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NOTICE OF ENTITLEMENT

WE, EREMA ENGINEERING RECYCLING MASCHINEN UND ANLAGEN GESELLSCHAFT M.B.H. of Freindorf, Unterfeldstrasse 3, A-4052, Ansfelden, Austria, being the applicant in respect of the attached Application state the following:-

The inventors of the invention are as follows:

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HELMUTH SCHULZ of A-4490 St. Florian, Badstrasse 20, Austria and

GEORG WENDELIN of Waldbothenweg 84, A-4033, Linz, Austria.

The person nominated for the grant of the patent: EREMA ENGINEERING RECYCLING MASCHINEN UND ANLAGEN GESELLSCHAFT M.B.H.,

is the applicant of the application listed in the declaration under Article 8 of the PCT and has entitlement from the inventors by virtue of the fact that the inventors are managing partners of EREMA ENGINEERING RECYCLING MASCHINEN UND ANLAGEN GESELLSCHAFT M.B.H. and under an Agreement dated April 20 1983, which has been updated from time to time since, Patent Applications relating to inventions made by the inventors have to be filed in the name of EREMA ENGINEERING RECYCLING MASCHINEN UND ANLAGEN GESELLSCHAFT M.B.H., unless there is a decision to the contrary.

The basic application listed in the declaration made under Article 8 of the PCT is the first application made in a convention country in respect of the invention.

DATED THIS 14TH DAY OF SEPTEMBER 1994

EREMA ENGINEERING RECYCLING
MASCHINEN UND ANLAGEN GESELLSCHAFT M.B.H
By their Patent Attorneys
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- (57) Claim

1. Process for recycling of synthetic plastics material containing gas, in a plant in which the synthetic plastics material is molten, filtered, degassed, granulated and again mixed with a foaming agent, this again mixing with a foaming agent being performed in the same plant as the granulation, characterised in that the foaming agent is introduced again to that synthetic plastics material which was de-gassed and this before the granulation of the synthetic plastics material in such plasticised condition thereof which originates from the melting process and the degassing step, and that for homogenisation of the content the foaming agent volume introduced per time unit into the synthetic plastics material and the mixture volume processed per time unit by the mixer are controlled proportionally to the synthetic plastics material volume supplied per time unit to the foaming agent introduction.



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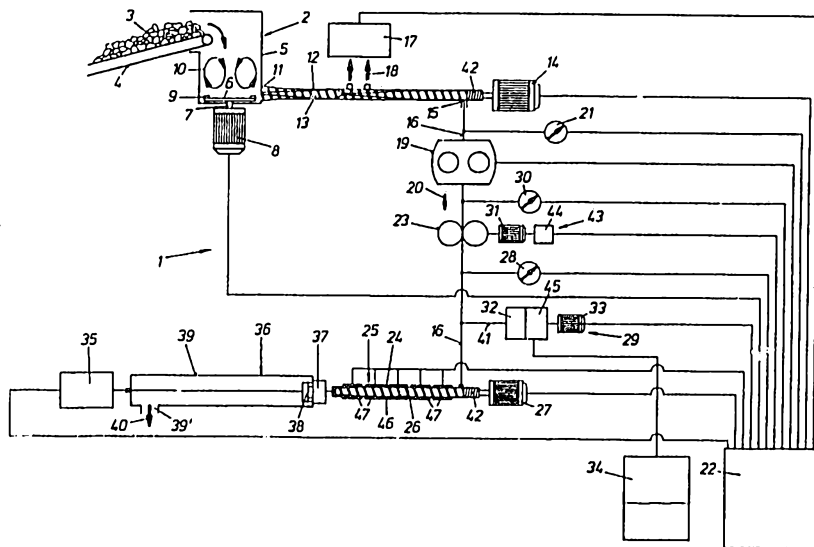
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(54) Title: PROCESS AND DEVICE FOR RECYCLING BLOWN PLASTICS

(54) Bezeichnung: VERFAHREN UND VORRICHTUNG ZUM RECYCLING VON BEGASTEM KUNSTSTOFFMATERI-
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(57) Abstract

In a process for recycling blown plastics, the plastic is first ground, melted, degassed and filtered. The degassed plastic is re-blown in the same plant before it has solidified, and, in order to make the degree of blowing uniform, the quantity of gas introduced into the plastic is controlled in relation to the quantity of plastic taken to the blowing plant per unit time and the pressure of the plastic taken to the blowing plant is preferably kept as constant as possible. The device for implementing said process has an extruder (12, 13) to plasticise and degas the plastic, the outlet (15) of which is connected via at least one line (16) to a mixer (25) to which a gas supply device (29) is also connected. In the line (16) there is a melt pump (23) for the plastic, the flow rate of which is used as a guiding factor for the gas supply which is provided via a device (29) which is controlled by a control device (22) in proportion to the running speed of the melt pump (23).

Process and apparatus for recycling of synthetic
plastics material containing gas

The invention relates to a process for recycling of synthetic plastics material containing gas, for example foamed polystyrene, in a plant in which synthetic plastics material is molten, filtered, degased, granulated and mixed with gas again, this gas re-introduction being performed in the same plant as the granulation. Further, the invention relates to an apparatus for performing such a process.

The usual process steps when re-introducing gas into foamed
10 synthetic plastics material, in particular polystyrene, consist in that the synthetic plastics material is comminuted in a tearing and densifying apparatus and is then plasticized in an extruder and de-gased. The so produced plasticized, de-gased synthetic plastics material is worked up to granules in a granulating apparatus and is solidified thereby. The granulate forms a pourable homogeneous, de-gased mass which then is introduced again into an extruder and is molten therein. During the extrusion which can be performed by means of extruders comprising one or more extruder screws, a gas is fed in a controlled manner to the extruder which gas is introduced within the extruder into the synthetic plastics
20 melt and is homogenized therewith, considering the necessary holding time in the extruder. When doing this, the use of a ~~porous~~ ^{pourable} homogeneous granulate is compulsory necessary because only in such a manner a continuous flow of the melt in the extruder and therefore a continuous filling degree of the foaming gas in the melt can be ensured.

