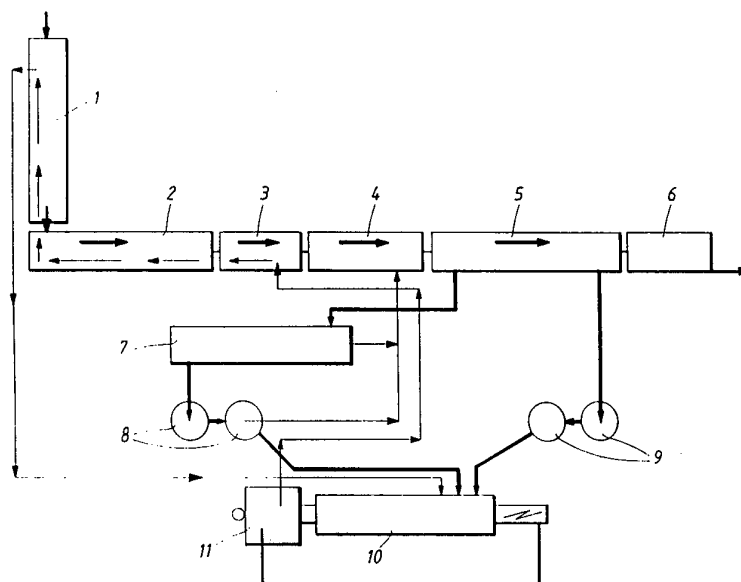




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : F23G 7/12, 5/02, C10B 53/00	A1	(11) International Publication Number: WO 94/10507 (43) International Publication Date: 11 May 1994 (11.05.94)
(21) International Application Number: PCT/SE93/00897 (22) International Filing Date: 28 October 1993 (28.10.93) (30) Priority data: 9203166-5 28 October 1992 (28.10.92) SE (71)(72) Applicant and Inventor: JOHANSSON, Alf [SE/SE]; Box 143, S-463 23 Lilla Edet (SE). (74) Agents: GRAUDUMS, Valdis et al.; Albiñ West AB, Box 142, S-410 22 Göteborg (SE). (81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).	Published <i>With international search report.</i> <i>With amended claims.</i> <i>In English translation (filed in Swedish).</i>	

(54) Title: METHOD FOR CONTINUOUS RECOVERY OF, FOR EXAMPLE, RUBBER AND PLANT FOR THE PERFORMANCE OF THE METHOD



(57) Abstract

The invention relates to a method for continuous recovery of, for example, rubber through pyrolysis. The pyrolysis products such as gas or oil are burnt and fed to the raw material counter-current in a last step before the feeding into the pyrolysis for expelling of oxygen and preheating of the material. The invention also comprises an arrangement for performing the method which includes an elongated pyrolysis chamber (5) having feeding devices (23) for the material intended for being pyrolysed, whereby the feeding device comprises a vertical silo (1), a hauling and/or preheating device (2) having an inerting zone (3) running from the underside of the silo (1) and terminating in a shaft-shaped dropping device (12) for the material into the chamber (5).

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TITLE:

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Method for continuous recovery of, for example, rubber and plant for the performance of the method.

TECHNICAL FIELD:

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The present invention relates to a method and an arrangement for recovery of, for example rubber which mainly originates from worn out car tyres.

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PRIOR ART:

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It is earlier known to recover rubber and the like by pyrolysis. Pyrolysis means that the material in question is heated without admission of air or oxygen so that it is decomposed in gaseous, liquid or solid substances. The most important material to be decomposed by pyrolysis is rubber, mainly in the form of worn out rubber tyres from cars.

25

It has earlier been usual to carry out these pyrolysis methods batch-wise which means that finely cut rubber parts which may have been mixed with oil are fed into a pyrolysis chamber which has been closed, inertized, that means that air removed by introducing inert gas, for example nitrogen, and then pyrolysed by heating for a sufficiently long period whereby gas, oil and pyrolysis residues consisting mainly of carbon which afterwards is ground to for example carbon black are collected. After the pyrolysis, it has been necessary to open the furnace, take out solid material, add new material, close the chamber and so on.

