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(54) PYROLYSIS PROCESS FOR SIMULTANEOUSLY CONVEYING AND AGITATING CRACKING FEEDSTOCK WITHIN A SCREW

(57) A pyrolysis process is incorporated with a pyrolysis furnace in the process. The pyrolysis furnace comprises an upper screw and a lower screw juxtaposed to the upper screw to smoothen the thermal cracking process, with each blade helically formed on the screw shaft being notched in the periphery of the screw blade to form a plurality of bifurcated fins on the blade, such that besides the conveying of feedstock in the screw as driven by the blade, the bifurcated fins may serve as agitating elements, thereby simultaneously conveying the feedstock and agitating the feedstock for increasing the production efficiency of the pyrolysis.

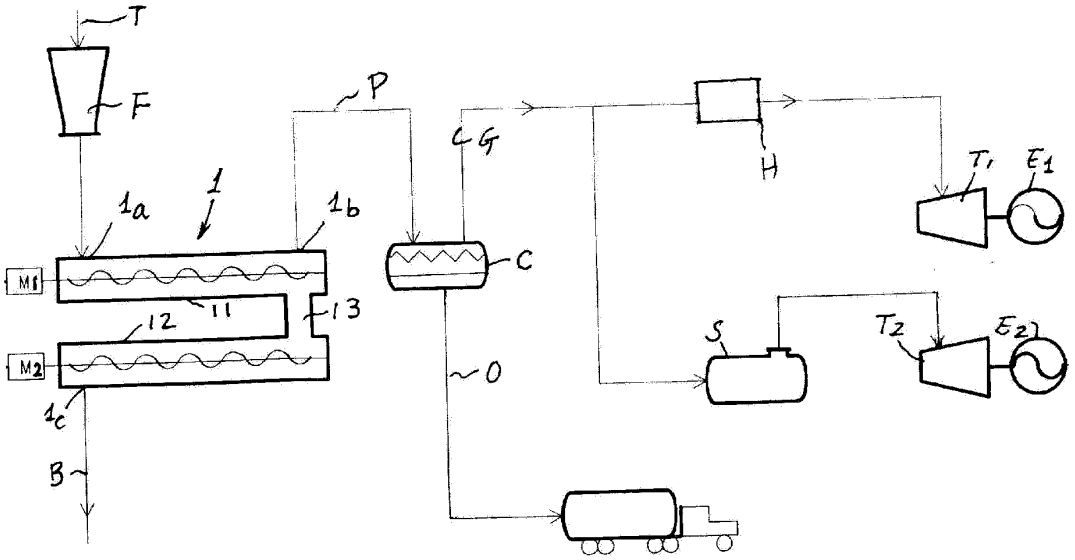

Fig. 1

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Description

BACKGROUND

[0001] A conventional pyrolysis furnace comprises a long screw having blade helically formed on a screw shaft for thermally cracking waste tires for producing pyrolysis oil and gas.

[0002] However, such a conventional pyrolysis furnace has the following drawbacks:

1. The screw only serves as a conveyor for forwarding the feedstock of waste tire chips. There is no further agitating elements provided in the screw. In order to provide enough heat to thermally crack the feedstock, a long screw (pipe) and higher temperature should be applied in such a conventional screw, thereby increasing the installation cost, and consuming much energy for thermally cracking the waste tire chips.
2. The feedstock as charged into the screw through the inlet, after bing thermally cracked, will be discharged through an outlet, which is distantly left from the inlet. The cracking gasified products including cracking oil and gas may exert a great back pressure within the screw, thereby retarding a conveying of the feedstock from the inlet towards the cutlet, and influencing a smooth operation of the pyrolysis process.
3. Since the waste tires always contain corrosive sulfur content, the sulfur will be gradually released during the conveying process within such a long screw pipe, and may cause corrosion on the screw blades and pipe wall of the screw, thereby shortening the service life of the screw, and increasing the maintenance cost.

[0003] The present inventor has found these drawbacks of a conventional pysolysis process, and invented a pyrolysis process to overcome the drawbacks of the conventional process.

