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- (71) Applicant: AIC SPÓŁKA AKCYJNA [PL/PL]; ul. Rdestowa 41, PL-81-577 Gdynia (PL).
- (72) Inventors: SZCZEPAŃSKI, Krzyszto; ul. Wigury 119, PL-83-110 Tczew (PL). BERNACIAK, Maciej; ul. Stefana Batorego 23/5, PL-81-365 Gdynia (PL).
- (74) Agent: POMIANEK, Grazyna; Kancelaria Patentowo-Prawna Grazyna Pomianek, ul. Subisława 23 C lok. 7, PL-80-354 Gdańsk (PL).
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(54) Title: CONDENSING HEAT EXCHANGER

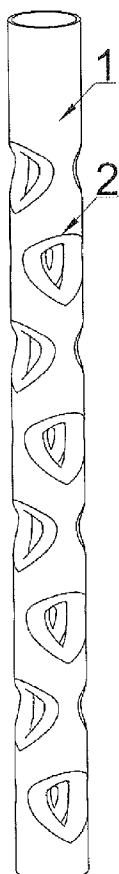


Fig.1

(57) Abstract: A condensing heat exchanger comprising a combustion chamber fitted in its top section which features an opening for inserting the burner, as well as flue tubes anchored in the sieve bottoms and encased in an outer jacket, where there is a chamber to accommodate the heated liquid formed inside the jacket and the jacket is fitted with stub tubes for the supply and discharge of the heated liquid, with a condensate container featuring the condensate discharge stub tube and a stub tube for the discharge of fumes to the vent, is characterised in that the flue tubes (1) feature dents (2) formed along the length of the tube (1), and said dents (2) are pointed towards the centre of the tube (1), and said dents (2) are positioned opposite each other, and two opposite dents (2) mark out a section, where the distance between the lowest points in the dents (2) measured inside the tube (1) in the section is 1.0 mm or less, and the ratio of the length (L) of the tube (1) to the tube cross section circumference around which the combustion gases flow falls within the range from 2.5 to 6.5.



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Condensing heat exchanger

The invention concerns a condensing heat exchanger designated for central heating and utility water installations.

Known are heat exchangers featuring a set of tube elements for the flow of hot fumes, fitted between two sieve walls in a chamber encased in an external jacket, where the heated water is supplied to the chamber through the inlet stub tube fitted in the lower section of the outer jacket and is discharged through the outlet stub tube fitted in the upper section of the outer jacket, and thus circulates inside the chamber. In these heat exchangers the combustion chamber is placed above the upper sieve bottom, and under the lower sieve bottom there is a condensate collecting bowl.

Known from patent application PL216290 B1 is a heat exchanger comprising an outer jacket which encases a set of vertical tube elements anchored in sieve walls on both ends, a gas combustion chamber positioned over the upper sieve wall, and baffles which are mounted perpendicular to the tube elements, with openings through which the tube elements run, plus liquid inlet and outlet stub tubes fitted in the side wall of the outer jacket.

The purpose of the invention is to improve heat exchange parameters of the heat exchanger and reduce the exchanger size. In particular, the purpose of the invention is to develop a flue tube for a fired condensing heat exchanger which would intensify the heat exchange process, at the same time reducing the combustion gas flow resistance and retaining the condensing nature of the processes which occur in the exchanger, all of which would allow to reduce the heat exchanger size.

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A condensing heat exchanger comprising a combustion chamber fitted in its top section which features an opening for inserting the burner, as well as flue tubes anchored in the sieve bottoms and encased in an outer jacket, where the jacket is fitted with stub tubes for the supply and discharge of the heated fluid, and inside the jacket there is a chamber for the heated liquid, a condensate container fitted with the condensate discharge stub tube and a stub tube for the discharge of fumes to the vent, according to the invention is characterised in that the flue tubes feature dents formed along the length of the tube, and said dents are pointed towards the centre of the tube, and said dents are positioned opposite each other, and two opposite dents mark out a section, where the distance between the lowest points in the dents measured inside the tube in the section is 1.0 mm or less, and the ratio of the length of the tube to the tube cross section circumference around which the combustion gases flow falls within the range from 2.5 to 6.5.

Preferably, the flue tube is cylindrical in shape in its top and/or bottom section(s).

Preferably, the length of the cylindrical top section of the flue tube ranges from 0.25 to 1.5 of the tube's cross section circumference around which the combustion gases flow.

Preferably, the adjacent dent sections are arranged otherwise than collinearly to each other along the flue tube length, in particular at the angle of 90°.

Preferably, the dent sections are arranged at even distances along the flue tube length, or the distances between the dent sections decrease along the flue tube length.

Preferably, the dents are circular, oval, or drop-like in shape.

Preferably, the cross section of the flue tube in the fragment between the

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adjacent sections is circular, oval, or square in shape, with rounded apexes and sides indented towards the axis.

The designed proportions between the flue tube dimensions and the shape and arrangement of the dents according to the invention ensures retaining the condensing nature of the processes which occur in the exchanger while reducing the flow resistance of the combustion gases inside the tubes and increasing the flow turbulences.

Further benefits and advantages of the present invention will become apparent after a careful reading of the detailed description with appropriate reference to the accompanying drawings.

In the drawings:

Fig.1 shows the flue tube in the isometric projection with drop-shaped dents arranged at even distances along the tube length;

Fig.2 and Fig.3 show the flue tube as in Fig. 1 in side view;

Fig.4 depicts the flue tube as in Fig. 1 in bird's eye view;

Fig.5 and Fig.6 illustrate the flue tube as in Fig. 1 in axial section;

Fig.7 shows the flue tube as in Fig.1 in cross section;

Fig.8 shows the flue tube in the isometric projection with circular dents arranged at even distances along the tube length;

Fig.9 and Fig.10 show the flue tube as in Fig. 8 in side view;

Fig.11- depicts the flue tube as in Fig. 8 in bird's eye view;

Fig.12 and Fig.13 illustrate the flue tube as in Fig. 8 in axial section;

Fig.14 shows the flue tube as in Fig.8 in cross section;

Fig.15 shows the flue tube in the isometric projection with oval dents, arranged at even distances along the tube length;

Fig.16 and Fig.17 show the flue tube as in Fig. 15 in side view;

Fig.18 depicts the flue tube as in Fig. 15 in bird's eye view;

Fig.19 and Fig.20 illustrate the flame pipe as in Fig. 15 in axial section;

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Fig.21 shows the flue tube as in Fig.15 in cross section;
Fig.22 shows the flue tube in the isometric projection with drop-shaped dents arranged at even distances along the tube length in another variant;
Fig.23 and Fig.24 show the flue tube as in Fig. 22 in side view;
Fig.25 depicts the flue tube as in Fig. 22 in bird's eye view;
Fig.26 and Fig.27 illustrate the flue tube as in Fig. 22 in axial section;
Fig.28 shows the flue tube as in Fig.22 in cross section;
Fig.29 - shows the flue tube in the isometric projection with circular shaped dents arranged at even distances along the tube length in another variant;
Fig.30 and Fig.31 show the flue tube as in Fig. 29 in side view;
Fig.32 depicts the flue tube as in Fig. 29 in bird's eye view;
Fig.33 and Fig.34 illustrate the flue tube as in Fig. 29 in axial section;
Fig.35 - shows the flue tube as in Fig.29 in cross section;
Fig.36 shows the flue tube in the isometric projection with oval dents arranged at even distances along the tube length in another variant;
Fig.37 and Fig.38 show the flue tube as in Fig. 36 in side view;
Fig.39 depicts the flue tube as in Fig. 36 in bird's eye view;
Fig.40 and Fig.41 illustrate the flue tube as in Fig. 36 in axial section;
Fig.42 shows the flue tube as in Fig.36 in cross section;
Fig.43 shows the flue tube in the isometric projection with drop-shaped dents arranged at uneven distances along the tube length;
Fig.44 and Fig.45 show the flue tube as in Fig. 43 in side view;
Fig.46 depicts the flue tube as in Fig. 43 in bird's eye view;
Fig.47 and Fig.48 illustrate the flue tube as in Fig. 43 in axial section;
Fig.49 shows the flue tube as in Fig.43 in cross section;
Fig.50 shows the flue tube in the isometric projection with circular dents arranged at uneven distances along the pipe length;

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Fig.51 and Fig.52 show the flame pipe as in Fig. 50 in side view;
Fig.53 depicts the flue tube as in Fig. 50 in bird's eye view;
Fig.54 and Fig.55 illustrate the flue tube as in Fig. 50 in axial section;
Fig.56 shows the flue tube as in Fig.50 in cross section;
Fig.57 shows the flue tube in the isometric projection with oval dents arranged at uneven distances along the tube length;
Fig.58 and Fig.59 show the flue tube as in Fig. 57 in side view;
Fig.60 depicts the flue tube as in Fig. 57 in bird's eye view;
Fig.61 and Fig.62 illustrate the flue tube as in Fig. 57 in axial section;
Fig.63 shows the flue tube as in Fig.57 in cross section;
Fig.64 shows the flue tube in the isometric projection with drop-shaped dents arranged at uneven distances along the tube length in another variant;
Fig.65 and Fig.66 show the flue tube as in Fig. 64 in side view;
Fig.67 depicts the flue tube as in Fig. 64 in bird's eye view;
Fig.68 and Fig.69 illustrate the flue tube as in Fig. 64 in axial section;
Fig.70 shows the flue tube as in Fig.64 in cross section;
Fig.71 shows the flue tube in the isometric projection with circular dents arranged at uneven distances along the tube length in another variant;
Fig.72 and Fig.73 show the flue tube as in Fig. 71 in side view;
Fig.74 depicts the flue tube as in Fig. 71 in bird's eye view;
Fig.75 and Fig.76 illustrate the flue tube as in Fig. 71 in axial section;
Fig.77 shows the flue tube as in Fig.71 in cross section;
Fig.78 shows the flue tube in the isometric projection with oval dents arranged at uneven distances along the tube length in another variant;
Fig.79 and Fig.80 show the flue tube as in Fig. 78 in side view;
fig.81 depicts the flue tube as in Fig. 78 in bird's eye view;
Fig.82 and Fig.83 illustrate the flue tube as in Fig. 78 in axial section;

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Fig.84 shows the flue tube as in Fig.78 in cross section;

Fig.85 shows the heat exchanger in axial section.

In the exemplary embodiment, a heat exchanger comprises, in its top section, a combustion chamber 3 which features an opening for inserting the burner, as well as flue tubes 1 anchored in the sieve bottoms 4, 5 and encased in an outer jacket 6, inside which there is a chamber 7 for the heated liquid, where the jacket is fitted with inlet stub tube 8 and outlet stub tube 9 for the supply/ discharge of the heated liquid. In the bottom section of the outer jacket 6 there is a condensate container 10 fitted with a condensate discharge stub tube 11 and a stub tube for the discharge of fumes to the vent 12, as shown on Fig.43 and Fig. 44. The flue tubes 1 feature dents 2 pointing towards the centre of the flue tube 1. At the predetermined point there are two dents 2 made in the flue tube 1 opposite each other, which mark out a section. The distance between the lowest points in the dents 2 measured inside the flue tube in the section is 0.5 mm, and the ratio of the length L of the flue tube 1 to the tube cross section circumference around which the combustion gases flow is 3.5. The adjacent sections of the dents 2 are mutually arranged along the length of the flue tube 1 at the angle of 90°. In the top section, the flue tube 1 is cylindrical in shape and the length H of the top section amounts to 1.0 of the tube cross section circumference around which the combustion gases flow.

In the exemplary embodiments shown on Figs. 1 to 7 and Figs. 22 to 28, the dents 2 are drop-like in shape; in other variants which are shown on Figs. 8 to 14 and Figs. 29 to Fig. 35 dents 2 are circular in shape, and in further embodiments shown on Figs. 15 to 21 and Figs. 36 to 42 the shape of the dents 2 is oval.

In the invention embodiment variants referred to above the sections

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of dents 2 are arranged at even distances along the length L of the flue tube 1.

In the remaining invention embodiment variants shown on Figs. 43 to 49 and Figs. 64 to 70 (drop-shaped dents 2); Figs. 50 to 56 and Figs. 71 to 77 (circular dents 2); and Figs. 57 to 63 and Figs. 78 to 84 (oval dents), the sections of dents 2 are arranged at uneven distances along the length L of the flue tube in such a way that the distance S between the sections reduces along the tube length.

In the invention embodiment variants described above and shown on Figs. 1 to 21, and Figs. 43 to 63, the flue tube 1 in the fragment between the adjacent sections is circular in cross section, and in the variants illustrated on Figs. 22 to 42, and Figs. 64 to 84 the shape of the tube cross section is square with rounded apexes and sides indented towards the axis.

In other embodiment variants the flue tube 1 between the adjacent sections can be oval in cross section.

In other embodiment variants described above the distance between the lowest points in the dents 2 measured inside the flue tube 1 in the section cannot be larger than 1.0 mm and the ratio of the length L of the flue tube 1 to the tube cross section circumference around which the combustion gases flow ranges from 2.5 to 6.5, and the length of the cylindrical flue tube 1 in its top section ranges from 0.25 to 1.5 of the tube cross section circumference around which the combustion gases flow. It has been found that with the combustion gas temperature at the flue tube inlet ranging from 1450 to 1550 °C, the flow of the combustion gas in the flue tube between 0.83 and 0.89 kg/h (for natural gas, CO₂ = 9%), and the initial temperature of 30 °C and dT=20K of the heated liquid in counterflow of 22-26 l/h per tube, the combustion gas reaches the dew

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point at the distance of 155-225 mm from the tube inlet, and the pressure drop does not exceed 375Pa.

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Claims

1. A condensing heat exchanger comprising a combustion chamber fitted in its top section which features an opening for inserting the burner, as well as flue tubes anchored in the sieve bottoms and encased in an outer jacket, where there is a chamber to accommodate the heated liquid formed inside the jacket and the jacket is fitted with stub tubes for the supply and discharge of the heated liquid, with a condensate container featuring the condensate discharge stub tube and a stub tube for the discharge of fumes to the vent, characterised in that the tubes (1) feature dents (2) formed along the length of the tube (1), and said dents (2) are pointed towards the centre of the tube (1), and said dents (2) are positioned opposite each other, and two opposite dents (2) mark out a section, where the distance between the lowest points in the dents (2) measured inside the tube (1) in the section is 1.0 mm or less, and the ratio of the length (L) of the tube (1) to the tube cross section circumference around which the combustion gases flow falls within the range from 2.5 to 6.5.
2. The exchanger according to Claim 1, characterised in that the flue tube (1) is cylindrical in shape in its top section.
3. The exchanger according to Claim 1 or 2, characterised in that the flue tube (1) is cylindrical in shape in its bottom section.
4. The exchanger according to Claim 2, characterised in that the length (H) of the cylindrical top section of the flue tube (1) ranges from 0.25 to 1.5 of the tube's cross section circumference around which the combustion gases flow.