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Attempts have also been made during recent years to make this pyrolysis continuous by performing it on an endless conveyor in an elongated pyrolysis chamber, removing gas and oil along the chamber and passing the solid material through a lock at the end of the chamber. To feed the material intended for pyrolysis a lock-like device is arranged which, however, due to the locking in is made batch-wise. Such a method and such an arrangement is described in the American patent 4 900 401.

TECHNICAL PROBLEM:

Though the pyrolysis itself in the above said methods has been possible to be implemented without too much problem, none of the known methods has, however, been satisfactory. The batch-wise methods firstly require manual labour force, they are slow, they give a low yield of gas and oil, they require a lot of energy due to the fact that so much energy is lost through opening and closing of the chambers and they are consequently very uneconomic. What is possibly still worse is that this batch-wise system leads to very strong pollution of mainly the air and they are therefore not desirable for environmental reasons.

The earlier known continuous method is also uneconomic and only semi-continuous in that the locking in of the material has to be carried out batch-wise. The method is also uneconomic because of the square-shape of the chamber and poor flowing off of the oil. It is therefore easily clogged and it has shown to be very troublesome.

It has therefore long been a desire to be able to bring about a method and a plant for pyrolysis of primarily rubber residues which method should be economic and environmental friendly whilst give a good yield of the

substances recovered from the pyrolysis, which substances also should have such a degree of purity and consistency that they could be reused in different applications. The environmental aspect at this method and plant should be of utmost importance.

THE SOLUTION:

According to the present invention one has been able to solve the problems with the above mentioned known methods and arrangements and also been able to meet the demands put on them by bringing about a method for continuous recovery of, for example, rubber by pyrolysis in a continuous pyrolysis chamber, which method is characterized in that pyrolysis products such as gas or oil are burnt and thereafter fed back to the raw material in counter-current in a last step before the introduction into the pyrolysis chamber for removal of oxygen, so-called inerting and preheating of the raw materials.

According to the invention the used exhaust gases after the inerting and preheating are recycled to the furnace.

In accordance with the invention, the pyrolysis for rubber should occur at a temperature of 250-800°C, preferably at about 700°C and possibly have a heating zone of about 800° to 2.400°C at the start of the pyrolysis process. The heating should occur continuously.

The sediments obtained through the pyrolysis and which are recovered from the oil are, according to the invention, reintroduced into the pyrolysis process.

The invention also comprises an arrangement for continuous recovery of, for example, rubber through pyrolysis, comprising an elongated pyrolysis chamber having conveying

means for the material intended for pyrolysis, feeding arrangements for the material and feeding out arrangements for gas, oil and solids, which arrangement is characterized in that the feeding arrangement comprises one or more
5 vertical silos having a conical lower part for the material, a hauling and/or preheating device running from the underside of the silos and terminating in a shaft-shaped discharging device for the material into the chamber.

10

According to the invention the discharging device should comprise a funnel shaped container having an opening in the bottom and a feeding screw for feeding down the material towards the bottom hole. This bottom hole should be
15 provided with a rotating cutting knife. The feeding screw and the cutting knife should rotate in opposite directions for controlling of the feeding velocity and the fineness. The cutting knife, which rotates against a perforated disc, should be cooled.

20

Below the bottom hole in the discharging device a first heat-isolated pyrolysis reactor having heat-radiation elements should be arranged immediately above the front end of the conveyor in the pyrolysis chamber.

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The conveyor in the pyrolysis chamber can consist of an endless oil-permeable band having a flow off plate between the forward and backward running parts of the band.

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The arrangement according to the present invention is also characterized in that the chamber in section is round and that a feeding screw for oil is arranged in its bottom.

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According to the invention it is further suitable that the feeding out devices for gas and oil are located at the beginning of the pyrolysis chamber.

FIGURE DESCRIPTION:

The invention will be described in the following in greater detail with reference to the drawings in which

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Fig. 1 shows a flow-sheet of the method and the arrangement according to the present invention;

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Fig. 2 schematically shows the arrangement seen from the side, and

Fig. 3 shows a section through the central parts of the arrangement.

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In Fig. 1 a silo 1 for raw material is shown. This raw material which primarily originates from worn out vehicle tyres should be pretreated by shredding, fine shredding and sifting. It is therefore present in the shape of granules in the silo. This pretreatment is not part of the present invention.

