to form a molten gel mixture,

d) immediately after the molten gel mixture is formed, is decompressed in such a way that as to cause a spontaneous expansion of the finely dispersed moisture content thereof undergoes spontaneous expansion and turns whereby the moisture content is turned to steam, while a fibre and/or chip-based shaped part is formed which, compared to conventional shaped parts of similar type, has a lower overall density but a substantially denser surface than conventional shaped parts of similar type.

2. A process according to claim 1 characterized in that starch is used as the binder, and it is at least partially replaced by starch-containing plant parts taken from a least one of the groups of cereals, grains, and starch-containing roots, tubers and stems, either comminuted or in their natural state.

3. A process according to claims 1 or 2, characterized in that the fibre-containing or fibre-shaped material is selected from at least one of the groups of wood chips, plant fibres, cellulose materials, recycled cellulose materials, paper materials and recycled paper materials.

4. A process according to any one of claims 1 to 3, characterized in that the molten gel mixture is heated in the extruder to temperatures in excess of

100°C, by the action of the mechanical stresses, shear forces and increased pressure, and it is compressed to pressures of 15 to 600 bar.

5. The process of any one of claims 1 - 4, wherein the temperature is within the range of 125 to 250°C.

6. The process of claim 4 or claim 5, wherein the pressures are in the range of from 20 to 250 bar.

7. A process according to any one of claims 1 to 6, characterized in that as the molten gel forms in the extruder, the mixture is subjected to a specific mechanical energy input of 0.05 to 0.7 kWh/kg.

8. The process of claim 7, wherein the specific energy input is in the range of 0.1 to 0.3 kWh/kg.

9. A process according to any one of claims 1 to 8, characterized in that the molten gel mixture immediately emerging from the extruder undergoes spontaneous decompression while maintaining an expansion index of at least 1.1.

10. The process of claim 9, wherein the expansion index is within the range of 2 to 8.

11. A process according to any one of claims 1 to 10, characterized in that a mixture containing 5 to 85 wt.% biopolymeric binder relative to the dry extrusion mass, is subjected to extrusion and expansion.

12. The process of claim 11, wherein the mixture contains 10 to 50 wt.% biopolymeric binder relative to the dry extrusion mass.

13. A process according to any one of claims 1 to 12, characterized in that a mixture containing an addition of a liquid expansion agent, which is miscible with water and taken from either the alcohol group or the ketone group, which

boil in the range from 70 to 180°C under normal pressure, is subjected to extrusion and expansion.

14. A process according to any one of claims 1 to 13, characterized in that a mixture containing at least one hydrophobic agent modifying the starch material of the binder and selected from at least one of the groups of natural or synthetic oils, waxes, fats, resins, rubbers, paraffins, silicones and plastics, is subjected to extrusion and expansion.

15. A process according to any one of claims 1 to 14, characterized in that a mixture containing at least one at least bifunctional modifying agent capable of forming cross-linking bridges between molecules of the biopolymeric binder under the conditions of extrusion, the said modifier being chosen from at least one of the groups of short-chained di- or polycarboxylic acids, di- or poly(thi)ols and their derivates, molecules containing tertiary amino acid groups, and polyphosphoric acids is subjected to extrusion and expansion.

16. The process of claim 15, wherein the molecules of the biopolymeric binder are starch molecules.

17. A process according to any one of claims 1 to 16, characterized in that the surface of the extruded product made from the molten gel mixture is coated with a peripherally supplied coating mass before the product emerges from the extruder.

18. The process of claim 17, wherein the coating mass is resin or adhesive.

19. A process according to any one of claims 1 to 18, characterized in that the surface of the extruded product made from the molten gel mixture is coated immediately after it emerges from the extruder.

20. The process of claim 19, wherein the molten gel mixture is coated before the spontaneous expansion is completed.

21. A process according to any one of claims 1 to 20, characterized in that the extruded product formed in the extruder spontaneously starts to expand immediately after it merges from the extruder and this expansion is then limited in order to achieve the desired cross-sectional dimensions or profile section.

22. A process according to any one of claims 1 to 21, characterized in that as the extruded product undergoes spontaneous expansion, a surface coating is applied or bonded to the extruded product.

