



AU9212533

(12) PATENT ABRIDGMENT (11) Document No. AU-B-12533/92
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 657947

- (54) Title
MODULAR UNIT FOR A TUBULAR ULTRASONIC REACTOR
- International Patent Classification(s)
(51)⁵ **B06B 003/00 B01D 019/00 B01F 003/00 B01J 019/10**
- (21) Application No. : **12533/92** (22) Application Date : **15.01.92**
- (87) PCT Publication Number : **WO92/12790**
- (30) Priority Data
- (31) Number (32) Date (33) Country
91 00499 17.01.91 FR FRANCE
- (43) Publication Date : **27.08.92**
- (44) Publication Date of Accepted Application : **30.03.95**
- (71) Applicant(s)
PHILIPPE VAXELAIRE
- (72) Inventor(s)
PHILIPPE VAXELAIRE
- (74) Attorney or Agent
CARTER SMITH & BEADLE , Qantas House, 2 Railway Parade, CAMBERWELL VIC 3124
- (56) Prior Art Documents
US 4347110
US 4339247
US 4392380
- (57) Claim

1. Modular reactor unit for continuous ultrasonic treatment of materials and/or reagents characterized in that it comprises a tubular metal body having a cylindrical interior and a circular transverse cross-section open at a feed end and a discharge end, in that the exterior surface of said tubular metal body has in the vicinity of the nodal zone a projecting radially collar coaxial with said tube, and in that at least one ultrasonic converter is disposed radially and attached to said collar at its periphery, the frequency of said converter being equal to the frequency of vibration of said collar and to the frequency of longitudinal vibration of said tubular metal body.

10. Ultrasonic reactor characterized in that it comprises a series coupling of a plurality of modular reactor units according to any one claims 1 to 9 to create an in-line multireactor.



DEMANDE

RE DE BREVETS (PCT)

(51) Classification internationale des brevets ⁵ : B01J 19/10, B01F 3/00 B06B 3/00, B01D 19/00	A1	(11) Numéro de publication internationale: WO 92/12790 (43) Date de publication internationale: 6 août 1992 (06.08.92)
(21) Numéro de la demande internationale: PCT/FR92/00029 (22) Date de dépôt international: 15 janvier 1992 (15.01.92) (30) Données relatives à la priorité: 91/00499 17 janvier 1991 (17.01.91) FR (71)(72) Déposant et inventeur: VAXELAIRE, Philippe [FR/ FR]; 6, rue Henri-Jaccaz, F-74100 Ville-la-Grand (FR). (74) Mandataire: AHNER, Francis; Cabinet Régimbeau, 26, avenue Kléber, F-75116 Paris (FR). (81) Etats désignés: AT (brevet européen), AU, BE (brevet euro- péen), CA, CH (brevet européen), DE (brevet européen), DK (brevet européen), ES (brevet européen), FI, FR (bre- vet européen), GB (brevet européen), GR (brevet euro- péen), IT (brevet européen), JP, KR, LU (brevet euro- péen), MC (brevet européen), NL (brevet européen), NO, SE (brevet européen), US.		Publiée <i>Avec rapport de recherche internationale.</i> 657947

(54) Title: MODULAR UNIT FOR A TUBULAR ULTRASONIC REACTOR

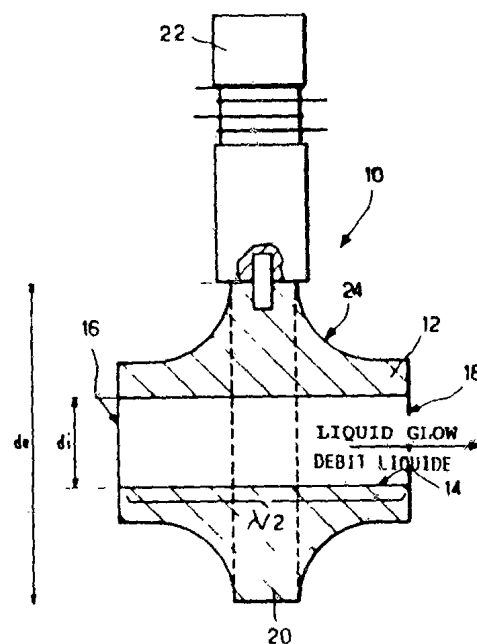
(54) Titre: UNITE MODULAIRE DE REACTEUR ULTRA-SONIQUE TUBULAIRE

(57) Abstract

Modular reactor unit for continuous ultrasonic processing of substances and/or reagents, characterized in that it comprises a tubular metallic body (12) having a cylindrical inner surface and a straight circular cross section, open at its feed (26) and discharge ends (18), in that the surface of said tubular metallic body has, in the region of its nodal zone, a radially projecting collar (20) coaxial to said tube, and in that at least one ultrasonic converter (22) is radially arranged integral with said collar at the periphery of the latter, the frequency of said converter (22) being equal to the frequency of vibration of said collar (20) and to the frequency of longitudinal vibration of said tubular metallic body (12).