20

From the silo 1 the raw material is fed through a preheating zone 2 which ends with an inerting zone 3. After this inerting the material which is now substantially free from air and oxygen is brought into the first step in a pyrolysis reactor 4 and from there into the pyrolysis chamber 5. At the end thereof a carbon lock 6 is arranged which locks out the solid material substantially consisting of carbon. The solid material can be treated in a suitable way and is a good source for the production of carbon black.

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The oil produced from the pyrolysis chamber 5 is fed during the process to an oil sedimenting plant 7 and further to one or more oil cisterns 8. Sediments from the oil sedimenting plant 7 and possibly from the oil cisterns 8 are

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returned to the pyrolysis reactor 4, the pyrolysis chamber 5 or to the silo 1.

5 The gas from the pyrolysis chamber or pyrolysis reactor 4 is collected in one or more gas tanks 9.

10 Oil from the oil cistern 8 or gas from the gas tanks 9 can be used to drive a turbine 10 which for example generates electric current. The exhaust gases from the turbine which are collected in an exhaust pan 11 can partly be released to the atmosphere after usual and conventional purification in heating pans whereas a fraction of these exhaust gases is returned to the inerting step 3 and there replaces air which has followed the granules into the silo 1. These
15 exhaust gases which are fed to the inerting step 3 are fed in counter-current to the mass intended to be pyrolysed through the preheating step 2 where they preheat the mass and then up into the silo 1 where they give off their last heat. The gases which stream up through the silo are,
20 however, not released into the atmosphere but can be fed back to the burning step in the generator. Accordingly no release of gas or oil whatsoever comes from the system. During starting up of the pyrolysis process nitrogen can, however, be used or some other inert gas for inertising as
25 the oxygen-free exhaust gases are not yet present in the system.

30 The oil in the cistern 8 and gas in the gas tanks 9 which are not used for burning can be distributed further to the market. In the same way produced electrical energy in the generator can be distributed via the electric network and heat from the heating pan can be used in the same way.

35 Fig. 2 shows the main part of the arrangement seen from the side comprising a silo 1 of suitable construction and a preheating unit 2 with successive inerting zone 3. In the

present case the preheating and inerting zones consist of pipe-formed units in which hauling means are arranged. These pipe constructions start at the bottom of the silo and extend upwardly to finally drop the material down into the pyrolysis reactor 4 for further treatment in the pyrolysis chamber 5. After this the carbon lock 6 is arranged which feeds the carbon material to a carbon tank. Pipes for feeding of gas, oil etc are not shown in the figure for the sake of simplicity.

10

Fig. 3 shows how a preheating step 2 is constructed. Centrally therein a feeding screw 11 is arranged which feeds the material towards the inerting step 3, wherefrom it may drop down into the funnel shaped container 12. As appears from the figure the preheating and inerting steps consist of, three concentric pipes whereby the central pipe houses the screw 11 with material which is to be pyrolysed, the closest surrounding pipe 13 contains hot gases for preheating and the outermost pipe 14 is provided with insulating mass. The preheating of the material occurs up to a temperature of about 120°C.

20

The funnel shaped container 12 which is the main part in a dropping arrangement for the material comprises a feeding screw for feeding down the mass through a hole in the lower part of the container 12. In this hole a cutting knife 16 is arranged which makes the material fall in an even stream down into the pyrolysis reactor 4. In the funnel shaped container 12 granulated material will always be present which is fed with a constant velocity into the chamber. This material together with the cutting knife 16 in the opening, constitutes a sufficient lock for preventing passage of gas from the pyrolysis part to the preheating zone. In this way, a complete continuity of the feeding is created. It is important that the cutting knife and the plate against which it works will not be too hot. The knife

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and the plate are therefore cooled and arranged at some distance above the hot zone in the pyrolysis reactor.

5 A feeding arrangement 31 is also connected to the upper part of the container. This device adds primarily the above mentioned oil sediments.