THE INVENTION

[0004] The object of the present invention is to provide a pyrolysis process by incorporating a pyrolysis furnace in the process. The pyrolysis furnace comprises an upper screw and a lower screw juxtaposed to the upper screw to smoothen the thermal cracking process, with each blade helically formed on the screw shaft being notched in the periphery of the screw blade to form a plurality of bifurcated fins on the blade, such that besides the conveying of feedstock in the screw as driven by the blade, the bifurcated fins may serve as agitating elements, thereby simultaneously conveying the feedstock and agitating the feedstock for increasing the production efficiency of the pyrolysis.

Brief Description of the Drawings:

[0005]

Fig. 1 shows a flow sheet of the pyrolysis of the present invention.
Fig. 2 is an illustration showing the operation of the pyrolysis furnace of the present invention.
Fig. 3 is a partial perspective view showing the bifurcated fins as formed on the blade of screw.
Fig. 4 is an illustration showing the upper furnace and lower furnace of the pyrolysis furnace of the present invention.
Fig. 5 shows the blades on the screw with different pitches.

Detailed Description:

[0006] As shown in the drawings, the present invention comprises a pyrolysis furnace 1 comprised of an upper furnace 11 and a lower furnace 12 juxtaposed to and positioned under the upper furnace 11, a screw 2 having at least a blade 21 helically formed on a screw shaft 20 rotatably mounted in each furnace 11 or 12, a duct 13 connected between the upper finance 11 and the lower furnace 12 and also serving as a chimney between the lower furnace 12 and the upper furnace 11, with each screw 2 driven by a motor M1 or M2 as shown, and at least a heating device 3 disposed around each screw for heating the feedstock as conveyed within the screw 2, a feed port 1a formed on a leftmost end portion of the upper furnace 11 for feeding the tire chips T into the upper furnace 11 through a feeder or hopper F, a gas outlet 1b formed on a rightmost end portion of the upper furnace 11 for leading gasified product P outwardly to be separated as condensed cracking oil O and uncondensed cracking gas G.

[0007] The heating device 3 may be an electric heating element or heating coil disposed around each screw 2, or may be a heating element for supplying supply hot gas for heating each screw 2, not limited in the present invention.

[0008] The upper furnace 11 especially as shown in Fig. 4 includes: a first preheating chamber H1 formed on a left position of the upper furnace 11 for preheating the feedstock as fed into the upper furnace 11, a second preheating chamber H2 formed on a right side of the first preheating chamber H1 for further preheating the fed feedstock, a melting chamber H3 formed on a right side of the second preheating chamber H2 for melting the feedstock adapted for thermal cracking of the preheated feedstock, a first gasification chamber H4 formed on the right end of the upper furnace 11 and on a right side of the melting chamber H3 for producing gasified products P after pyrolysis cracking, which will be led outwardly through the gas outlet 1b; and a second gasification chamber H5 formed on the right end of the lower furnace 12 and positioned under the first gasification chamber H4 and fluidelly communicated with the upper furnace

through the duct 13, a first drying chamber H6 formed in the lower furnace 12 on the left side of the second gasification chamber H5 for drying and removing the gasified residual oil after the gasification step, a second drying chamber H7 formed on the left side of the first drying chamber H6 for further drying and removing the still remained residual oil of the gasified product, and a cooling chamber H8 formed on a left end portion of the lower furnace 12 and on a left side of the second drying chamber H7 for cooling the dried product, namely the carbon black B which may be discharged through a discharge port 1c formed on a leftmost end of the lower furnace 12.

[0009] The operating temperatures in each chamber H1-H8 may be summarized as follows:

H1.... (30°C ~150°C)
H2... (150°C ~350°C)
H3....(300°C ~550°C)
H4....(450°C ~650°C)
H5....(550°C ~850°C)
H6....(450°C ~650°C)
H7....(300°C ~500°C)
H8....(100°C -300°C)

[0010] The first driving motor M1 (Fig. 2) operatively drives the screw of upper furnace 11 rightwardly in order to drive the feedstock from the left side towards the right side adjacent to the gas outlet 1b. The second driving motor M2 operatively drives the screw of lower furnace 12 leftwardly from the right end of the lower furnace towards the left end of the lower furnace adjacent to the discharge outlet 1c for discharging the carbon black after the pyrolysis.

