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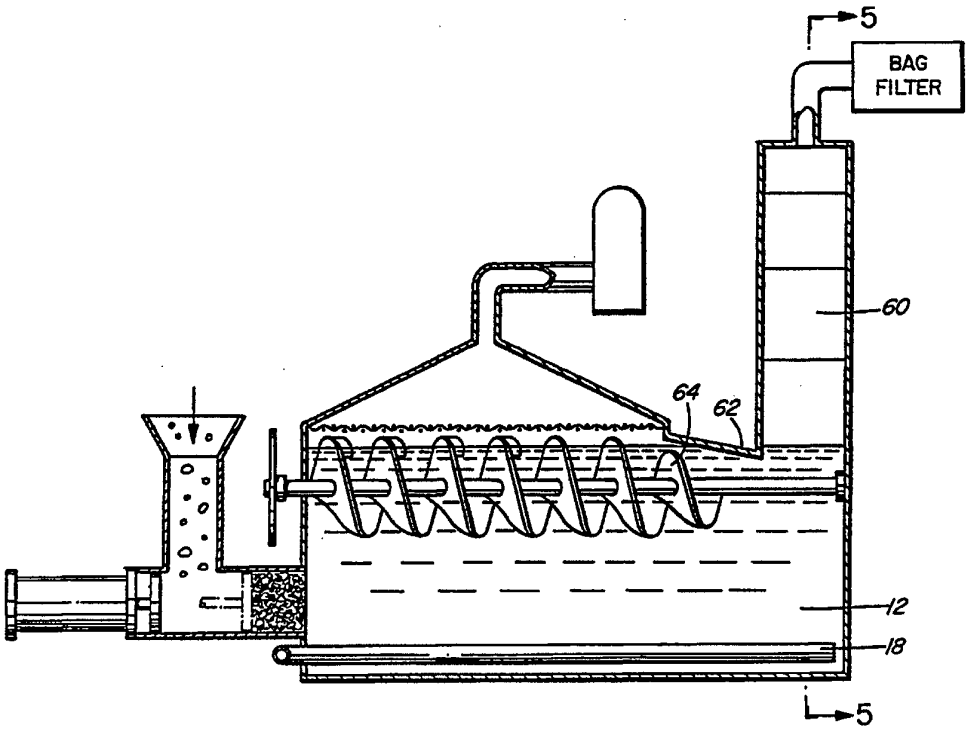
(54) Title: HYDROCARBON THERMAL PROCESSING APPARATUS

(57) Abstract

Apparatus for the thermal conversion of solids containing hydrocarbons. In one embodiment for solids which can be converted entirely to vapour, pieces of the solids are continually fed into a molten lead bath in an oxygen free atmosphere in an elongated conversion chamber. An auger partially immersed in the lead bath carries the floating pieces along in the molten lead bath until they are gradually converted to hydrocarbon vapour which rises upwardly to a condenser. In another embodiment for solids which can be converted to a vapour, particulate matter and residual solids, the lead bath extends further into a separation chamber with an inclined retaining skirt extending between the conversion chamber and the separation chamber. The auger forces the particulate matter and residual solids remaining after vaporization down under the inclined skirt, but the hydrocarbon vapour is prevented from escaping into the separation chamber. A scraper mechanism draws the remaining particulate matter and residual solids out of the molten lead bath up along an inclined surface. Inert gas blown through a screen in the inclined surface separates the particulate matter from the residual solids. The particulate matter is carried upwardly to a collector and the residual solids drop down through a residual solids outlet.



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HYDROCARBON THERMAL PROCESSING APPARATUS

TECHNICAL FIELD

This invention relates to the thermal conversion of solids containing hydrocarbons into a vapour and possibly also other constituents such as particulate matter and residual solids.

BACKGROUND ART

The disposal of organic materials such as vehicle tires and numerous plastic products have become more and more of a problem. They are not accepted at many landfills because they decompose very slowly, if at all, and may produce contaminating products. While it is known to thermally convert organic solids to their reusable constituents in a batch process, this has been found to be very inefficient.