10 The pyrolysis reactor 4 which is shown in section B-B consists of an outer steel cover 17, ceramic heat insulation 18 and 19 and has heating coils 20 around the central channel. These heating coils 20 are suitably electric but they can also add heat by burning of gas. The gas created in this zone is deviated downwardly and is allowed to stream out through the cylindrically shaped gas exit 21. Therefrom the gas is pumped out together with
15 further gas which is created during the pyrolysis through the gas pump 22 at the lower part of the pyrolysis chamber.

20 Material from the feeding falls down onto the endless rotating band 23 for further transport through the chamber. In the chamber the material is subjected to heat in the order of 700°C if it is a question of rubber and the material then decomposes in a gas mixture, oil and solid material. The heat of 700°C has suitably been preceded by
25 a quick heating of 800°C to 2.400°C in the pyrolysis reactor 4. The heat for bringing about this high temperature comes from the heating pump 24 above the band 23. These heating pipes can either be electrically heated or heated by means of gas. A section through the pyrolysis
30 chamber 5 is shown in the section A-A wherefrom it can be seen that the chamber itself is round and is housed in a square cover. The space between the round part and the square cover is heat insulated.

The band 23 on which the material lies should be oil-permeable and consists preferably of a steel net. Between the forwards and backwards running parts of the band 23, a
5 plate 25 for the oil flow is arranged. This plate guides the oil which flows from the band to the outer side of the return part and conducts it further down towards the bottom part of the chamber where a screw 26 is arranged. This screw 26 is of the shaftless type for avoiding problems
10 with depositions and cloggings. The screw 26 is driven by an electric motor and conducts the oil down into a recess in the pyrolysis chamber from where it is brought out by means of a further screw 27.

15 At the end of the band a carbon lock 6 is arranged where the solid material may fall down into a recess and is screwed out by means of a carbon screw 28. A level indicator 29 is arranged in this recess for indicating how much carbon is present.

20 The different screws are driven by electric motors in known ways.

25 For possible cleaning, the chamber is provided with inlet pipes 30 for flushing. Herethrough and by means of the movable and suitable inner parts in the chamber, the chamber can be kept clean without disassembly and cleaning of the parts.

30 The preheating device and the pyrolysis chamber can be constructed according to the module principle whereby one can choose the length which suits the different application areas. It is also possible to couple these plants in series.

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By means of the present invention, an arrangement and a method are provided which do not release any air-contaminating gases; instead these are practically completely trapped. At the same time, a system, is provided
5 in which all parts of the fed material are collected and this together with a very economic energy consumption has led to a system with unusually good economy.

The invention is not limited to the embodiment example
10 shown but can be varied in different ways within the scope of the patent claims.

5 CLAIMS:

1. Method for continuous recovery of materials such as gas, oil and solid substances from, for example, rubber through anaerobic pyrolysis in a continuous substantially horizontal pyrolysis chamber, characterized in that pyrolysis products such as gas or oil are burnt and thereafter fed to the raw material counter-currently in a last step before the introduction of the raw material into the pyrolysis chamber for expelling of oxygen, so-called inerting and preheating of the raw material.

2. Method according to claim 1, characterized in that the spent exhaust gases used are returned to the burning furnace.

3. Method according to claim 1-2, characterized in that the pyrolysis is carried out at a temperature of 700°C.

4. Method according to any of the claims 1-2, characterized in that the pyrolysis material runs through a heating zone of about 800°C to 2.400°C at the beginning of the pyrolysis process.

5. Method according to any of the claims 1-4, characterized in that sediments from oil produced through the pyrolysis are returned to the pyrolysis process.

6. Arrangement for continuous recovery of materials such as gas, oils and solid substances from, for example, rubber through anaerobic pyrolysis comprising an elongated substantially horizontal pyrolysis chamber (5) having feeding arrangements (23) for the material intended for pyrolysing, feeding arrangements for the material and feeding out devices (22, 27, 28) for gas, oil and solid materials, characterized in that the feeding-in device comprises at least a vertical silo (1) for the material, a hauling and/or preheating and inerting device (2, 3) from the underside thereof terminating in a shaft-shaped dropping arrangement (12) for the material in the chamber.

7. Arrangement according to claim 6, characterized in that the dropping arrangement comprises a funnel-shaped container (12) having an opening in the bottom and a feeding screw (15) for feeding down material towards the bottom hole.

