(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 505 856 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.07.2019 Bulletin 2019/27

(21) Application number: **17002085.3**

(22) Date of filing: **27.12.2017**

(51) Int Cl.:
F27B 5/04 (2006.01) *C21D 1/773* (2006.01)
C21D 1/613 (2006.01) *F27B 5/16* (2006.01)
F27D 9/00 (2006.01) *F27B 5/06* (2006.01)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

(71) Applicant: **Seco/Warwick S.A.**
66-200 Swiebodzin (PL)

(72) Inventors:
- **KORECKI, Maciej**
  66-200 Swiebodzin (PL)
- **OLEJNIK, Józef**
  66-200 Swiebodzin (PL)
- **FUJAK, Wieslaw**
  66-210 Zbaszynek (PL)
- **RYBCZYNSKI, Bartosz**
  66-200 Swiebodzin (PL)
- **ZADWÓRNY, Marcin**
  66-004 Zielona Góra (PL)

(74) Representative: **Passowicz, Marek**
Rzecznicy Patentowi
"Dr. Andrzej Au & Co." s.c.
P.O. Box 85
60-967 Poznan 9 (PL)

(54) SINGLE-CHAMBER HIGH PRESSURE GAS QUENCH (HPGQ) FURNACE FOR HEAT TREATMENT OF LONG PIECES

(57) A single-chamber HPGQ vacuum furnace is equipped with a load cooling nozzle system which is divided into two subsystems. The first of which is installed on the side walls of the heating chamber (2), with the nozzle system directed towards the load (21), while the second one is built into the insulating wall of the hearth (3), executed in the form of collectors (24) placed in a circular arrangement in relation to each workpiece (21) situated vertically on hearth supports (3). Each of the collectors (24) has a row of blowing nozzles (30) arranged at the height of the workpiece (21) and directed at an angle between 75° and 105° towards the workpiece surface.

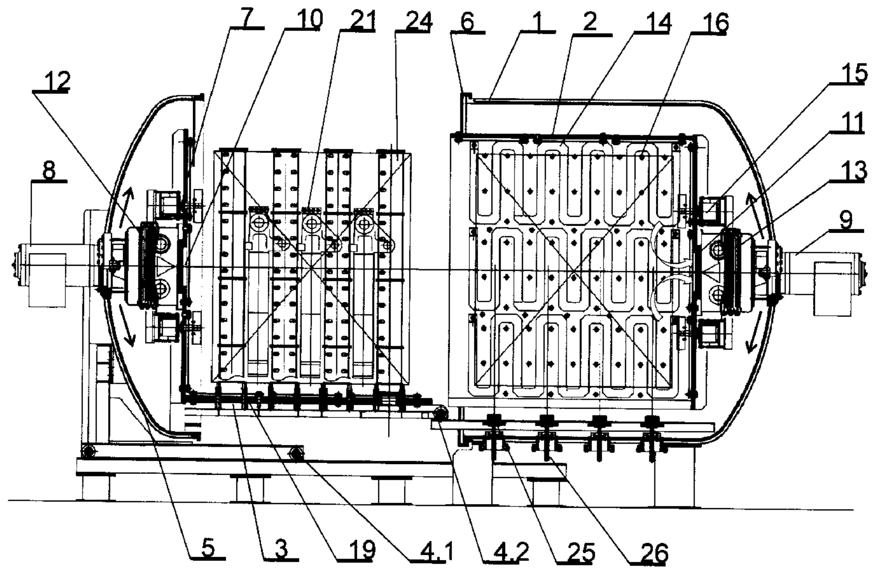


Fig.1

EP 3 505 856 A1

Description

[0001] The present invention is a single-chamber HPGQ vacuum furnace intended for heat treatment of long pieces, and particularly a single-chamber High Pressure Gas Quench (HPGQ) vacuum furnace intended for heat treatment of landing gear struts for passenger and transport aircrafts made of HSLA steel for quenching and tempering.

[0002] Known solutions of single-purpose vacuum furnaces for heat treatment of struts and landing gear parts made of HSLA steel for quenching and tempering have been described in the paper by C. Filice, D. Herring and P. Vanderpol entitled "Landing-Gear Heat Treatment" published in Industrial Heating (2011), where the load is heated and soaked in a separate heating chamber, while quenching takes place in another chamber, in quenching oil, in order to achieve cooling rate appropriate for those materials. Another known design solution of a vacuum furnace is the V6-TH model described in materials of BMI Fours Industriels (France), where the load - after heat treatment in a dedicated heating chamber - is lowered to a separate quenching tank with quenching oil. Moreover, patent application no. P.401445(A1) presents a solution for a dual-chamber vacuum furnace with horizontal loading and load transfer from the heating chamber to the quenching chamber, where the load is also quenched in oil using a quenching tank flood system.

[0003] Currently, the state of the art in terms of heat treatment (quenching) of these landing gear parts is mainly focused on the oil quenching method due to the significant dimensions and sections of such parts, which preclude the application of other hardening methods. In all the methods listed above, heating and austenitisation take place in a vacuum, while furnace constructions and solutions are designed specifically for heat treatment of long parts, especially aircraft landing gear struts.

[0004] Known solutions also include industrial single-chamber vacuum furnaces with inert gas quench systems involving Ar, N_2 or He - referred to as HPGQ in professional literature - where cooling rates sufficient for HSLA steel quenching are achieved at small chamber dimensions and gas pressures of 6-25 bar. A typical example of such HPGQ furnaces, successfully applied in the industry for quenching workpieces and parts made of HSLA steel, includes furnaces with heating chamber dimensions of 600x600x900 mm or 900x800x1200 mm. During quenching in such furnaces at a cooling gas pressure of e.g. 15 bar, workpieces made of HSLA steel - **300M** and **2340H** according to AISI - achieve cooling rates at a level required by relevant material standards, even for ca. Ø100 mm sections. However, appropriate cooling rates are only achieved in vacuum furnaces with the above-mentioned small heating chambers, where the chamber construction allows to achieve cooling gas flow rate in the load at the level of e.g. 5-10 m/s.