U.S. Patent Numbers 4,925,532 to Meuser et al. which issued May 15, 1990 and 5,085,738 to Harris et al. which issued February 4, 1992 do disclose apparatus for continuous feed pyrolysis processes having an oxygen free atmosphere over a molten metal bath in which organic solids are thermally converted to hydrocarbon vapours, particulate matter and residual solids. However, both of these processes have been found to have too many operational problems to be commercially viable. The problems include difficulties with the separation and removal of particulate matter and residual solids and, referring particularly to the apparatus in U.S. Patent Number 5,085,738, difficulties in maintaining an oxygen free atmosphere over the molten metal bath while continually feeding the organic solids therein and high maintenance.

DISCLOSURE OF THE INVENTION

Apparatus for thermal processing solids containing hydrocarbon wherein pieces of the solids are continually fed into a heated liquid bath in an elongated conversion chamber through an inlet at the first of the conversion chamber. The

conversion chamber has a substantially oxygen free vapour collection portion extending above the liquid bath to a vapour outlet. The pieces of solids float in the liquid bath and are conveyed along the conversion chamber until conversion to a vapour occurs. In one embodiment, particulate matter and residual solids remaining in the conversion chamber after removal of the vapour are forced downwardly into the liquid bath beneath an inclined skirt into an adjacent separation chamber. The particulate matter and residual solids are drawn out of the liquid bath and recovered separately in the separation chamber.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a partial sectional view of apparatus having a conversion chamber according to one embodiment of the invention,

Figure 2 is a cross-sectional view along line 2-2 in Figure 1,

Figure 3A is an isometric view of a portion of the auger seen in Figures 1 and 2,

Figure 3B is a similar view from the opposite side,

Figure 4 is a view similar to Figure 1 of apparatus also having a separation chamber according to another embodiment of the invention, and

Figure 5 is a cross-sectional view along line 5-5 in Figure 4.

MODES FOR CARRYING OUT THE INVENTION

Reference is first made to Figures 1 and 2 which show apparatus according to one embodiment of the invention for the thermal conversion of solids containing hydrocarbon. In this case, the solids such as pieces of various types of plastic 10 which are fed into an elongated conversion chamber 12 are entirely converted to a vapour and no separation chamber is required. As can be seen, the conversion chamber 12 has a first end 14 and a second end 16 with gas heater

pipes 18 extending therein to heat a liquid bath 20 to a predetermined temperature. In this case, the liquid bath 20 is molten lead and the temperature is between 850°F and 950°F. In other embodiments, the liquid bath 20 can be a different suitable material such as aluminium nitrite with the same or a different predetermined temperature depending upon the thermal characteristics of the material being processed. The molten lead bath 20 has an upper surface 22 at a predetermined level in the conversion chamber 12. The conversion chamber 12 has a vapour collection portion 24 extending above the molten lead bath 20 to a vapour outlet 26 with a pipe 28 leading to a hydrocarbon condenser 30. The condenser 30 is cooled in a conventional way to condense at least most of the heavier hydrocarbons received and includes collection tanks (not shown). Although not shown for ease of illustration, some of the recovered hydrocarbons can be pumped to the heater pipes 18 and burned to maintain the temperature of the molten lead bath 20.

