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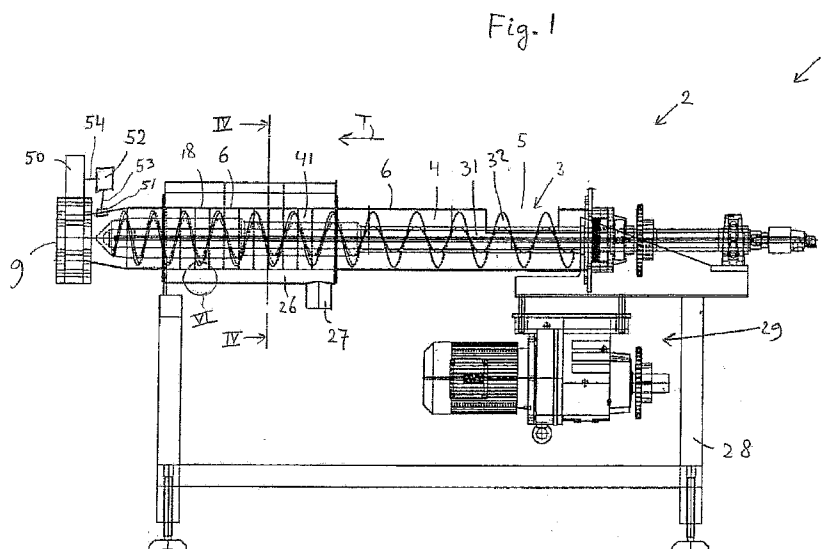
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(54) Title: APPARATUS AND METHOD FOR RECYCLING BITUMINOUS ROOFING WASTE



(57) Abstract: An apparatus (1) for recycling bituminous roofing waste comprises a screw conveyor system (2) which is provided with: a conveying space (4) for accommodating a bituminous mass; a screw conveyor (3) with a screw boss (31) and a screw blade (32) linking up with the screw boss for propelling the mass in a conveying direction (T); a pressure section (41); a sieve (18) provided with sieve openings (20) for sieving the mass in the pressure section, wherein a fine fraction of the mass is discharged from the conveying space via the sieve openings while leaving a coarse fraction of the mass behind in the conveying space; and a discharge boss (9) for discharging the coarse fraction from the conveying space. In the conveying direction, an increase of the diameter of the screw boss occurs.

Title: Apparatus and method for recycling bituminous roofing waste.

The invention relates to an apparatus for recycling bituminous roofing waste according to the preamble of claim 1. The invention also relates to a method for recycling bituminous roofing waste.

Such an apparatus is known from NL1029511. A drawback of the
5 **known apparatus is that its efficiency leaves to be desired. The fact is that in**
operation, the sieving efficiency is limited in that in the pressure section of the
conveying space, the mass flows back to too large an extent, i.e. has an
advancing component in a direction opposite to the conveying direction. The
screw conveyor also appears to rotate the mass to a large extent instead of
10 **moving the mass forward in the desired conveying direction, i.e. axially.**
Therefore, undesired backflow losses and rotational losses, respectively, are
involved. Related thereto is the occurrence of pressure loss in the pressure
section. The result is a reduced sieve yield.

An object of the invention is to provide a solution according to which
15 **the efficiency of the apparatus is improved.**

To this end, according to the invention, an apparatus of the initially
indicated type is characterized in that in a path from the supply through to the
sieve in the conveying direction an increase occurs in the diameter of the screw
boss. The invention is also embodied in a method according to claim 10.

20 **As in this path in the conveying direction an increase occurs in the**
diameter of the screw boss, at a first position in the path, the screw boss has a
first screw boss diameter that is smaller than the screw boss diameter at a
second position located at a distance from the first position in the path in the
conveying direction. In the described configuration of the apparatus, the
25 **difference in screw boss diameter between the first position and the second**
position appears to have the combined effects that the pressure build-up of the
mass in the conveying direction (i.e. in the direction of the pressure section) is

promoted, while the backflow losses and rotational losses of the mass mentioned are reduced too. This appears to result in that in operation, the sieve yield is improved.

Without wishing to be bound to any theory, achieving these effects is attributed to the following factors. A first factor is that increasing the boss diameter in the conveying direction leads to a decrease in volume between casing and screw boss. Another factor is that with increase of the boss diameter, the center of gravity of the propelling action of the screw blade shifts to a larger radius of the screw blade. As, due to the shape of a screw blade, with screw blade sections on greater radii the ratio between axial propulsion and tangential propulsion is typically greater than with screw blade sections on smaller radii, the mass is more effectively propelled by the screw blade, i.e. relatively more in axial direction. A further factor is related to the fact that the part of the screw conveyor occupied by the screw boss, in itself, does not directly contribute to the propulsion. This means that the occurring increase of the boss diameter in the conveying direction results in a decrease of the propelling action of the screw conveyor in the conveying direction. Especially in combination with the decreasing volume between the casing and the screw boss, this decreasing propelling action in conveying direction has a favourable influence on sieving.