23. The process of claim 22, wherein the spontaneous expansion takes place while the expansion process is being limited.

24. The process of claim 22 or 23, wherein the surface coating is a coating foil.

25. A machine for implementing the process according to any one of claims 1 to 24, the said machine being fitted with devices for at least one of (a) comminuting, and/or (b) conditioning, and/or (c) pre-mixing the starting components and also with devices for feeding these components to an extruder having at least one shape-determining extrusion opening, characterized in that the screw extruder (2, 20), which is provided with devices (10, 11, 12) for supplying lump-shaped or small-particled starting components, is provided upstream of the extrusion nozzle (26, 260) with a processing zone (204) in which partial decompression, causing partial internal expansion, of the mixture being processed is carried out.

26. The process of claim 25, wherein the lump-shaped or small-particled starting components are solid components.

27. A machine for implementing the process according to any one of claims 1 to 24, characterized in that essentially immediately following the extrusion opening (26, 260), it is provided with a device (3, 30) for limiting the spontaneous expansion of the extruded product (4, 40) by means of roller and/or continuous belt elements (32, 33, 320, 330) which can be brought or adjusted to the respective speed of advance of the extruded product.

28. The machine of claim 25 or 26, characterized in that essentially immediately following the extrusion opening (26, 260), it is provided with a device (3, 30) for limiting the spontaneous expansion of the extruded product (4, 40) by means of roller and/or continuous belt elements (32, 33, 320, 330) which can be brought or adjusted to the respective speed of advance of the extruded product.

29. A machine according to any one of claims 25-28, characterized in that the roller elements (32, 33) of the dimension-limited device (3,30) are oriented essentially transverse to the direction of movement of the extruded product and are arranged or shaped according to the desired cross section or profile of the expanded, extruded product (4, 40), and the said rollers (32, 33) are provided with a non-stick, possibly structured surface and are provided with a non-stick, possibly structured surface and they may rotate freely in contact with, or they may be driven at a speed matched to the speed of advance of, the extruded product.

30. A machine according to any one of claims 25 to 29, characterized in that the elements (320, 330) of the dimension-limiting device (30) take the form of wall elements or endless belts (32, 330), with a non-stick, smooth or structured surface, running essentially in the direction of motion of the extruded product at essentially the speed of advance of the extruded product, and shaped or arranged according to the desired cross section or profile of the expanded, extruded product (40).

31. A device according to any one of claims 25 to 30, characterized in that it is provided with at least one device (5) for continuously feeding product-coating foils (50), at essentially the same rate of advance as the extruded product, into the gap between the surface of the product and the roller and/or belt elements (32, 33) of the dimension-limiting device (3).

32. A device according to any one of the claims 25, to 31, characterized in that the extruder (2) has several feed pipes (208) discharging close to the nozzle (26) into the exit area (205) of the extruder chamber, said pipes are

being distributed around the inner periphery of the chamber and they being arranged to supply surface-coating or gluing media under pressure.

33. The use of a shaped part produced from at least one moist, natural, fibre-containing material and at least one binder, and used to manufacture construction material, furniture material, structural material, insulating material or packaging material, characterized in that the shaped part is provided with an essentially dense surface and is formed from at least one melted gel mixture which undergoes spontaneous expansion immediately after being extruded and in which small particles of a fibre-containing and/or fibre-shaped biogenic, high-molecular material are distributed within an essentially structure-determining matrix containing a large number of small cavities, the said matrix being based on a melt of a binder formed with at least one biopolymeric natural substance taken from at least one of the groups of starches, dextrins, pectins, collagens, proteins or caseins, the said melt being hardened following the application of elevated temperature, elevated pressure and/or mechanical stress, and the percentage of the binder is 5 to 85 wt.% relative to the dry extrusion mass.

34. The use as recited in claim 33, wherein said percentage of the binder is 10 to 50 wt.%.

35. The use of a shaped part as described in claim 33 or 34, obtained by the process as outlined in one of claims 1 to 24.

36. The use of a shaped part as described in any one of claims 33 to 35, containing essentially discrete, small-dimensioned cavities and having a density lower than the overall density of the non-gaseous components of which it is made up, namely 0.05 to 1.0 $t/m^3$.