A feeder 32 receives the pieces of plastic 10 through a hopper 34. In this embodiment, the pieces of plastic 10 are continually fed into the molten lead bath 20 through an inlet 36 at the first end 14 of the conversion chamber 12 by a reciprocating ram 38 driven by a hydraulic cylinder 40. The force of the ram builds up a plug 41 which prevents the escape of the liquid bath 20 from the conversion chamber 12. In other embodiments, the feeder 32 can be a screw extruder or other suitable means. The pieces of plastic 10 then float upward in the molten lead bath 20 where they are engaged by an auger 42 which extends along the conversion chamber 12 from the first end 14 and is partially immersed in the molten lead bath 20. The auger 42 has a flight extending helically around a central shaft 46. The auger 42 is rotated continually by a motor (not shown) through a drive pulley 48 on the central shaft 46 which extends out through the first end 14 of the conversion chamber 12. As best seen in Figure 2, in this embodiment of the invention a solids retaining

screen 50 having a semicircular cross-section fits around an upper portion 52 of the auger 42 with a small space between it and the auger flight to prevent the floating solids accumulating along the sides 54 of the conversion chamber. The screen 50 has a mesh small enough to retain the solids, but large enough to allow vapour to flow through and in this embodiment is a VEE (Trade Mark of Johnson Filtration System for V-shaped wire screens) screen.

In use, the apparatus is assembled as shown and pieces 10 of plastic are fed in with the ram activated to build up the plug 41. After the vapour collection portion 24 of the conversion chamber 12 above the molten lead bath 20 is purged with an inert gas to remove substantially all of the oxygen therefrom the molten lead bath 20 is heated to a predetermined temperature. Pieces of plastic 10 are then loaded into the hopper 34 from which they are continually fed into the molten lead bath 20 in the conversion chamber 12 through inlet 36 by the feeder 32. The pieces of plastic 10 are heated and gradually converted by pyrolysis to hydrocarbon vapour as they float upwardly to the surface 22 of the molten lead bath 20 and are carried along by the auger 42. The hot hydrocarbon vapour rises in the vapour collection portion 24 of the conversion chamber 12 upwardly through the screen 50 to the outlet 26 and then to the hydrocarbon condenser 30 for recovery. As best seen in Figures 3A and 3B, in this embodiment the auger flight 44 has a number of curved plough portions 56 spaced along it. These plough portions 56 extend at 90° from the outer edge of auger flight 44 and have a trailing tip 58 to catch the pieces of plastic 10 floating on the surface 22 of the molten lead bath 20 as the auger 42 rotates. This reimmerses the pieces of plastic 10 in the molten lead bath 20 as the plough portions 56 rotate downwardly and then releases them under the surface 22 of the molten lead bath 20 as they rotate upwardly. This constant reimmersion of the pieces of plastic 10 expedites conversion and avoids the formation of larger lumps of solids.

Reference is now made to Figures 4 and 5 in describing another embodiment of the invention in which pieces of solids containing hydrocarbon such as used vehicle tires are thermally converted to hydrocarbon vapour, hydrocarbon particulate matter such as carbon black, and residual solids such as steel belt from the tires. As many elements are the same or similar to those described above, their description will not be repeated and elements common to both embodiments will be described and illustrated using the same reference numerals. In this case, the molten lead bath 20 also extends into a separation chamber 60 which extends from the second end 16 of the conversion chamber 12 with a vapour retaining skirt 62 extending therebetween. The auger 42 has an inwardly tapered portion 64 which extends under the downwardly inclined skirt 62. Thus, the carbon black and steel belt left after the hydrocarbon vapour has been removed are forced by the action of the auger 42 under the inclined skirt 62 and into the separation chamber 60 without allowing the hydrocarbon vapour to escape from the vapour collection portion 24 of the conversion chamber 12 into the separation chamber 60. As best seen in Figure 5, the separation chamber 60 has a mid-portion 66 which extends along a beach or surface 68 inclined upwardly out of the molten lead bath 20. The separation chamber 60 has a scraper mechanism 70 with a number of spaced blades 72 which travel in a continuous cycle through a portion of the lead bath 20 and up along the inclined surface 68 to draw the carbon black and steel belt floating on the molten lead bath 20 upwardly along the inclined surface 68.