A similar process has become known from the document "Plastverarbeiter", volume 42, 1991, number 6, pages 124, 125. This document suggests to mill packages of polystyrene and subsequently to heat this



material in a roller extruder so that the material is de-gased and plasticized. The thus obtained solidified final product, namely cristallized polystyrene, is then foamed again in an extruder.

These known processes have the disadvantage that two melting steps are necessary which, as a rule, have to be carried out at different places, because the homogeneous introduction of the gas is a critical thing and, therefore, cannot be made everywhere. Therefore, as a rule, the synthetic plastics material to be recycled is granulated there where an apparatus for comminuting and densifying the material is at disposal. The granulate is then sent to a plant where the material is provided with a gas content again. This involves costs for transport and transformation which lead to a high price of the recycled and gas-containing material so that the thus obtained recycling product can hardly be sold. The consequence is an environmental load by foamed synthetic plastics material scrap or by improperly processed synthetic plastics material. In this connection it is of detrimental influence that in the past frequently such gases have been used as foaming gases (for example fluorocarbons) which are critical for environmental reasons and, therefore, should not get into the atmosphere.

It is also known to melt and de-gas scraps of foamed thermoplastic synthetic plastics material in an extruder comprising several worms. In parallel to this extruder a further extruder is provided in which thermoplastic particles, hence new material, are molten and mixed with gas. The outlets of the two extruders are combined to a mixing and cooling station to which a further extruder as well as a mould are connected, in which the material is foamed. Finally, the foamed material is cut to the desired shape or is granulated. For performing this process, a considerable effort in apparatus and space is required and the



above described disadvantages can not fully be avoided by this process, because the granulate of new material must at first be produced and then be stored so that the enthalpy is lost which was in the new material until its granulation.

The invention has ^{as} ~~as~~ its object to improve a process of the last described kind so that the recycling process of the gas-containing synthetic plastics material can be effected quicker, simpler and requiring considerably less effort in apparatus and space and without environmental load and without the use of new material. The invention solves this task in
10 that the gas is fed to that synthetic plastics material which was de-gased and this before its granulation in such plasticized condition of the synthetic plastics material which originates from the melting process and the degasing step, and that for homogenisation of the gas content the gas volume introduced per time unit into the synthetic plastics material and the mixture volume processed per time unit by the mixer are controlled proportionally to the synthetic plastics material volume supplied per time unit to the gas-introduction step. For performing the inventive process, therefore, only one single plant is required and comminuting, plasticising, filtering, re-gasing and solidifying of the processed synthetic plastics
20 material can be effected at the same place and, therefore, avoiding transport costs. Within this, the known tearing and comminuting apparatus can be used, which must only be provided with a device for the introduction of the gas and with a device for the subsequent mixing and solidifying, in order to be able to perform the inventive process. The plant expenses required for this are comparatively low and amortize already within a short time by the saved transport costs and charge fees for the extraneous device for re-introduction of the gas. The quality of the obtained final product is good, also with respect to homogeneity of the foaming gas content, what



is obtained by the inventive control of the gas introduction in dependence from the amount of flow of the synthetic plastics material supplied to the gas introduction step. A further advantage of the inventive process consists in that the processed synthetic plastics material must be molten one single time only so that the second melting process required hereuntofore can be saved. This means also, that the synthetic plastics material is treated more gently because each melting process is combined with the danger of a reduction of the molecule chain length of the synthetic plastics material. Further, when performing the inventive process, the synthetic plastics material must be solidified one single time only, and this - in contradiction to the initially described known processes - after introduction of the gas only.

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In contradiction to the last described known process, within the inventive process only such synthetic plastics material is processed which was subjected to the recycling process. Therefore, the use of new material and therefore the expenses for material, transport, storage and melting connected therewith can be saved. Further, the inventive process requires substantially less effort in apparatus, when compared with the known processes.

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The invention considers also that the synthetic plastics material subjected to the recycling process is not always of the same quality, in particular with respect to the specific weight or, respectively, to the foaming degree. The invention considers that, when material of lower weight (higher foaming degree) is processed, the output of the apparatus used for the melting process will decrease. As a consequence thereof, the synthetic plastics material amount supplied per time unit to the gas introduction step, decreases. If this volume measured per time unit

is used in the sense of the invention as the command variable for the gas amount used per time unit for being added to the synthetic plastics material, the gas content for the final recycling product remains at least substantially constant ^{with} what is desired with respect to the further processing of this final product. The homogeneity of this final product is also enhanced by the proportional readjustment of the mixture amount worked up per time unit by the mixer, in dependence from the mentioned command variable, because undermixing as well as overmixing are avoided and thus the cell structure of the regenerate obtained as the final product is kept at least substantially constant.

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Since as a rule it is desired to operate the plant with an output as high as possible or, respectively, as far as possible to fully utilize the capacity of the present plant, according to a preferred embodiment of the inventive process, the volume of the synthetic plastics material supplied per time unit to the gas introduction step is kept within a predetermined interval, preferably near the maximum capacity of the plant used. This can easily be obtained by operating the plant elements used for plasticizing and de-gasing of the supplied synthetic plastics material quicker or, respectively, with an increased output.

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As a rule, a pump for the synthetic plastics material flow supplied to the gas introduction step is inserted between those plant elements that serve for plasticizing the supplied synthetic plastics material, and those plant elements that serve for ~~again introduction~~ ^{the re-introduction} of the gas. According to a preferred embodiment of the inventive process, the supplied synthetic plastics material is comminuted and then is plasticized and de-gased by means of a screw, that the so obtained de-gased melt is supplied by means of a melt pump, preferably a gear pump, to a mixer to which also the gas



used is supplied, and that the synthetic plastics material amount delivered per time unit by the melt pump is measured and is used as the command variable for the gas supply, and that the pressure of the synthetic plastics material on the suction side of the melt pump is measured and is kept by varying the speed of the melt pump and/or the speed of the worm within a predetermined interval, preferably at a value that is as constant as possible. Therefore, the melt pressure before the melt pump is kept almost constant by adjusting the delivery of the plasticizing screw or the melt pump, and by proportional readjustment of the gas supply in dependence on the delivery per time unit of the melt pump used as the command variable, the desired constant gas content in the final product produced by the mixer is obtained. Keeping the pressure of the material supplied to the melt pump within a predetermined interval ensures that the melt pump does not make idle strokes, and that therefore the volume delivered is exactly proportional to the run of the melt pump, in particular to the speed of the gear pump. Further, in such a manner the plant can easily be operated near its maximum capacity.