(57) Abrégé

Unité modulaire de réacteur pour le traitement ultra-sonique en continu de matières et/ou de réactifs, caractérisé en ce qu'elle comprend un corps métallique tubulaire (12) de surface intérieure (14) cylindrique et de section droite circulaire, ouvert à ses deux extrémités d'alimentation (26) et d'évacuation (18), en ce que la surface dudit corps métallique tubulaire présente, au voisinage de la zone nodale, une couronne (20) coaxiale audit tube et faisant saillie radialement, et en ce qu'au moins un convertisseur ultra-sonique (22) est agencé radialement et de façon solidaire de ladite couronne à la périphérie de cette dernière, la fréquence dudit convertisseur (22) étant égale à la fréquence de vibration de ladite couronne (20) et à la fréquence de vibration longitudinale dudit corps métallique tubulaire (12).



MODULAR UNIT FOR A TUBULAR ULTRASONIC REACTOR

The present invention concerns a modular unit for a tubular ultrasonic reactor and various applications of said unit in the form of multireactors adapted to various specific applications.

In the current state of the art various ultrasonic devices are known for treating liquids. These are mainly devices derived from the technology of ultrasonic cleaning and usually in the form of thin metal tanks with a plurality of emitters fixed to the bottom.

Vibrating the bottom of the tank induces cavitation in the liquid it contains, the intensity of such cavitation decreasing in the direction away from the source, i.e. the bottom of the tank.

Another known technique uses two diaphragms in opposition. Just as in the aforementioned cleaning technology, a number of emitters are disposed on two metal plates facing each other with a distance of between 1.5 and 4 mm, called the coupling distance, between them. The liquid to be treated is passed between the two emitter plates.

Another configuration uses a plurality of emitters fixed to the periphery of a metal tube. This configuration can be used to treat a liquid in motion but has the drawbacks of requiring a large number of emitters, of being unable to achieve amplitudes exceeding those routinely achieved by the cleaning technology and of requiring replacement of the entire system in the event of wear of the treatment tube in contact with the treated product.

All the known techniques are in fact equivalent to ultrasonic cleaning techniques in which emitters are fixed directly to metal diaphragms, tubes or tank bottoms.



Finally, there are ultrasonic probes for use in laboratory experiments of which well known examples are the Sonifier (BRANSON) and Vibracell (SONIC'S and MATERIALS). This type of equipment can treat small
5 volumes or low flowrates.

An object of the present invention is to propose a tubular ultrasonic reactor using the principle of mechanical resonance to propagate ultrasonic vibration for treating fluid passing through said reactor
10 coherently from a small number of emitters.

According to the present invention, this objective has been achieved by developing a modular reactor unit characterized in that it comprises a tubular metal body with a cylindrical inside surface and a circular
15 transverse cross-section open at feed and discharge ends, in that the outside surface of said tubular metal body has, near the nodal zone, a radially projecting collar coaxial with said tube, and in that at least one ultrasonic converter is disposed radially and fastened to
20 said collar at its periphery, the frequency of said converter being equal to the vibration frequency of said collar and to the longitudinal vibration frequency of said tubular metal body.

Other features and advantages of the present
25 invention will emerge from the following detailed description given with reference to the appended drawings showing a number of specific embodiments, in which drawings:

- figure 1A is a view in cross-section of one
30 modular reactor unit in accordance with the invention,

- figure 1B shows an end view of the modular reactor unit from figure 1A,

- figure 2 shows an in-line multireactor comprising a plurality of modular reactor units in accordance with
35 the invention associated with a single converter,



- figure 3 shows an in-line multireactor comprising a plurality of modular reactor units associated with three separate converters,

5 - figure 4 shows an in-line multireactor comprising a single modular unit with the tubular part of said reactor extended asymmetrically,

- figure 5 shows another embodiment of an in-line multireactor combining various modular units with a plurality of converters, and

10 - figure 6 shows a modular unit whose collar is attached to the tubular metal body, by means of a force fit, for example,

15 - figure 7 shows a modular unit employing an interior tubular member coupled to said unit in the vicinity of longitudinal maximum amplitude regions (stress nodes).

As shown in figures 1A and 1B, which are respectively a side view and an end view of the modular reactor unit 10 in accordance with the invention, said
20 unit mainly comprises three essential characteristic members. The unit 10 firstly comprises a tubular metal body 12 having a cylindrical interior surface 14 and a circular transverse cross-section. The tubular metal body 12 is open at both ends, i.e. its feed end 16 and
25 its discharge end 18. The materials and/or reagents to be treated flow in the direction of the arrow from the end 16 to the end 18. The feed and discharge ends 16, 18 would be associated with feed and discharge pipes, possibly fitted with pumps. The remainder of the
30 installation is not shown as it employs entirely conventional units well known to the man skilled in the art.