In this embodiment, the inclined surface 68 has at least an upper portion 74 formed of the VEE screen and an inert gas purge 76 blowing upwardly through the screen 74 to remove the carbon black 78 from the steel belt through an upwardly extending particulate matter outlet 80 leading to a collector 82 such as a bag filter. The remaining steel belt 84 then drop downwardly from the inclined surface 68 to a residual solids outlet 86 where they are collected. In

addition to removing the particulate matter 78, the inert gas purge 76 also keeps the separation chamber 60 substantially free of oxygen. While, in this embodiment, the blades 72 travel along the stationary inclined surface 68, in other embodiments an inclined conveyer can be used to draw the remaining particulate matter 78 and residual solids 84 out of the molten lead bath 20.

While the description of the thermal processing apparatus has been given with respect to preferred embodiments, it will be evident that various other modifications are possible without departing from the scope of the invention as understood by those skilled in the art and as defined in the following claims.

INDUSTRIAL APPLICABILITY

The apparatus of the present invention provides an advantageous and efficient thermal conversion process which operates continuously. The apparatus shown in Figures 1, 2, 3A and 3B is used for materials such as various types of plastic which are entirely converted to a vapour. The pieces of the material 10 float along in the heated liquid bath 20 until they are converted to a vapour which is removed through the vapour collection portion 24 of the conversion chamber 12. The apparatus shown in Figures 4 and 5 is used for materials such as used vehicle tires which are converted to hydrocarbon particulate matter and residual solids as well as hydrocarbon vapour. In this case, after the hydrocarbon vapour is removed in the conversion chamber 12, the hydrocarbon particulate matter and the residual solids pass under an inclined skirt into an adjacent separation chamber where they are separated and removed. Thus, an efficient continuous process is provided for recovering the constituents of materials such as used vehicle tires and the like.

CLAIMS

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Thermal processing apparatus for thermally converting solids containing hydrocarbon to vapour comprising an elongated conversion chamber (12) with a first end (14) and a second end (16), the conversion chamber (12) being filled to a predetermined level with a heated liquid bath (20) having a predetermined temperature with a substantially oxygen free vapour collection portion (24) extending above the liquid bath (20) to a vapour outlet (26), characterized by;

(a) feed means (32) to continually feed pieces (10) of the solids containing hydrocarbon into the liquid bath (20) through an inlet (36) at the first end (14) of the conversion chamber (12) whereby the pieces (10) of solids float in the heated liquid bath (20), and

(b) conveying means (42) extending from the first end (14) of the conversion chamber (12) to continually move the pieces (10) of solids floating in the heated liquid bath (20) along the elongated conversion chamber (12) until conversion to a vapour occurs.

2. Thermal processing apparatus as claimed in claim 1 wherein the conveying means is an auger (42) extending along the conversion chamber (12), the auger (42) being partially immersed in the heated liquid bath (20).

3. Thermal processing apparatus as claimed in claim 2 wherein the solids inlet (36) at the first end (14) of the conversion chamber (12) is below the auger (42).

4. Thermal processing apparatus as claimed in claim 3 further comprising;

(c) a first solids retaining screen (50) extending along the conversion chamber (12) above the auger (42), the first solids retaining screen (50) having a semicircular cross-section to fit around and be spaced a predetermined distance from an upper portion (52) of the auger (42).

5. Thermal processing apparatus as claimed in claim 4 wherein the auger (42) has at least one helical flight (44) extending from a central shaft (46), the flight (44) having a plurality of plough portions (56) spaced therealong, the plough portions (56) being shaped and extending at an angle from the flight (44) sufficient to reimmerse the pieces (10) of solids in the heated liquid bath (20) as the auger (42) revolves.

6. Thermal processing apparatus as claimed in claim 5 wherein the heated liquid bath (20) is molten lead and the predetermined temperature is between 850°F. and 950°F.