In summary, the improved sieving yield is a result of the decreasing volume mentioned between the casing and the screw boss in combination with the decreasing, yet more effective axial propelling of the mass by the screw conveyor.

Specific embodiments of the invention are laid down in the dependent claims.

In the following, the invention is further elucidated with reference to the schematic Figures in the appended drawings.

Fig. 1 shows, in side view, a longitudinal cross section, partly in transparent view, of an example of an embodiment of an apparatus according to the invention;

Fig. 2 shows the apparatus of Fig. 1 in top plan view;

5 Fig. 3 shows, in side view, a longitudinal cross section, partly in transparent view, of an example of a screw conveyor utilized in the apparatus of Fig. 1;

Fig. 4 shows a cross section, partly in transparent view, of the apparatus of Fig. 1 along the lines IV-IV in Figs. 1 and 2;

10 Fig. 5 shows an enlarged part V of Fig. 4; and

Fig. 6 shows an enlarged part VI of Fig. 1.

An apparatus 1 is shown for recycling bituminous roofing waste. The apparatus 1 comprises a frame 28 from which various other parts of the apparatus are suspended, such as, for instance, drive means 29 for the screw conveyor system of the apparatus described in the following.

15 The apparatus 1 comprises a screw conveyor system 2. The screw conveyor system 2 comprises a conveying space 4 designed for accommodating a bituminous mass. The screw conveyor system 2 further comprises a supply 5 for supplying this mass to the conveying space. Towards the outside, the conveyor space is substantially bounded by a substantially cylindrical casing 6. The supply 5 is formed by an interruption of this casing 6.

20 The mass to be supplied to the screw conveyor system comprises at least partially melted and mixed granules of bituminous roofing material. This mass to be supplied can be obtained with the aid of other apparatuses or with the aid of another part (not shown) of the apparatus 1.

A short explanation of ways of obtaining the mass to be supplied is the following. Bituminous roofing waste typically consists of layers of various types of bituminous membranes with carriers of, for instance, glass fiber, polyester fiber or wool felt, jute, glass-wool or the like. The bitumen may be
30 blown (oxidized) or modified with polymers, such as atactic polypropylene or

styrene butadiene styrene block copolymer. Bituminous roofing waste may come from rejected specimen of the production of roofing rolls, or from material obtained with roof dismantling. The roofing waste may have undergone various pretreatments. For instance, with material from roof dismantling, materials such as aggregate, wood and the like may already have been removed, while for instance slate granules or other contaminations can still be present to a greater or lesser extent in the roofing waste. Granulation of the bituminous roofing waste may have taken place by means of cold shredding techniques. Granules may also have been manufactured in other suitable manners. The granules may have been transported and mixed by means of a conveyor screw apparatus with heating so that a preheated mass is obtained of at least partially melted and mixed granules of bituminous roofing waste. An example of a typical temperature of the preheated mass is approximately 210°C. However, other temperatures are possible too.

In the parts of the apparatus 1 described in further detail hereinbelow, it is supposed that a thus or similarly pretreated and preheated mass is supplied via the supply 5 to the screw conveyor system 2. However, it is noted that, in principle, it is also possible to for instance present the roofing waste to the supply 5 in the form of granules, in which case a part of the screw conveyor system 2 described hereinbelow effects conveying, mixing and heating as intended hereinabove.

The screw conveyor 2 further comprises a screw conveyor 3 arranged for propelling the mass in a conveying direction through the conveying space 4. In Figs. 1 – 3, this conveying direction is indicated with an arrow T. The screw conveyor 3 has a screw axis/screw boss, indicated hereinbelow as screw boss 31, and a screw blade 32 linking up with the screw boss. The casing 6 extends with some clearance around the screw conveyor. In the example mentioned, the casing is arranged coaxially with the screw conveyor.

In the example shown, the screw conveyor 3 is bearing mounted with its screw boss 31 only on the right side shown in Figs. 1 and 2. On the left

side shown in Figs. 1 and 2, the screw boss 31 is not bearing mounted. However, other manners of mounting the screw conveyor are possible.

The screw conveyor system 2 further comprises a pressure section 41 of the conveying space extending in the conveying direction T. In this pressure section, the mass can be pressurized as a result of the propelling force of the screw conveyor. The pressure section comprises the casing 6 extending coaxially with the screw conveyor and with some clearance around the screw conveyor.