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5. The exchanger according to Claim 1, characterised in that the adjacent sections of the dents (2) are arranged otherwise than collinearly to each other along the length of the flue tube (1).
6. The exchanger according to Claim 5, characterised in that the adjacent sections of dents (2) are mutually arranged at the angle of 90° .
7. The exchanger according to Claims 1 or 5 or 6, characterised in that the sections of dents (2) are arranged at even distances along the length of the flue tube (1)
8. The exchanger according to Claims 1 or 5 or 6, characterised in that the distances (S) between the sections of the dents (2) decrease along the length of the flue tube (1).
9. The exchanger according to Claim 1 or 5 to 8, characterised in that the dents (2) are circular in shape.
10. The exchanger according to Claim 1 or 5 to 8, characterised in that the dents (2) are oval in shape.
11. The exchanger according to Claim 1 or 5 to 8, characterised in that the dents (2) are drop-like in shape.
12. The exchanger according to Claims 1 to 8 characterised in that the cross section of the flue tube (1) in the fragment between the adjacent sections is circular in shape.
13. The exchanger according to Claims 1 to 8, characterised in that the cross section of the flue tube (1) in the fragment between the adjacent sections is oval in shape.
14. The exchanger according to Claims 1 to 8 characterised in that the cross section of the flue tube (1) in the fragment between the adjacent sections is rectangular or square in shape with rounded apexes and sides indented towards the axis.

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15. The method of heat exchange in the exchanger according to Claims 1 to 14, characterised in that with the combustion gas temperature at the inlet of flue tube (1) ranging from 1450 to 1550 °C, the flow of the combustion gas in the flue tube (1) between 0.83 and 0.89 kg/h (for natural gas, CO₂ = 9%), and the initial temperature of 30 °C and dT=20K of the heated liquid in counterflow of 22-26 l/h in the flue tube (1), the combustion gas reaches the dew point at the distance of 155 – 225 mm from the inlet of the tube (1), and the pressure does not drop below 375 Pa.

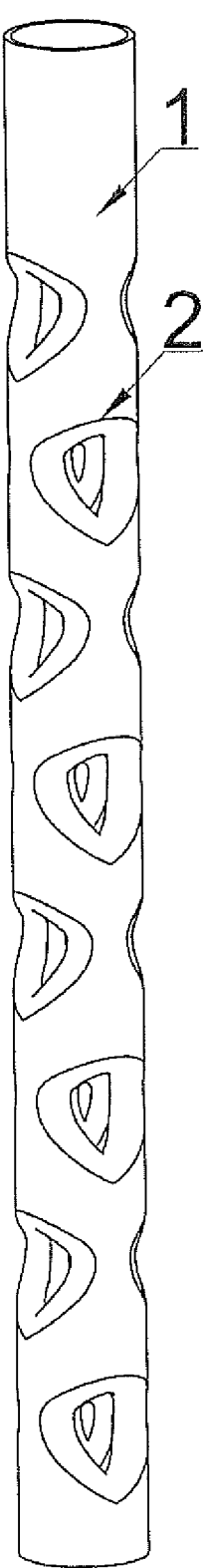


Fig.1

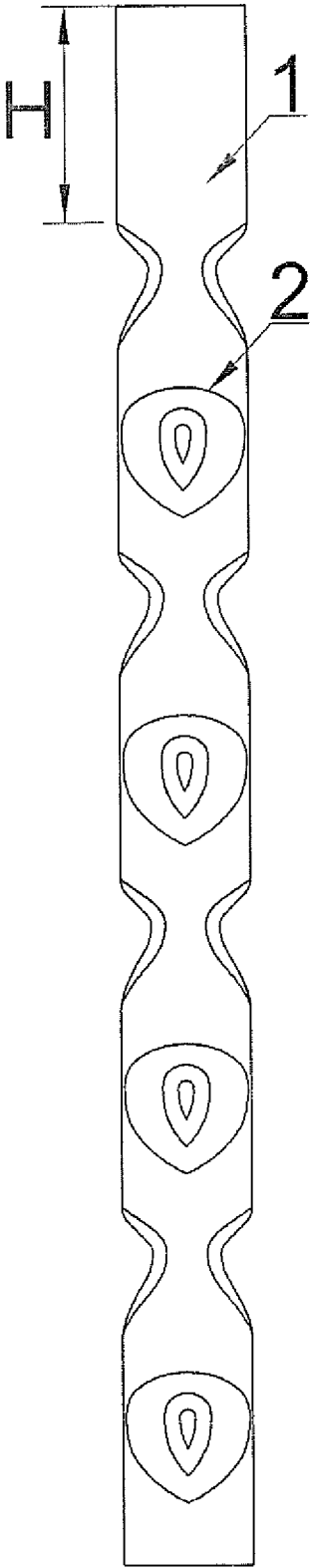


Fig.2

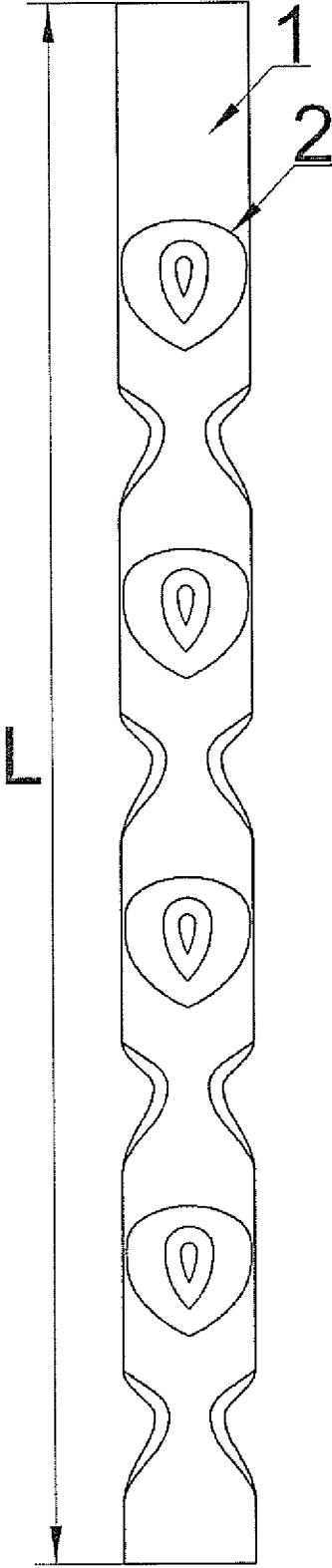


Fig.3

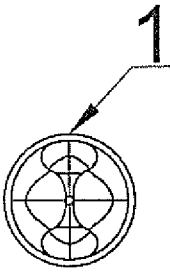


Fig.4

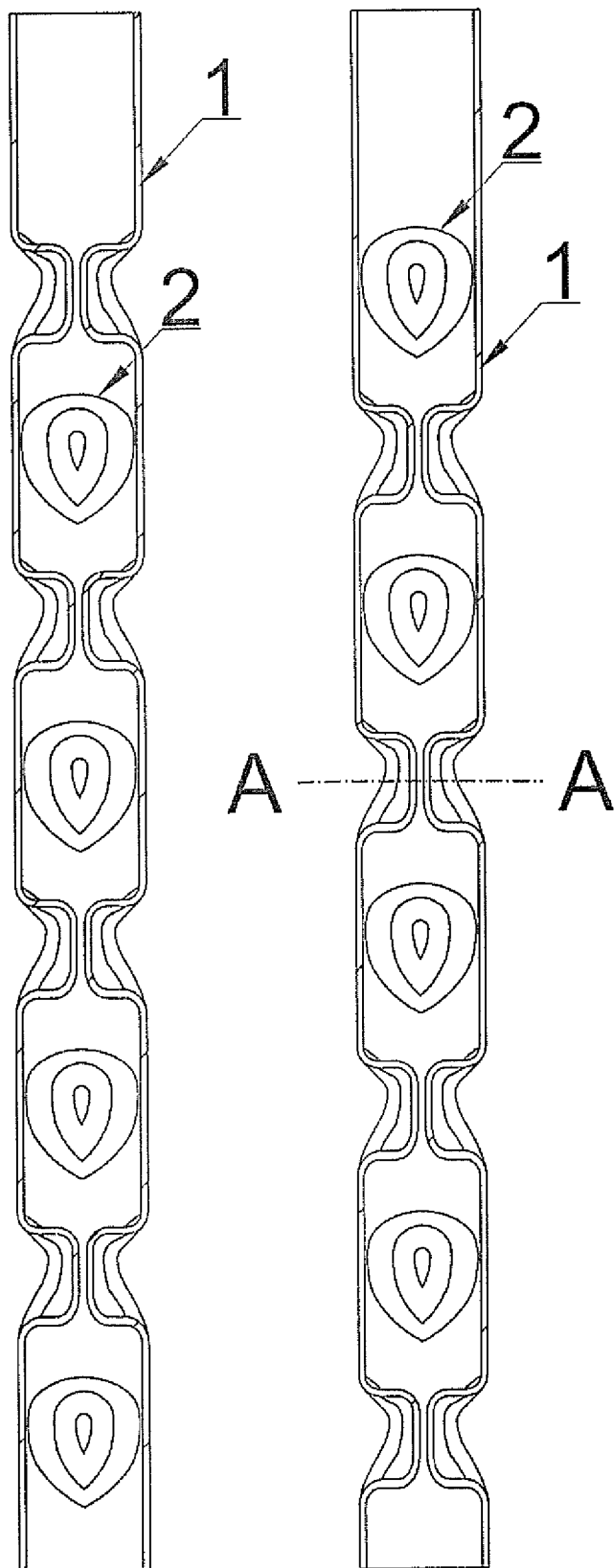
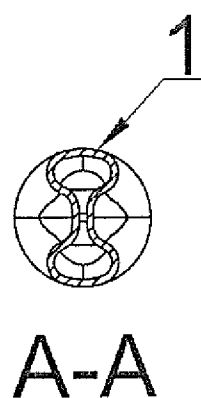