7. Thermal processing apparatus for thermally converting solids containing hydrocarbon to vapour, particulate matter and residual solids comprising an elongated conversion chamber (12) with a first (14) and a second end (16), the conversion chamber (12) being filled to a predetermined level with a heated liquid bath (20) having a predetermined temperature with a substantially oxygen free vapour collection portion (24) extending above the liquid bath (20) to a vapour outlet (26), characterized by;

(a) feed means (32) to continually feed pieces (10) of the solids containing hydrocarbon into the liquid bath (20) through an inlet (36) at the first end (14) of the conversion chamber (12) whereby the pieces (10) of solids float in the

heated liquid bath (20), and

(b) conveying means (42) extending from the first end (14) of the conversion chamber (12) to continually move the pieces of solids floating in the heated liquid bath (20) along the elongated conversion chamber (12) until conversion to a vapour occurs,

(c) a first solids retaining screen (50) extending along the conversion chamber (12) above the auger (42), the first solids retaining screen (50) having a semicircular cross-section to fit around and be spaced a predetermined distance from an upper portion of the auger (42),

(d) a separation chamber (60) extending from the second end (16) of the conversion chamber (12), the heated liquid bath (20) extending into the separation chamber (60) with a vapour retaining skirt (62) inclined downwardly into the heated liquid bath (20) between the conversion chamber (12) and the separation chamber (60) to prevent the vapour escaping from the vapour collection portion (24) of the conversion chamber (12) into the separation chamber (60) while the particulate matter (78) and residual solids (84) remaining in the conversion chamber (12) after removal of the vapour are forced by the auger (42) downwardly into the heated liquid bath (20) beneath the inclined skirt (62) into the separation chamber (60), and

(e) separation means in the separation chamber (60) to remove the particulate matter (78) and residual solids (84) from the heated liquid bath (20) and separate the particulate matter (78) from the residual solids (84), with the particulate matter (78) flowing to a particulate matter collector (82) and the residual solids (84) dropping downwardly to a residual solids outlet (86).

8. Thermal processing apparatus as claimed in claim 7 wherein the separation means comprises an inclined surface (68) along which the particulate matter (78) and residual solids (84) are drawn upwardly out of the heated liquid bath (20) and from which the residual solids (84) are dropped to the residual solids outlet (86), at least a portion of the inclined surface (68) being a screen (50) through which an inert gas is blown upwardly to the particulate matter collector (82) to separate the particulate matter (78) from the residual solids (84).

9. Thermal processing apparatus as claimed in claim 8 further comprising;

(f) scraper means (70) mounted in the separation chamber (60) having a plurality of spaced blades (72) travelling in a continuous cycle through a portion of the heated liquid bath (20) and up along the inclined surface (68) to draw the particulate matter (78) and residual solids (84) floating in the heated liquid bath (20) upward along the inclined surface (68).

10. Thermal processing apparatus as claimed in claim 9 further comprising heating pipes (18) extending through the heated liquid bath (20) in the conversion chamber (12) and the separation chamber (60) to heat the liquid bath (20) to the predetermined temperature.

11. Thermal processing apparatus as claimed in claim 10 wherein the heated liquid bath (20) is molten lead and the predetermined temperature is between 850°F. and 950°F.