[0011] As shown in Fig. 5, the pitches of the screw 2 may be varied from lower pitch P1 towards higher pitch P2 in order to smoothly or quickly convey the feedstock from an upstream towards a downstream of the feedstock or pyrolized product. Fig. 5 is just served as an illustration showing one optional variation of pitches of this invention, but not limited for the pitch variation in this invention.

[0012] As shown in Fig. 3, each bifurcated fin 22 formed on the blade 21 helically formed on shaft 20 includes a first fin member 23 protruding leftwardly and a second fin member 24 protruding rightwardly opposite to the first fin member 23. During the production or processing, the blade 21 is notched or splitted and then formed or bent to be the two fin members 23, 24 leftwardly or rightwardly as shown in Fig. 3. The words "leftwardly" or "rightwardly" are defined to explain the opposite directions of the fin members 23, 24.

[0013] The number of the bifurcated fins 22 are not limited in this invention, which may be four or plural fins along a periphery of each blade segment.

[0014] Such a bifurcated fin 22 is very helpful to facilitate the agitation of feedstock as conveyed by the screw blade 21. The fins 22 in the screw may agitate the feedstock very well to enhance heat conduction in the feedstock when heated by the heating device 3 and to homogeneously mix the feedstock as being thermally cracked so as to increase the production efficiency of the present invention.

[0015] The depth D of each bifurcated fin 22 may be equal to 0.2R, of which R is the radius of each blade as shown in Fig. 3, but not limited in this invention.

[0016] Each fin member 23 or 24 may be formed or bent from the blade surface for an angle ranging from 120 to 150 degrees, but also not limited.

[0017] A geneal flow sheet of the present invention is shown in Fig. 1 to present the pyrolysis process, in which:

1. The waste tires are shredded into tire chips which is separated from steel wires in the tires, then stored into feeder or hopper F and fed into pyrolysis furnace 1 of the present invention.
2. The feedstock (tire chip) T as fed through the feed port 1a into the upper furnace 11 is thermally cracked to preheat, melt the chips and then gasified in the upper furnace to produce gasified products P including cracking oil and gases, which are then output through the gas outlet 1b to be separated, after being cooled by cooler C, to obtain cracking oil O as condensed by cooler C, and cracking gas G as uncondensed.
3. The partially gasified feedstock is then transferred to the lower furnace 12 through the duct 13 to be further gasified to be output through duct 13 and outlet 1b. Then, the feedstock is dried and cooled to produce carbon black B, which is drained through discharge or outlet port 1c. The carbon black may be further ground, pelletized, dried and packed for sales (not shown).
4. The uncondensed cracking gases G after cooler C will be output for power generation. Partial cracking gas is combusted in a combustion chamber H to produce hot gas for driving a gas (or syngas) turbine T1 and first generator E1 for generating power. Another partial cracking gas is fed into a steam boiler S for producing steam for driving a steam turbine T2 and a second generator E2 for power generation in another way.

[0018] The pyrolysis furnace 1 of the present invention is generally formed as a U shape (but not limited) to have the following advantages:

1. The furnace 1 is divided into an upper furnace 11 and a lower furnace 12, which may be "assumed" to bend a long-pipe furnace to be two parts, an upper part and a lower part. By so doing, major portion of feedstock is melted, and gasified in the upper furnace 11 and the major gasified product P produced in the upper furnace 11 will be released through outlet 1b. The remaining feedstock as partially gasified will then be transferred into the lower furnace 12 through

the duct 13 to be further gasified, dried and cooled for producing carbon black B to be discharged through outlet 1c. Since major pyrolized products have been removed from outlet port 1b, the conveying speed of the remaining feedstock as transferred into lower furnace 12 will be driven with less resistance, thereby increasing the production efficiency.

2. The duct 13 plays multiple roles, namely, firstly serving a connector to link the upper furnace 11 with the lower furnace 12; secondly serving as a "drain" port for transferring the feedstock partially cracked in the upper furnace 11 towards the lower furnace 12; and serving as a "chimney" for leading the gasified product from the lower furnace 12 towards the upper furnace 11, then discharged through outlet 1b, with such a "chimney" effect, the further gasified product will be fastly output through the duct 13 and outlet 1b.