Fig.5

Fig.6



A-A

Fig.7

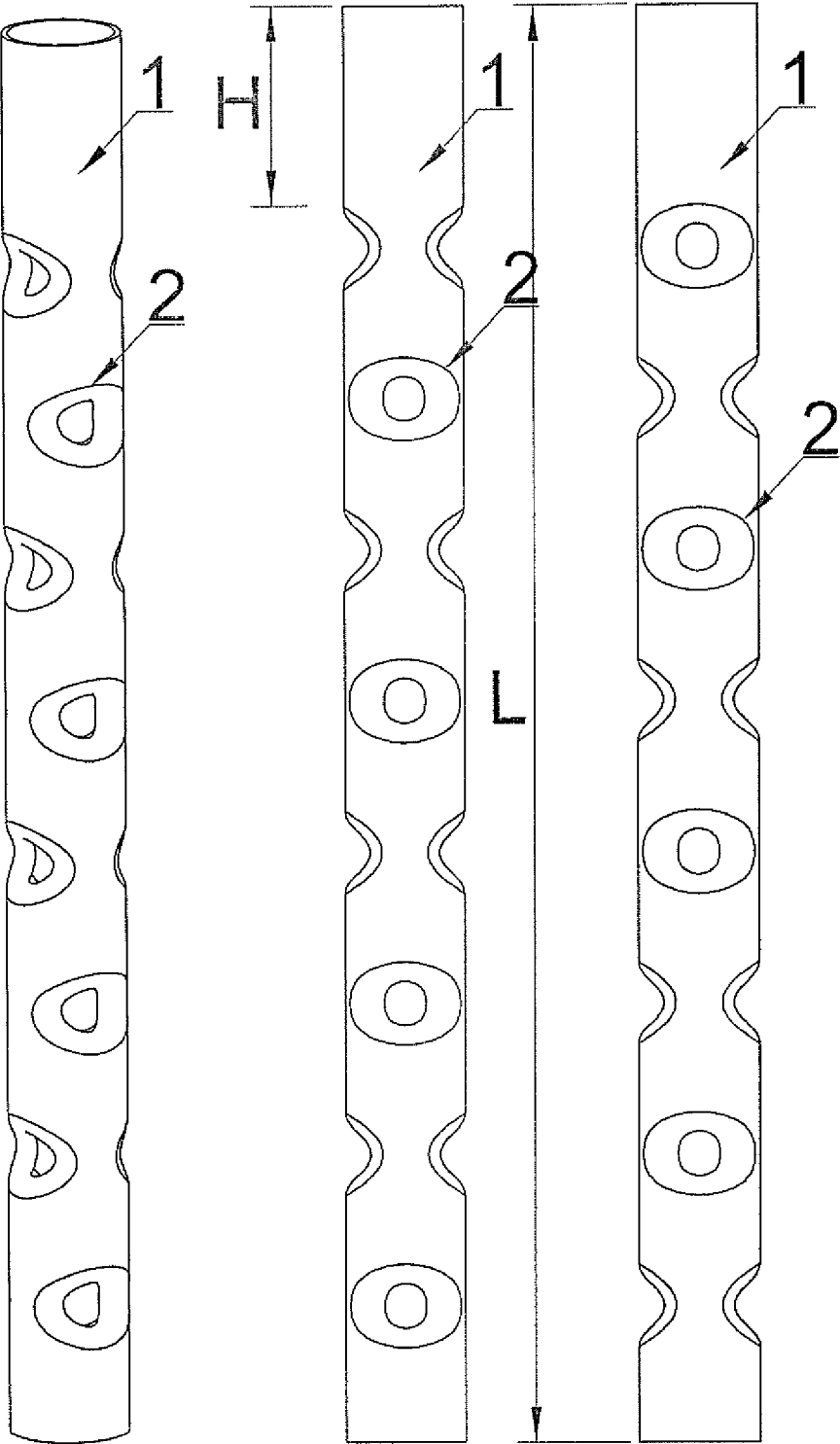


Fig.8

Fig.9

Fig.10

Fig.11

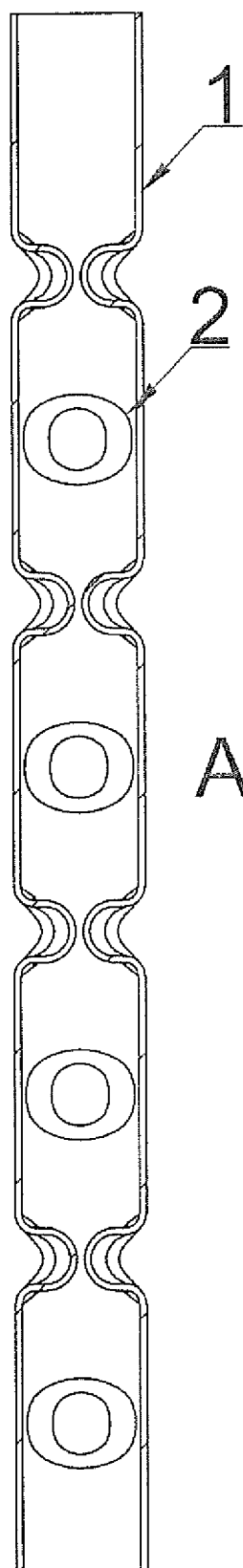


Fig.12

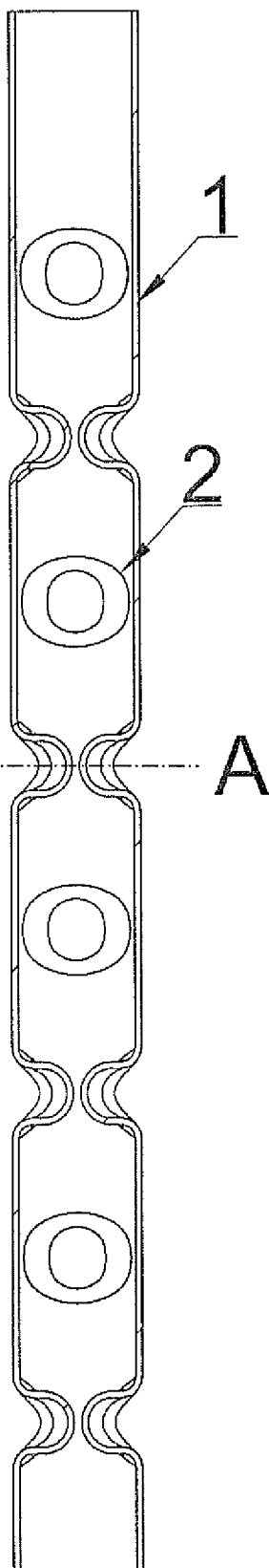


Fig.13

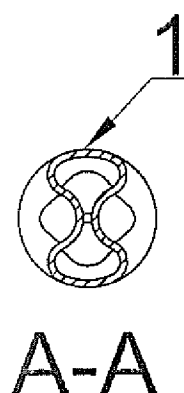


Fig.14

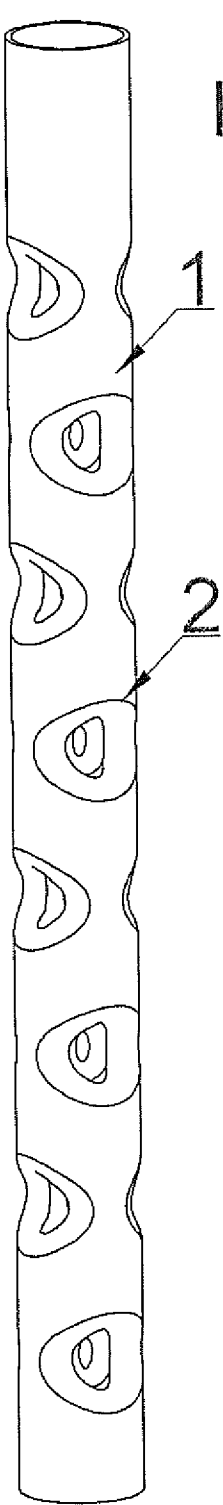


Fig.15

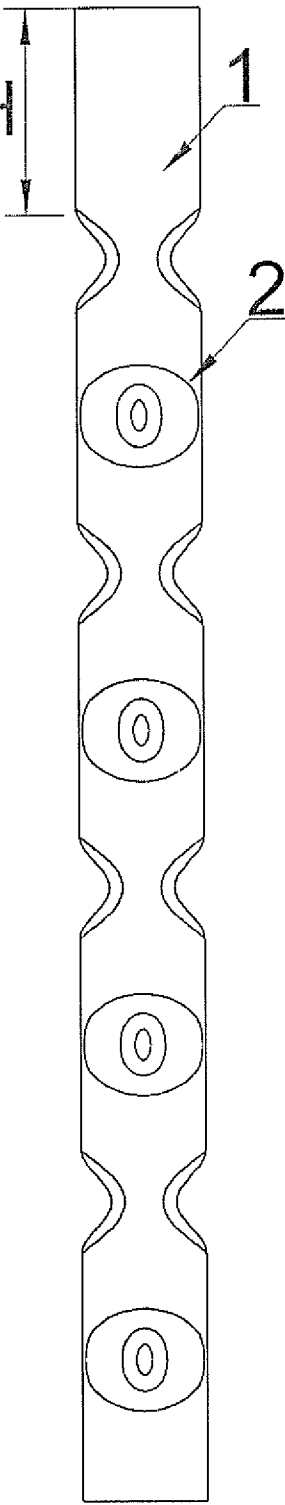


Fig.16

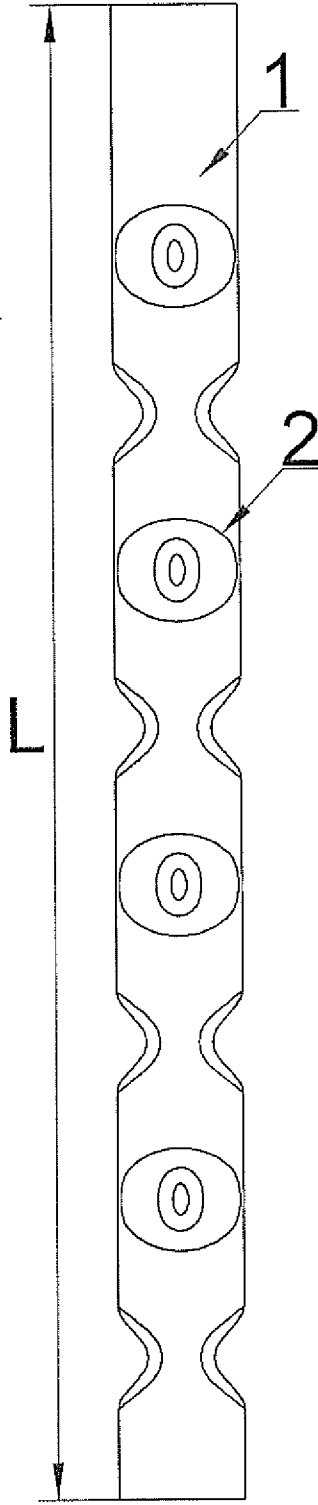


Fig.17

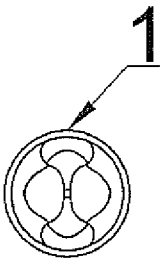


Fig.18

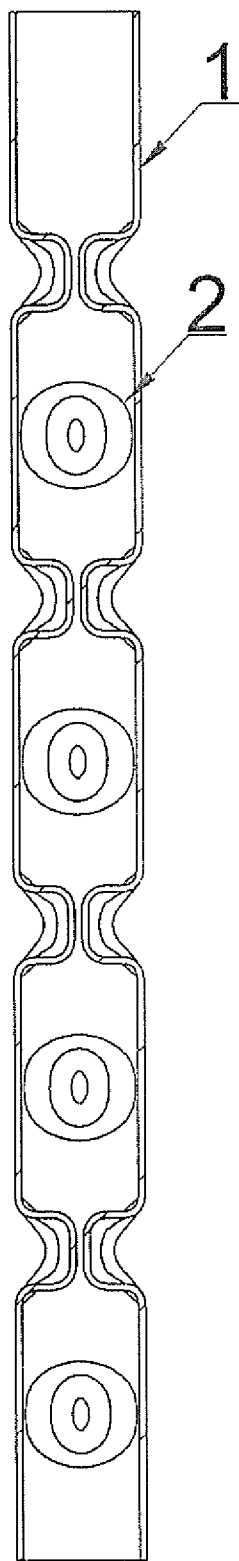


Fig.19

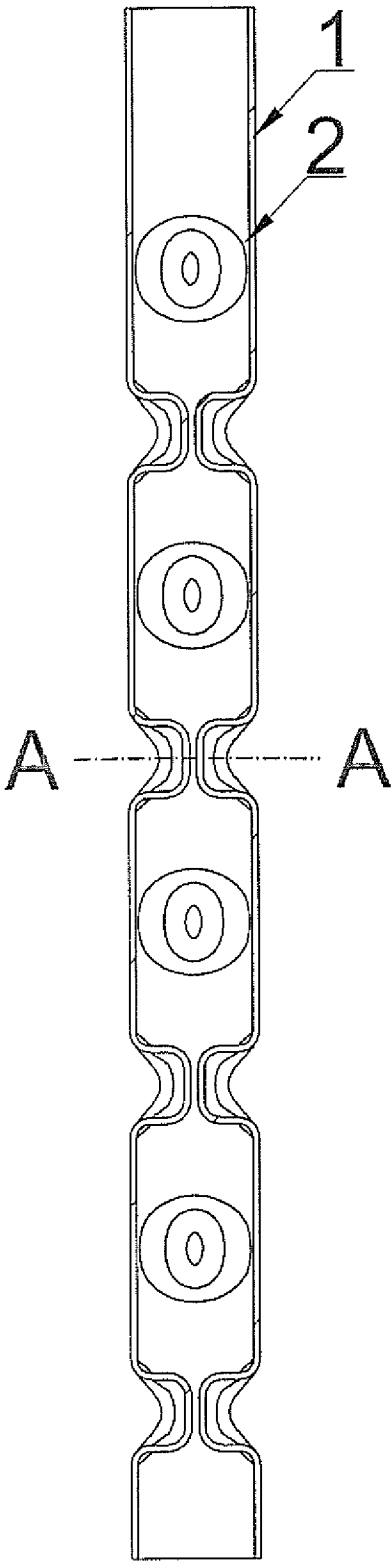


Fig.20

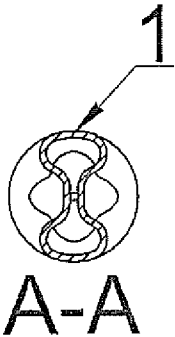