The modular unit 10 further comprises on the exterior surface of the tubular metal body 12, in the
35 vicinity of the nodal zone of the latter, a collar 20

coaxial with said tube, said collar projecting radially outwards from the outside surface of the tubular body 12.

The modular unit 10 finally comprises at least one ultrasonic converter 22 which is disposed radially and fastened to said collar 20 at its periphery. In accordance with the present invention the frequency of said converter 22 is equal to the vibration frequency of said collar 20 and to the longitudinal vibration frequency of the tubular metal body 12.

In practise a conventional ultrasonic converter 22 is used, a piezoelectric excitation type converter, for example. This may be of the "Langevin triplet" type described in "High Intensity Ultrasonics" by B. Brown and J.E. Goodman.

In the specific embodiment described and shown in figures 1A and 1B the coaxial collar 20 is machined in one piece with the tubular metal body 12. In this type of embodiment the collar 20 merges with the exterior surface of the tubular body 12 through rounded fillets 24. Note that in the embodiment described the length of the tubular metal body 12 is equal to one half-wavelength at the frequency used. Note also that the ultrasonic vibration frequency supplied by the emitter or the converter 22 is usually between 5 and 100 kHz. In this specific embodiment the length of the tubular metal body is strictly equal to one half-wavelength at the ultrasonic vibration frequency. Nevertheless, it is possible within the scope of the present invention to use a tubular metal part of greater length, extended on one or both sides of the coaxial collar 20 over a distance equal to an integer multiple of the half-wavelength at the output frequency, for example, this metal part being joined to the modular unit at longitudinal maximum amplitude regions (stress nodes) by means of screwthreads, a force fit, welding or like procedures, or

machined in one piece with it.

It should be remembered that the inside and outside diameters of the collar 20 determine the radial frequency of the coaxial collar 20, the inside diameter of the collar 20 being equal to the inside diameter of the tubular metal body 12. On the other hand, the length of the tubular metal body 12, which is a multiple of half the wavelength, determines the longitudinal frequency of the reactor as a whole.

In the specific embodiment shown in figures 1A and 1B a single converter or emitter 22 is used and this may be of the electrostrictive, magnetostrictive, electrocapacitive or (and more usually) piezo-electric type. The converter 22 is fixed to the periphery of the collar 20, preferably at a flat 26 adapted to ensure perfect contact between the emitter 22 and the collar 20. The mechanical coupling between these two units is advantageously provided by a pin or like member 28.

With reference to the ultrasonic vibration frequency delivered by the converter of the modular reactor unit 10 in accordance with the invention, the inside and outside diameters of d_i and d_e of the collar 20 may be conventionally determined by the man skilled in the art with reference to said vibration frequency delivered by the emitter. In the case of a collar 20 approximately 15 mm thick, for example, the inside and outside diameters of the collar are determined as a function of the vibration frequency F by the equation:

$$F = \frac{1.08.C}{\frac{d_i + d_e \cdot \pi}{2}}$$

where C represents the speed of sound in cm/s in the metal from which said collar 20 is made.

Consider, for example, an aluminum alloy collar excited by a 40 mm diameter 20 kHz piezo-electric emitter. In this case the collar has a thickness of 30 mm, an outside diameter of 130 mm and an inside diameter of 42 mm for the emitter output frequency of 20 kHz.

A reactor unit of this kind operates in the following manner. The vibration produced by the converter(s) 22 causes radial vibration of the collar 20 which causes longitudinal vibration of the tubular metal body 12 whose length is a multiple of half the wavelength. The phase in which the collar 20 is compressed corresponds to the phase in which the tubular body 12 expands longitudinally and expansion of the collar 20 corresponds to the phase in which the tubular body 12 is compressed longitudinally. To achieve this result the coaxial collar 20 must be near the nodal plane of the tubular body 12. The reactor in accordance with the invention uses the radial vibration of the inside diameter of the collar 20 to cause cavitation in any liquid to be treated flowing continuously through the interior of the tubular metal body 12.

Any liquid, gas, colloid or other material to be treated must be passed through the interior of the tubular metal body 12 of the reactor by conventional means (not shown).

Figure 2 shows an ultrasonic reactor obtained by coupling in series a plurality of modular reactor units as shown in figures 1A and 1B. The figure 2 embodiment comprises three modular units 10 forming an in-line multireactor but uses only one ultrasonic converter 22. An assembly of this kind may be of unitary construction or obtained by rigidly coupling said modular units at longitudinal maximum amplitude regions (stress nodes).

As shown in figure 3 it is also possible to obtain

an in-line multireactor by associating a plurality of modular reactor units 10 coupled to a plurality of converters 22. In the specific embodiment described three complete modular units are employed each equipped with its converter 22. These complete units are disposed at the two ends and at the center of the tubular reactor. Note that between these complete half-wavelength modular units 10 there is disposed an assembly comprising a tubular metal body 12 also one half-wavelength long extended at its periphery by a coaxial collar 22. This is equivalent to an association of modular reactor units as previously described some of which have a length of one half-wavelength and others of which have a length of one wavelength.