[0005] Regarding gas quenching technology applied in HPGQ furnaces, specialist literature commonly refer to the relationship of heat transfer coefficient **[**α**]** that is directly responsible for the load cooling rate, according to the following formula:

$$\alpha = C\, \mathbf{p}^{\mathbf{0.7}}\, \mathbf{w}^{\mathbf{0.7}}\, \mathbf{d}^{\mathbf{-0.3}}\, \eta^{-0.39}\, c_p^{\;0.31}\, \lambda^{0.69}\ [\ \mathrm{W/m^2K}]$$

[0006] For a given section of the quenched (cooled) part **[d],** the coefficient is equally dependent on the pressure of the cooling gas **[**$\mathbf{p^{0.7}}$**]** and on the flow rate of that gas **[** $\mathbf{w^{0.7}}$**].** This defines and distinguishes the capabilities of single-chamber vacuum furnaces with HPGQ technology, where in the case of furnaces with larger heating chambers it is very difficult to install cooling systems that are proportionally larger compared with those used in furnaces with small heating chambers, e.g. 600x600x900 mm. In effect, larger furnaces are characterised by significantly lower cooling gas flow rates at the workpiece surface **[**ω**]** - ca. 1.5-2.5 m/s - which precludes quenching of large-size HSLA steel parts and/or workpieces with larger sections.

[0007] Heat treatment of long products - including main large-size struts and landing gear components for passenger and transport aircrafts, with maximum piece lengths up to e.g. 3200 mm, whose constructions (usually with tubular cross-sections) feature cross-sections even up to 60 to 80 mm - requires adherence with the cooling time of such sections - as defined in relevant aviation standards - from austenitisation temperature to less than 300°C in under 9.5 minutes. It is necessary to maintain the heat transfer coefficient **[**α**]** at the level achieved in single-chamber HPGQ furnaces with small heating chamber dimensions (600x600x900 mm / 900x800x1200 mm), while the cooling systems of such a vacuum furnace - in terms of heat exchanger solutions and the power of cooling gas recirculation blower motors - will feature solutions available for and applied in industrial HPGQ furnaces discussed above, e.g. 900x800x1200 mm.

[0008] The essential feature of the single-chamber vacuum furnace design according to the invention consists in the fact that the nozzle system implemented for the purpose of load cooling is divided into two subsystems, the first of which is installed - with blowing nozzle system directed towards the load - on the side walls of the heating chamber, while the second one - built into the insulating wall of the hearth - is executed in the form of collectors placed in a circular arrangement in relation to each workpiece situated vertically on hearth supports, where each collector has a row of blowing nozzles arranged at the height of the workpiece and directed at an angle between 75° and 105°, preferably 90°, towards the workpiece surface.

[0009] It is advantageous when four collectors are positioned around each workpiece with a height dimension up to

3200 mm, while when three workpieces are placed at the depth of the furnace chamber, the collectors between these workpieces are applied for two workpieces each.

[0010] Further, it is advantageous when the gas blow nozzles situated in the collectors are placed at 150 - 300 mm from the surface of the workpieces, while the flow rate of supplied cooling gas from the nozzles is forced at 35 - 45 m/s.

[0011] Next, it is advantageous when each collector is made up - along its height - of segments connected by flanges, enabling the installation of collectors up to 3200 mm high, which can consist of segments with nozzles aligned lengthwise along the height, and with a possibility of incorporating a segment with transverse nozzle rows for cooling the crossbars of [T] workpieces.

[0012] Further, it is advantageous when the gas flow collectors have a fixed part built-up to the height of the supporting tray, where a sliding thermal block of a hatch with a pneumatic drive is installed in the passage through the hearth insulation.

[0013] It is also advantageous when the sum of nozzle opening areas on the collector corresponds with the opening area of the hatch passage.

[0014] Next, it is advantageous when the nozzle system - arranged lengthwise and along the height of the side walls of the heating chamber - is advantageously divided into 3-4 zones along the height, where each zone has an independent pneumatic closing/opening drive for the nozzle passages situated in this zone.

[0015] Further, it is advantageous when zone control is executed with reversible opening of the zone nozzles on both sides, in order to facilitate gas outflow from the load area to the outlet hatches.

[0016] It is also advantageous when additional hatches with a diameters up to 80 mm are placed along the axis of the strut workpiece base, allowing to supply cooling gas through a vertical pipe or through flexible pipes directly into the internal volume of the workpiece, usually into pipe interiors.

[0017] Moreover, it is advantageous when the workpiece is cooled from two sides, using two collectors placed on the opposite sides of the workpiece.

[0018] The collectors - advantageously made of CFC - ensure thermal stability and low weight, also facilitating installation to the fixed part in the hearth. The segmental division along the length provides possibilities of adjusting the length of the collector to the length of the workpieces to be processed. It is also advantageous to build CFC collectors with square or rectangular sections for easy installation of cooling gas nozzles on the walls with such sections. Additionally, it is possible to manufacture these collectors from thin-walled heat-resistant steel pipes or solid graphite with a circular collector section. When loading - for example - two workpieces for heat treatment, they are cooled by an assembly of six collectors with six thermal hatches opened in the hearth insulation during the cooling cycle.

[0019] The furnace according to the invention will be described in greater detail on the basis of an executed model presented in the drawing, in which respective figures represent:

- fig. 1 - vacuum furnace in longitudinal section,
- fig. 2 - vacuum furnace in cross section,
- fig. 3 - horizontal section of the heating chamber,
- fig. 4 - installation method of the external blowing nozzle collector,
- fig. 5 - installation method of internal blower collector,
- fig. 6 - external blower collector with a detailed drawing of modification for cooling of type T workpieces, and
- fig. 7 - cross section of modification for blower collector for type T workpieces, at the level of transverse arms of the workpiece.