Within the spirit of the invention, it is particularly favourable to add the gas to the flow of the synthetic plastics material already before its introduction into the mixer, in order to obtain a certain mixture between the synthetic plastics material and the foaming gas already before the synthetic plastics material or, respectively, the gas enters the mixer.

For a uniform absorption of the gas, the melt pressure behind the melt pump is of importance. According to a further embodiment of the invention, therefore, the process is conducted so that when the pressure of the synthetic plastics material melt supplied by the melt pump deviates from a predetermined desired value, the viscosity of the mixture prepared by the

mixer is correspondingly changed by cooling and/or heating, preferably until the desired value is reached.

As a rule, pentane is used for the gas that is again introduced. In order to avoid an explosion in the plant section behind the degasing step, within the spirit of the invention the vacuum is controlled that is used for degasing the synthetic plastics material.

The inventive apparatus for performing the inventive process starts from a plant having a comminuting means for the synthetic plastics material to be processed, to which means a motor-driven screw
10 for plasticizing this material is connected, a de-gasing means for the synthetic plastics material being related to that screw. Starting therefrom, the inventive apparatus is characterized in that the outlet of the screw is connected by means of at least one line to a mixer to which also a device for supplying gas is connected, and that to at least one of these lines a device for measuring the synthetic plastics material amount flowing per time unit in this line is connected, which device is connected to a control unit for the gas supply to the mixer and for the speed of the motor of the screw. In such a manner the inventive process can be
20 performed with low constructional effort. Since, however, the pressure in the outlet of the screw and, therefore, in the line leading to the mixer alone will frequently not be sufficiently high in order to reliably supply the plasticized synthetic plastics material into the mixer, according to a preferred embodiment of the inventive apparatus, a melt pump, in particular a gear pump, for supplying the synthetic plastics material melt is inserted into the line leading from the screw to the mixer, a measuring device for the speed of this melt pump being provided, noting that to this line a pressure sensor for the pressure at

the suction side of this melt pump is connected, which pressure sensor, as well as the measuring device, are connected to the control unit. The, suitably electronic, control unit calculates the measuring results obtained from the pressure sensor and from the measuring device and controls in correspondence to these measuring results the gas supply to the synthetic plastics material melt in such a manner that the gas content thereof is kept at least substantially constant so that a homogeneous final product is obtained.

10 Further characteristics and advantages of the present invention can be seen from the description of two embodiments of the inventive apparatus which are schematically shown in the drawings.

According to the embodiment of Fig.1 the plant 1 for carrying out the process has a comminuting apparatus 2 formed by a tearing and condensing machine, to which the synthetic plastics material 3 to be recycled, in particular foamed polystyrene, for example STYROPOR (registered trademark) is supplied by means of a conveyor 4. The synthetic plastics material 3 falls from above into a receptacle 5 of the comminuting ~~means~~ ^{apparatus 2} 4 and a tool 6 for comminuting and/or mixing of the synthetic plastics material 3 rotates in the bottom region of the comminuting apparatus ² 4 around a vertical axis 7, the tool 6 being driven by a motor 8. The tool 6 is provided with knives 9 acting on the synthetic plastics material 3, which knives comminute and mix the material 3 which rotates in the receptacle 5 in form of a mixing thrombe 10. An outlet opening 11 is disposed in the sidewall of the receptacle ⁵ at the level of the tool 6, to which opening the housing 12 of a screw 13 is connected in radial direction. The screw is driven for rotation by a motor 14 disposed at that end of the screw which does not face the

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receptacle 5. By means of the screw 13 the synthetic plastics material supplied from the receptacle 5 is plasticized and is pressed in plasticized or molten condition at the outlet 15 of the housing 12 into a line 16. The housing 12 is further provided with lateral openings through which gases carried along by the melt conveyed by the worm 13 can escape into a degasing device 17 via one or more lines 18. Suitably, these gases are collected, cleaned (if necessary) and supplied to a recycling process.

At least one filter means 19 is inserted into the line 16 by which filter the synthetic plastics material melt is freed from impurities carried along. In front of the filter 19, when seen in flowing direction of the synthetic plastics material melt (arrow 20), a pressure sensor 21 is connected to the line 16, which sensor is also connected to a control unit 22 by which the entire plant 1 is monitored and is controlled in the sense of an optimal operation condition. To this control unit 22 also the motor 14 is connected. A melt pump 23 formed by a gear pump is inserted into the line 16 behind the filter 19, which pump is driven by a motor 31 and supplies the synthetic plastics material through the line 16 into the housing 24 of a mixer 25 which may be formed by a static or dynamic mixer. The embodiment illustrated shows a dynamic mixer which comprises a mixing element, for example a mixing worm 26 bearingly supported for rotation within a housing 24 and driven for rotation by a motor 27. Instead of such a dynamic mixer also a static mixer can be used which comprises baffels in the housing 24 by which the supplied synthetic plastics material is mixed. In the mixer 25 also the gas is introduced again into the synthetic plastics material or is worked up into this plasticized or melt-like synthetic plastics material, which constitutes an intermediate product only and is directly supplied by the pump 23 to the mixer 25 without

adding any gas-containing synthetic plastics material or new synthetic plastics material. For this, a further pressure sensor 28 and a means 29 for the addition of gas to the synthetic plastics material melt are connected to the line 16 between the melt pump 23 and the mixer 25. A further pressure sensor 30 is connected to the line 16 between the filter 19 and the pump 23. The means 29 for supplying gas has a proportioning device 32 comprising a pump for the propelling gas to be added to the synthetic plastics material melt, which proportioning device 32 is driven by a motor 33 and is supplied with a foam producing ^{foaming agents} gas, for example pentane which is liquid at atmospheric pressure, from a foaming gas source 34. All these motors 14, 27, 31, 33 as well as the pressure sensors 21, 28, 30 and the filter 19 are connected to the control unit 22. Further, a motor 35 for a granulating means 36 is connected to this control unit 22, to which granulating means the synthetic plastics material to be granulated is supplied from the mixer 25 via an extruder head 37. Before the extruder head 37 rotates at least one knife 38 driven by a motor 35 and the cut-off synthetic plastics material particles gather within a granulator housing 39 where they are cooled and conveyed off through an outlet 39' in direction of the arrow 40.