Fig.21

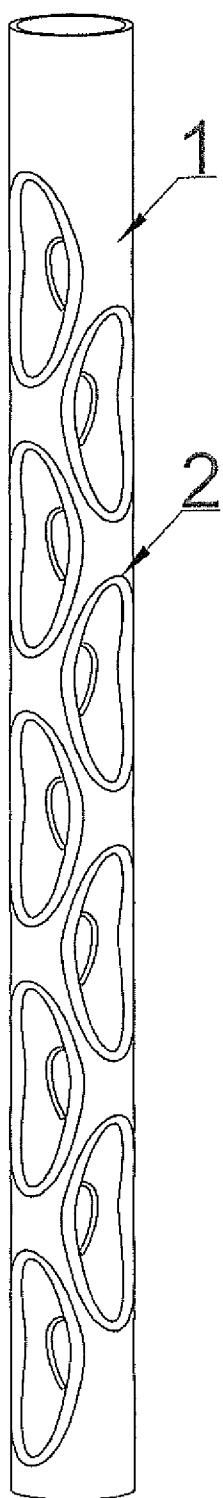


Fig.22

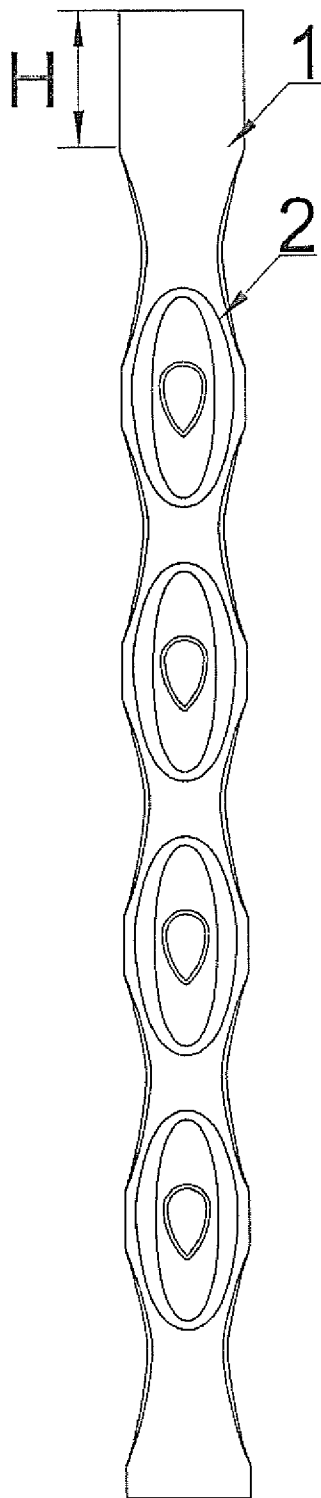


Fig.23

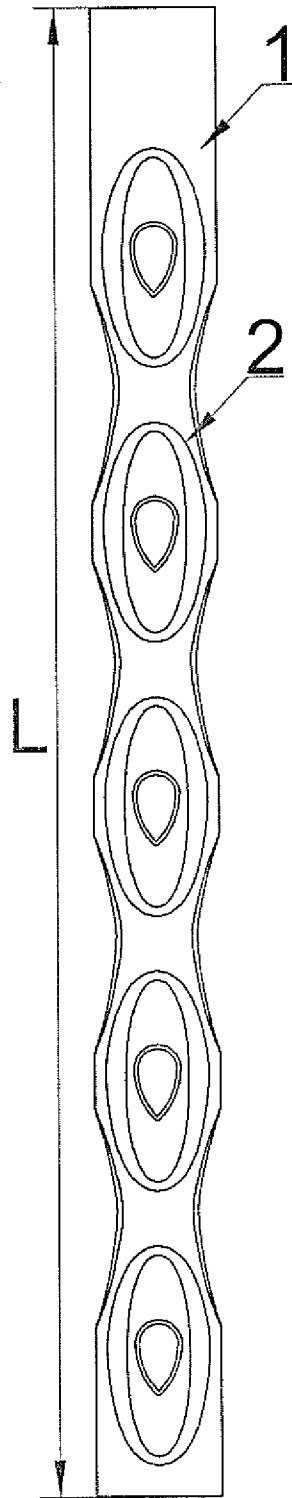


Fig.24

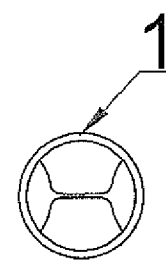


Fig.25

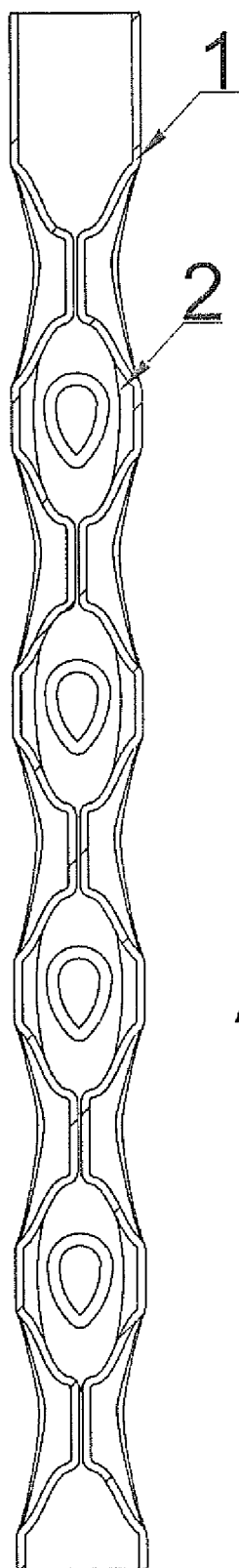


Fig. 26

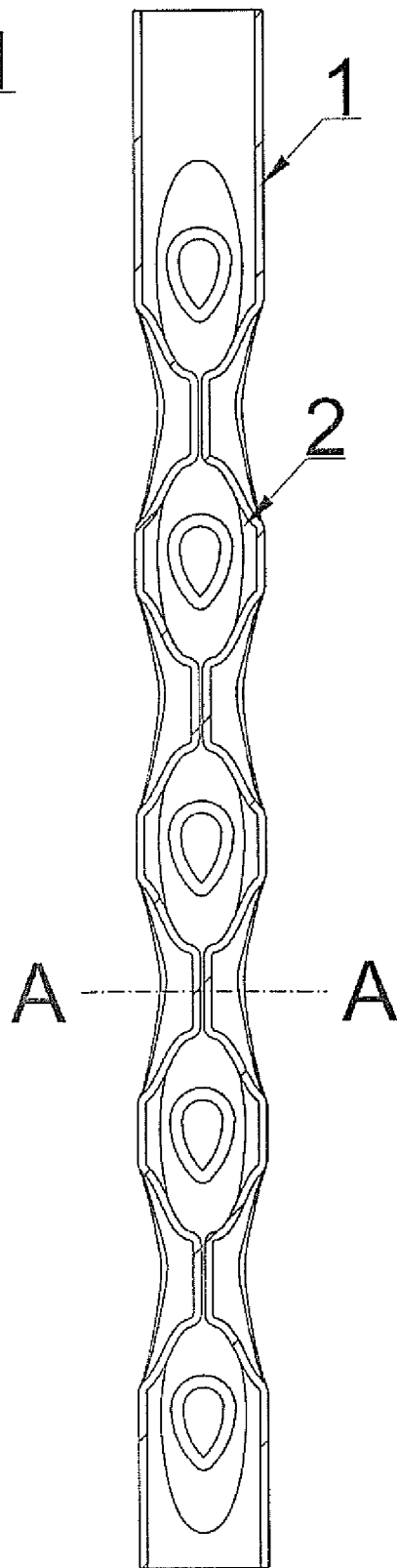


Fig. 27

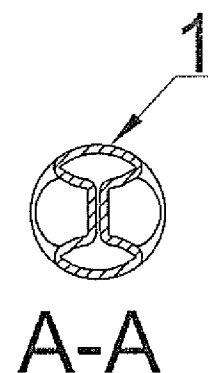


Fig. 28

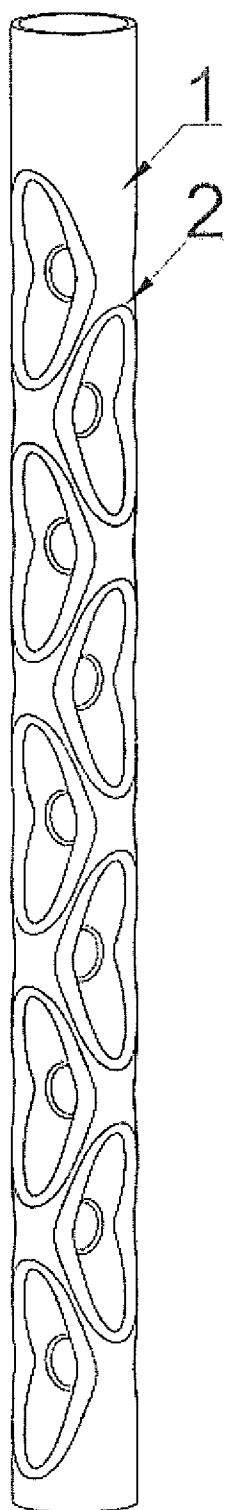


Fig.29

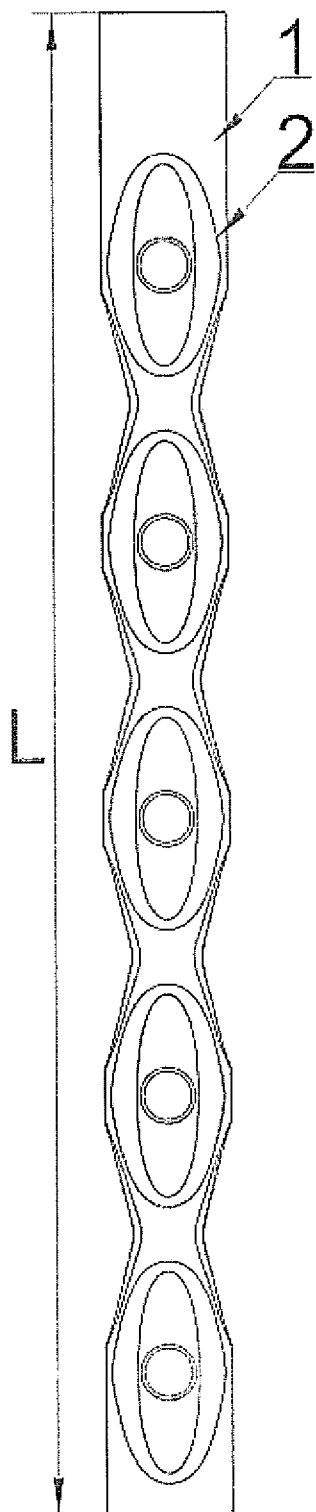


Fig.30

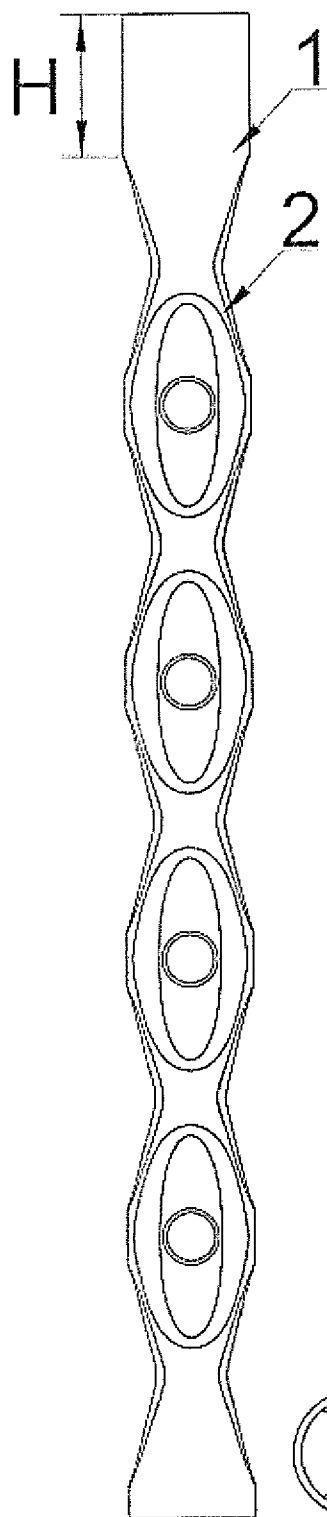


Fig.31

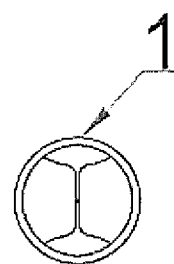


Fig.32