[0020] The furnace has a vacuum-pressure housing 1, in which a rectangular heating chamber is installed 2. The front wall and the bottom wall of the heating chamber are installed on the furnace hearth 3, which is fitted with a trolley 4.1, 4.2 enabling hearth movement outside of the furnace for the purpose of loading and unloading. The furnace hearth trolley is equipped with a vacuum-pressure door 5, which slides together with the hearth after unlocking the quick-opening closure of the vacuum-pressure housing 6. In the volume of the door bottom behind the thermal insulation 7 of the front wall of the heating chamber, and in the volume of the housing bottom 1 behind the rear wall of the heating chamber 2, a front and rear cooling gas recirculation blowers 8 and 9 are placed with outlet hatches 10 and 11 - installed in the route supplying cooling gas from the heating chamber - intended for such gas flow from the heating chamber containing the load, as well as appropriately sized heat exchangers 12 and 13 that enable load and heating chamber cooling from austenitisation temperature to less than 200/300°C in under 9.5 minutes. All internal walls of the heating chamber, including the hearth, feature installed heating element system 14, divided into relevant control zones. On the front and rear walls there are fans for convection heat circulation 15 - this heating method, e.g. in the range up to 750°C, is advantageous for accelerating load heating at low temperatures, at the same time allowing for clean stress relieving or tempering after the quenching process. For the purpose of executing this functionality (among others), in the convection heating phase the nozzles of the load cooling system arranged on the side walls of the heating chamber 16 are closed with a block system 17. Nozzle blocks are connected into zones with one pneumatic drive 18 for each zone. Each wall with the nozzles arranged on it is divided into three to four zones, at the height of the heating chamber. This allows one or more zones to be switched off in the cooling cycle, especially for the purpose of reversible disengagement of one of the side zones - alternately - on one side and then on the other side, after a programmable time, which facilitates the release of hot gases from the load volume, etc. In the cooling phase, hatches 10 and 11 of gas outlets from the heating chamber to blower fans 8 and 9 are opened via heat exchangers 12 and 13. The hearth on which the load is to be placed is fitted with load base supports 19. The load may comprise the support tray 20, HSLA steel workpieces 21 for heat treatment, as well as fixtures for workpiece positioning and fixing 22. In the space between the load supports 19, which are advantageously situated in a perpendicular position to the furnace axis, hatches 23 are installed around the axis of the position of, for example, three details 21, along with vertically positioned cooling gas flow collectors 24 four around each workpiece, whereas central hatches 23 and collectors arranged along the length of the heating chamber 2 serve two workpieces 21 each. Each collector 24 with a hatch in the hearth insulation is extended in a segmental manner to the height of workpiece 21, which makes it possible each time to adjust the height of the collector to the dimension of the workpiece. After setting the hearth in the closed position of the heating chamber for heat treatment, and after locking the quick-opening closure 6 of the furnace housing, all hatches are locked with independent 25 thermal blocks with pneumatic drives 26. During the heating and soaking cycle phase, pneumatically driven thermal blocks seal the heating chamber, while in the load cooling phase they allow for independent management of cooling gas flows to individual collectors 24 and workpieces 21 subject to quenching. Each collector has a permanently installed connection segment 27 terminated with a flange 28 at a height just below the load-bearing support level 19 with a solution enabling quick installation of segments above the flange. Depending on the type of landing gear elements (T/L/I) and their height, this allows to install surrounding collectors up to a suitable height (up to 3200 mm for the furnace with a heating chamber of this working space height). For T-type elements, it is also advantageous to use transverse collectors 29 with gas supply to nozzles positioned parallel to the transverse arms of a given workpiece. Advantageously, each collector made of CFC (for example) has a rectangular or square shape in cross-section for the purpose of easy construction of this collector tunnel and mounting flanges, using cheaper, commercially accessible profiles and CFC panels. On one wall of these collectors 24 (or on two walls, in the case of collectors serving two workpieces, when situated between the first, second and third workpiece) nozzles 30 are installed along the height for cooling gas inflow onto the workpiece 21. Nozzle spacing is comparable to that of the HPGQ vacuum furnaces sized 600x600x900 mm or 900x800x1200 mm (e. g. every 250-300 mm) and to the placement of the nozzles from 200 to 300 mm from the workpiece surface. The cooling gas is supplied onto the workpiece from four sides. The nozzles are positioned perpendicularly to the axis of the workpiece; they can also be positioned at a low angle, e.g. up to 5-15°, which is beneficial for reducing the disturbance of cooling gas outflow from the workpiece surface; it also improves the uniformity of cooling, affecting deformation and the linear velocity of the cooling gas [ω] at the workpiece surface. Different angles can be set along the workpiece height, depending on the wall thickness of the workpiece, which usually has a tubular section. Collectors 34 and hatches 23 for cooling gas inflow are characterized by a cross-sectional area equal to or greater than the sum of jet areas of nozzles that can be installed on a given collector using all segments up to a height of 3000 mm. Collectors 34 with a circular cross-section can also be used, e.g. advantageously made of graphite materials or heat-resistant steels. Additionally, installed in the insulating wall of the furnace hearth 3 there are e. g. three hatches 31 with diameters, e. g. 60-80 mm, with thermal blocks 32 driven by pneumatic cylinders 33 and positioned along the axis of the workpieces 21, whereas installed above this extension there are collectors 34 fitted with nozzle (pipes) connections for direct injection of cooling gas into the pipe 35 and/or be means of a metal hose 36, for example; this enables the supply of cooling gas flow into the workpiece, in various essential workpiece sections characterized by thicker walls. Each collector 34 can be fitted with several flexible connections 36. Nozzle systems installed in the collectors and nozzle systems installed in the heating chamber walls have a specifically calculated diameter to provide a cooling gas flow at 35-45 m/s, at cooling gas pressures (e.g. nitrogen) up to 16 bar. The units of cooling gas recirculation installed in the front and rear bottom of the furnace housing ensure cooling gas circulation, forced by means of blowers directed onto the load, with gas inflow from two nozzle systems and further through outflow hatches and heat exchangers, where gas is drawn in by the blower fans. Advantageously, the flow should be calculated in such a way so as to ensure divided supply at the level of 50% for the inflow through the nozzles of the heating chamber walls, and 50% for the inflow through the nozzles installed in the collectors. The engine power of installed blowers of the load cooling system is up to 2 x 500 kW. The furnace can also be operated with vertical collectors removed, which enables the heat treatment of bulk loads situated on tray 20.