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The synthetic plastics material to be provided with gas again is supplied exclusively from the extruder formed by the housing 12 and the screw 13, however, of course a plurality of such extruders may in common be connected to the line 16. Therefore, no addition of new material takes place to that synthetic plastics material which is conveyed by the screw 13 into the line 16, unless new material together with other synthetic plastics material is conveyed by the conveyor 4 into the comminuting means 2. The latter may be the case if scraps obtained from

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the production of new foamed synthetic plastics material are processed, for example rests of foamed synthetic plastics material blocks or the like.

The entire plant 1 is controlled by the control means 22 so that the filling degree of the foaming gas in the synthetic plastics material granulate that is conveyed off through the outlet 39' remains at least substantially constant, even if the quality of the synthetic plastics material 3 supplied by the conveyor 4 changes. For this, the plant comprises a device 43 for measuring the synthetic plastics material amount flowing per time unit in the line 16, which device 43 is connected to the control unit 22. Since the pressure sensor 30 and the control unit 22 ensure that the pressure of the synthetic plastics material supplied to the gear pump 23 via the line 16 is kept within a predetermined pressure interval so that the gear pump 23 is always completely filled, however also an unstable compression of the synthetic plastics material is avoided, the synthetic plastics material mass conveyed by the gear pump 23 is proportional to the speed of revolution of the gear pump 23. In the simplest case, this speed can be measured by means of a revolution counter 44 forming the means 43 and can be transmitted to the control means 22. In order to consider also changes of the quality of the synthetic plastics material supplied to the entire plant 1, the pressure sensor 30 is provided which senses the pressure in front of the gear pump 23. Thus, if for example the screw 13 forming an extruder takes up synthetic plastics material 3 of lower weight (material having a higher foaming degree), the synthetic plastics material mass delivered per time unit through the outlet 15 into the line 16 decreases. As a consequence, also the pressure in front of the gear pump 23 will decrease what is

transmitted to the control unit 22 by the pressure sensor 30. The control unit causes that the screw 13 is driven quicker by the motor 14 and/or that the melt pump 23 is driven by the motor 31 with a reduced speed. If the speed of the gear pump 23 is changed, the revolution counter 44 of the means 43 causes the control unit 22 at the same time to proportionally adjust a gas pump 45 provided in the dosing device 32. In order to keep the pressure in front of the gear pump 23 sensed by the pressure sensor 30 - as mentioned above - within a predetermined interval so that it is avoided that the spacewidths of the gear pump 23 are not completely filled with synthetic plastics material or that the synthetic plastics material is additionally compressed by the melt pump 23, mainly the operational speed of the plasticizing screw 13 is correspondingly controlled via the control unit 22 by controlling the speed of the motor 14. In addition thereto - in particular if the mentioned speed control of the motor 14 should not be sufficient - also the speed of the motor 31 of the gear pump may be controlled correspondingly by the control unit 22. This causes that the flow delivered per time unit by the gear pump 23 is changed what is transmitted via the revolution counter 44 to the control unit 22 which causes a corresponding proportional control of the gas dosing in the device 29, for example in a simple manner by controlling the operational speed of the gas pump 45 by means of the motor 33. Further, the delivery pressure of the gear pump 23 is measured by the pressure sensor 28 connected to the line 16 behind the gear pump 23. Since this pressure is of importance for the gas take up of the melt, the control unit 22 keeps this pressure as constant as possible. For this, at first the motor 27 of the mixer is so influenced by the control unit 22 that the mixer 25 takes up just that volume of the synthetic plastics

material-gas-mixture that is supplied to it from the gear pump 23 or, respectively, from the gas pump 45. In addition thereto, the resistance in the mixer 25 may be influenced by changing the viscosity of the synthetic plastics material within the mixer 25. For this, a plurality of heating zones or, respectively, cooling zones 47 are disposed on the periphery of the housing 46 of the mixer 25, which zones together build up a heating- and cooling-cascade control and may be switched in individually or in any desired combination by the control unit 22 in dependence of the constant pressure in that section of the line 16 that is disposed behind the gear
10 pump 23, which pressure serves as a command variable.

As it is shown in the drawing, the line 41 via which the foaming gas is added to the melt, ends into the line 16 so that in that section of the line 16 ~~so that in that section of the line 16~~ that is disposed between the line 41 and the mixer 25, already a pre-mixing of the synthetic plastics material and the foaming gas takes place. However, the line 41 may also be connected directly to the housing of the mixer 25. Suitably, a non-return valve (not shown) is inserted into the line 41.

As it is further shown in the drawing, the two screws 13, 26 are provided on their ends facing the motors 14, 27 with volutions 42
20 conveying in inverse direction, so that a sealing for the driving shafts driven by the motors 14, 27 is formed.

The pressure sensor 21 serves for sensing the pressure of the synthetic plastics material melt directly at the outlet 15 and in front of the filter 19. Thereby, soiling of the filter 19 can be monitored and a screen exchange or screen backwashing step can be initiated in time, if the pressure in the line 16 in front of the filter 19 exceeds a predetermined value. These steps are also initiated by the control unit



22. Suitable filter means 19 which enable one to change a screen or to clean a screen, for example by backwashing, without substantial impairment of the synthetic plastics material pressure in the line 16 behind the filter 19, are known.

Of course it is also possible to connect more than one comminuting means 2 and extruders 12, 13 connected thereto by a plurality of lines 16 to a common mixer 25. In an analogous manner it would also be possible to connect one single extruder 12, 13 by means of a plurality of parallel lines 16 to the mixer 25.