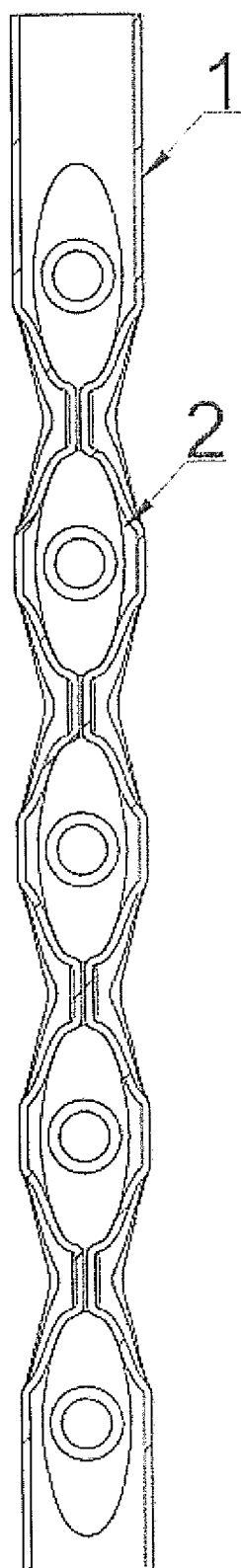


Fig.33

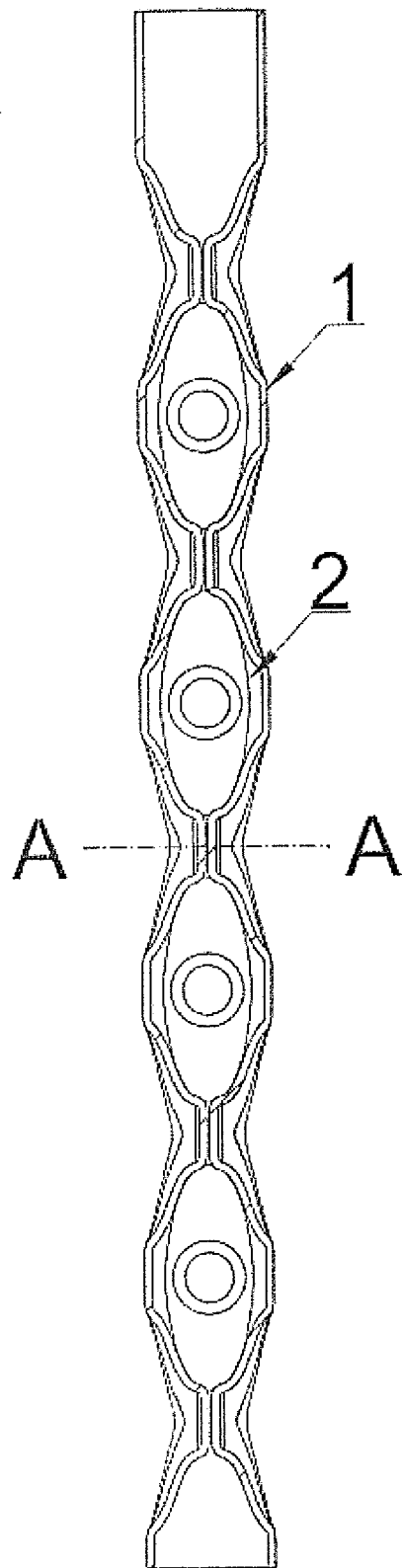


Fig.34

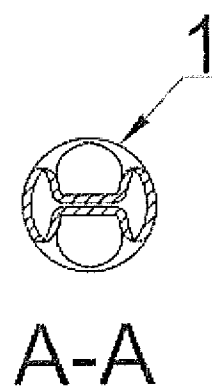


Fig.35

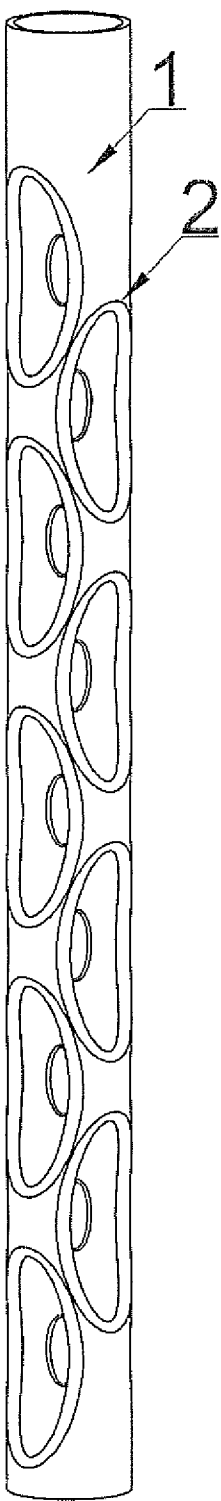


Fig.36

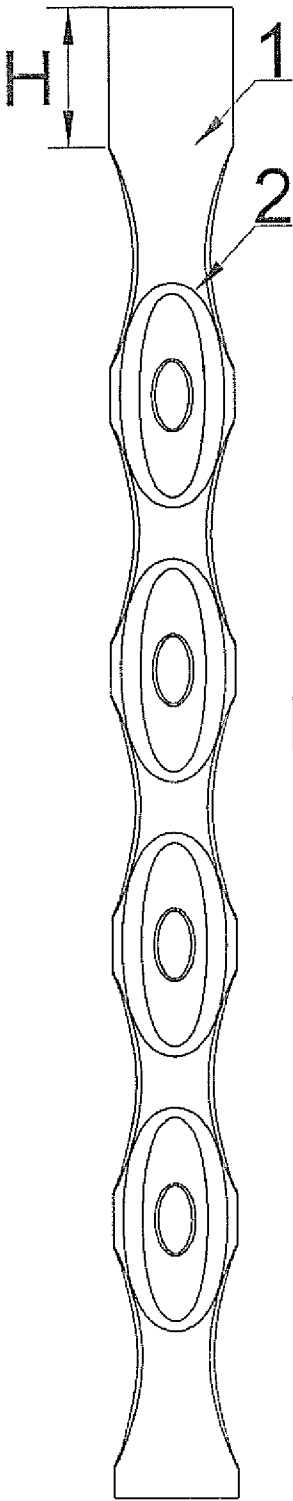


Fig.37

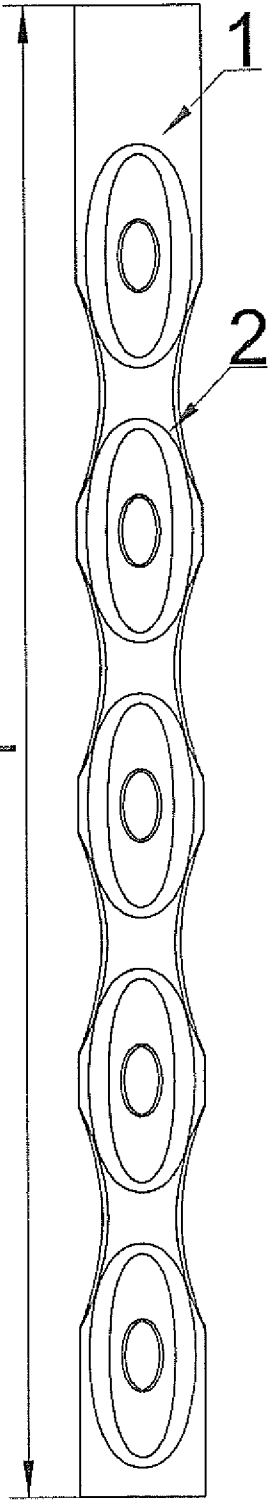


Fig.38

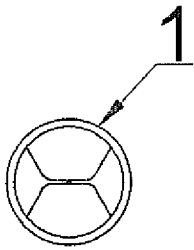


Fig.39

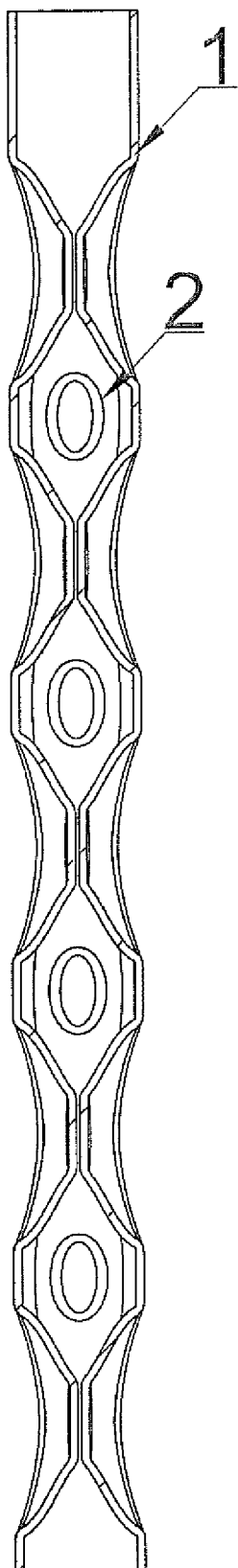


Fig.40

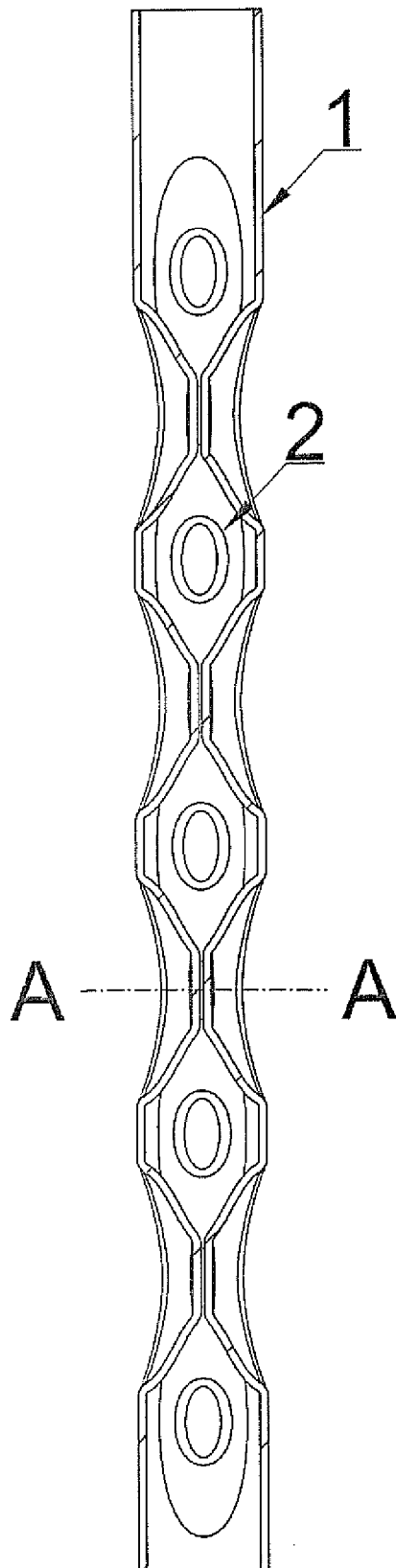


Fig.41

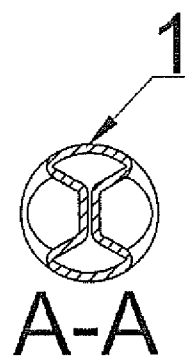


Fig.42

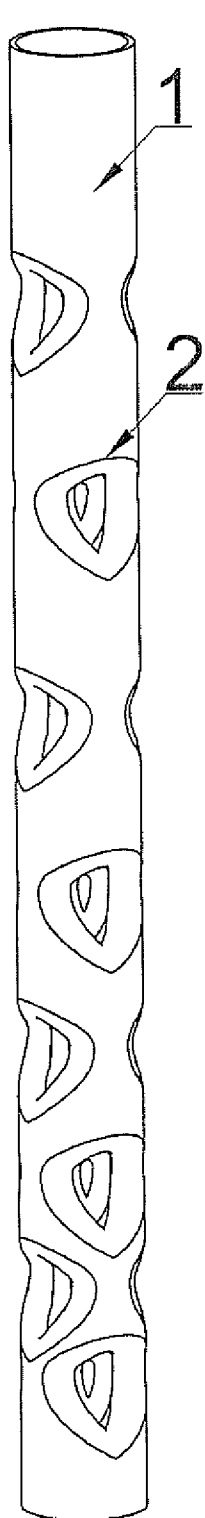


Fig. 43

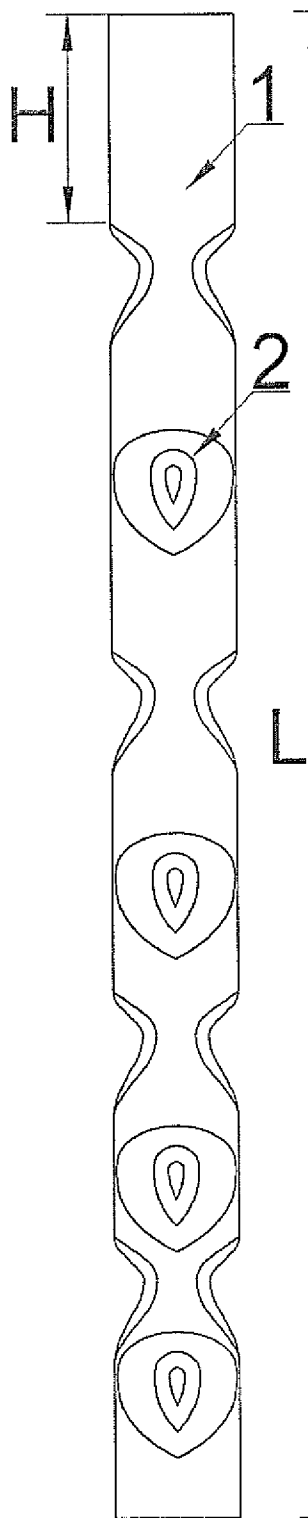


Fig. 44