The screw conveyor system 2 further comprises a sieve 18 situated, in the conveying direction, at a distance from the supply, provided with sieve openings 20 for sieving the mass in the pressure section, whereby a fine fraction of the mass is discharged from the conveying space via the sieve openings while a coarse fraction of the mass is left behind in the conveying space. The fine fraction is useful bitumen that can be reused, for instance when manufacturing new roofing rolls.

The sieve can, in principle, be included in the screw conveyor system 2 at different locations and in different manners. In the example shown, the sieve 18 is formed by a longitudinal section of the cylindrical casing 6 designed as a sieve, i.e. by a drum screen of the type as known from NL1029511. In the example shown, the drum screen substantially has the form of the drum screen shown in NL1029511, while the parts of the drum screen located between the elongated sieve openings 20 are formed by rod/wire shaped metal parts of the drum screen. In Fig. 5 of the present application, these metal parts are indicated with reference numeral 38. For reinforcement, the metal parts 38 can be mutually connected by one or more axially spaced apart reinforcement rings of the drum screen.

At a distance from the drum screen 18, the drum screen is partly surrounded by a second casing 26 (see, for instance, Fig. 4). The fine fraction of the mass discharged from the conveying space via the sieve openings is

captured in a collecting space formed by the second casing 26 and can be discharged further via a discharge 27.

The screw conveyor system 2 further comprises a discharge 9 for discharging the coarse fraction from the conveying space. The coarse fraction
5 can, in general, be incinerated in a customary incinerator.

In the apparatus 1, in a path from the supply 5 through to the sieve 18 in the conveying direction T, an increase occurs in the diameter of the screw boss 31.

In the example shown, such an increase in the screw boss diameter
10 is realized as follows. The portion of the screw boss 31 which is operatively located in the conveying space, is subdivided into three longitudinal sections A, B, and C, successive, respectively, in the conveying direction T, see Fig. 3. The sections A, B and C of the screw boss 31 have mutually different boss diameters, indicated with DA, DB, and DC, respectively, wherein DA is
15 smaller than DB and DB is smaller than DC. Such an increase in the screw boss diameter can also be realized with two, or with more than three such longitudinal sections successive in the conveying direction T with increasing screw diameter, respectively. Such an increase in the screw boss diameter can also be realized with a screw boss diameter increasing in the conveying
20 direction not in a stepped manner but gradually. An advantage of such a stepped increase of the screw boss diameter is the simplicity of manufacture of a screw conveyor with such a screw boss. Such an increase in the screw boss diameter can for instance be such that the ratio of this screw boss diameter, divided by the diameter of the screw conveyor in the conveying direction,
25 increases from approximately 0.50 in the longitudinal section A to approximately 0.75 in the longitudinal section C. The diameter of the screw conveyor can then be, for instance, 850 mm and the sum of the lengths of the longitudinal sections A, B and C for instance 7500 cm.

Preferably, in the path in the conveying direction T mentioned, also,
30 a reduction of the pitch of the screw blade 32 occurs. Such a reduction in the

pitch may be such that the ratio of this pitch divided by the diameter of the screw conveyor in the conveying direction decreases from approximately 0.80 in the longitudinal section A to approximately 0.50 in the longitudinal section C. In a similar manner to the above described increase of the screw boss diameter, both a gradual pitch reduction and a stepped pitch reduction in two, three, four or more steps can be used.

The occurring reduction of the pitch in the conveying direction results in a decrease in the conveying direction of the propelling action of the screw conveyor. Especially in combination with the decreasing volume in conveying direction between the casing and the screw boss mentioned, this propelling action decreasing in the conveying direction has a further favourable influence on sieving.

As stated, the sieve 18 mentioned in the example forms part of the casing 6 around the screw conveyor 3. An advantage of this is that a large effective sieving surface is achieved.

Reference is now made to Fig. 5, which shows an enlarged part of Fig. 4, indicated with V in Fig. 4. In Fig. 5, it can be seen that as preferred embodiment, the sieve openings 20 of the sieve are passages which widen in a direction of passage for the fine fraction. This widening in direction of passage is realized in that the metal parts 38 of the drum screen in the cross section shown in Fig. 5 are wedge-shaped. Such a widening passage offers the advantage that once a small, lumpy particle in the mass, such as, for instance, a pebble or a different contamination in the mass has passed the narrowest part of the passage, it will not get stuck there. This is beneficial to the reliability of the sieve.