The operation of this type of in-line reactor is identical to the operation of the modular units previously described. In the same phase of the vibratory movement there will thus be observed for the various associated elements simultaneous states, progressively, of compression and expansion.

When the linear ultrasonic reactor comprises a plurality of ultrasonic emitters or converters 22, the latter may advantageously be fed in parallel from the same generator. However, as a precaution the plurality of even ranked emitters should be inverted compared to the odd ranked emitters because of the phase inversion that occurs every half-wavelength.

The specific embodiment shown in figure 4 comprises a radial collar 20 which excites in series a length of tubular metal body extending the tubular part of the central modular element on either side of the latter. Note that the length of the tube on each side of the central modular unit is an integer multiple of half the wavelength. Said tubes may be screwed or force fitted to the modular unit at longitudinal maximum amplitude

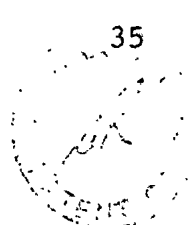


regions (stress nodes), for example. The arrangement need not be symmetrical. As shown in figure 4, in some intended applications it may be advantageous to provide a longer or shorter tubular area on the upstream or downstream side of the intense ultrasonic vibration area. In practise a number of half-wavelengths between 1 and 10 is usually chosen, depending on the material from which the reactor is made, the products to be treated and, of course, the nature and the conditions of the reaction occurring in the reactor. It may be advantageous, for example, as shown in figure 4, to provide a feed inlet relatively near the intense cavitation area, so that the energy required to initiate the reaction may be imparted quickly, the reaction then continuing in the downstream tubular part of the reactor, i.e. in an area where the ultrasonic cavitation is of lower amplitude and lower power.

Depending on the specific application intended, the man skilled in the art will choose a suitable length for said tubular metal body 12 equal to an integer number of half-wavelengths at the ultrasonic vibration frequency delivered by the converter(s) 22.

Figure 5 shows a final embodiment in which a plurality of radial collars 20 are used to excite in series a length of tube which in this example is one half-wavelength long but could equally well comprise greater tube lengths equal to an integer number of half-wavelengths. The principle of operation is exactly the same.

Figure 6 shows an alternative embodiment of a modular reactor unit in accordance with the invention. In this variant, rather than being machined in one piece, the coaxial collar 20 and the tubular metal body 12 are made separately. This enables the choice of a material having excellent acoustical properties, such as aluminum



and/or titanium alloy, for the collar 20 and a different material having greater resistance to the erosion caused by ultrasonic cavitation for the metal tubular part 12 in which the liquid to be treated flows. The tubular part 12 might be made from a special steel such as stainless steel, for example. Furthermore, the interior surface 14 of the tubular reactor is advantageously provided with a protective layer to protect it against erosion due to cavitation, a ceramic coating, a hard metal coating or a combined ceramic/metal coating, for example. In the figure 6 embodiment the collar is attached to the tubular part by appropriate mechanical means providing a firm and homogeneous coupling. A rigid coupling is essential for the modular reactor unit in accordance with the invention and may be obtained, for example, by mechanical means such as screws, wedging or a force fit. Other non-mechanical means such as adhesive bonding, welding or the like may equally well be used.

- Figure 7 shows another embodiment of a modular reactor unit in accordance with the invention.

In this embodiment the modular reactor unit is adapted to receive inside it a tubular member 30 tuned to the frequency of the emitter 22, vibrating from the axial mode by clamping its two ends 32, 34 near longitudinal maximum amplitude regions (stress nodes) of said unit.

In this embodiment said tubular member 30 is clamped between two parts tuned to the emitter frequency, for example tubular metal bodies 36 and 38 as shown in figure 4.

The attached tubular member 30 advantageously has precision bearing surfaces (i.e. 45°) for perfect centering and good coupling with the members 36 and 38 clamping it at each end 32 and 34. Note, as shown in figure 7, a clearance 40 relative to the interior diameter of the modular unit to enable unrestricted

radial expansion and compression of the tubular member 30 within which the fluid to be treated flows.

Modular reactor units in accordance with the invention may be used to treat all types of liquid, gas, 5 colloid, etc flowing naturally or pumped through the interior of the reactors. Note that an exterior flow of liquid could be treated simultaneously by the cavitation caused by exterior vibration of the collars 20, i.e. two different flows of liquid could be treated 10 simultaneously, one passing through the interior of the reactor and the other flowing over its exterior.