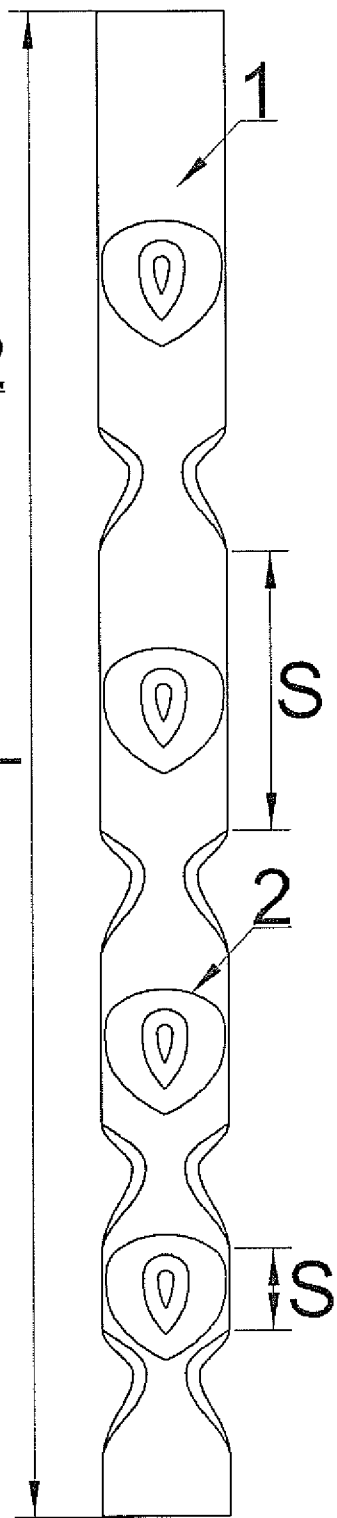


Fig. 45

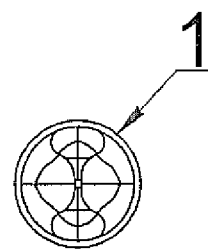


Fig. 46

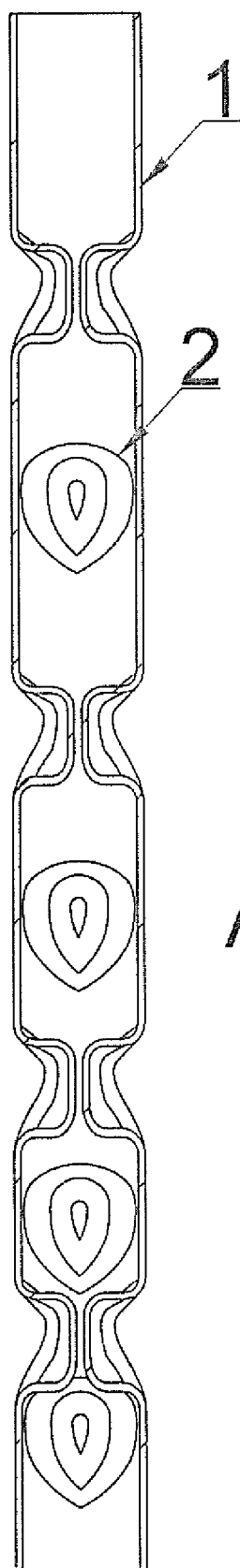


Fig.47

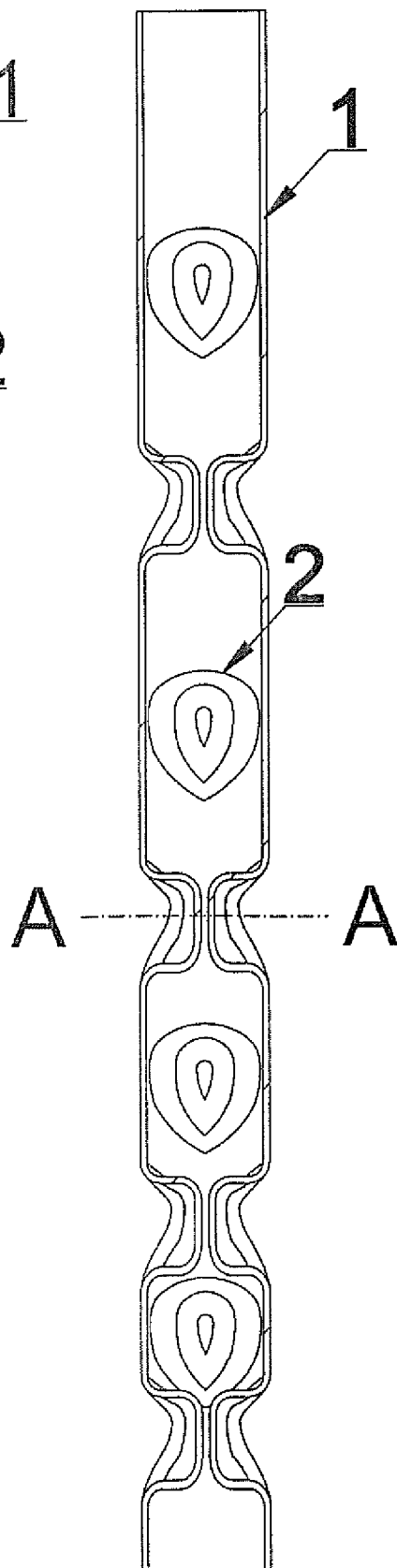


Fig.48

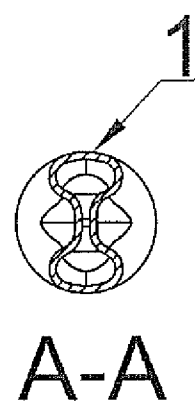


Fig.49

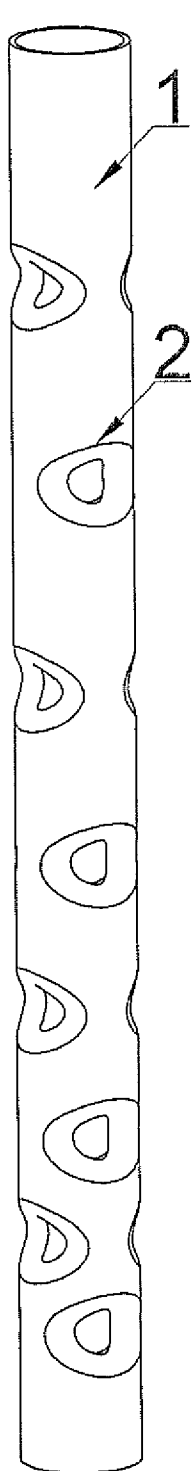


Fig. 50

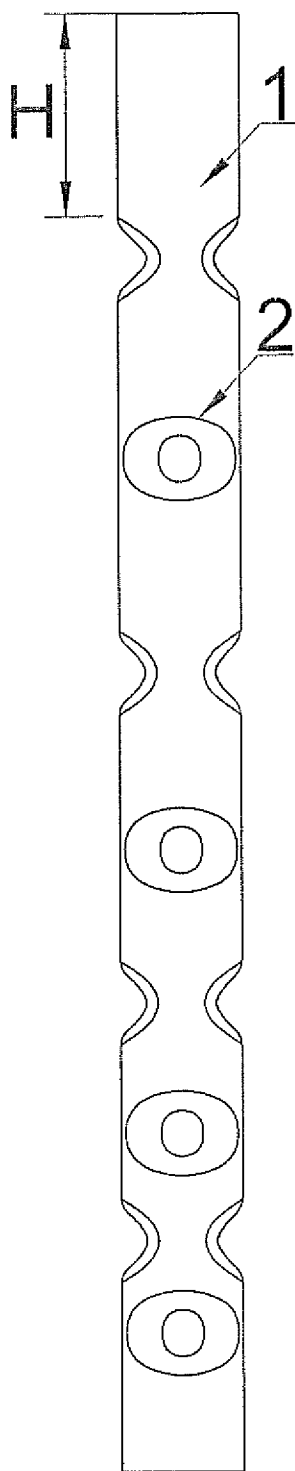


Fig. 51

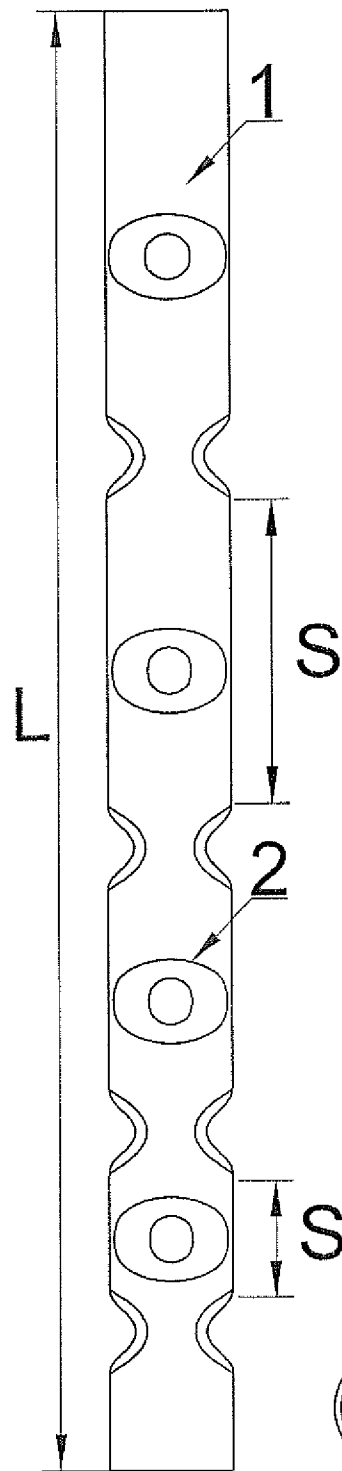


Fig. 52

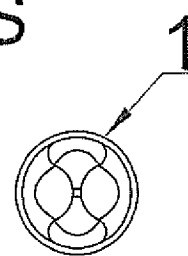


Fig. 53

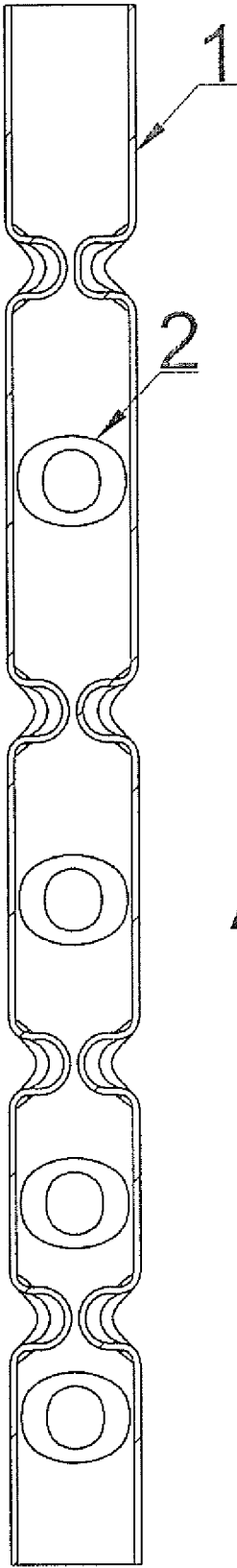


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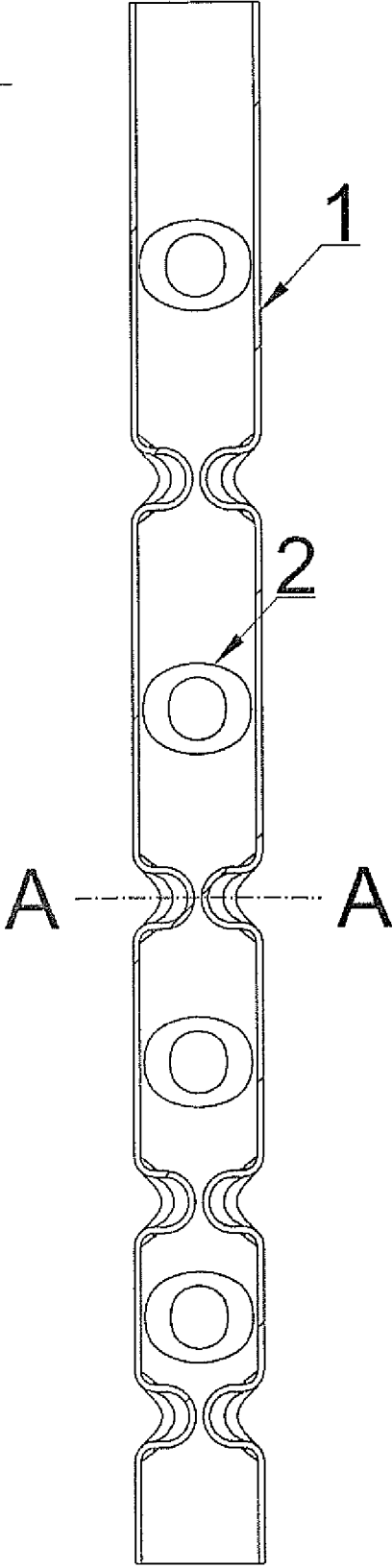