37. The use as recited in claim 36, wherein the density of said non-gaseous components is 0.1 to 0.4 $t/m^3$.

38. The use of a shaped part as described in any one of claims 33 to 37, provided with a coating bonded to the surface of the extruded, spontaneously expanded product.

39. The use of a shaped part pressed board having a thickness in the ranges 13-20-25-32-40-50 mm coupled with bending strength values of at least 14.5, 13.5, 13, 11, 9.5 and 7 N/mm$^2$, for the purpose of manufacturing construction material, furniture material, structural material, insulating material or packaging material.

40. The use of a wood chipboard or a laminated flat pressed board having a thickness in the ranges 13-20-25-32-40-50 mm coupled with bending strength values of a least 14.5, 13.5, 13, 11, 9.5 and 7 N/mm$^2$, for the purpose of manufacturing construction material, furniture material, structural material, insulating material or packaging material.

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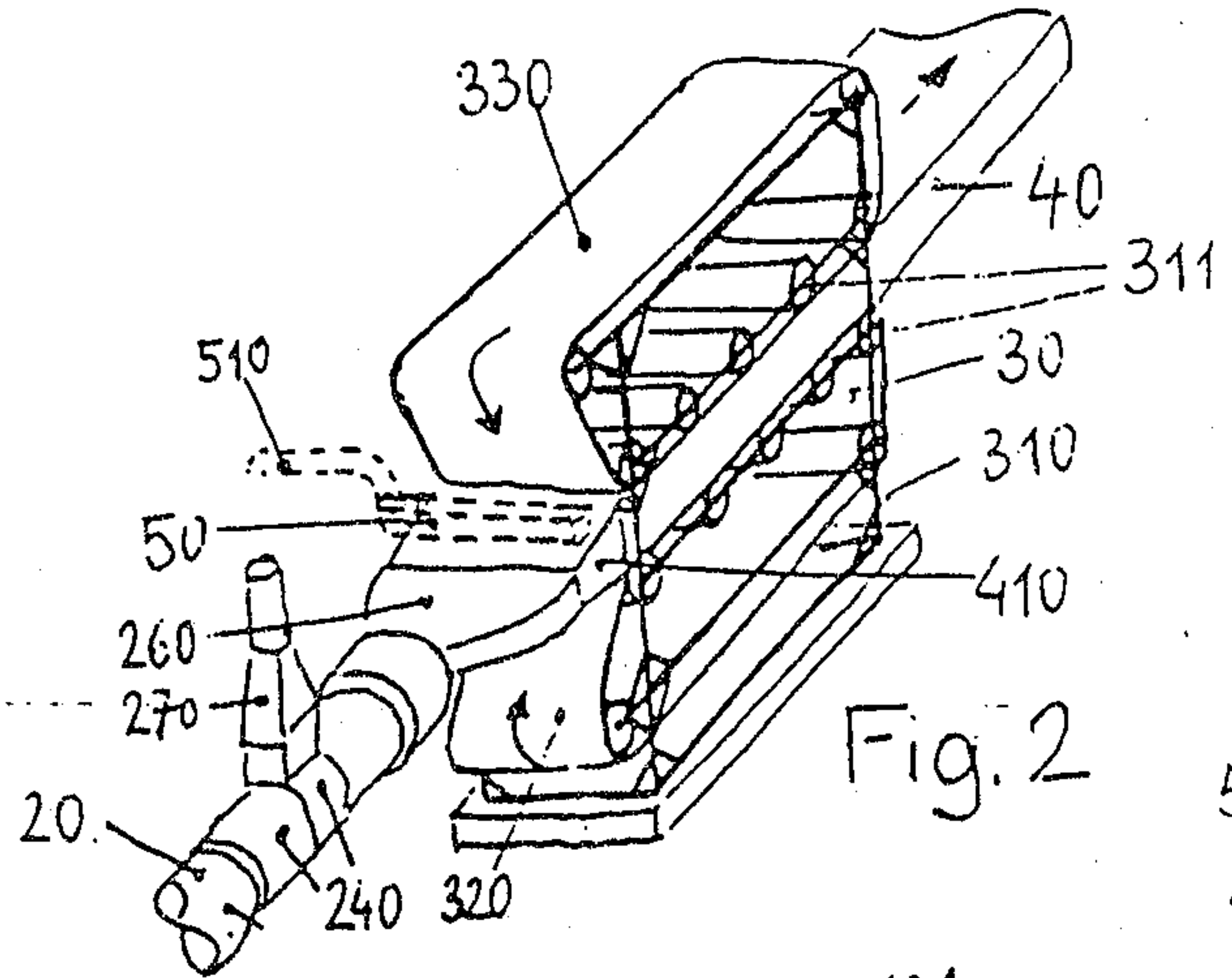