8. Arrangement according to any of the claims 6-7, characterized in that a rotating cutting knife (16) having opposite rotation to the feeding screw (15) is arranged in the bottom hole.

9. Arrangement according to any of the claims 6-8, characterized by a first heat-insulating pyrolysis reactor (4) having heat radiation elements (20) below the bottom hole and above the forward end of the feeding arrangement (23).

10. Arrangement according to any of the claims 6-9,
c h a r a c t e r i z e d i n that the feeding device
(23) in the pyrolysis chamber (5) consists of an endless
5 oil permeable band (23) having a run off plate (25) between
the forward and backward running parts of the band (23).

11. Arrangement according to any of the claims 6-10,
c h a r a c t e r i z e d i n that the chamber, in
10 section, is round and that in its bottom a feeding screw
(26) for oil is arranged.

12. Arrangement according to any of the claims 6-11,
c h a r a c t e r i z e d i n that the feeding out
15 devices for gas (22) and oil (27) are located at the
beginning of the pyrolysing chamber.

AMENDED CLAIMS

[received by the International Bureau on 24 March 1994 (24.03.94);
original claim 6 amended; other claims unchanged (3 pages)]

5

1. Method for continuous recovery of materials such as gas, oil and solid substances from, for example, rubber through anaerobic pyrolysis in a continuous substantially horizontal pyrolysis chamber, characterized in that pyrolysis products such as gas or oil are burnt and thereafter fed to the raw material counter-currently in a last step before the introduction of the raw material into the pyrolysis chamber for expelling of oxygen, so-called inerting and preheating of the raw material.

20

2. Method according to claim 1, characterized in that the spent exhaust gases used are returned to the burning furnace.

3. Method according to claim 1-2, characterized in that the pyrolysis is carried out at a temperature of 700°C.

25

4. Method according to any of the claims 1-2, characterized in that the pyrolysis material runs through a heating zone of about 800°C to 2.400°C at the beginning of the pyrolysis process.

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5. Method according to any of the claims 1-4, characterized in that sediments from oil produced through the pyrolysis are returned to the pyrolysis process.

6. Arrangement for continuous recovery of materials such as gas, oils and solid substances from, for example, rubber through anaerobic pyrolysis comprising an elongated substantially horizontal pyrolysis chamber (5) having feeding arrangements (23) for the material intended for pyrolysing, feeding arrangements for the material and feeding out devices (22, 27, 28) for gas, oil and solid materials, characterized in that the feeding-in device comprises at least a vertical silo (1) for the material, a hauling and/or preheating and inerting device (2, 3) from the underside thereof terminating in a shaft-shaped dropping arrangement (12) for the material in the chamber, and a turbine or the like where at least a part of the pyrolysis products are burnt, the arrangement including conducts for partly feeding the burnt exhaust gases to the inerting device (2, 3).

7. Arrangement according to claim 6, characterized in that the dropping arrangement comprises a funnel-shaped container (12) having an opening in the bottom and a feeding screw (15) for feeding down material towards the bottom hole.

8. Arrangement according to any of the claims 6-7, characterized in that a rotating cutting knife (16) having opposite rotation to the feeding screw (15) is arranged in the bottom hole.

9. Arrangement according to any of the claims 6-8, characterized by a first heat-insulating pyrolysis reactor (4) having heat radiation elements (20) below the bottom hole and above the forward end of the feeding arrangement (23).

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c h a r a c t e r i z e d i n that the feeding out
15 devices for gas (22) and oil (27) are located at the
beginning of the pyrolysing chamber.