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It would also be possible to introduce the plasticized synthetic plastics material via the line 16 directly into the mixer 25, thus without that this material is conveyed by a melt pump 23. This, however, requires that the flow of the synthetic plastics material 16 in this line can be monitored in a suitable manner, for example by means of a usual flow meter. By the said reasons also the pressure in the line 16 must be monitored. Control of the gas supply or of the speed of the worm 13 or of the speed of the mixer 25 is done by the control unit 22 in an analogous manner to that described above.

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Within the embodiment according to Fig.2, a vacuum control means 48 is connected to the housing 12 of the worm 13, said means 48 transmits the measured vacuum to the control unit 22. Thereby the function of the degasing device 17 is monitored so that any danger of explosion of the pentane used for the gas addition is avoided. Further, the granulating device 36 is not directly connected to the granulating head 37 or its nozzle ~~44~~⁴⁹, but by intermediary insertion of a flow cooling device 50, in which the nozzle 49 is disposed. The synthetic plastics material cord produced by it is conveyed within a cooling



bath in the cooling device 50 and enters the granulating device 36 only after having passed the flow cooling device 50, and in the granulating device 36 there are disposed rotating knives which cut the granulate particles in a wellknown manner from the synthetic plastics material cord. The granulate leaves the granulating device 36 through the outlet 39' in direction of the arrow 40. Also the conditions within the flow cooling device 50 may be influenced by the control unit 22 in any desired manner.

The claims defining the invention are as follows:

1. Process for recycling of synthetic plastics material containing gas, in a plant in which the synthetic plastics material is molten, filtered, degassed, granulated and again mixed with a foaming agent, this again mixing with a foaming agent being performed in the same plant as the granulation, characterised in that the foaming agent is introduced again to that synthetic plastics material which was de-gassed and this before the granulation of the synthetic plastics material in such plasticised condition thereof which originates from the melting process and the degassing step, and that for homogenisation of the content the foaming agent volume introduced per time unit into the synthetic plastics material and the mixture volume processed per time unit by the mixer are controlled proportionally to the synthetic plastics material volume supplied per time unit to the foaming agent introduction.
2. Process according to claim 1, characterised in that the volume of the synthetic plastics material supplied per time unit to the foaming agent introduction is kept within a predetermined interval, preferably near the maximum capacity of the plant used.
3. Process according to claims 1 or 2, characterised in that the synthetic plastics material to be recycled is comminuted and then is plasticised and de-gassed by means of a screw, that the so obtained de-gassed melt is supplied by means of a melt pump, preferably a gear pump, to a mixer, to which also the foaming agent to be added is supplied, and that the synthetic plastics material amount delivered per time unit by the melt pump is measured and is used as the command variable for the foaming agent supply, and that the pressure of the synthetic plastics material on the suction side of the melt pump is measured and is kept by varying the speed of the melt pump and/or the speed of the screw within a predetermined interval, preferably at a value that is as constant as possible.



4. Process according to claim 3, characterised in that the foaming agent is added to the flow of the synthetic plastics material already before its introduction into the mixer.

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5. Process according to claims 3 or 4, characterised in that if the pressure of the synthetic plastics material melt delivered by the melt pump deviates from a predetermined desired value, the viscosity of the mixture worked up by the mixer is correspondingly varied by cooling and/or heating, preferably until this desired value is reached.

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6. Process according to any of the claims 1 to 5, characterised in that the vacuum used for de-gassing the synthetic plastics material is controlled.

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7. Process according to any one of claims 1 to 6 wherein the recycled synthetic plastics material is foamed polystyrene.

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8. Apparatus including a comminuting means for the synthetic plastics material to be processed, to which comminuting means a screw driven by a motor for plasticising this material is connected, a de-gassing device for the synthetic plastics material being related to said screw, characterised in that the outlet of the screw only is connected by at least one line to a mixer to which also a device for supplying a foaming agent is connected, and that to at least one of these lines a device for measuring the synthetic plastics material amount flowing per time unit in this line is connected, which measuring device is connected with a control unit for the foaming agent supply to the mixer and for the speed of the motor of the screw.

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9. Apparatus according to claim 8, characterised in that a melt pump, in particular a gear pump, for supplying synthetic plastics material which is inserted into the line leading from the screw to the mixer, a measuring device, for the speed of the melt pump being



provided, and that to this line a pressure sensor for measuring the pressure on the suction side of this melt pump is connected, and that this pressure sensor and the measuring device, are connected to the control unit.

10. Apparatus according to claim 9, wherein the measuring device is a revolution speed meter.

10 11. Apparatus according to claims 8, 9 or 10, characterised in that the device for the foaming agent supply is connected by means of a line to the line supplying the synthetic plastics material to the mixer.

15 12. Apparatus according to claims 9, 10 or 11, characterised in that a filter for the synthetic plastics material is inserted before the melt pump.

13. Apparatus according to claim 10, characterised in that a further pressure sensor is connected in front of the filter to the line supplying the synthetic plastics material to the melt pump, which pressure sensor is also connected to the control unit.

20

14. Apparatus according to any of claims 10 to 13, characterised in that also a pressure sensor for the pressure of the synthetic plastics material supplied from the melt pump to the mixer is connected to the line, which said pressure sensor further being connected to the control unit.

25

15. Apparatus according to claim 14, characterised in that the mixer is provided with, preferably a plurality of, heating or cooling zones connected to the control unit.

16. Apparatus according to any of claims 9 to 15, characterised in that the screw is



disposed within a housing and a vacuum control device is connected to this housing in the region of the de-gassing device.

5

17. A process for recycling synthetic plastics material which contains gas comprising the steps of:

- (a) plasticising the synthetic plastics material;
- 10 (b) de-gassing the synthetic plastics material;
- (c) introducing a foaming agent into the plasticised synthetic plastics material to produce a mixture thereof;
- (d) controlling the volume of the foaming agent introduced per time unit into the synthetic plastics material and the volume of said mixture processed per time
15 unit so that these volumes are maintained at a predetermined proportion for homogenising the foaming agent content in the mixture; and
- (e) granulating the mixture containing the foaming agent.

18. A process for recycling synthetic plastics material containing gas substantially as
20 hereinbefore described with reference to any one of the accompanying drawings.