Fig. 2

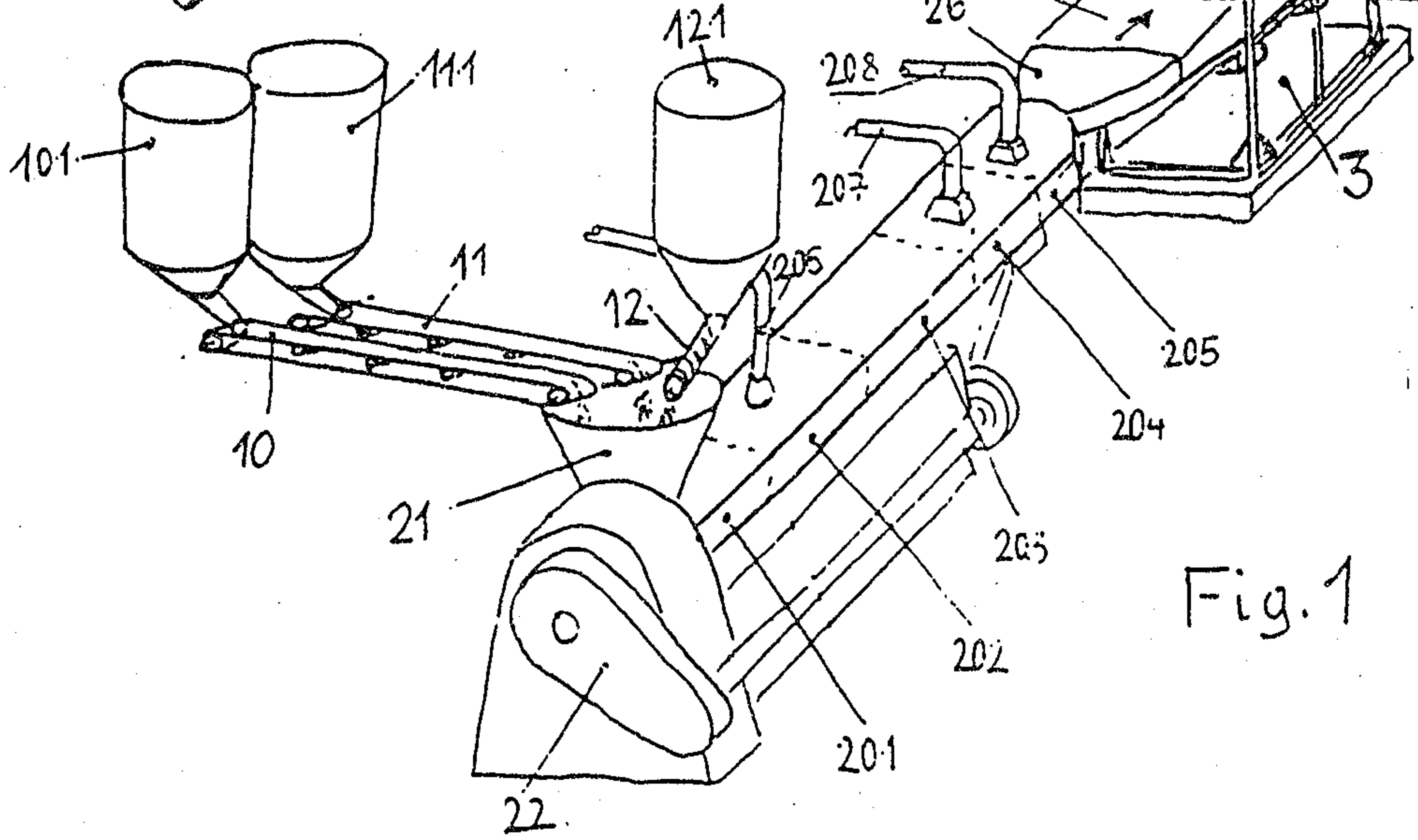


Fig. 1

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