[0021] Furnace loading takes place with the hearth extended. After the workpieces 21 have been placed on the load supports 19, positioned on the tool tray 20, and after the collector 22 has been fixed in a vertical position, the hearth is moved until the flanges of the vacuum-pressure door 5 are connected to the flange of the housing 1. Next, after the quick-opening closure 6 is locked, the furnace housing is closed in vacuum and pressure-tight manner. After vacuum pumping is completed in the housing 1, a heating and soaking cycle of workpieces is initiated, e.g. for 4340H steel acc. to AISI - at the level of 840°C, while for 300M steel - at the level of 870°C. After the necessary technological austenitisation time has elapsed, the housing 1 is filled with nitrogen up to the specified pressure, e.g. in the range of up to 16 bar. Meanwhile, the withdrawal of pneumatic cylinders 18 results in the opening of side nozzle passages in the heating chamber walls 16, as well as gas outflow hatches 9 and 10 from heating chamber 2; next the motors of blowers 7 and 8 are engaged and the valves of cooling water supply to heat exchangers 12 and 13 are opened. Afterwards, the hatches 23 enabling cooling gas inflow to collectors 24 are opened (with thermal blocks 25 of hatches 23 being pulled by pneumatic cylinders 26) and, depending on needs, hatches 31 are opened (with thermal blocks 32 being pulled by pneumatic drive 33) for the purpose of supplying cooling gas into the tubular workpieces from the bottom of the workpiece 35 base, or through ducts (bellows pipes) to similar places at the workpiece height 36. During the cooling cycle, the zones of cooling gas inflow from the side walls can be reversibly closed, in order to facilitate the discharge of cooling gases from the load volume. After cooling the furnace chamber and the load down to e.g. under 100°C, the blowers are stopped and the water supply of the exchangers is switched off, and nitrogen is removed from the housing to equalize pressure with ambient pressure. After the quick-opening closure is released and the hearth is extended, the workpieces are unloaded and another load is fed. Loading and unloading is always carried out on the side of the hearth, which is facilitated by laterally positioned load supports 19; this solution also facilitates the installation and disconnection of load thermocouples according to AMS 2750E.

Claims

1. A single-chamber HPGQ vacuum furnace intended for treatment of long metal pieces, and particularly for quenching struts and landing gear parts for passenger and transport aircrafts made of HSLA steel - 4340H and 300M according to AISI - with a rectangular heating chamber installed in a vacuum-pressure housing, including necessary equipment divided into heating zones, with an extendable hearth and highpressure gas quenching system, as well as with load base supports situated on the insulating wall of the hearth; **characteristic in that** the load cooling nozzle system is divided into two subsystems, the first of which is installed on the side walls of the heating chamber (2), with the nozzle system directed towards the load (21), while the second one is built into the insulating wall of the hearth (3), executed in the form of collectors (24) placed in a circular arrangement in relation to each workpiece (21) situated vertically on hearth supports (3) where each collector (24) has a row of blowing nozzles (30) arranged at the height of the workpiece (21) and directed at an angle between 75° and 105°, preferably 90°, towards the workpiece surface.

2. The single-chamber furnace according to claim 1, **characteristic in that** around each workpiece with a height up to 3200 mm there are - advantageously - four collectors (24) situated in circular arrangement, while when three workpieces (21) are placed at the depth of the furnace chamber, the collectors (24) between these workpieces (21) serve two workpieces each.

3. The single-chamber furnace according to claim 1 or 2, **characteristic in that** the gas blow nozzles (30) situated in the collectors (24) are placed from 150 to 300 mm away from the surface of workpieces (21), while cooling gas flow rates from the nozzles are forced to 35 - 45 m/s.

4. The single-chamber furnace according to claim 1 or 2 or 3, **characteristic in that** each collector (24) is made up - along its height - of segments connected by flanges, enabling the installation of collectors (24) up to 3200 mm high, which can consist of segments with nozzles (30) aligned lengthwise along the height, and with a possibility of incorporating a segment (29) with transverse nozzle rows for cooling the crossbars of [T] workpieces (21).

5. The single-chamber furnace according to claim 2 or 4, **characteristic in that** the gas flow collectors (24) have a fixed part built-up to the height of the supporting tray (20), where a sliding thermal block (25) of a hatch with a pneumatic drive (26) is installed in the passage through the hearth insulation (3).

6. The single-chamber furnace according to claim 1 or 5, **characteristic in that** the sum of nozzle (30) opening areas on the collector (24) corresponds with the opening area of the hatch passage.

7. The single-chamber furnace according to claim 1, **characteristic in that** the nozzle (30) system - arranged lengthwise and along the height of the side walls of the heating chamber (2) - is advantageously divided into 3-4 zones along the height, where each zone has an independent pneumatic closing/opening drive (26) for the nozzle (30) passages situated in that zone.

8. The single-chamber furnace according to claim 1 or 7, **characteristic in that** the zone control is executed with reversible opening of the zone nozzles (30) on both sides, in order to facilitate gas outflow from the load area to the outlet hatches.

9. The single-chamber furnace according to claim 1 or 2, **characteristic in that** additional hatches with a diameters up to 80 mm are placed along the axis of the strut workpiece base (21), allowing to supply cooling gas through a vertical pipe or through flexible pipes directly into the internal volume of the workpieces, usually into pipe interiors.

10. The single-chamber furnace according to claim 1 or 2, **characteristic in that** the workpiece (21) is cooled from two sides, using two collectors (24) placed on the opposite sides of the workpiece (21).