In the example shown, the sieve openings 20 of the drum screen 18 are elongated and extend with their longitudinal direction parallel to the conveying direction T. An advantage thereof is that the mass propelled forward in the conveying space 4 experiences less resistance from the drum screen 18 in the conveying direction than in other directions. This has a

favourable effect on the propulsion yield. A further advantage thereof is that if a more or less solid (coarse) particle in the mass, such as for instance, a pebble or other (fibrous) contamination in the mass, due to its (form)properties, does not fit through the sieve openings 20 and comes to lie against the entrances of these openings, it is directed via these entrances in the conveying direction T, i.e. in the direction of the discharge 9 for discharging the coarse fraction. Here, the elongated forms of the sieve openings 20 prevent the sieve openings 20 from forming an obstruction of such particles in the conveying direction T, and hence do not only promote the reliability of the sieve, but also a low friction between those particles and the drum screen 18.

Reference is now made to Fig. 6, which shows an enlarged part of Fig. 1 indicated in Fig. 1 with VI. In Fig. 6, a blade tip of the screw blade 32 is shown. In operation, the melted mass propelled substantially in the conveying direction T will, at the location of the blade tip of the screw blade 32, flow around this blade tip in a manner as indicated in Fig. 6 with arrow R. This local, relative flowing around movement of the mass relative to the blade tip has an important component which is opposite to the conveying direction T. Preferably, as shown in Fig. 6, the screw blade 32 is provided with a bevelled blade tip 39, which bevel is such that the clearance between the blade tip 39 and the casing is a passage for the mass, which passage widens, viewed in a direction opposite to the conveying direction T. A thus widening passage offers the advantage that once a small, lumpy particle in the mass, such as for instance a pebble or other contamination in the mass, has passed the narrowest part of the passage, it needs not remain stuck there. This is beneficial to the reliability of the screw conveyor system.

Preferably, the apparatus 1 comprises a temperature control system (not shown in the Figures) for controlling the temperature of the mass in the conveying space. The temperature control system can be designed for keeping the mass in the conveying space at the desired temperature. The temperature control system can be based on circulation of thermal oil and comprise screw

blades 32 and/or screw boss 31 of hollow design and/or walls of the casing 6 of hollow design for instance for the purpose of this circulation. However, other temperature control systems can also be used.

Preferably, the temperature of the mass in the conveying space is controlled with the aid of heating from the screw boss 31 such that, viewed in cross section through the screw conveyor system, portions of the mass adjacent the screw boss are held at a higher temperature than portions of the mass adjacent the casing 6. This can be realized for instance by setting the temperature of the thermal oil in the hollow screw boss at values of, for instance, approximately 230 °C, while the temperature of the thermal oil in the hollow casing 6 is set at lower values of, for instance, approximately 200 °C. An advantage of keeping portions of the mass adjacent the screw boss at a higher temperature relative to portions of the mass adjacent the casing 6 is that, as a result, the first portions of mass obtain a lower viscosity than the latter portions of mass. This means that due to their lower viscosity, the first mentioned portions of mass are dragged along by the propelling screw boss to a lesser extent and that due to their higher viscosity, the portions of mass mentioned last are delayed to a larger extent by the wall 6 in their rotational movement generated by the screw action. Reduced rotational losses and, hence, a further increased efficiency of the apparatus are advantageous results thereof.

The apparatus 1 preferably comprises a controllable shutoff 50 (see Fig. 1) for the discharge 9. More preferably, the apparatus comprises measuring means for measuring properties of the mass in the pressure section, and a control unit for controlling the controllable shutoff 50, depending on measuring results obtained through the measuring means. In Fig. 1, the measuring means (reference numeral 51) and the control unit (reference numeral 52) are represented in a highly schematic manner. The measuring means 51 are communicatively connected (reference numeral 53) to the control unit 52 which, in turn, is communicatively connected (reference numeral 54) to

the controllable shutoff 50. The measuring means can comprise pressure and/or temperature and/or level and/or other sensors. Although the (only highly schematically represented) measuring means 51 are shown in Fig. 1 at a location adjacent the controllable shutoff 50, the measuring means can be included at various places in the screw conveyor system 2, for instance integrated in the wall 6. For instance, a level sensor can be provided in the proximity of the supply 5.

It is advantageous when the control unit cooperates with the above-described temperature control system so that the control of the controllable shutoff and the control of the temperature can perform their relative controlling tasks in unilateral or mutual dependency. It can for instance be effected that the temperature of the coarse fraction, just before it leaves the conveying space, is relatively low so that then, the coarse fraction is relatively more solid. Controls whereby the coarse fraction of the mass leaves the discharge 9 continuously, but also periodically, are possible too.

It is noted that the above-mentioned examples of embodiments do not delimit the invention and that within the range of the accompanying claims, various alternatives are possible.

For instance, various types of screw conveyors can be used. For instance, on one screw boss, instead of one screw blade elongated in helicoidal direction, also, more than one such screw blade can be provided. Also, elaborations are possible wherein instead of one single screw conveyor, several screw conveyors placed parallel to each other in a common conveying space are utilized. Further, various dimensions of the screw conveyors used are possible, for instance various dimensions as to length, diameter, screw boss diameter and pitch. Further, the speed of the screw conveyor can be varied. However, other variants or modifications are possible too. These and similar alternatives are understood to fall within the framework of the invention as defined in the appended claims.