19. An apparatus substantially as hereinbefore described with reference to any one of the accompanying drawings.

DATED THIS 19TH DAY OF FEBRUARY 1996.

EREMA ENGINEERING RECYCLING MASCHINEN
UND ANLAGEN GESELLSCHAFT m.b.H.

By their Patent Attorneys
KELVIN LORD AND COMPANY
PERTH, WESTERN AUSTRALIA

Kelvin Lord



A b s t r a c t

In a process for recycling of gas-containing synthetic plastics material, this material at first is comminuted, molten, degased and filtered. The degased synthetic plastics material is supplied in the same plant and already before its solidification to an again gas introduction, and in order to homogenize the gas content, the gas amount introduced into the synthetic plastics material per time unit is controlled in dependence from the synthetic plastics material amount supplied per time unit to the gas introduction, and preferably the pressure of the synthetic plastics material to which gas is to be added, is kept almost constant.

The apparatus suitable for performing this process comprises an extruder (12,13) for plasticizing and degasing the synthetic plastics material, the outlet (15) thereof is connected by means of at least one line (16) to a mixer (25), to which also a device (29) for supplying gas is connected. A melt pump (23) for the synthetic plastics material is inserted into the line (16) and the amount of melt delivered by this pump is used as a command variable for the gas supply, for which a device (29) is provided that is controlled by a control unit (22) proportional to the speed of the melt pump (23) (Fig.1).