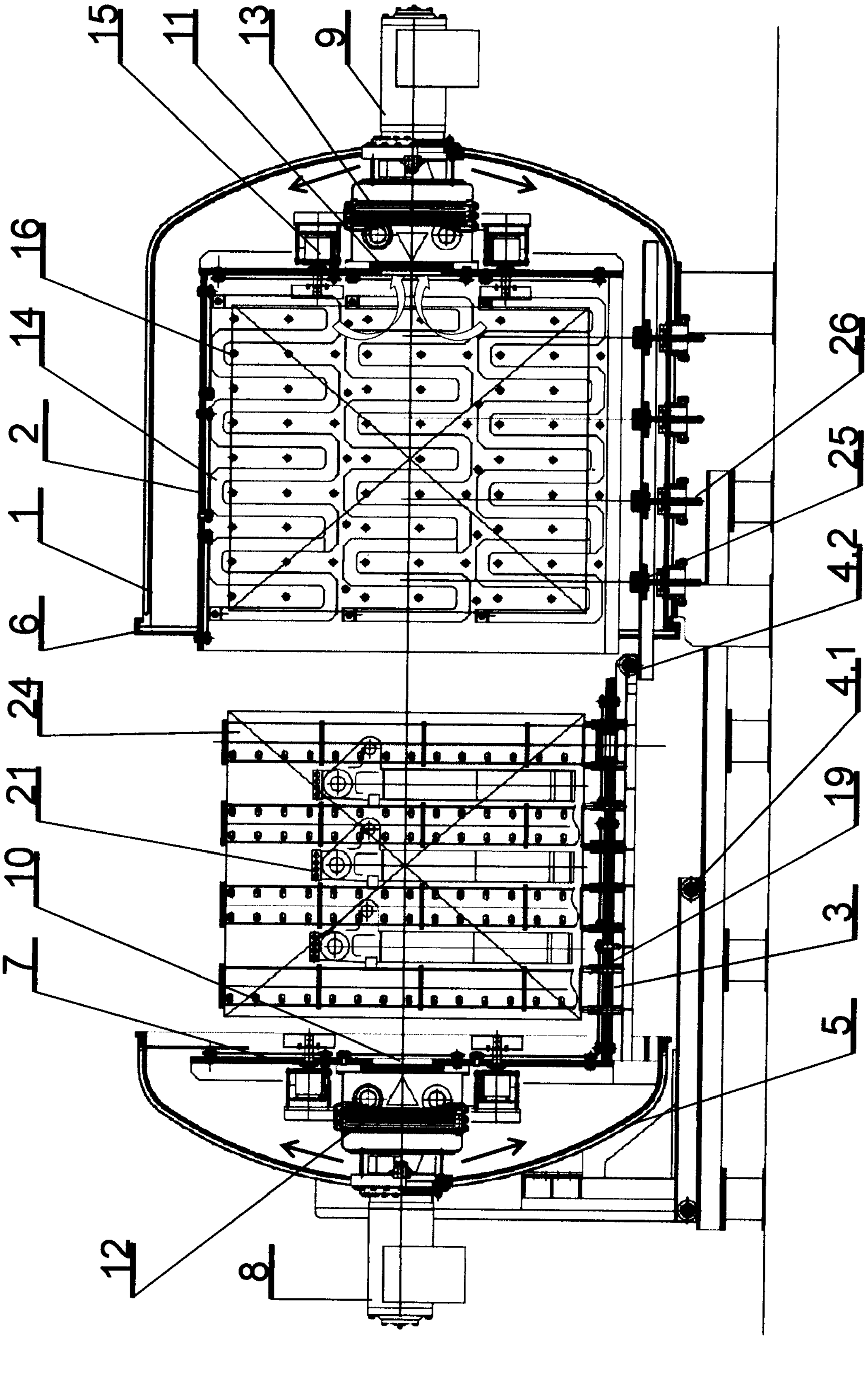


Fig.1

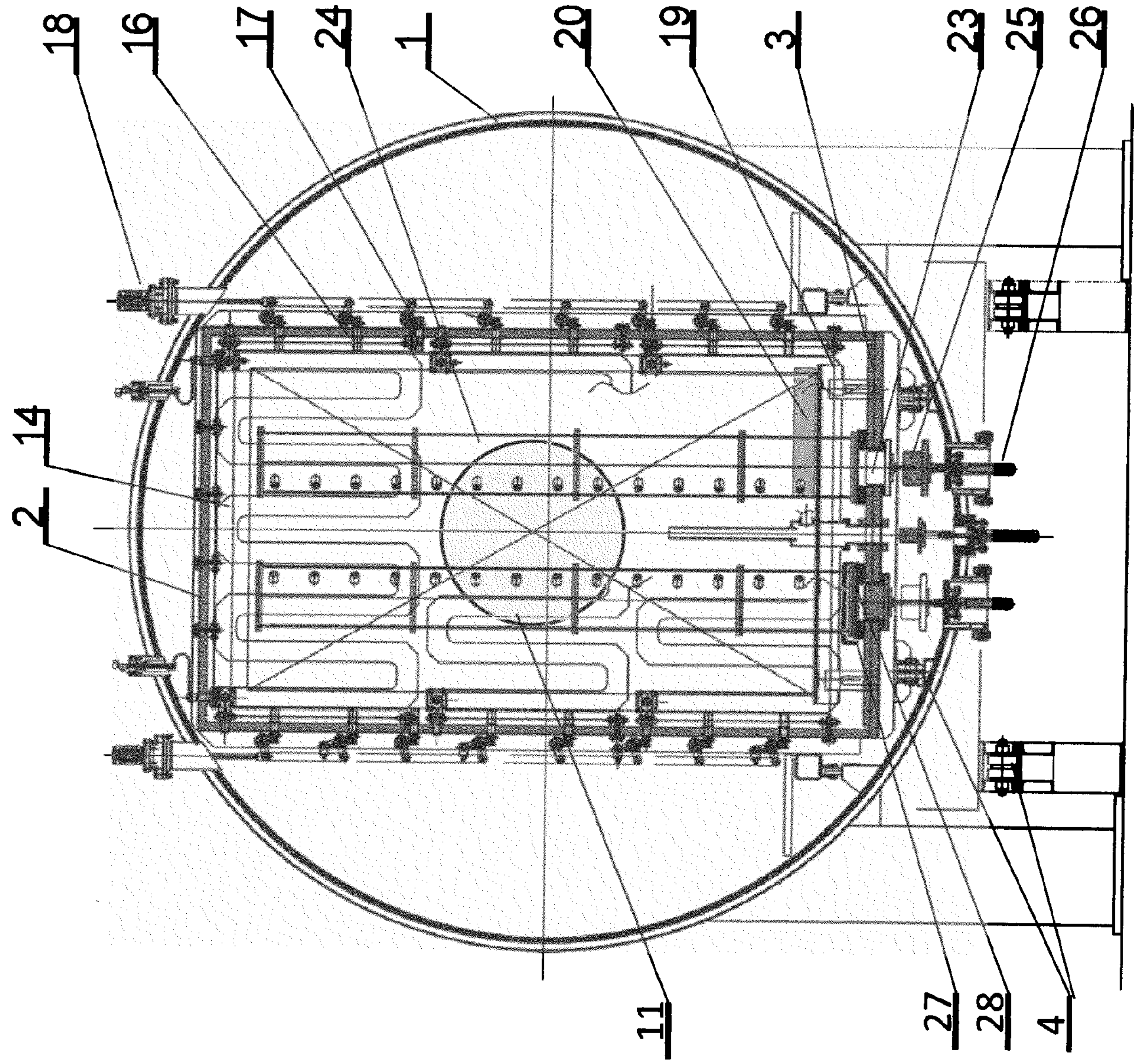