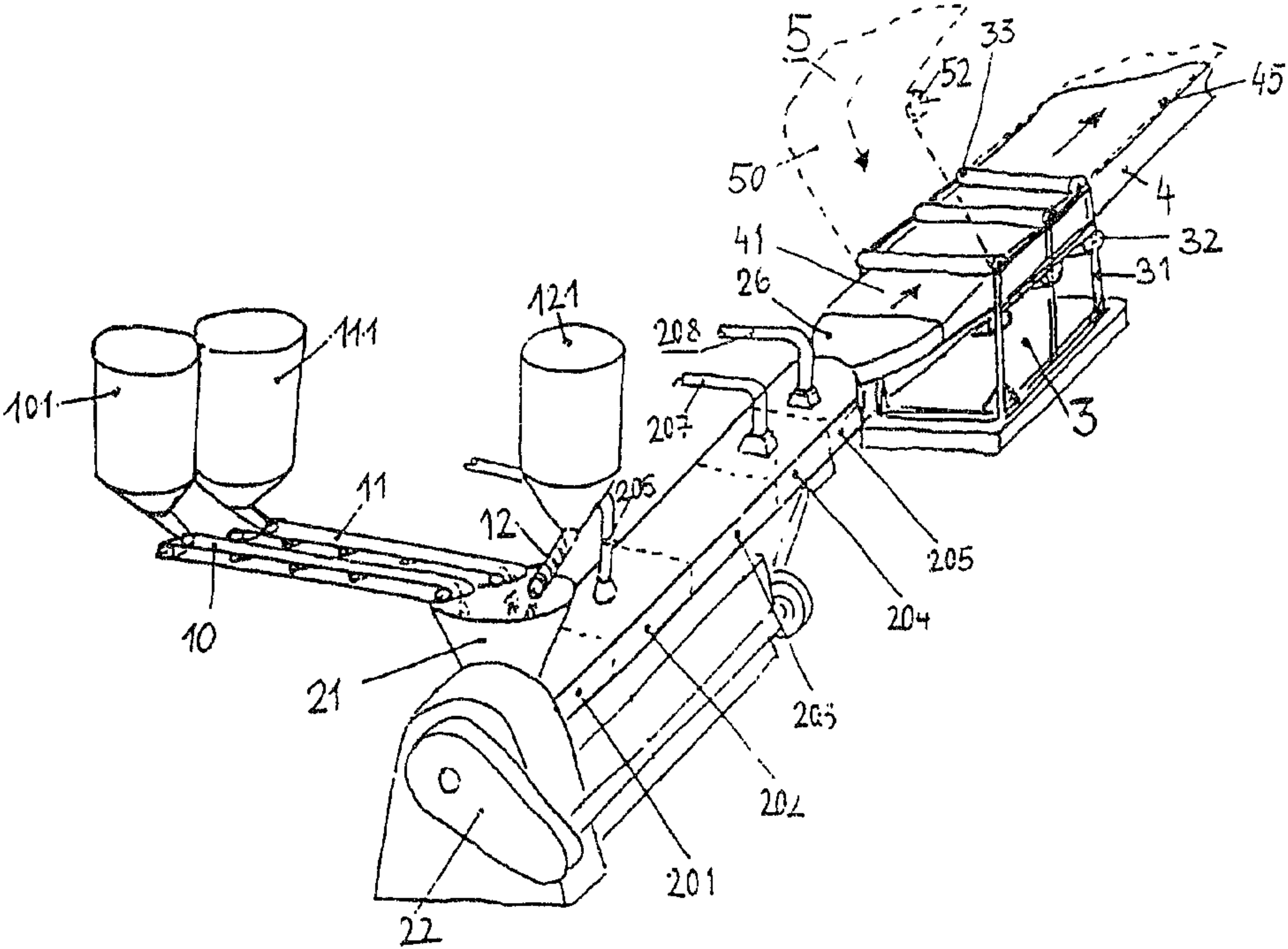

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