Reactors of this type have many industrial applications, for example:

- 15 - activation of chemical reactions (Grignard, Barbier, etc),
- de-agglomeration and washing of metal, ceramic and mineral powder,
- treatment of ore,
- wetting and dispersion of pigments, coloring 20 agents,
- accelerated dissolving of gases,
- degassing,
- homogenization,
- wire cleaning,
- 25 - emulsification, etc.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Modular reactor unit for continuous ultrasonic treatment of materials and/or reagents characterized in that it comprises a tubular metal body having a cylindrical interior and a
5 circular transverse cross-section open at a feed end and a discharge end, in that the exterior surface of said tubular metal body has in the vicinity of the nodal zone a projecting radially collar coaxial with said tube, and in that at least one ultrasonic converter is disposed radially and attached to
10 said collar at its periphery, the frequency of said converter being equal to the frequency of vibration of said collar and to the frequency of longitudinal vibration of said tubular metal body.
2. Modular reactor unit according to claim 1 characterized in
15 that the length of said tubular metal body is equal to an integer multiple of half the wavelength at the frequency of ultrasonic vibration emitted by said converter.
3. Modular reactor unit according to claim 1 or claim 2 characterized in that the frequency of ultrasonic vibration
20 delivered by said converter is between 5 and 100 kHz.
4. Modular reactor unit according to any one of claims 1 to 3 characterized in that said ultrasonic converter is fixed to the periphery of said collar at a flat adapted to ensure perfect coupling of the converter and the collar, the
25 mechanical coupling being provided by a pin or the like.
5. Modular reactor unit according to any one of claims 1 to 4 characterized in that said collar is machined in one piece with the tubular metal body.
6. Modular reactor unit according to any one of claims 1 to
30 4 characterized in that said collar is attached to said tubular metal body by any means providing a rigid coupling.
7. Modular reactor unit according to claim 6 characterized in that said collar is made from a metal having good acoustical properties such as aluminum and/or titanium alloy and in that
35 said tubular metal body is made from a metal having a good resistance to erosion caused by cavitation such as stainless steel.

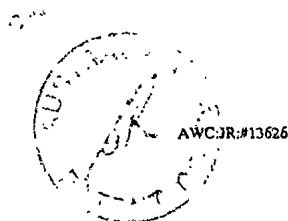


AWC:JR:13626

8. Modular reactor unit according to any one of claims 1 to 7 characterized in that the interior surface of the tubular reactor has a ceramic, hard metal or combined ceramic/metal coating to protect it against erosion by cavitation.
- 5 9. Modular reactor unit according to any one of claims 1 to 6 characterized in that a tubular member is attached to the interior of said unit by clamping means in the vicinity of longitudinal maximum amplitude regions of said unit.
- 10 10. Ultrasonic reactor characterized in that it comprises a series coupling of a plurality of modular reactor units according to any one claims 1 to 9 to create an in-line multireactor.
- 15 11. Ultrasonic reactor according to claim 10 characterized in that it comprises a plurality of converters fed in parallel by the same generator.
12. Modular reactor unit substantially as herein described with reference to the accompanying drawings.
13. Ultrasonic reactor substantially as herein described with reference to the accompanying drawings.