Fig.2

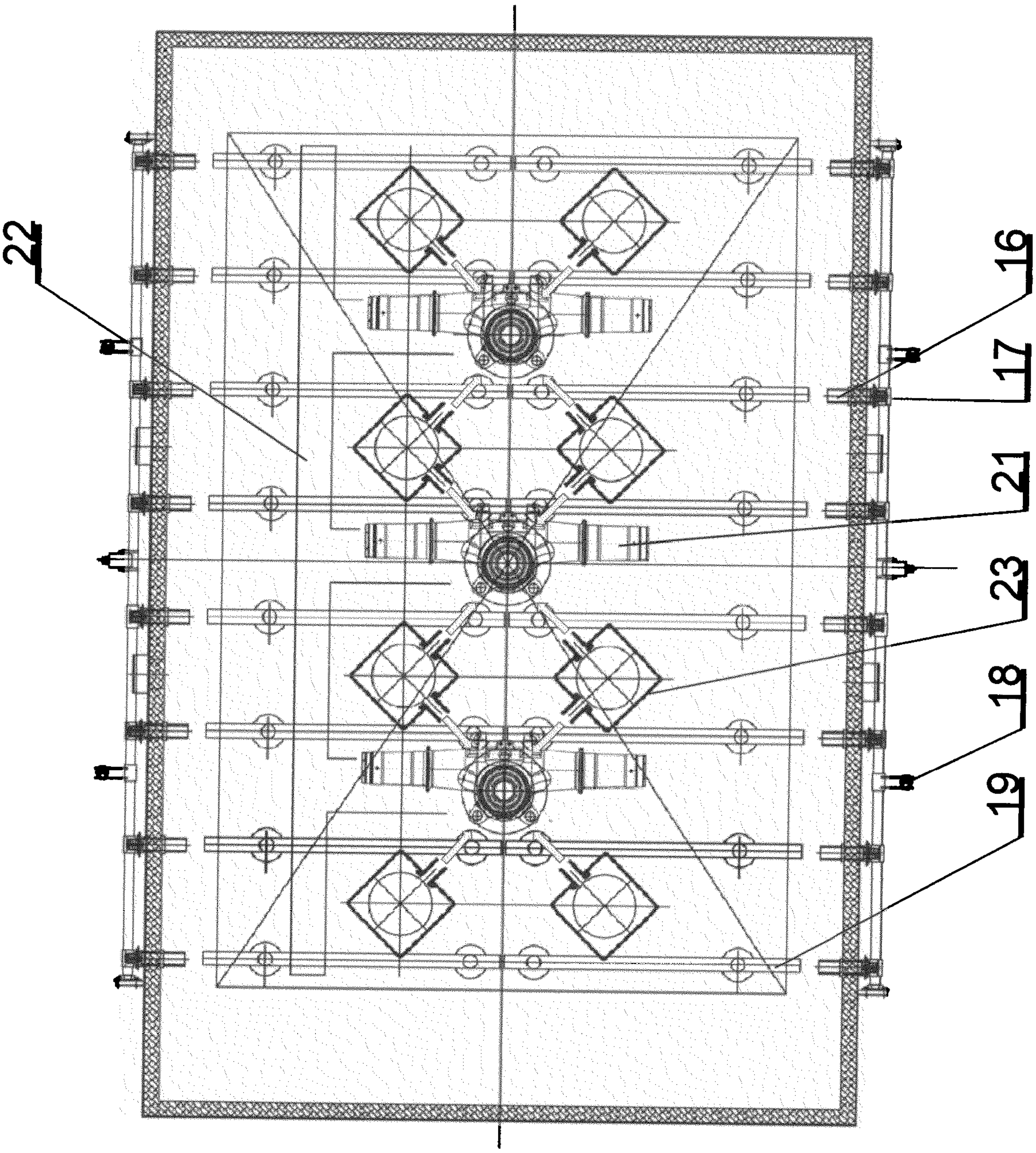
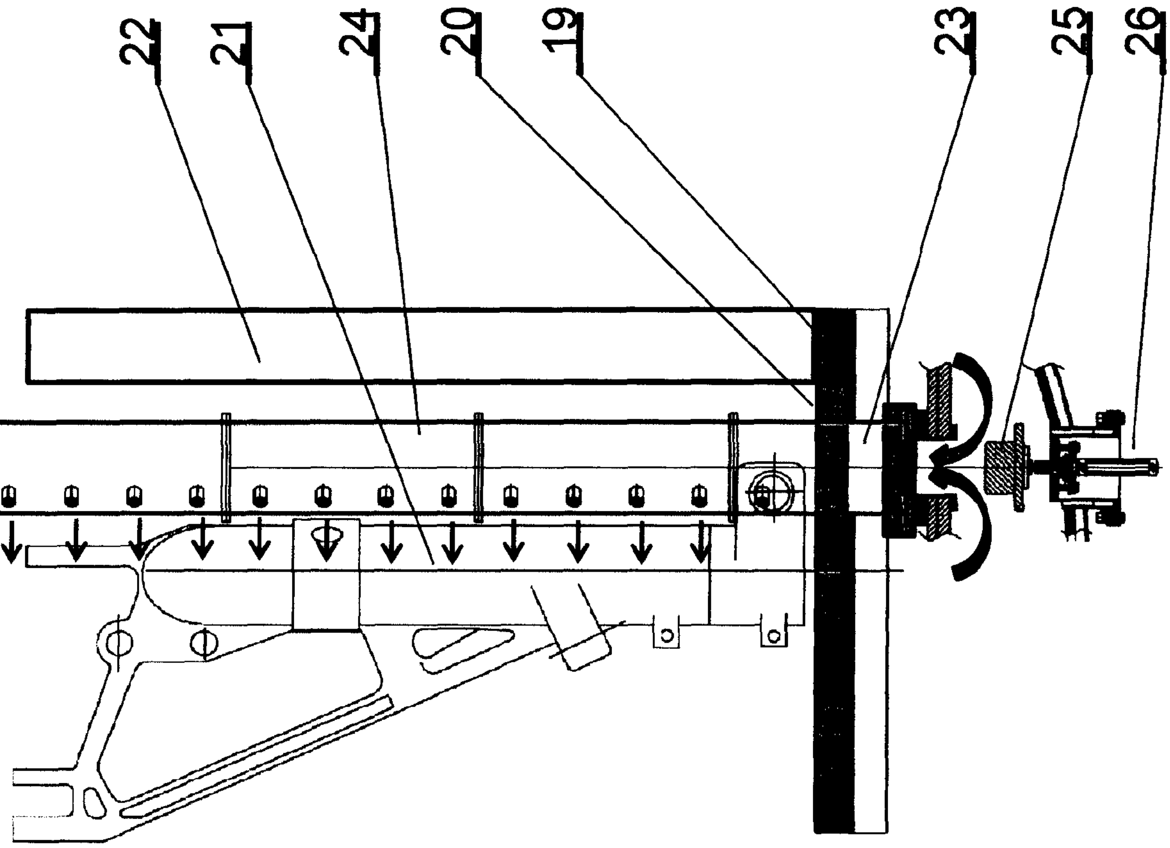