3. The running path of the feedstock or product is shortened, either in the upper furnace 11 or lower furnace 12 to prevent from jamming or clogging in the furnace for facilitating the production. Since the back pressure as exerting during the conveying may be minimized, the production efficiency may then be increased.

4. The running path as above-mentioned may also minimize the corrosion problem, even rare sulfur-contained products existing in the feedstock, since the contact of the sulfar-contained product with the screw pipe wall, blade and other related equipment has been minimized.

[0019] By the aid of the bifurcated fins 22 formed on the screw blade 21, the feedstock may be further agitated for enhancing heat transfer from the heating device 3 for facilitating the production.

Claims

1. A pyrolysis process incorporating a pyrolysis furnace (1) in the process, said pyrolysis furnace (1) comprising an upper furnace (11) and a lower furnace (12) juxtaposed to and positioned under the upper furnace (11), a screw (2) having at least a blade (21) helically formed on a screw shaft (20) rotatably mounted in each said upper furnace (11) or lower furnace (12), a duct (13) connected between the upper furnace (11) and the lower furnace (12) and also serving as a chimney between the lower furnace (12) and the upper furnace (11), with each said screw (2) driven by a motor (M1 or M2), and at least a heating device (3) disposed around each said screw (2) for heating the feedstock as conveyed within the screw (2), a feed port (1a) formed on a leftmost end portion of the upper furnace (11) for feeding tire chips (T) into the upper furnace (11), a gas outlet (1b) formed on a rightmost end portion of the upper furnace (11) for leading gasified product (P) outwardly to be separated as condensed cracking oil (O) and uncondensed cracking gas (G), and a discharge port (1c) formed on a left end of said lower furnace (12) for discharging carbon black (B) as produced.

2. A process according to Claim 1, wherein said upper furnace (11) includes: a first preheating chamber (H1) formed on a left position of the upper furnace (11) for preheating the feedstock as fed into the upper furnace (11), a second preheating chamber (H2) formed on a right side of the first preheating chamber (H1) for further preheating the fed feedstock, a melting chamber (H3) formed on a right side of the second preheating chamber (H2) for melting the feedstock adapted for thermal cracking of the preheated feedstock, a first gasification chamber (H4) formed on the right end of the upper furnace (11) and on a right side of the melting chamber (H3) for producing gasified products (P) after pyrolysis cracking, which will be led outwardly through the gas outlet (1b); and a second gasification chamber (H5) formed on the right end of the lower furnace (12) and positioned under the first gasification chamber (H4) and fluidically communicated with the upper furnace (11) through the duct (13), a first drying chamber (H6) formed in the lower furnace (12) on a left side of the second gasification chamber (H5) for drying and removing a gasified residual oil after a gasification step, a second drying chamber (H7) formed on a left side of the first drying chamber (H6) for further drying and removing the residual oil of the gasified product, and a cooling chamber (H8) formed on a left end portion of the lower furnace (12) and on a left side of the second drying chamber (H7) for cooling the dried product, including carbon black (B) which is discharged through said discharge port (1c) formed on a left end of the lower furnace (12).

3. A process according to Claim 2, wherein said upper furnace (11) comprises a first driving motor (M1) operatively driving the screw (2) of upper furnace (11) rightwardly in order to drive the feedstock from the left side towards the right side adjacent to the gas outlet (1b); and said lower furnace (12) comprises a second driving motor (M2) operatively driving the screw (2) of lower furnace (12) leftwardly from the right end of the lower furnace towards the left end of the lower furnace (12) for discharging the carbon black (B) through the discharge outlet (1c) after the pyrolysis.

4. A process according to Claim 1, wherein each said furnace comprises a plurality of bifurcated fins (22) formed on each blade (21) of each screw (2), each said bifurcated fin (22) formed on the blade (21) helically formed on a shaft (20) in each screw (2), includes a first fin member (23) protruding leftwardly

and a second fin (24) member protruding rightwardly opposite to the first fin member (23) for agitating a feedstock in each screw (2).

5. A process according to Claim 4, wherein each said bifurcated fin (22) has a depth (D) in said blade (21), said depth (D) of each said fin (22) being equal to 0.2R, of which R is the radius of said blade (21).