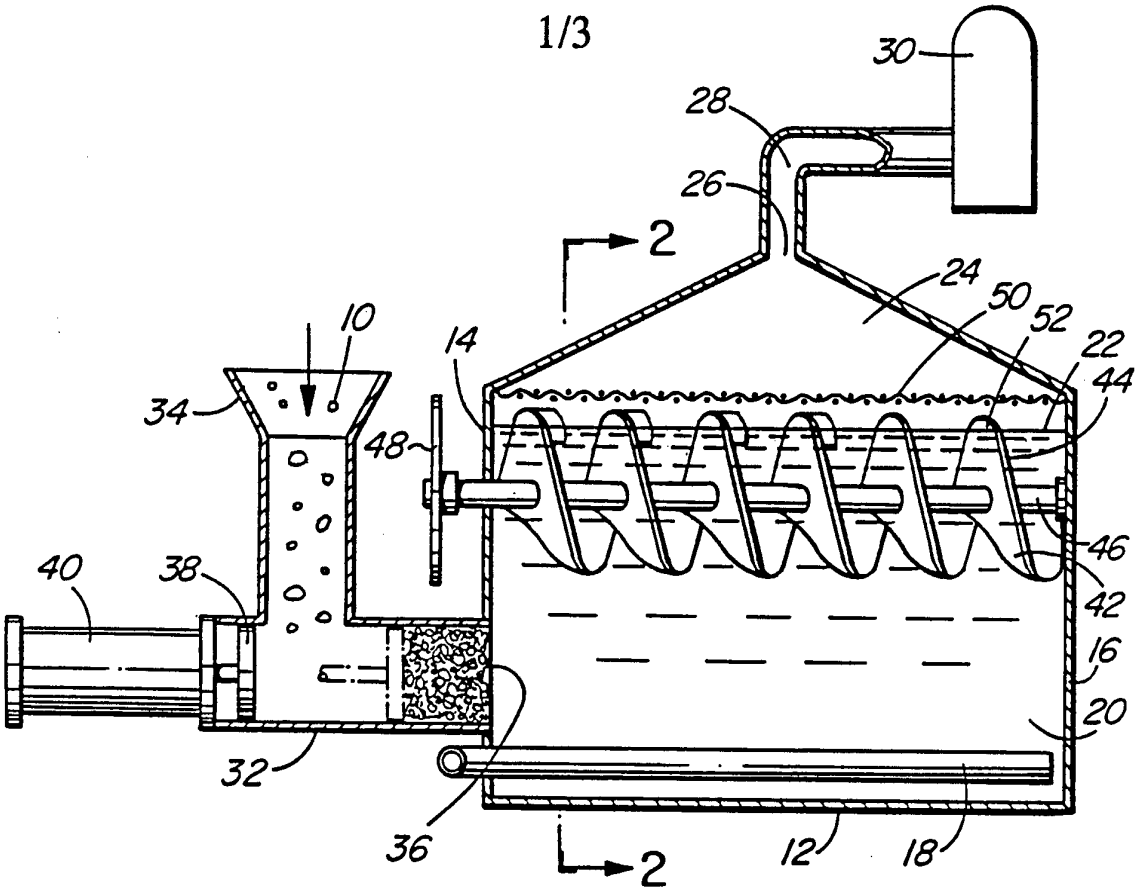

FIG. 1

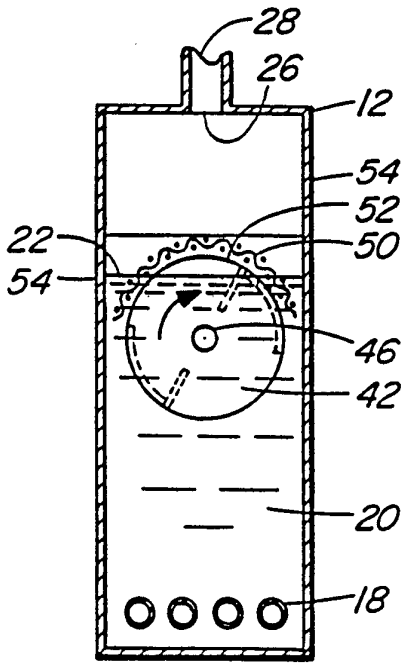

FIG. 2

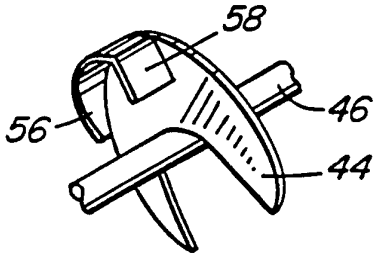

FIG. 3A

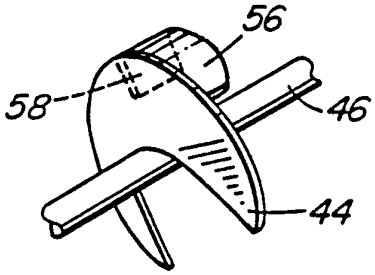

FIG. 3B

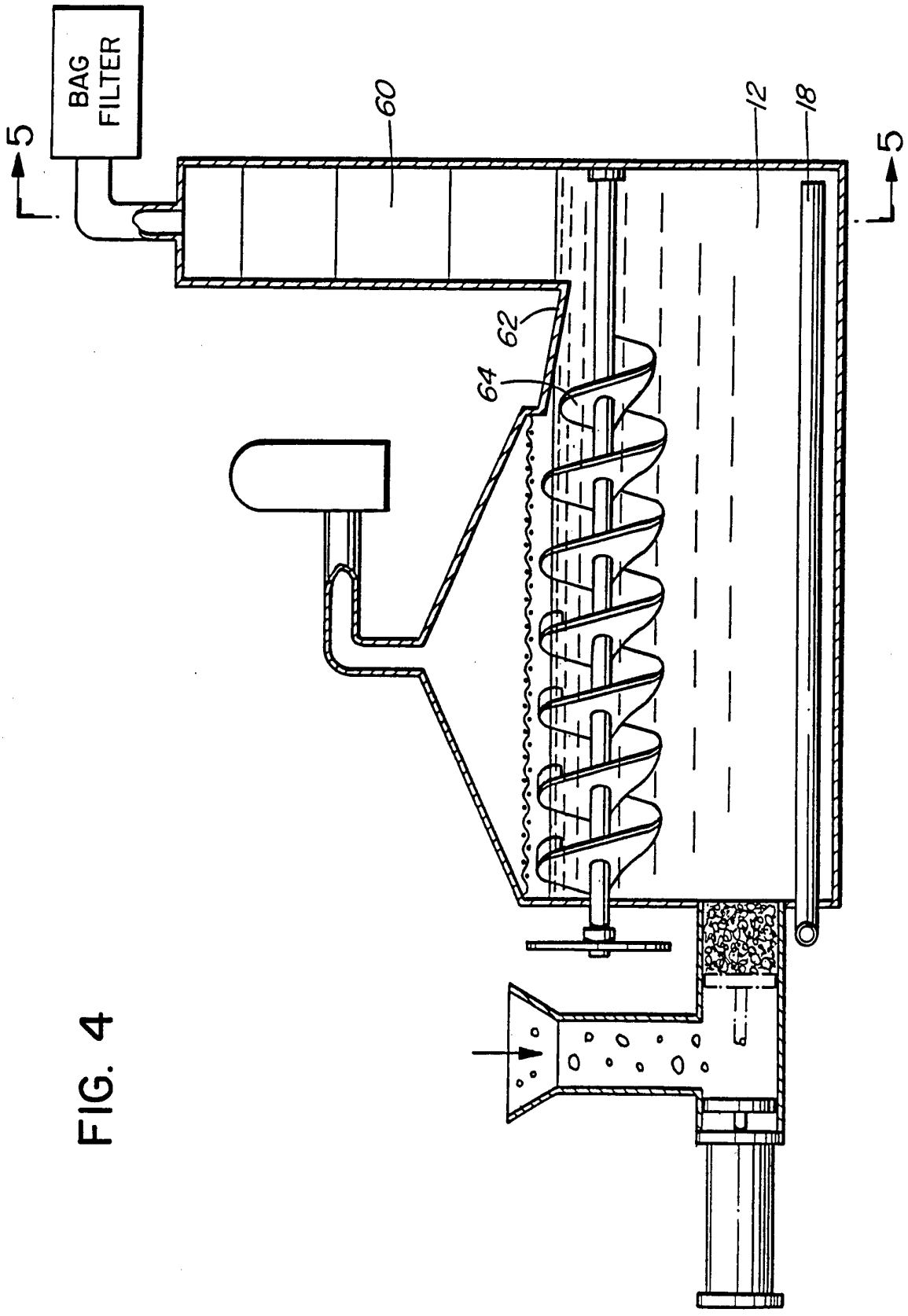

FIG. 4

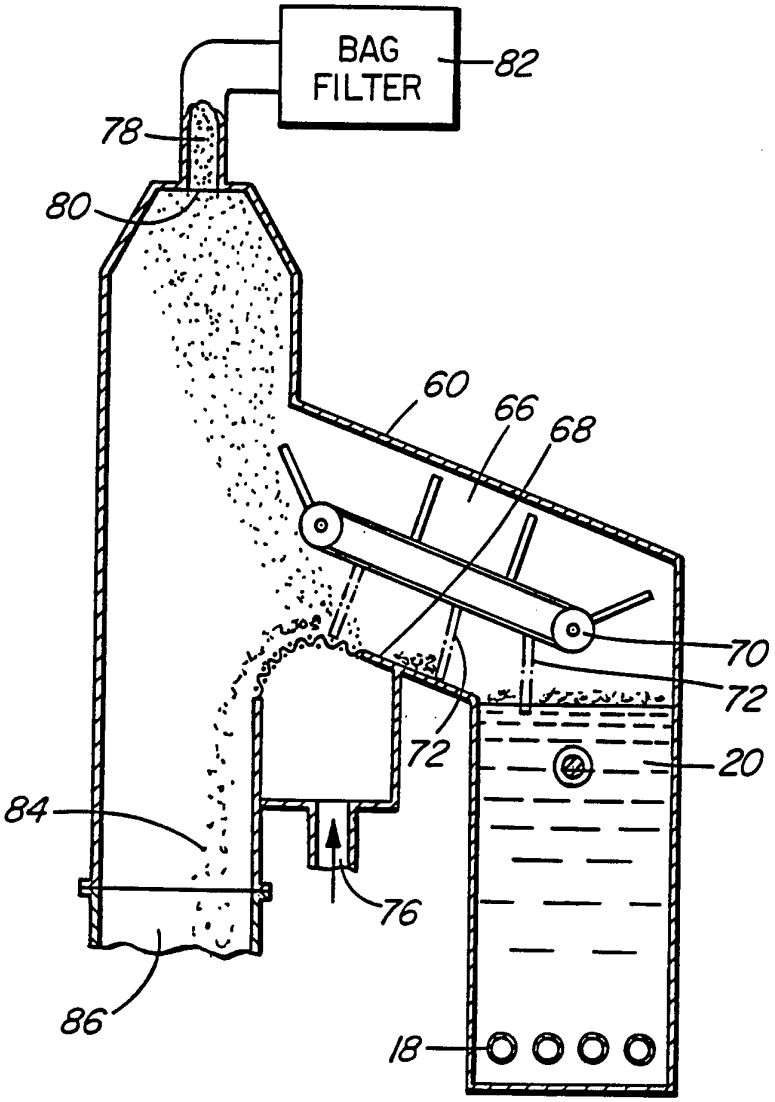

FIG. 5

INTERNATIONAL SEARCH REPORT

Inter ıal Application No
PCT/CA 95/00366

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C10G1/02 C10B49/14 C10B53/00

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)
IPC 6 C10G C10B

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,86 00331 (SANKYO YUKI KK) 16 January 1986	1-3
A	*abstract* see figure 1 ---	1-3,6
A	US,A,4 357 231 (ESTES JOHN H ET AL) 2 November 1982 ---	
A	EP,A,0 025 319 (PYRO CONVERSION INC) 18 March 1981 -----	

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Date of the actual completion of the international search	Date of mailing of the international search report
25 September 1995	04 -10- 1995

Name and mailing address of the ISA	Authorized officer
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Information on patent family members

Interr al Application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-8600331	16-01-86	NONE	
US-A-4357231	02-11-82	NONE	
EP-A-0025319	18-03-81	AU-A- 6191780	05-03-81
		GB-A- 2061473	13-05-81
		JP-A- 56065084	02-06-81