Fig.3

Fig.4



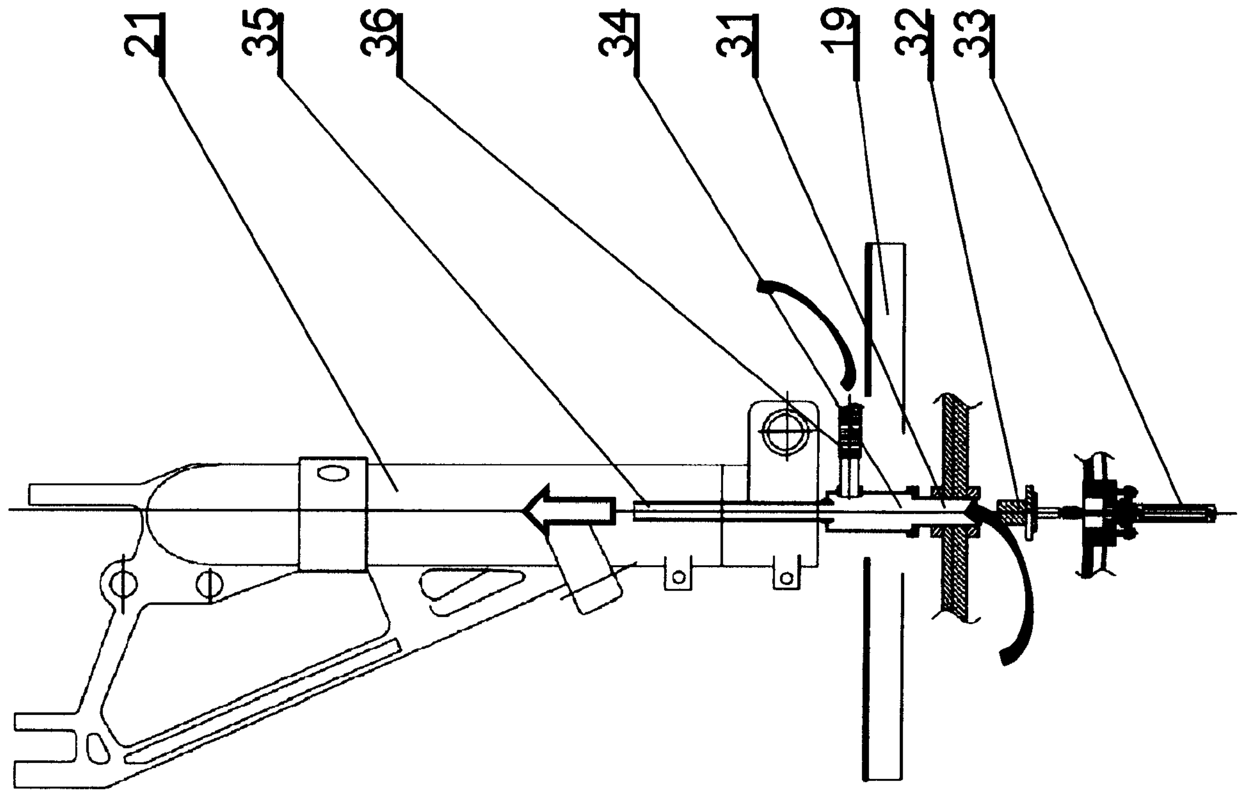


Fig.5

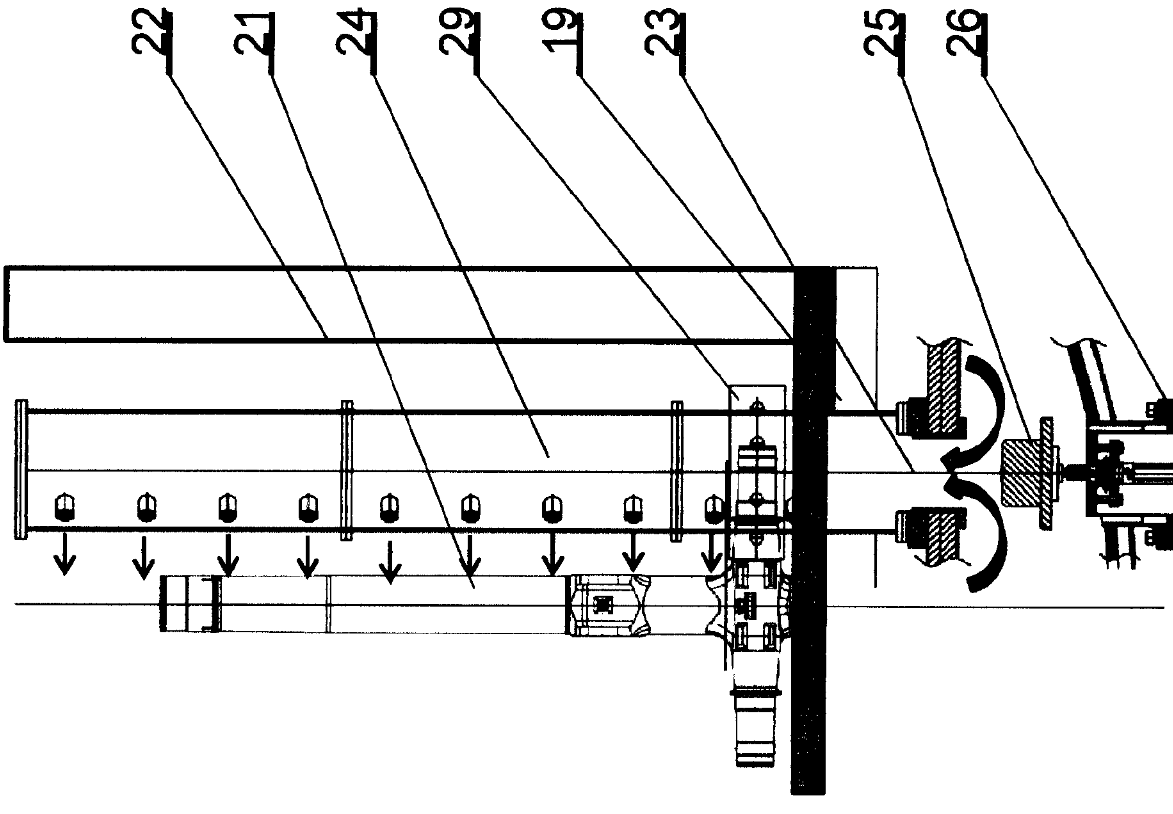
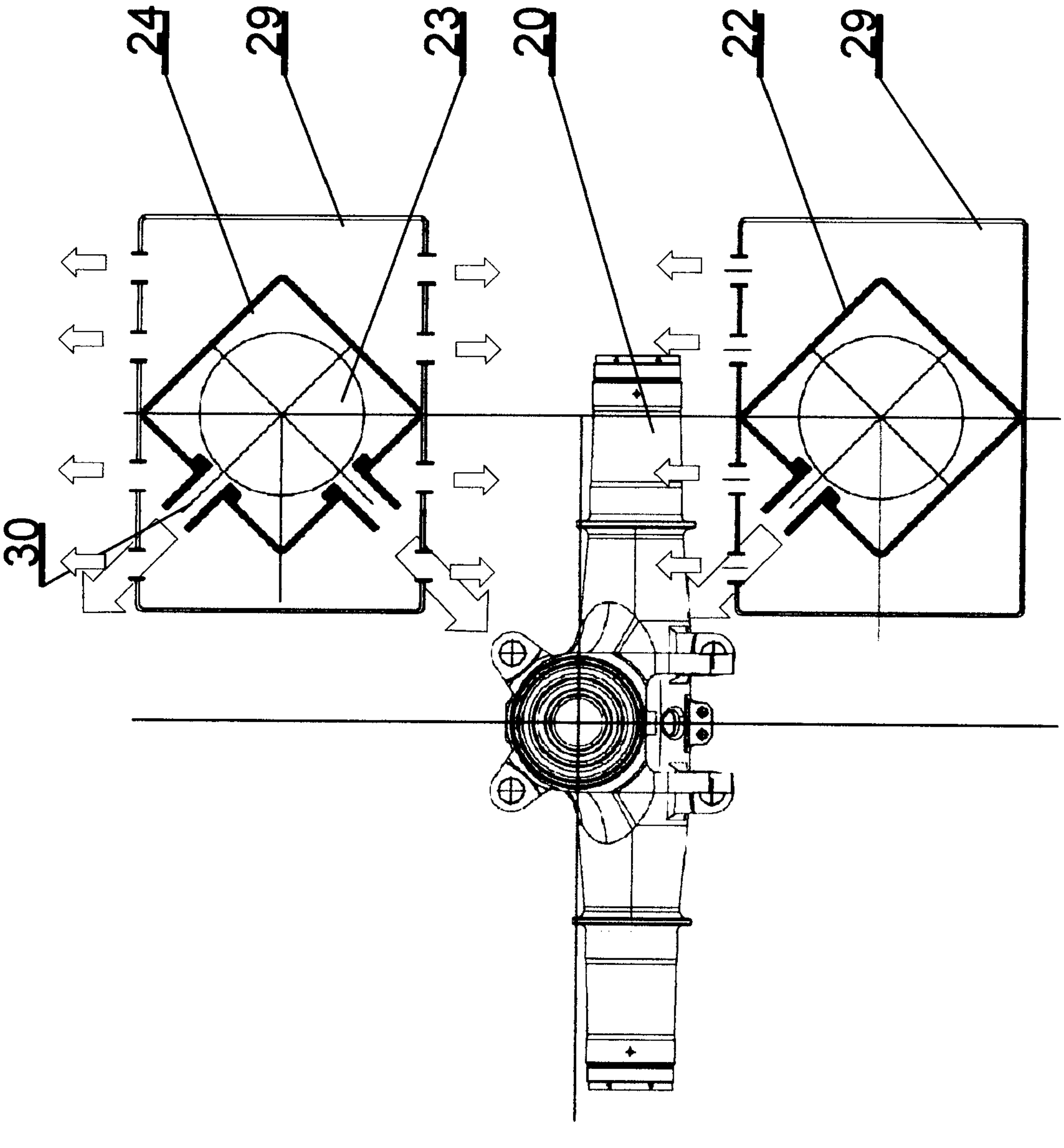


Fig.6

Fig.7



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 00 2085

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 4 906 182 A (MOLLER CRAIG A [US]) 6 March 1990 (1990-03-06) * figures 1-4 * * column 1, line 5 - line 17 * * column 1, line 57 - column 2, line 16 * * column 2, line 40 - column 3, line 40 * -----	1-10	INV. F27B5/04 C21D1/773 C21D1/613 F27B5/16 F27D9/00 F27B5/06
Y	US 7 427 375 B1 (CUSHMAN FLOYD [US]) 23 September 2008 (2008-09-23) * figures 1, 2, 6 * * column 1, line 28 - line 64 * * column 3, line 13 - line 64 * -----	1-10	
A	US 4 854 860 A (HEMSATH KLAUS H [US]) 8 August 1989 (1989-08-08) * figures 1, 2 * * column 1, line 7 - line 19 * * column 9, line 52 - column 10, line 4 * -----	1-10	

TECHNICAL FIELDS SEARCHED (IPC)

F27B
F27D
C21D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	28 May 2018	Jung, Régis

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 00 2085

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

28-05-2018

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4906182	A	06-03-1990	NONE	
US 7427375	B1	23-09-2008	NONE	
US 4854860	A	08-08-1989	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO P401445 A1 **[0002]**

Non-patent literature cited in the description

- **C. FILICE ; D. HERRING ; P. VANDERPOL.** Landing-Gear Heat Treatment. *Industrial Heating,* 2011 **[0002]**