Claims

1. An apparatus for recycling bituminous roofing waste, comprising a screw conveyor system (2) provided with:
- a conveying space (4) designed for accommodating a bituminous mass, which mass comprises at least partially melted and mixed granules of bituminous roofing waste;
 - a supply (5) for supplying said mass to the conveying space;
 - a screw conveyor (3) designed for propelling the mass in a conveying direction (T) through the conveying space, which screw conveyor has a screw boss (31) and a screw blade (32) linking up with the screw boss;
 - a pressure section (41) of the conveying space, extending in the conveying direction, for pressurizing the mass as a result of the propelling force of the screw conveyor in the pressure section, which pressure section comprises a casing (6) around the screw conveyor, extending with some clearance around the screw conveyor;
 - a sieve (18) situated in the conveying direction at a distance from the supply, provided with sieve openings (20) for sieving the mass in the pressure section, whereby a fine fraction of the mass is discharged from the conveying space via the sieve openings while leaving a coarse fraction of the mass behind in the conveying space;
 - a discharge (9) for discharging the coarse fraction from the conveying space; characterized in that in a path from the supply through to the sieve in the conveying direction an increase occurs in the diameter of the screw boss.
2. An apparatus according to claim 1, wherein in said path in the conveying direction (T) a reduction occurs in the pitch of the screw blade (32).
3. An apparatus according to claim 1 or 2, wherein the sieve (18) forms part of said casing (6) around the screw conveyor (3).

4. An apparatus according to any one of the preceding claims, wherein the sieve openings (20) of the sieve (18) are passages which widen in the direction of passage for the fine fraction.
5. An apparatus according to any one of the preceding claims, wherein
5 the sieve openings (20) of the sieve (18) are elongated and extend with their longitudinal direction substantially parallel to the conveying direction (T).
6. An apparatus according to any one of the preceding claims, wherein the screw blade (32) is provided with a bevelled blade tip (39) which bevel is such that the clearance between the blade tip and the casing (6) is a passage
10 for the mass, which passage widens, viewed in a direction opposite to the conveying direction (T).
7. An apparatus according to any one of the preceding claims, further comprising a temperature control system for controlling the temperature of the mass in the conveying space (4).
- 15 8. An apparatus according to any one of the preceding claims, further comprising a controllable shutoff (50) for the discharge (9).
9. An apparatus according to claim 8, further comprising measuring means (51) for measuring properties of the mass in the pressure section (41), and a control unit (52) for controlling the controllable shutoff depending on the
20 measuring results obtained by the measuring means.
10. A method for recycling bituminous roofing waste while utilizing an apparatus (1) according to any one of claims 1 – 9, wherein:
- the bituminous mass is provided;
 - the mass is supplied via the supply (5) to the conveying space (4);
 - 25 - the mass is propelled in the conveying direction (T) through the conveying space;
 - the mass is pressurized in the pressure section (41);
 - the mass is sieved by means of the sieve (18);
 - the fine fraction is discharged from the conveying space via the sieve
30 openings (20); and

- the coarse fraction is discharged from the conveying space via the discharge (9).

11. A method according to claim 10, wherein the temperature of the mass in the conveying space (4) is controlled with the aid of heating from the screw boss (31) such that, viewed in cross section through the screw conveyor system (2), portions of the mass adjacent the screw boss are kept at a higher temperature than portions of the mass adjacent the casing (6).