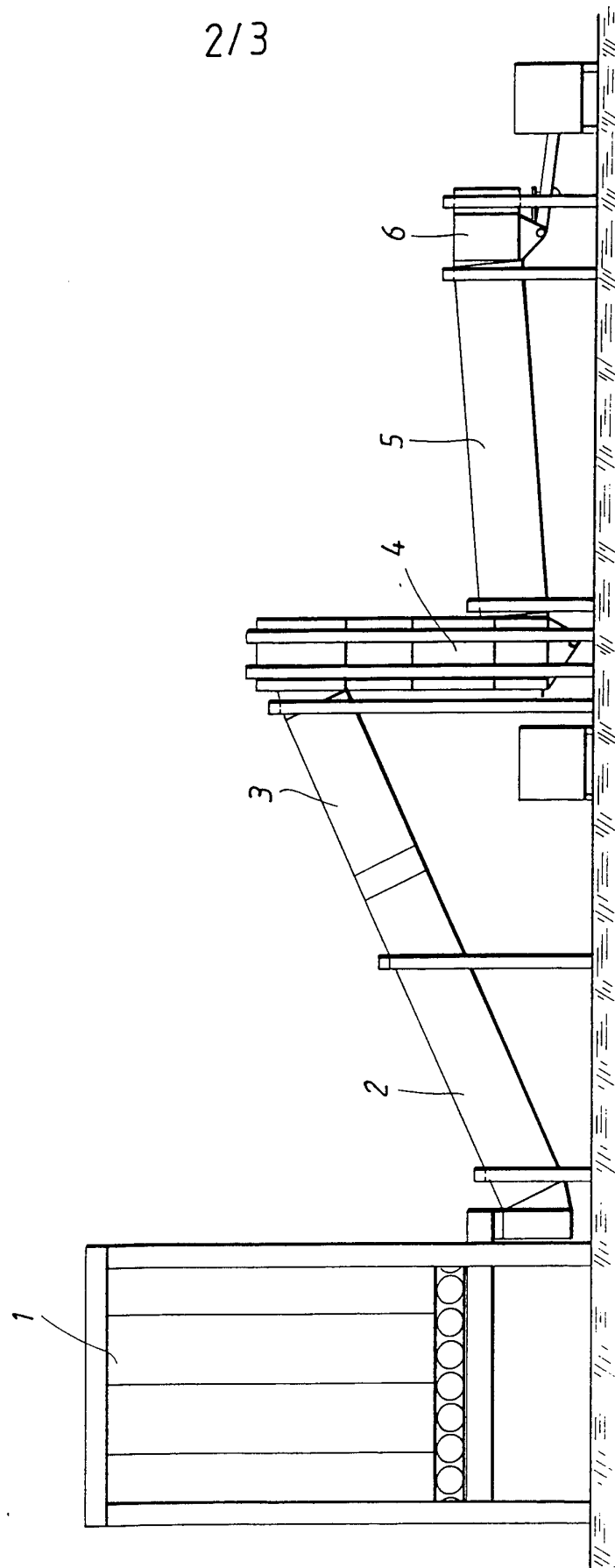
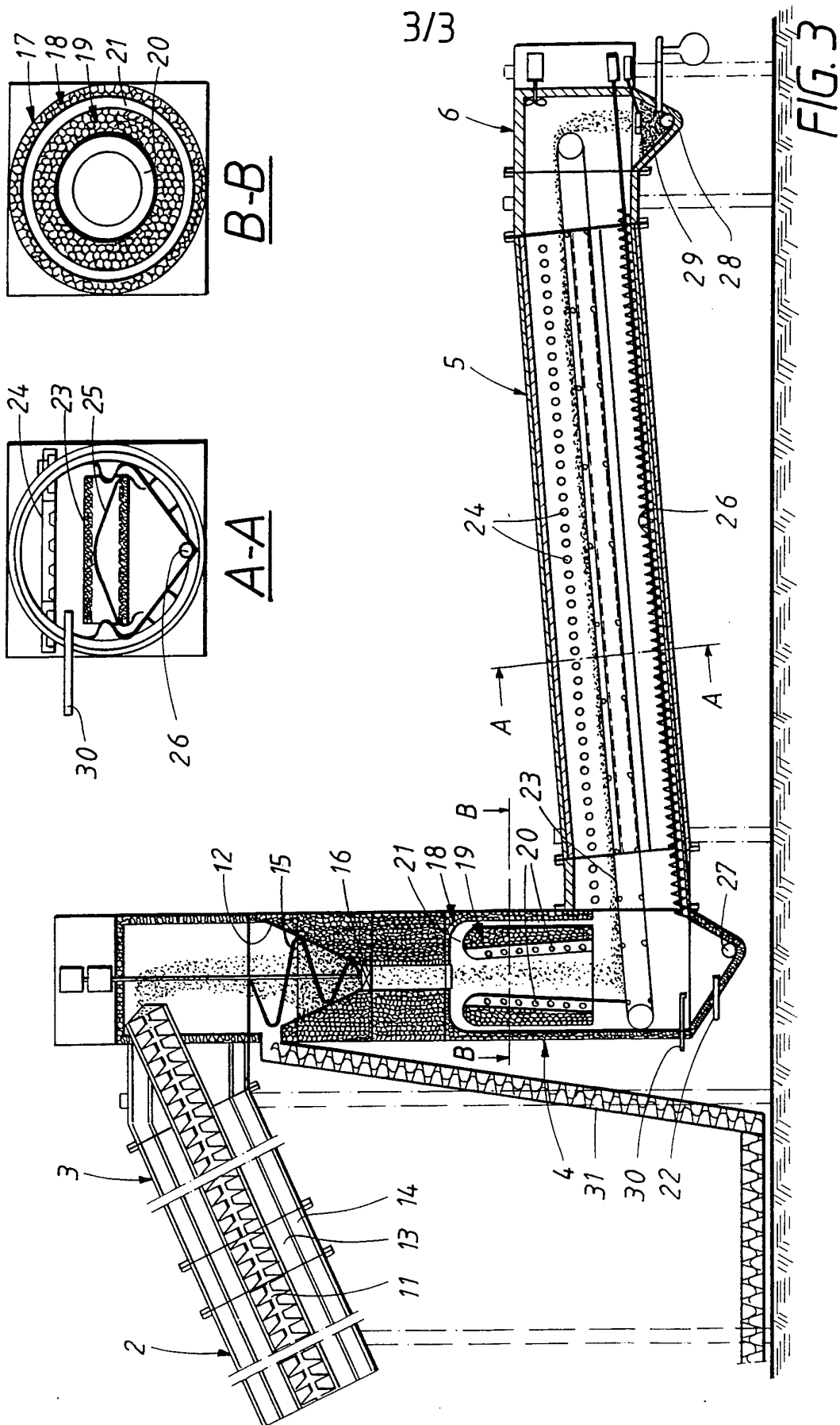