6. A process according to Claim 4, wherein each said fin member (22) is formed or bent from a blade surface for an angle ranging from 120 to 150 degrees.

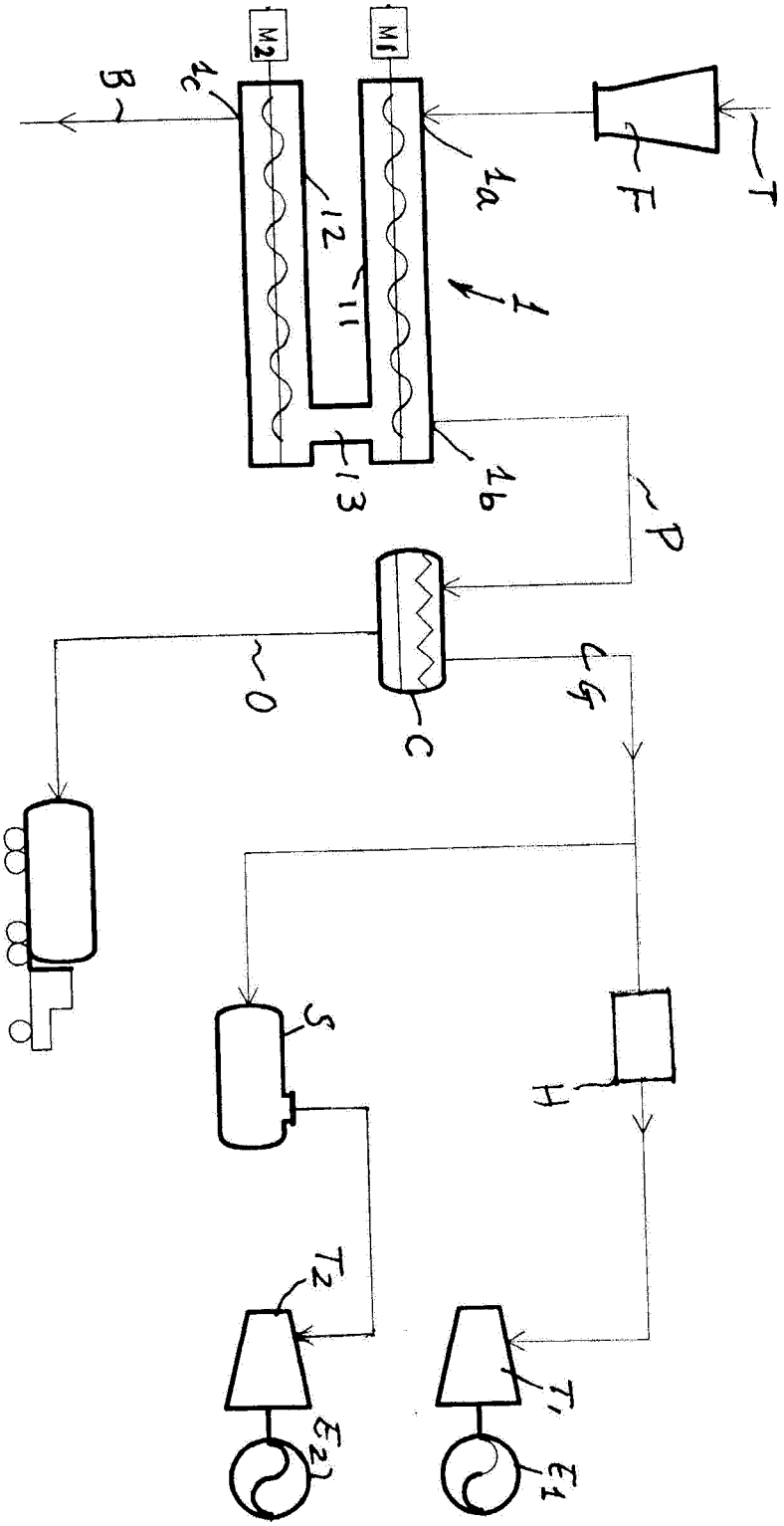

Fig. 1

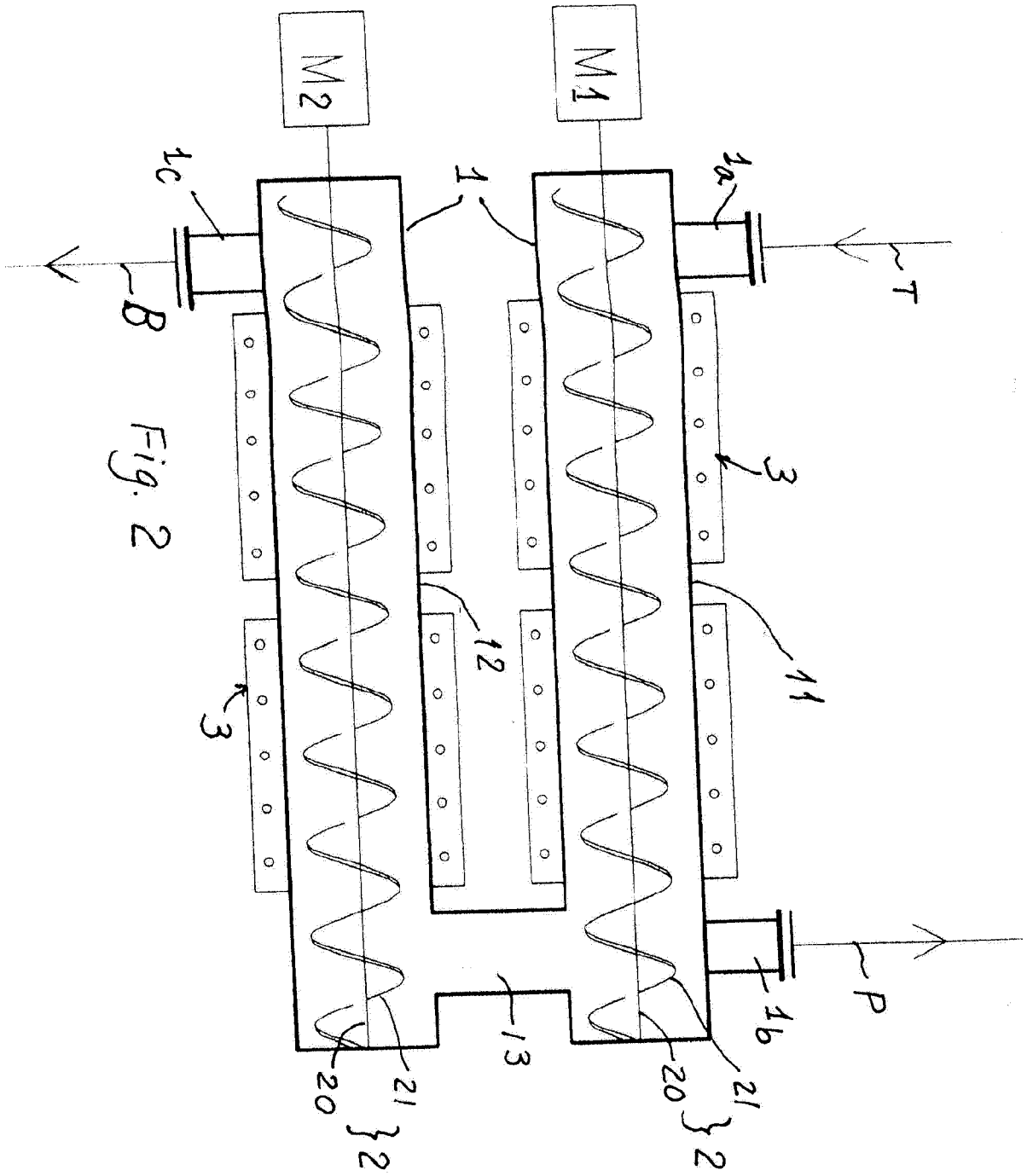