Fig. 1

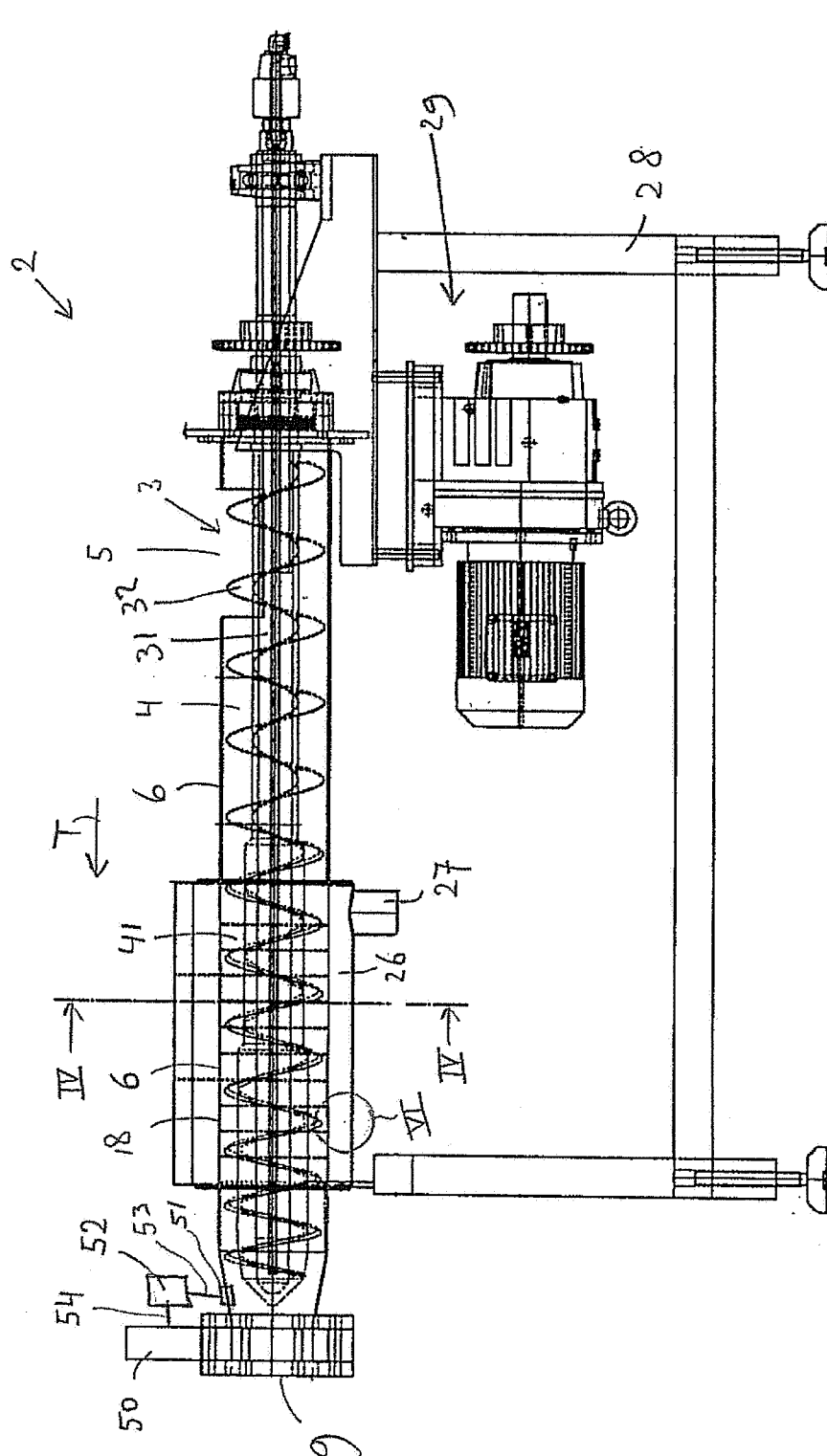


Fig. 2

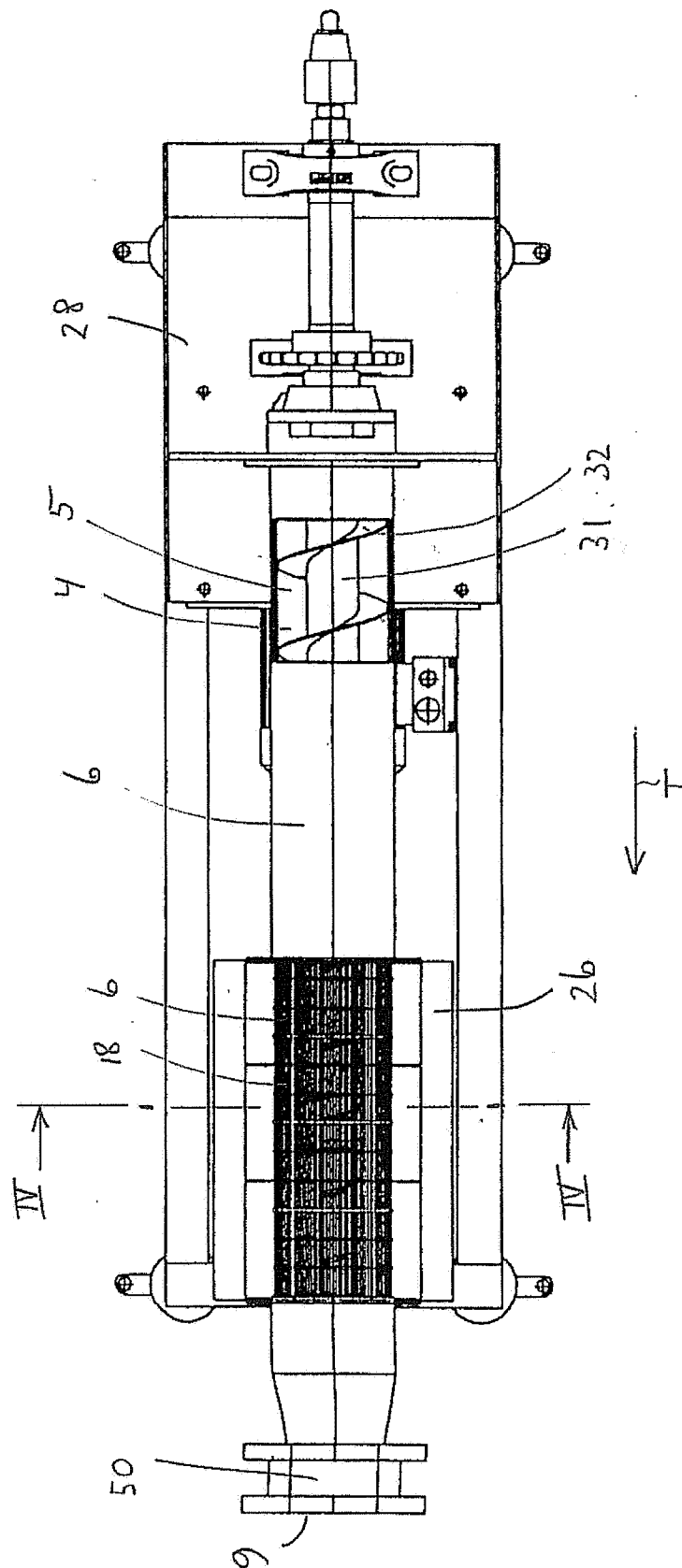


Fig. 3

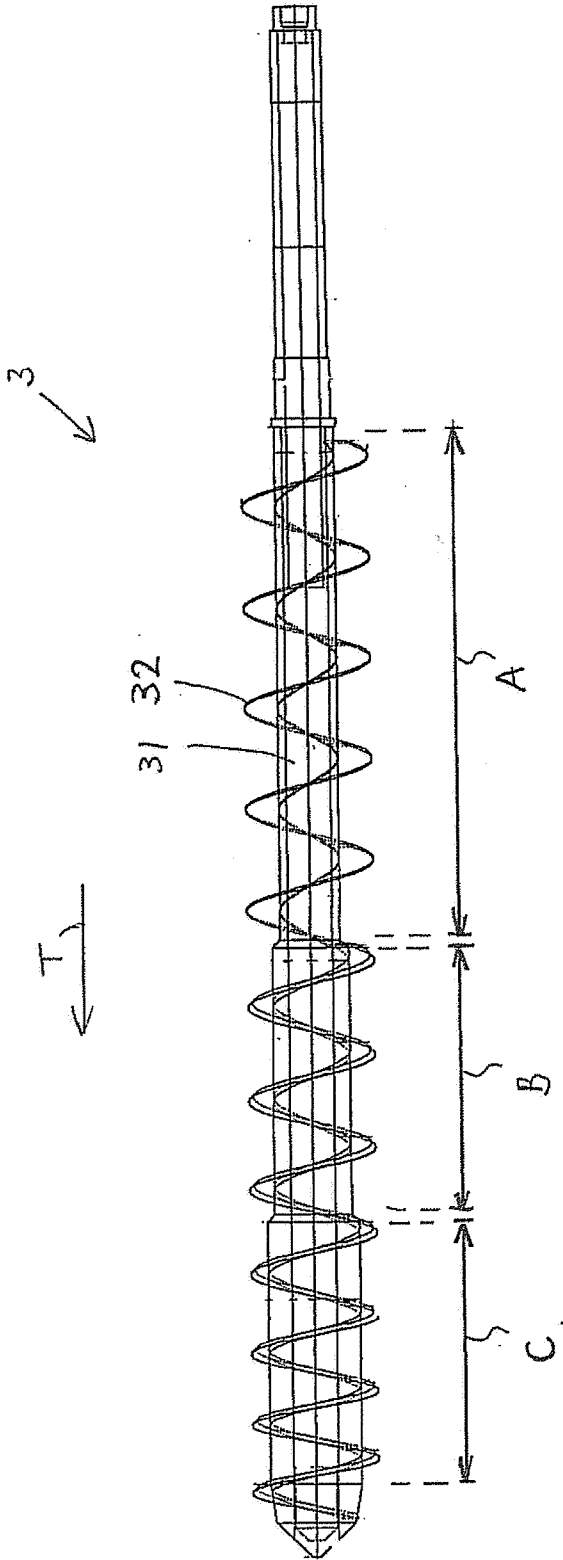


Fig. 4

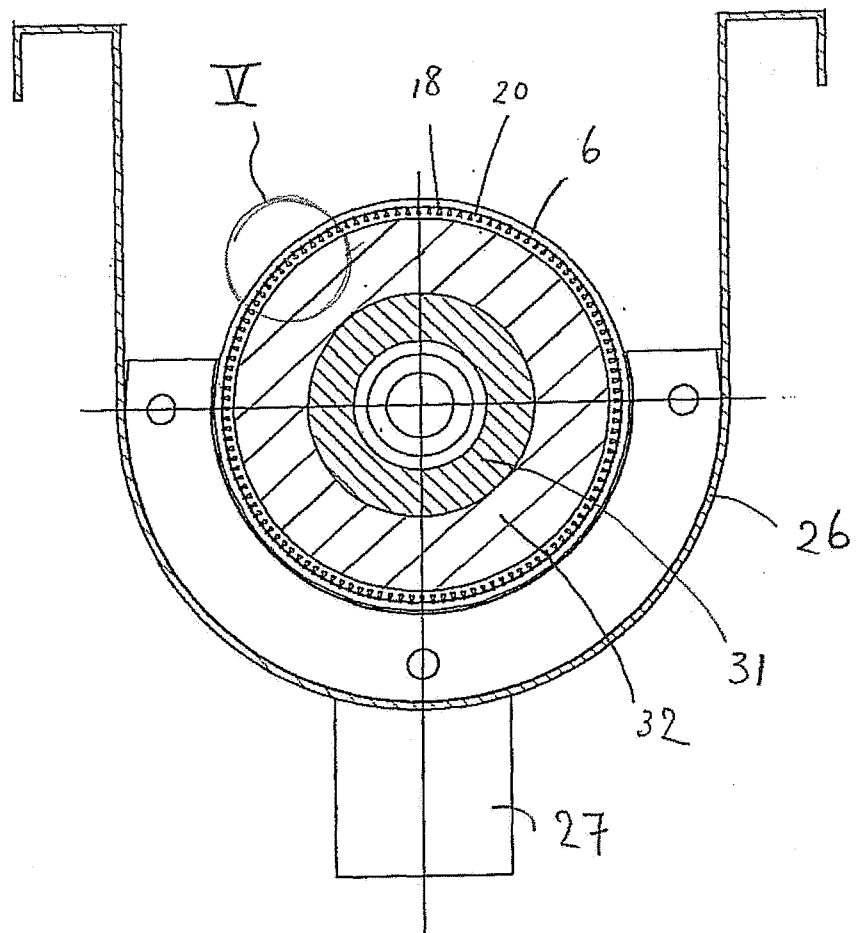


Fig. 5

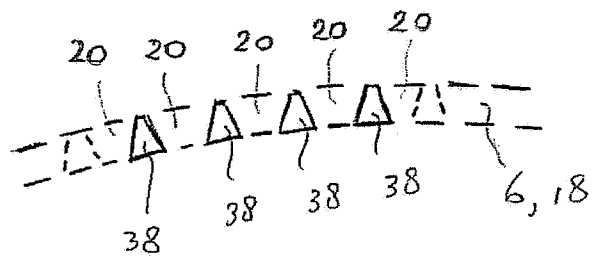