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 93/00897

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: F23G 7/12, F23G 5/02, C10B 53/00

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)

IPC5: F23G, C10B

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

SE,DK,FI,NO classes as above

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

WPI, CLAIMS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP, A2, 0495766 (TBR GESELLSCHAFT F. TECHN. BODENREINIGUNG GES.M.B.H.), 22 July 1992 (22.07.92), page 2, line 10 - line 20, figure 1, claim 1, abstract --	1-5
Y	US, A, 5084141 (KENNETH M. HOLLAND), 28 January 1992 (28.01.92), figure 1, abstract --	1-5
A	EP, A1, 0224999 (G.G.C.INC), 10 June 1987 (10.06.87), figure 1 --	1-5

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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"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

"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

10 March 1994

16-03-1994

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 Swedish Patent Office
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 Facsimile No. +46 8 666 02 86

Authorized officer

Mårten Hulthén
 Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 93/00897

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP, A2, 0257018 (VOEST-ALPINE AKTIENGESELLSCHAFT), 24 February 1988 (24.02.88), column 5, line 21 - line 26, figure 1 --	1-5
A	EP, A1, 0330070 (STENAU, THEO), 30 August 1989 (30.08.89), figure 1, abstract --	1-5
A	WO, A1, 8102302 (DEUTSCHE KOMMUNAL-ANLAGEN MIETE GMBH), 20 August 1981 (20.08.81), figure 1 --	1-5
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A	US, A, 4900401 (NORMAN P. HORTON), 13 February 1990 (13.02.90), figure 3, claim 1 -- -----	1-5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 93/00897

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Claims 1-5: A method for continuous recovery of materials such as gas, oil and solid substances from, e.g., rubber.

Claims 6-10: Arrangement for continuous recovery of materials such as gas, oil and solid substances from, e.g., rubber. The arrangement is not specifically designed for carrying out the method as defined by claims 1-5.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

28/01/94

International application No.
PCT/SE 93/00897

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US-A- 5084141	28/01/92	DE-A- 3880155 EP-A,B- 0409835 SE-T3- 0409835	13/05/93 30/01/91
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US-A- 4900401	13/02/90	NONE	