Fig. 2

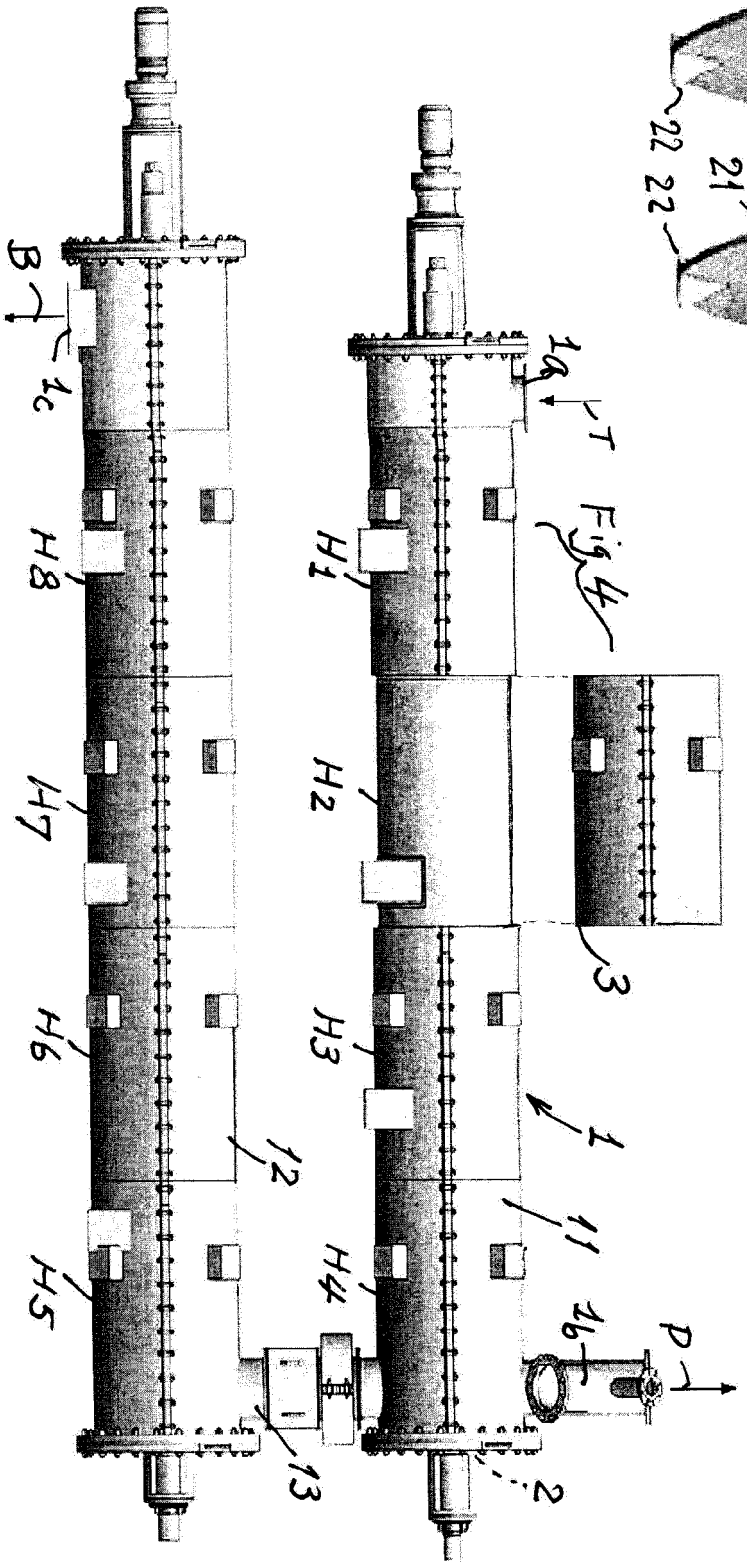
B
1c
H8
H7
H6
H5
12
13
H1
H2
H3
H4
1a
T
3
1
11
1b
P
2