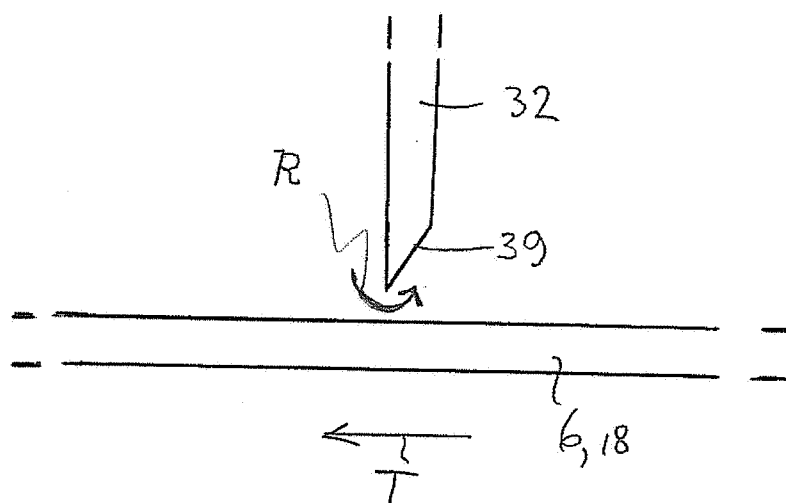


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No

PCT/NL2008/050090

A. CLASSIFICATION OF SUBJECT MATTER

INV. B29B17/02 B01D29/11 B29B7/48

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B29B B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 5 599 097 A (CHRISTIE ANDREW W [US]) 4 February 1997 (1997-02-04) abstract	1-11
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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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