DATED: 25 January 1995

CARTER SMITH & BEADLE
Patent Attorneys for the Applicant:
PHILIPPE VAXELAIRE



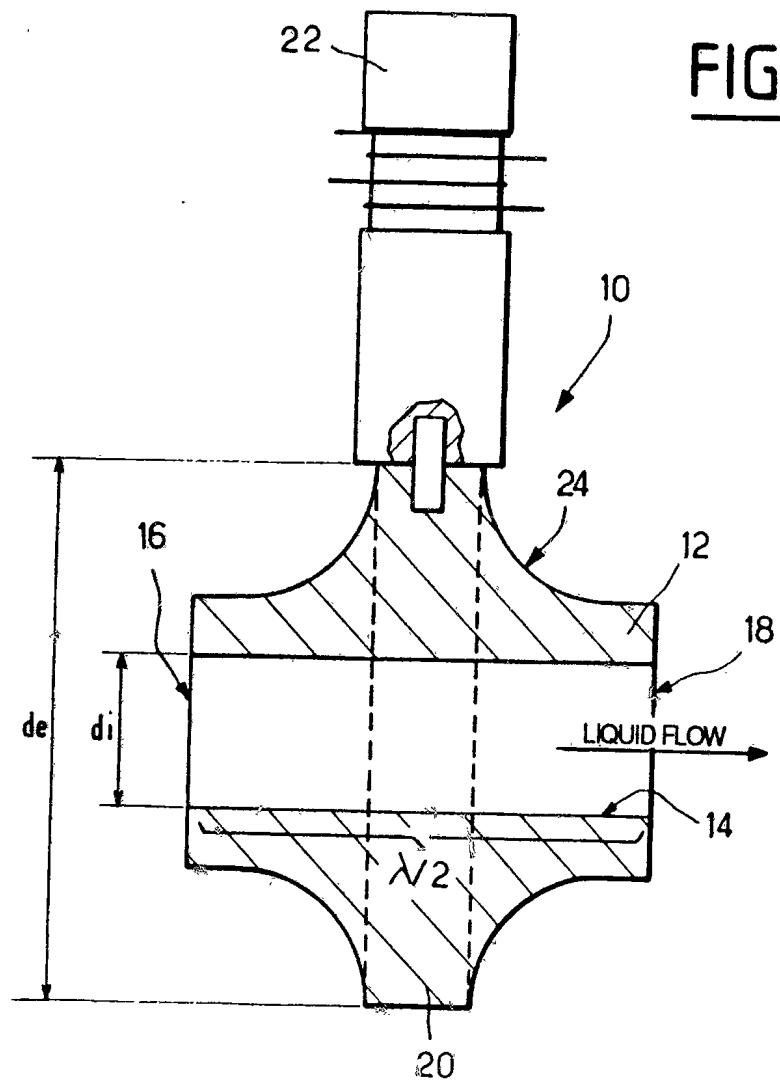