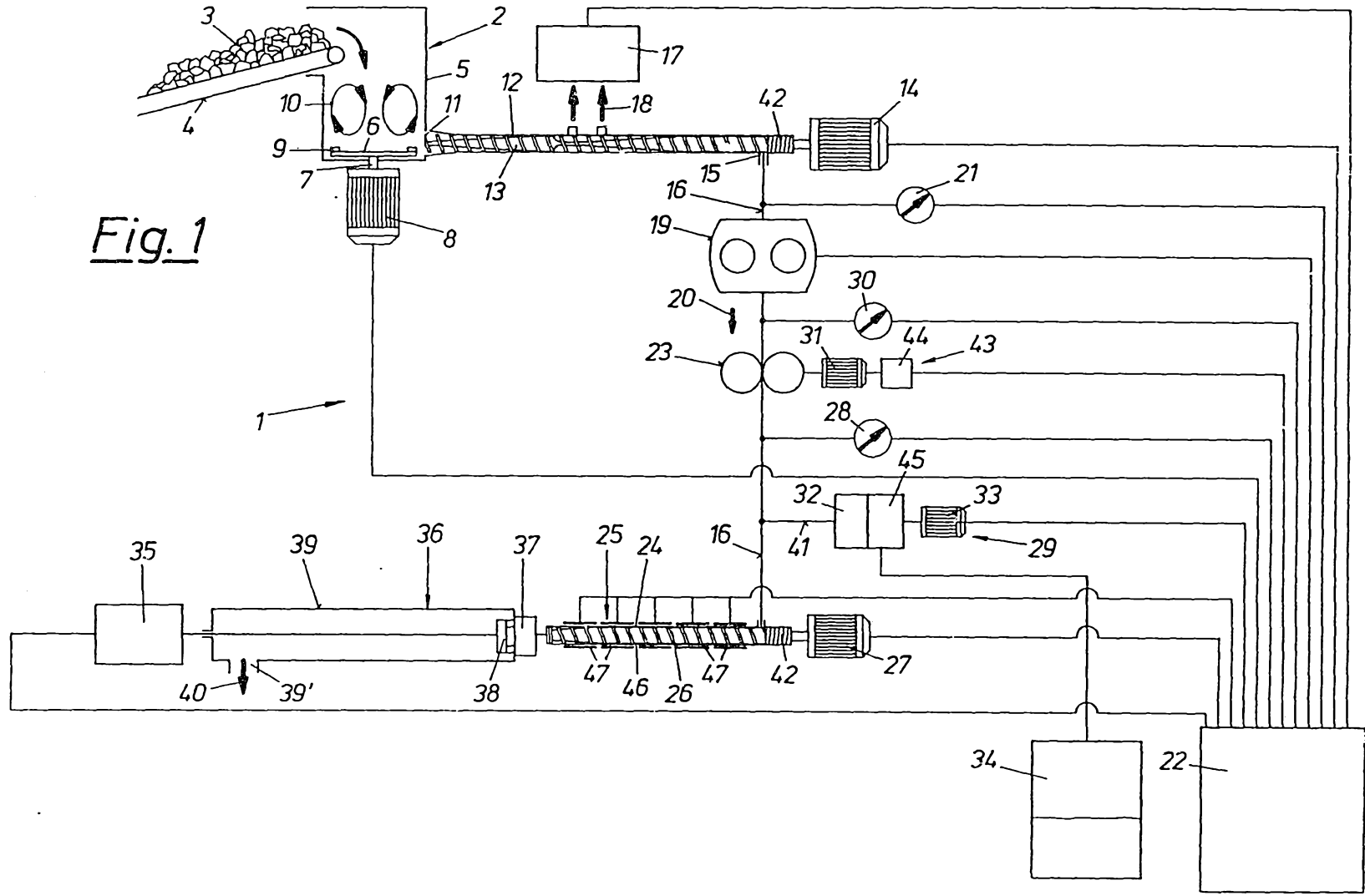


Fig. 1

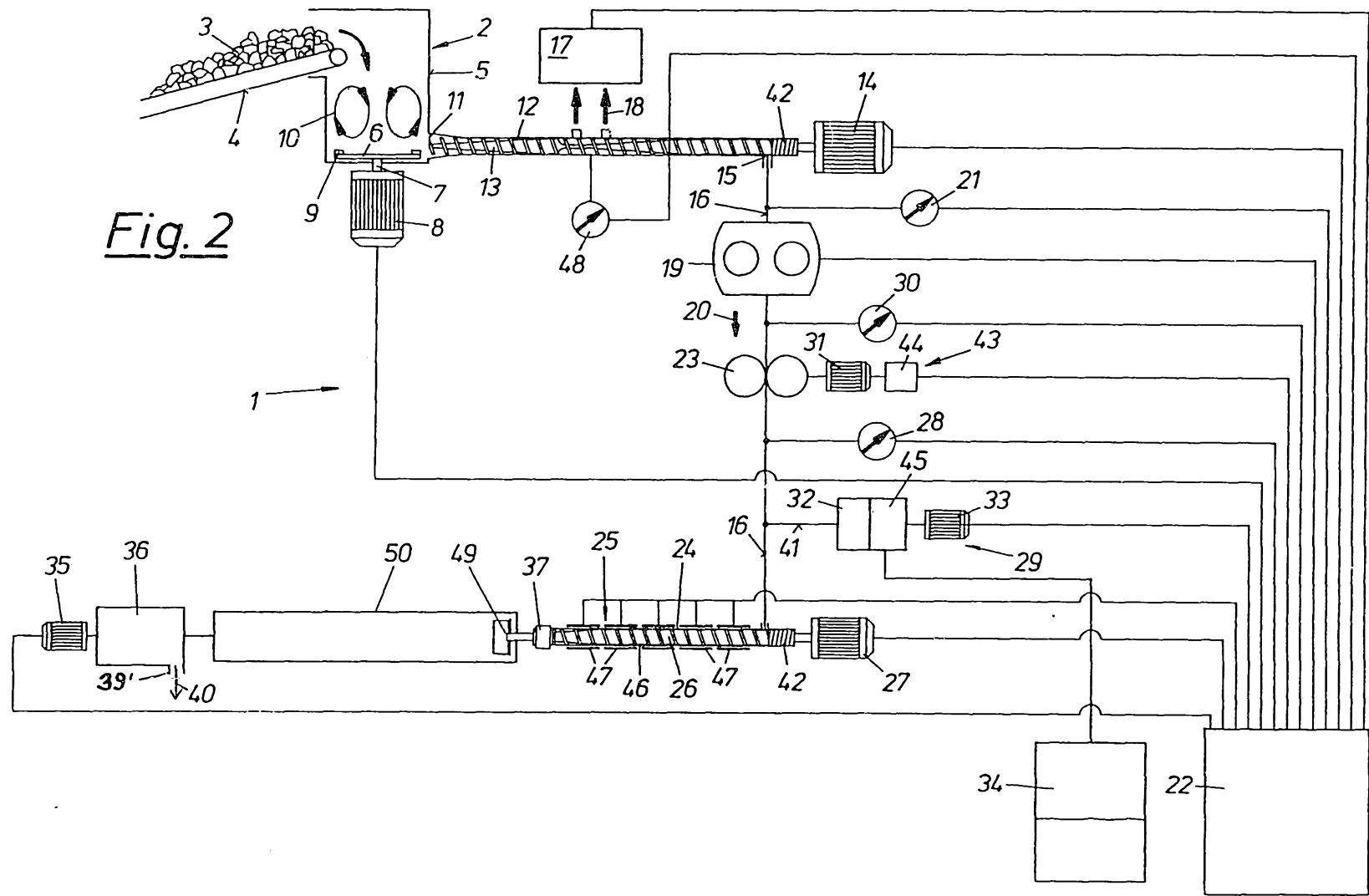


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AT 93/00073

<p>A. CLASSIFICATION OF SUBJECT MATTER</p> <p>Int.Cl.5 B29B17/00; C08J11/02; //B29K25:00</p> <p>According to International Patent Classification (IPC) or to both national classification and IPC</p>																							
<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols)</p> <p>Int.Cl.5 B29B; C08J</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)</p>																							
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>PLASTVERARBEITER Vol. 42, No. 6, June 1991, SPEYER AM RHEIN pages 124 - 125, XP000233431 "VERWERTUNGSMÖGLICHKEIT FÜR GEBRAUCHTE EPS- VERPACKUNGEN" see page 125, column 2, line 20 - line 42</td> <td>1</td> </tr> <tr> <td>A</td> <td>---</td> <td>2-5,7-13</td> </tr> <tr> <td>A</td> <td>PLASTVERARBEITER Vol. 42, No. 6, June 1991, SPEYER AM RHEIN page 141 "EPS-Recyclingverfahren" ---</td> <td>1-5,7-13</td> </tr> <tr> <td>A</td> <td>TECHNISCHE RUNDSCHAU Vol. 83, No. 29, 19 July 1991, BERN CH page 52, XP000240484 "EPS-Recycling" ---</td> <td>1-4,7</td> </tr> <tr> <td>A</td> <td>DE,A,3 933 811 (POHL, KÜHN & WERNLI) 18 April 1991 - see the whole document ---</td> <td>1-5,7</td> </tr> <tr> <td></td> <td>---</td> <td>-/--</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	PLASTVERARBEITER Vol. 42, No. 6, June 1991, SPEYER AM RHEIN pages 124 - 125, XP000233431 "VERWERTUNGSMÖGLICHKEIT FÜR GEBRAUCHTE EPS- VERPACKUNGEN" see page 125, column 2, line 20 - line 42	1	A	---	2-5,7-13	A	PLASTVERARBEITER Vol. 42, No. 6, June 1991, SPEYER AM RHEIN page 141 "EPS-Recyclingverfahren" ---	1-5,7-13	A	TECHNISCHE RUNDSCHAU Vol. 83, No. 29, 19 July 1991, BERN CH page 52, XP000240484 "EPS-Recycling" ---	1-4,7	A	DE,A,3 933 811 (POHL, KÜHN & WERNLI) 18 April 1991 - see the whole document ---	1-5,7		---	-/--
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<p><input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.</p>																							
<p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>																							
<p>Date of the actual completion of the international search 11 June 1993 (11.06.93)</p>		<p>Date of mailing of the international search report 21 June 1993 (21.06.93)</p>																					
<p>Name and mailing address of the ISA/ European Patent Office Facsimile No.</p>		<p>Authorized officer Telephone No.</p>																					

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AT 93/00073

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE,U,9 109 781 (FISCHER RECYCLING GMBH) 5 December 1991 see the whole document ---	1-3,7
A	US,A,3 344 212 (DANIEL V. FRANCIS) 26 September 1967 see the whole document ---	1,3-4, 7-9,12
A	GB,A,1 082 875 (HAVEG INDUSTRIES INC.) 13 September 1967 see page 5, column 43 - page 6, column 94; figures -----	1,3,6,12