Fig. 4

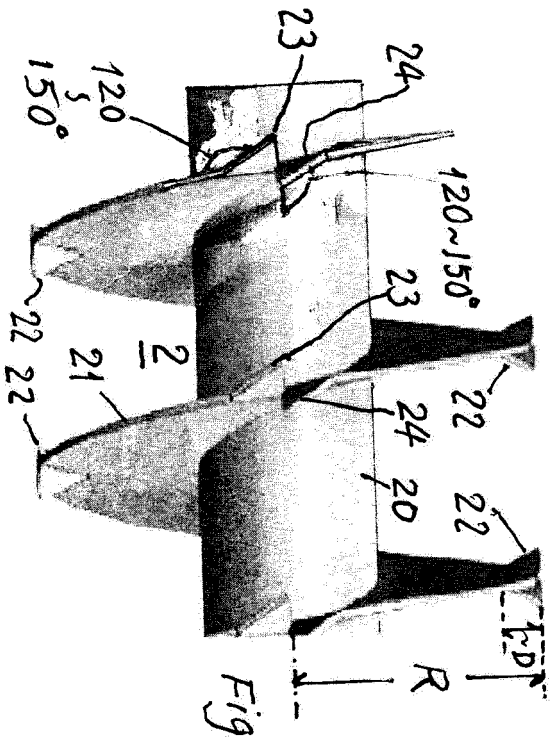
23
24
120
~
150°
120~150°
23
22
22
21
2
22
24
20
22
D
R

Fig. 3

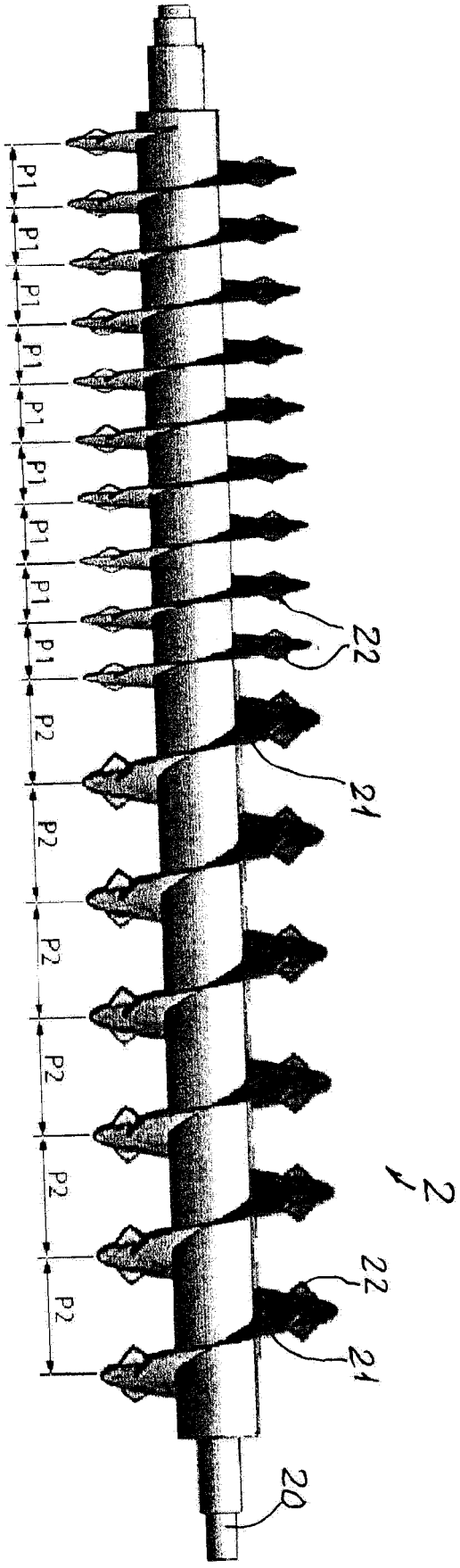

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 0759

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2009/250378 A1 (WU CHUN-YAO [TW] ET AL) 8 October 2009 (2009-10-08) * paragraphs [0024] - [0026], [0041] - [0044]; claims; figures 1-6 *	1-6	INV. C10B47/44 C10B53/07 C10G1/10
X	US 6 039 774 A (MCMULLEN FREDERICK G [US] ET AL) 21 March 2000 (2000-03-21) * column 21, lines 16-65; figures 4,5 * * column 11, line 44 - column 12, line 28 * * column 23, line 46 - column 26, line 33 *	1-6	ADD. C10B5/04 C10B7/10
X	US 2018/142174 A1 (GRAINGER JOHN [GB] ET AL) 24 May 2018 (2018-05-24) * paragraphs [0054] - [0076], [0126]; claims; figures 1a, 4 *	1-6	

TECHNICAL FIELDS SEARCHED (IPC)

C10B
C10G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	26 April 2024	Bertin, Séverine

CATEGORY OF CITED DOCUMENTS

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