Fig.55

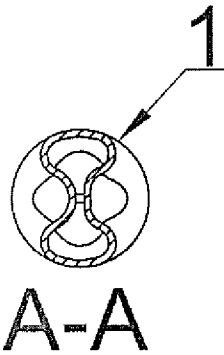


Fig.56

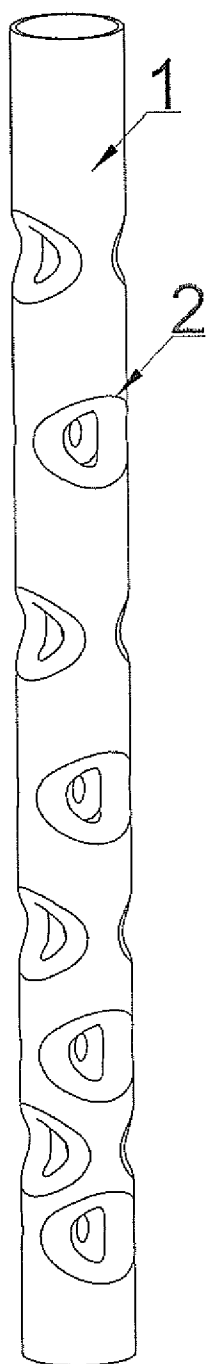


Fig. 57

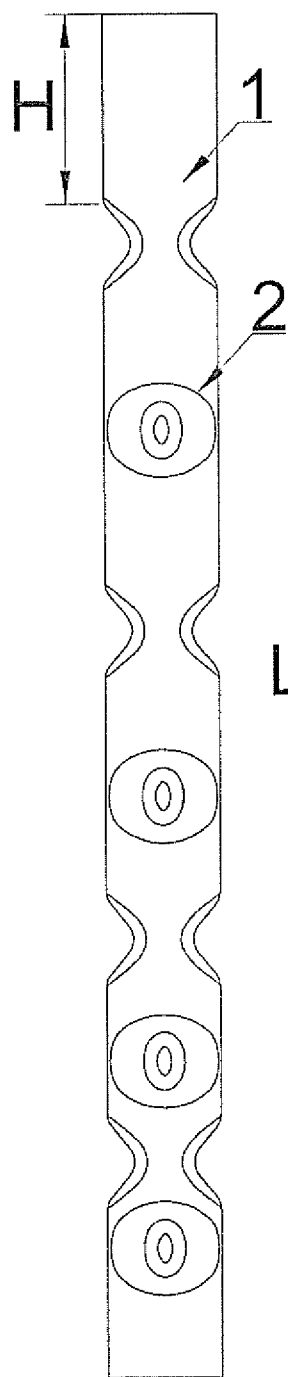


Fig. 58

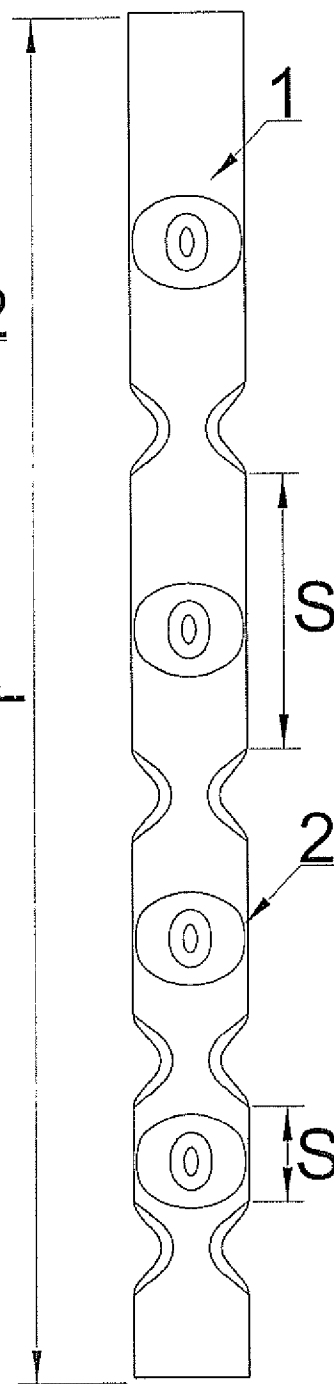


Fig. 59

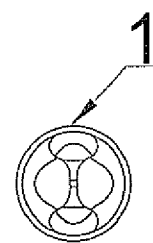


Fig. 60

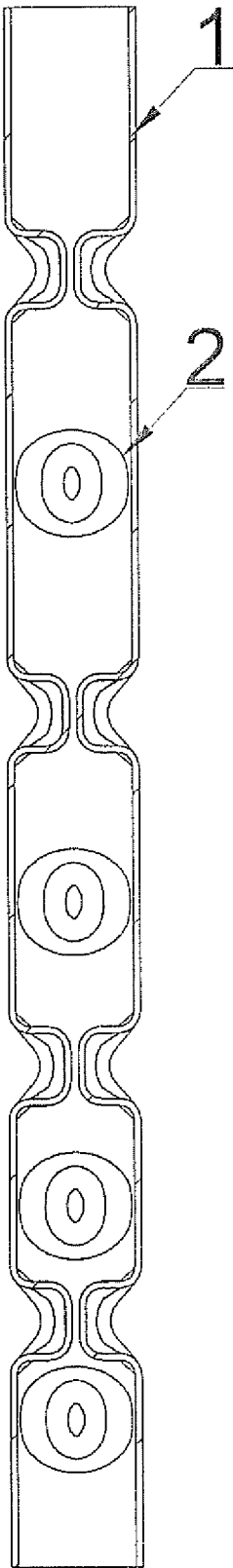


Fig.61

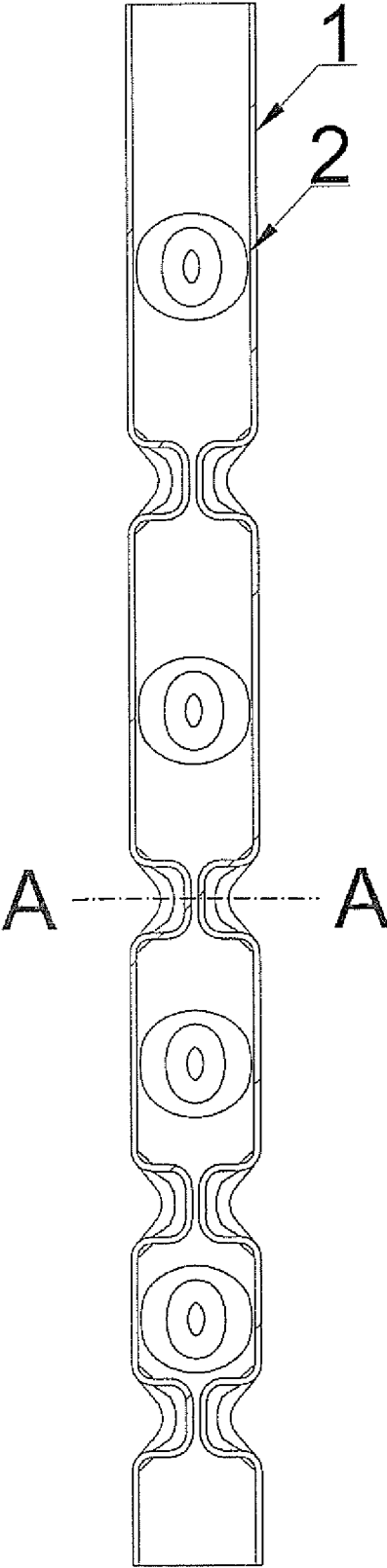


Fig.62

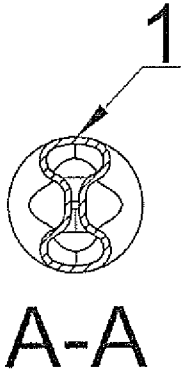
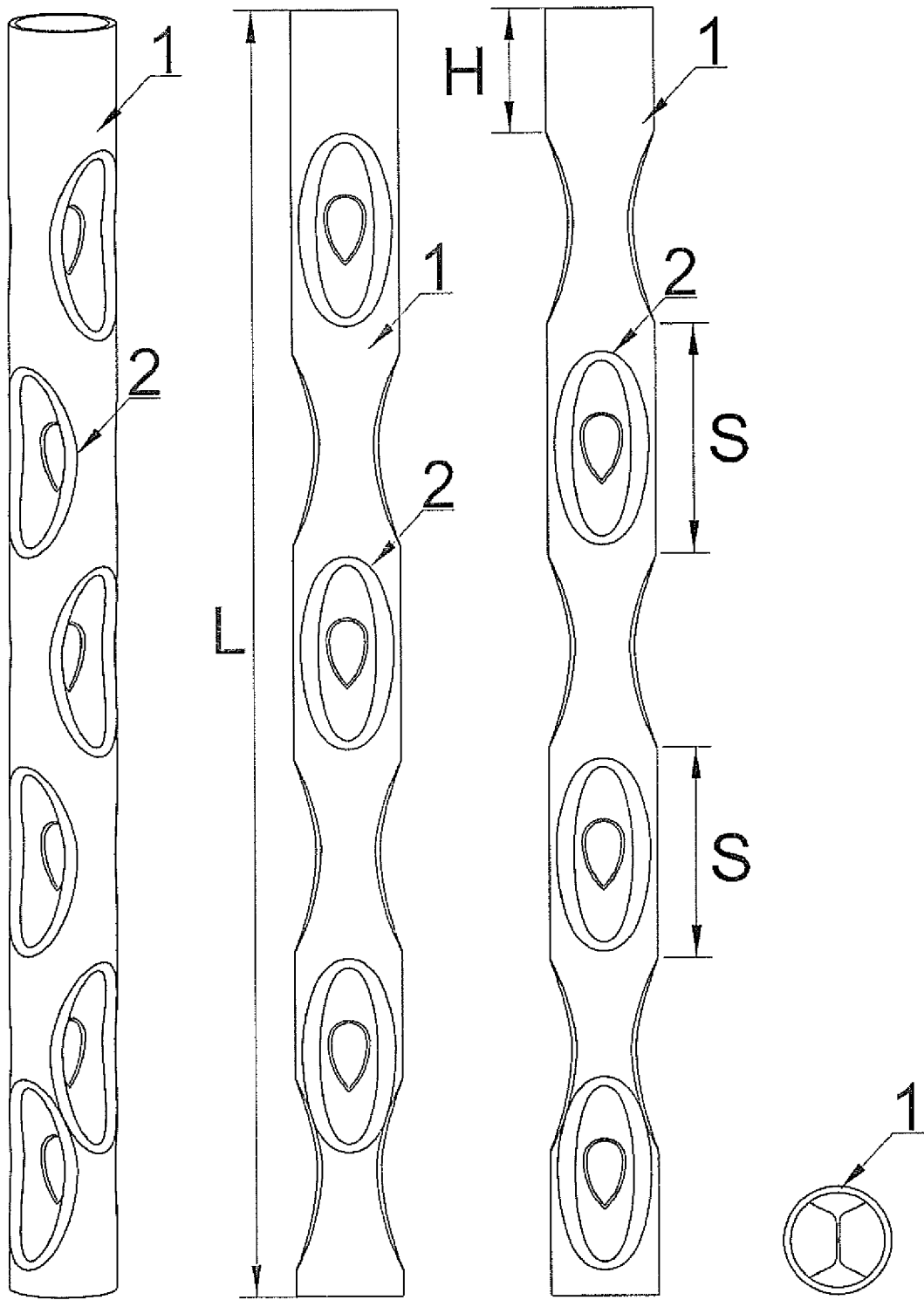