FIG. 1A

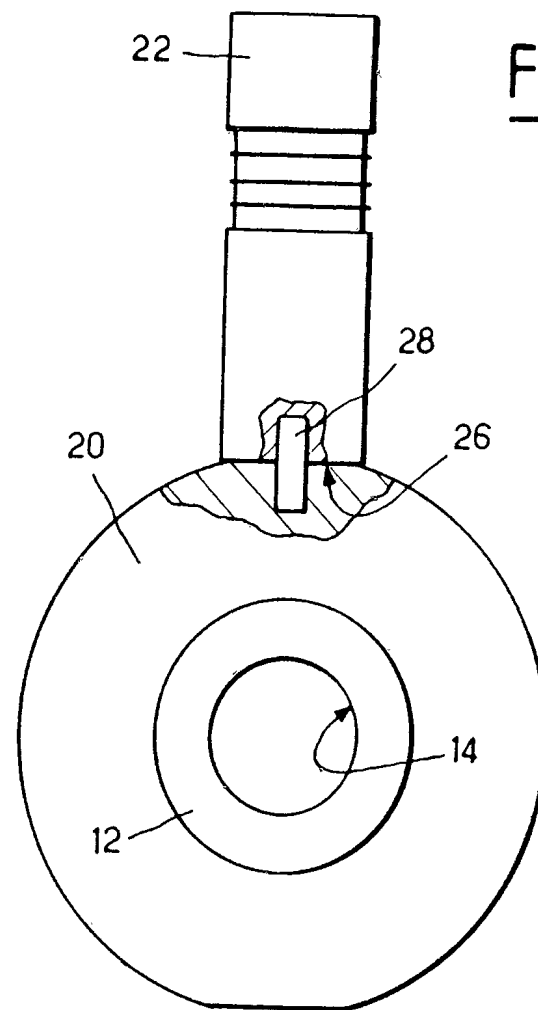


FIG. 1B

FIG. 2

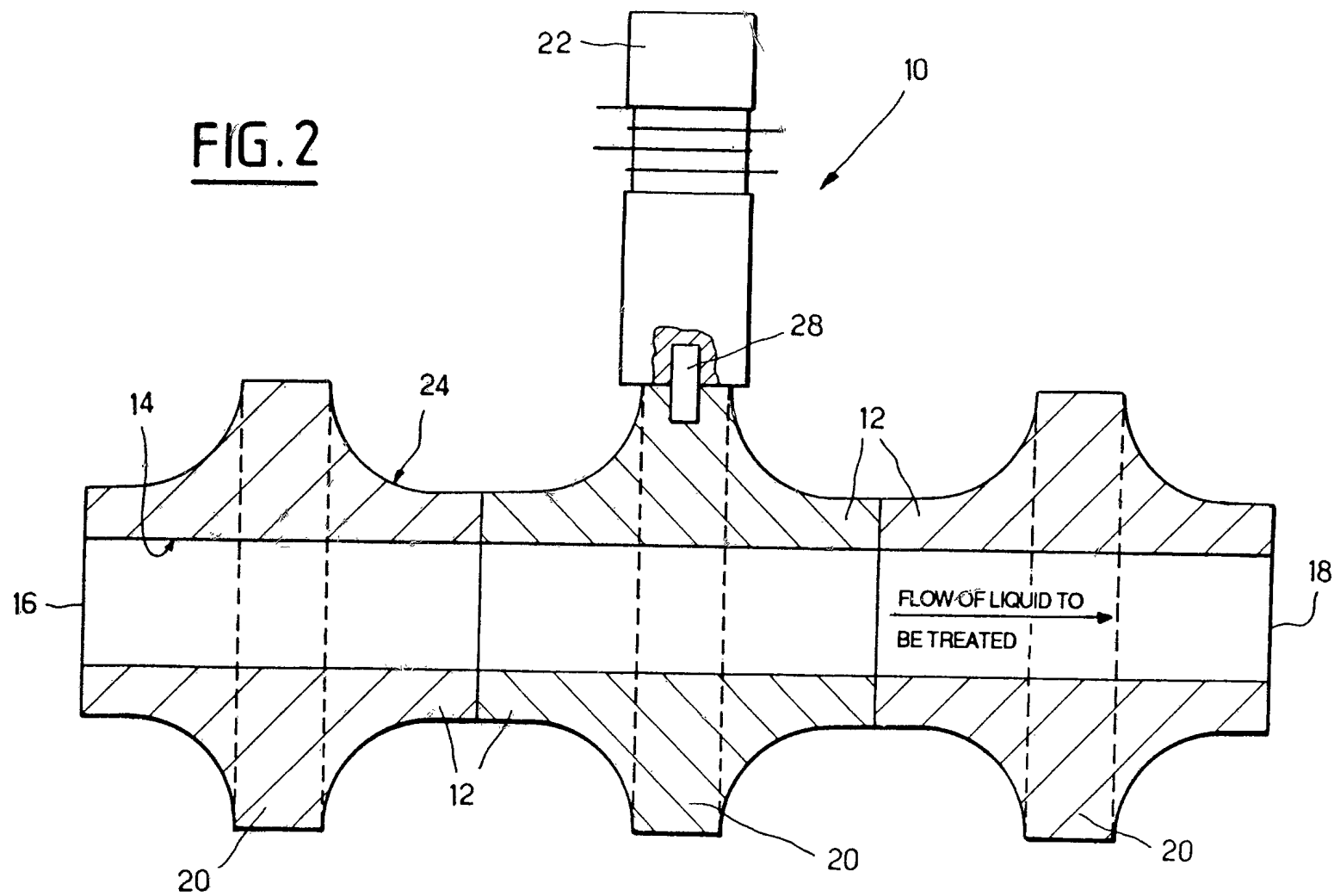
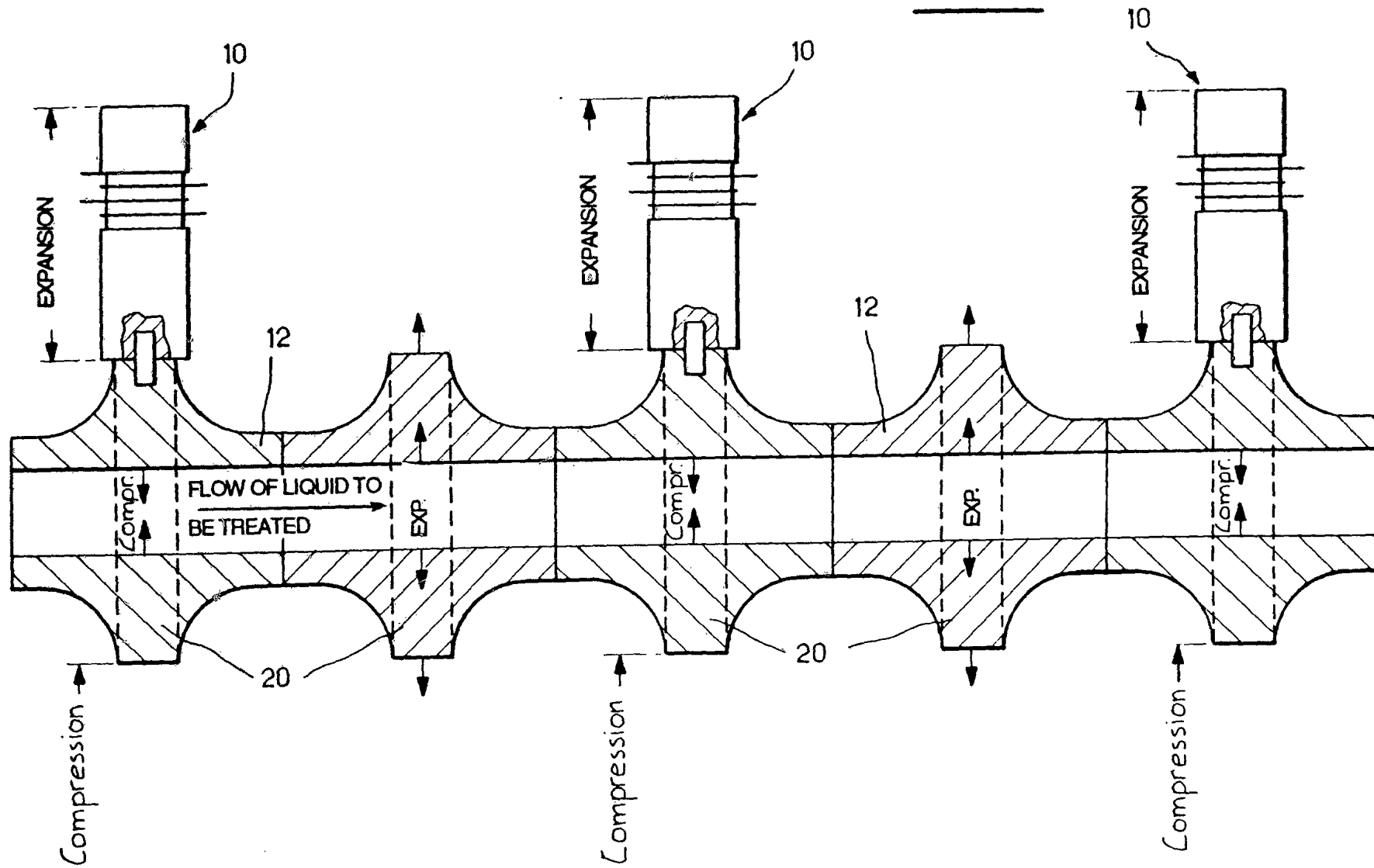