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

AT 9300073
SA 73006

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A-3933811	18-04-91	None	
DE-U-9109781	05-12-91	None	
US-A-3344212		None	
GB-A-1082875		DE-A- 1569024 FR-A- 1428881	11-09-69

INTERNATIONALER RECHERCHENBERICHT

PCT/AT 93/00073

Internationales Aktenzeichen

I. KLASSIFIKATION DES ANMELDUNGSGEGENSTANDS (bei mehreren Klassifikationssymbolen sind alle anzugeben) ⁶		
Nach der Internationalen Patentklassifikation (IPC) oder nach der nationalen Klassifikation und der IPC		
Int.Kl. 5 B29B17/00; C08J11/02; // B29K25:00		
II. RECHERCHIERTE SACHGEBIETE		
Recherchiertes Mindestprüfstoff ⁷		
Klassifikationssy ⁸	Klassifikationssymbole	
Int.Kl. 5	B29B ; C08J	
Recherchierte nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Sachgebiete fallen ⁸		
III. EINSCHLAGIGE VERÖFFENTLICHUNGEN ⁹		
Art. ⁹	Kennzeichnung der Veröffentlichung ¹¹ , soweit erforderlich unter Angabe der maßgeblichen Teile ¹²	Betr. Anspruch Nr. ¹³
X	PLASTVERARBEITER Bd. 42, Nr. 6, Juni 1991, SPEYER AM RHEIN Seiten 124 - 125, XPO00233431 'VERWERTUNGSMÖGLICHKEIT FÜR GEBRAUCHTE EPS-VERPACKUNGEN' siehe Seite 125, Spalte 2, Zeile 20 - Zeile 42	1
A	---	2-5,7-13
A	PLASTVERARBEITER Bd. 42, Nr. 6, Juni 1991, SPEYER AM RHEIN Seite 141 'EPS-Recyclingverfahren' ---	1-5,7-13
A	TECHNISCHE RUNDSCHAU Bd. 83, Nr. 29, 19. Juli 1991, BERN CH Seite 52, XPO00240484 'EPS-Recycling' ---	1-4,7
	--- -/-	
<p>¹⁰ Besondere Kategorien von angegebenen Veröffentlichungen:</p> <p>"A" Veröffentlichung, die den allgemeinen Stand der Technik definiert, aber nicht als besonders bedeutsam anzusehen ist</p> <p>"E" Älteres Dokument, das jedoch erst am oder nach dem internationalen Anmeldedatum veröffentlicht worden ist</p> <p>"L" Veröffentlichung, die geeignet ist, einen Prioritätsanspruch zweifelhaft erscheinen zu lassen, oder durch die das Veröffentlichungsdatum einer anderen im Recherchenbericht genannten Veröffentlichung belegt werden soll oder die aus einem anderen besonderen Grund angegeben ist (wie ausgeführt)</p> <p>"O" Veröffentlichung, die sich auf eine mündliche Offenbarung, eine Benutzung, eine Ausstellung oder andere Maßnahmen bezieht</p> <p>"P" Veröffentlichung, die vor dem internationalen Anmeldedatum, aber nach dem beanspruchten Prioritätsdatum veröffentlicht worden ist</p> <p>"T" Spätere Veröffentlichung, die nach dem internationalen Anmeldedatum oder dem Prioritätsdatum veröffentlicht worden ist und mit der Anmeldung nicht kollidiert, sondern nur zum Verständnis des der Erfindung zugrundeliegenden Prinzips oder der ihr zugrundeliegenden Theorie angegeben ist</p> <p>"X" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als n¹⁴ oder auf erfinderischer Tätigkeit beruhend betrachtet werden</p> <p>"Y" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als auf erfinderischer Tätigkeit beruhend betrachtet werden, wenn die Veröffentlichung mit einer oder mehreren anderen Veröffentlichungen dieser Kategorie in Verbindung gebracht wird und diese Verbindung für einen Fachmann naheliegend ist</p> <p>"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist</p>		
IV. BESCHEINIGUNG		
Datum des Abschlusses der internationalen Recherche	Absenddatum des internationalen Recherchenberichts	
11. JUNI 1993	21-06-1993	
Internationale Recherchenbehörde	Unterschrift des bevollmächtigten Bediensteten	
EUROPAISCHES PATENTAMT	JENSEN K.S.	

III. EINSCHLAGIGE VEROFFENTLICHUNGEN (Fortsetzung von Blatt 2)		
Art °	Kennzeichnung der Veröffentlichung, soweit erforderlich unter Angabe der maßgeblichen Teile	Betr. Anspruch Nr.
A	DE,A,3 933 811 (POHL, KUHN & WERNLI) 18. April 1991 siehe das ganze Dokument ----	1-5,7
A	DE,U,9 109 781 (FISCHER RECYCLING GMBH) 5. Dezember 1991 siehe das ganze Dokument ----	1-3,7
A	US,A,3 344 212 (DANIEL V. FRANCIS) 26. September 1967 siehe das ganze Dokument ----	1,3-4, 7-9,12
A	GB,A,1 082 875 (HAVEG INDUSTRIES INC.) 13. September 1967 siehe Seite 5, Spalte 43 - Seite 6, Spalte 94; Abbildungen -----	1,3,6,12

**ANHANG ZUM INTERNATIONALEN RECHERCHENBERICHT
 ÜBER DIE INTERNATIONALE PATENTANMELDUNG NR.**

AT 9300073
 SA 73006

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten internationalen Recherchenbericht angeführten Patentdokumente angegeben.

Die Angaben über die Familienmitglieder entsprechen dem Stand der Datei des Europäischen Patentamts am
 Diese Angaben dienen nur zur Unterrichtung und erfolgen ohne Gewähr.

11/06/93

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
DE-A-3933811	18-04-91	Keine	
DE-U-9109781	05-12-91	Keine	
US-A-3344212		Keine	
GB-A-1082875		DE-A- 1569024 FR-A- 1428881	11-09-69

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