Fig.63



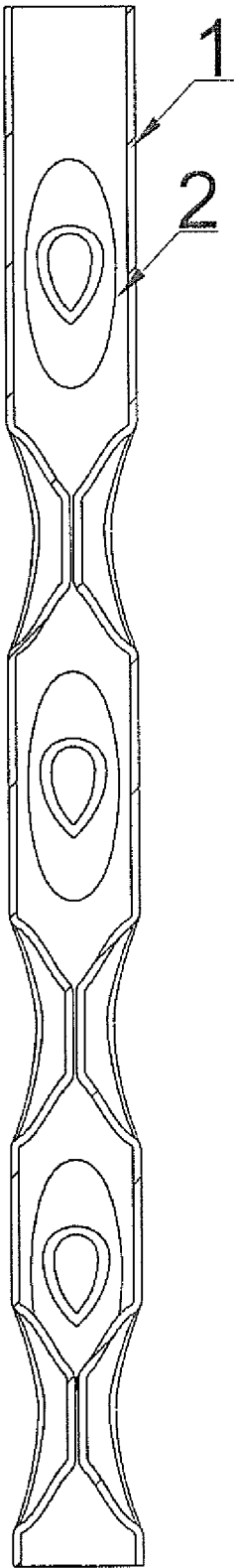


Fig.68

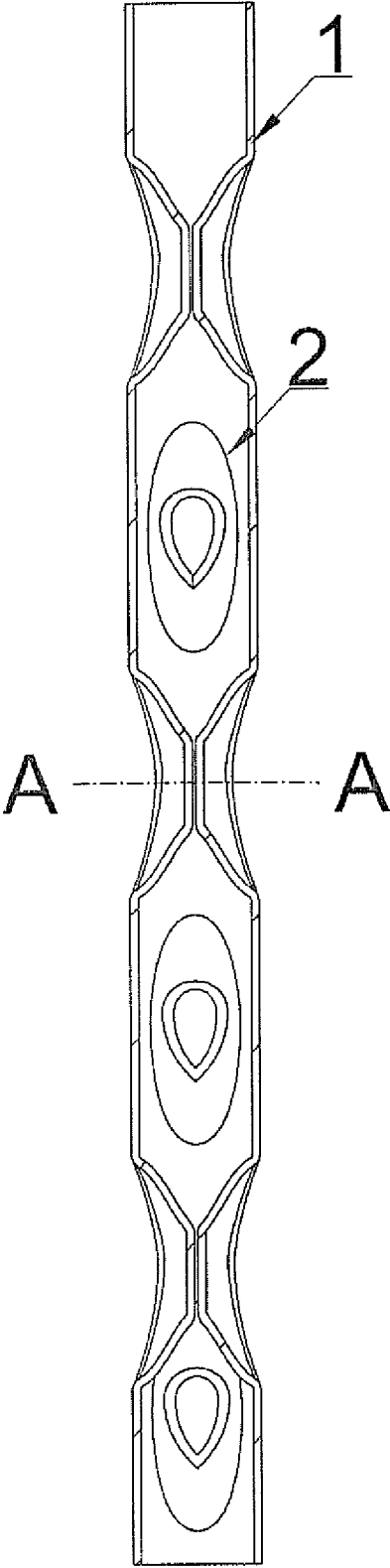


Fig.69

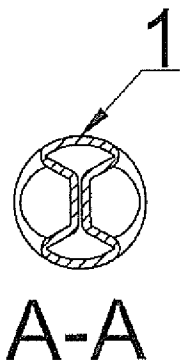


Fig.70

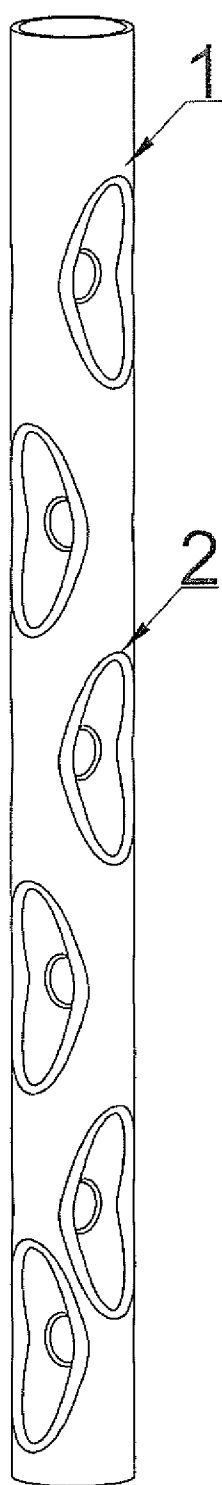


Fig. 71

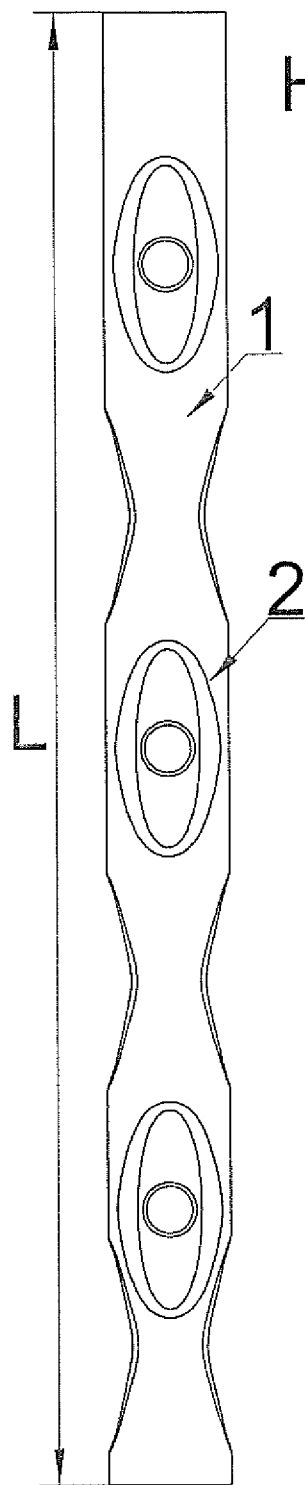


Fig. 72

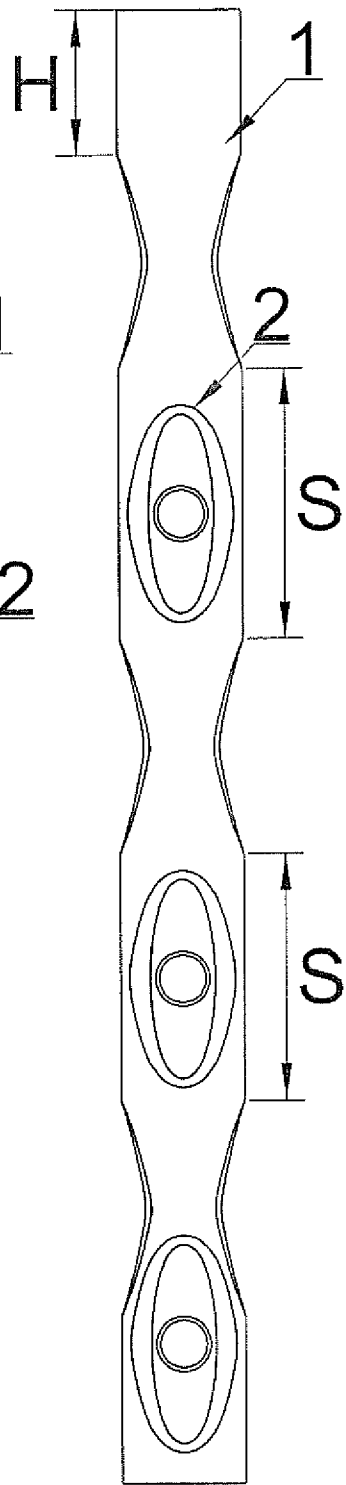


Fig. 73

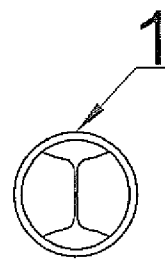


Fig. 74

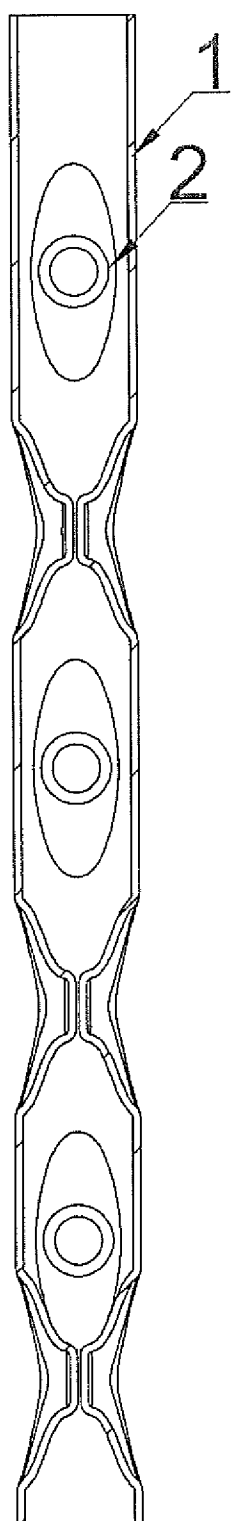


Fig.75

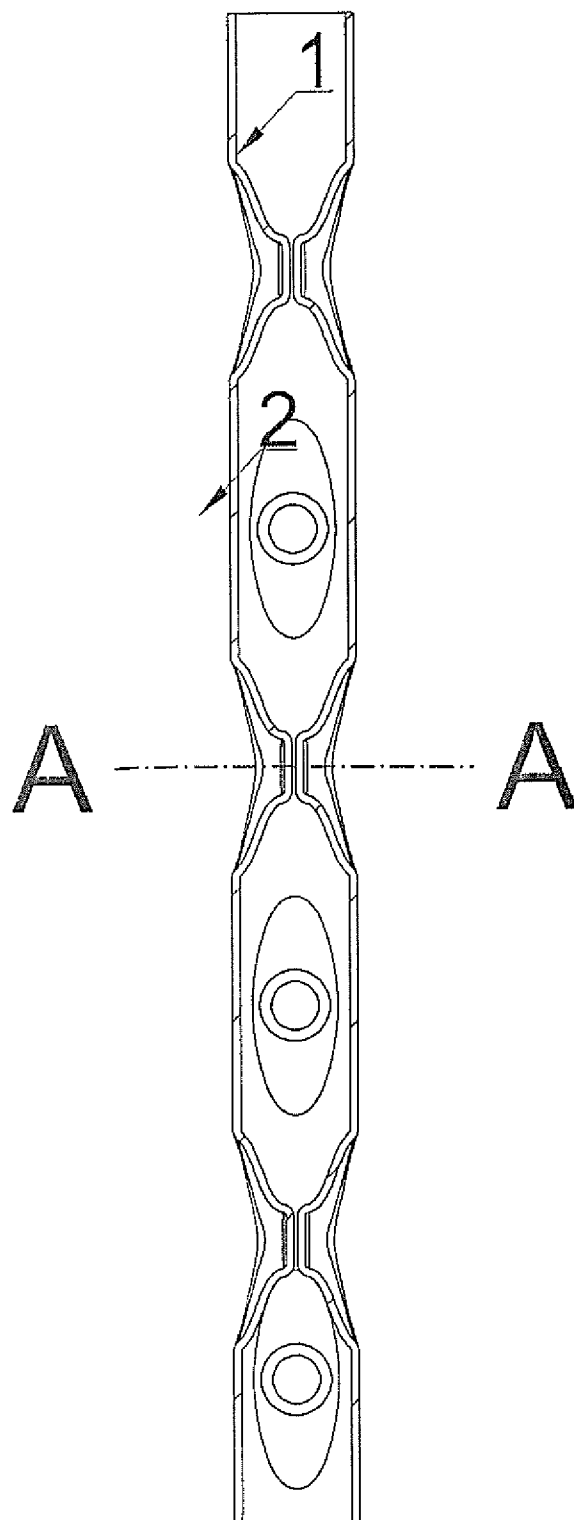


Fig.76

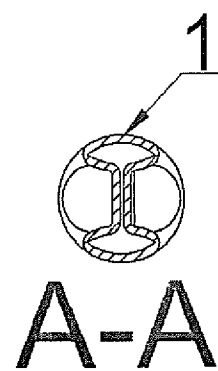


Fig.77

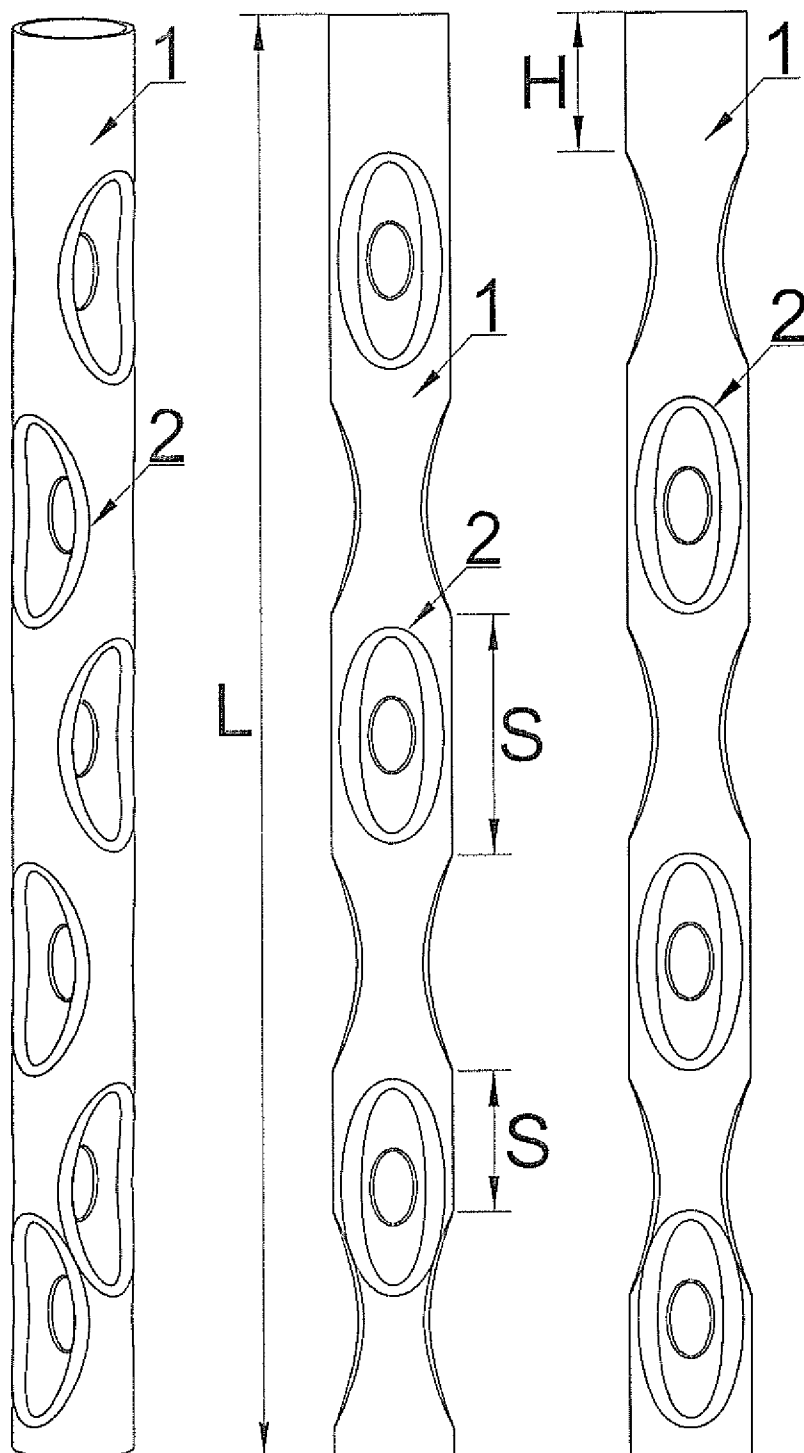


Fig.78

Fig.79

Fig.80

Fig.81

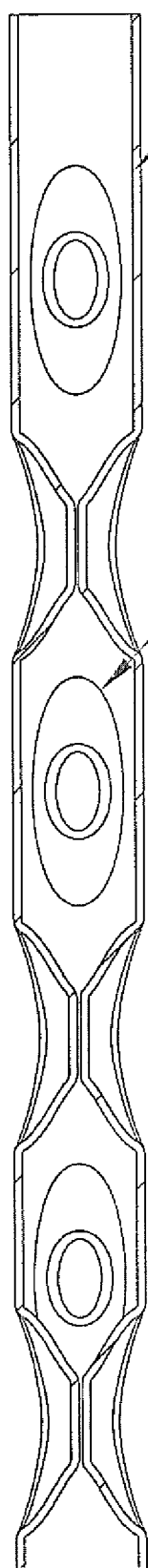


Fig. 82

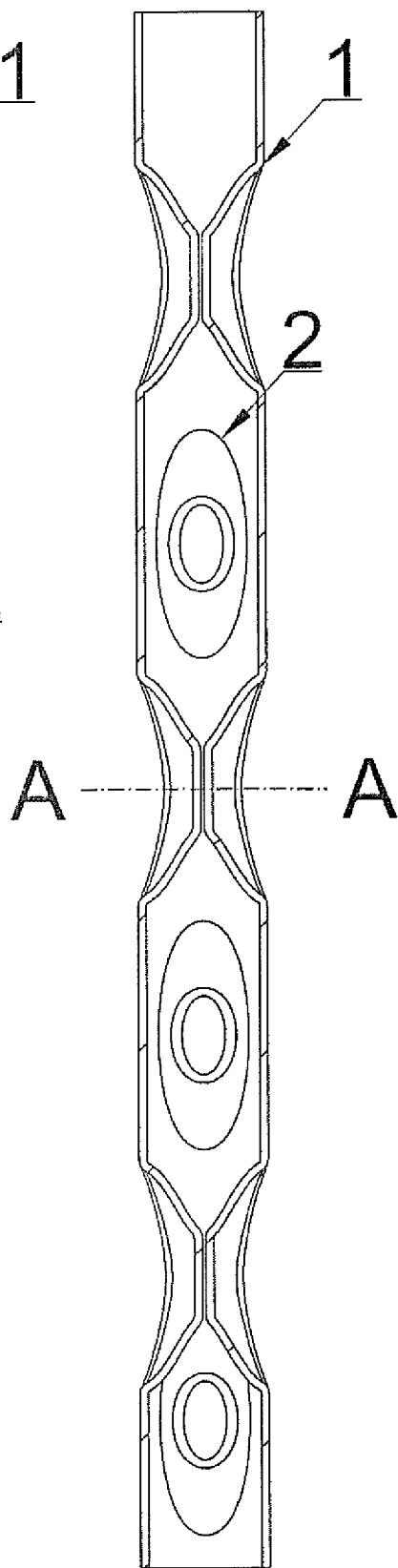
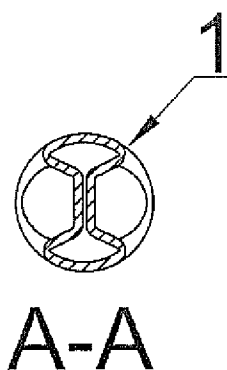


Fig. 83



A-A

Fig. 84

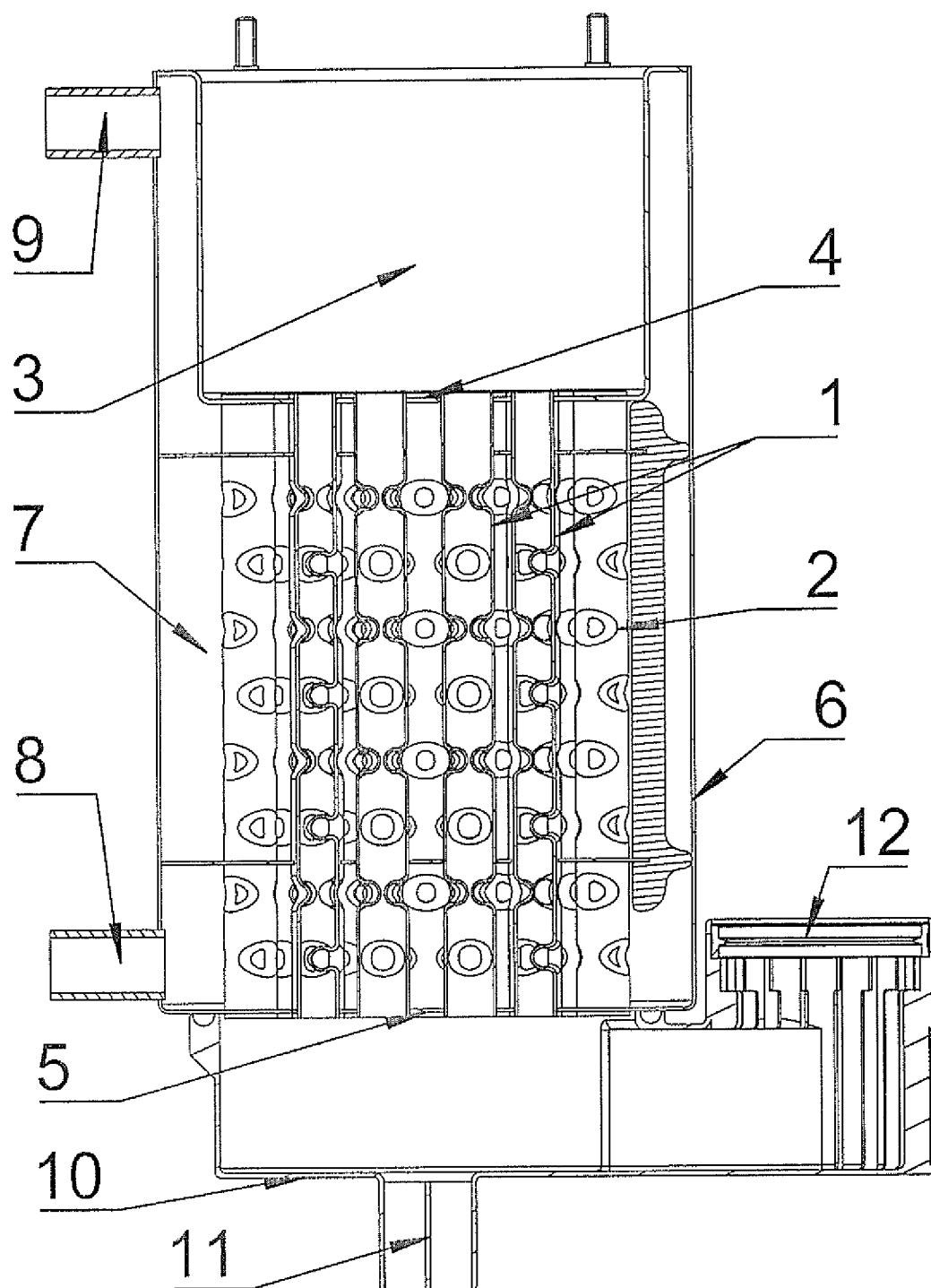


Fig.85

INTERNATIONAL SEARCH REPORT

International application No
PCT/PL2016/000070

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	F28F1/42	F28F13/08 F28F13/12 F28D21/00 F28F1/06
ADD.	F28F1/08	
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) F28F F28D		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PL 216 290 B1 (AIC SPOLKA AKCYJNA) 31 March 2014 (2014-03-31) cited in the application the whole document	1-15
Y	US 2002/005275 A1 (O'DONNELL MICHAEL J [US] ET AL) 17 January 2002 (2002-01-17) paragraphs [0022], [0026]; figure 3b	1-15
A	WO 2015/059537 A2 (TECNOINOX S R L [IT]) 30 April 2015 (2015-04-30) figures 3, 4	1-15
A	US 5 839 505 A (LUDWIG RICHARD M [US] ET AL) 24 November 1998 (1998-11-24) figures 7, 8	1-15
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* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "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 28 September 2016		Date of mailing of the international search report 08/11/2016
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Louchet, Nicolas

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/PL2016/000070

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		WO 2015059537 A2	30-04-2015

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