FIG. 3



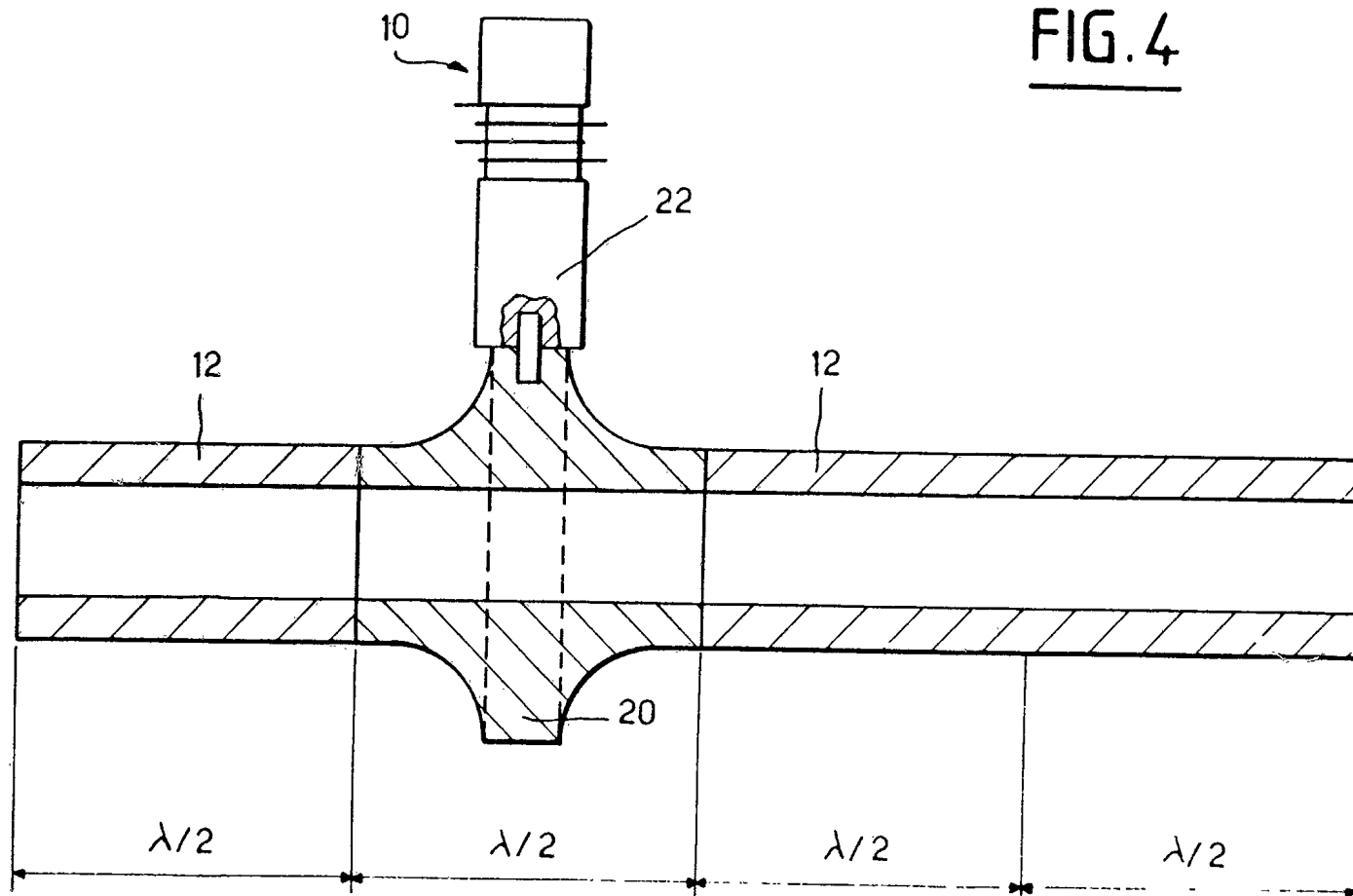


FIG. 5

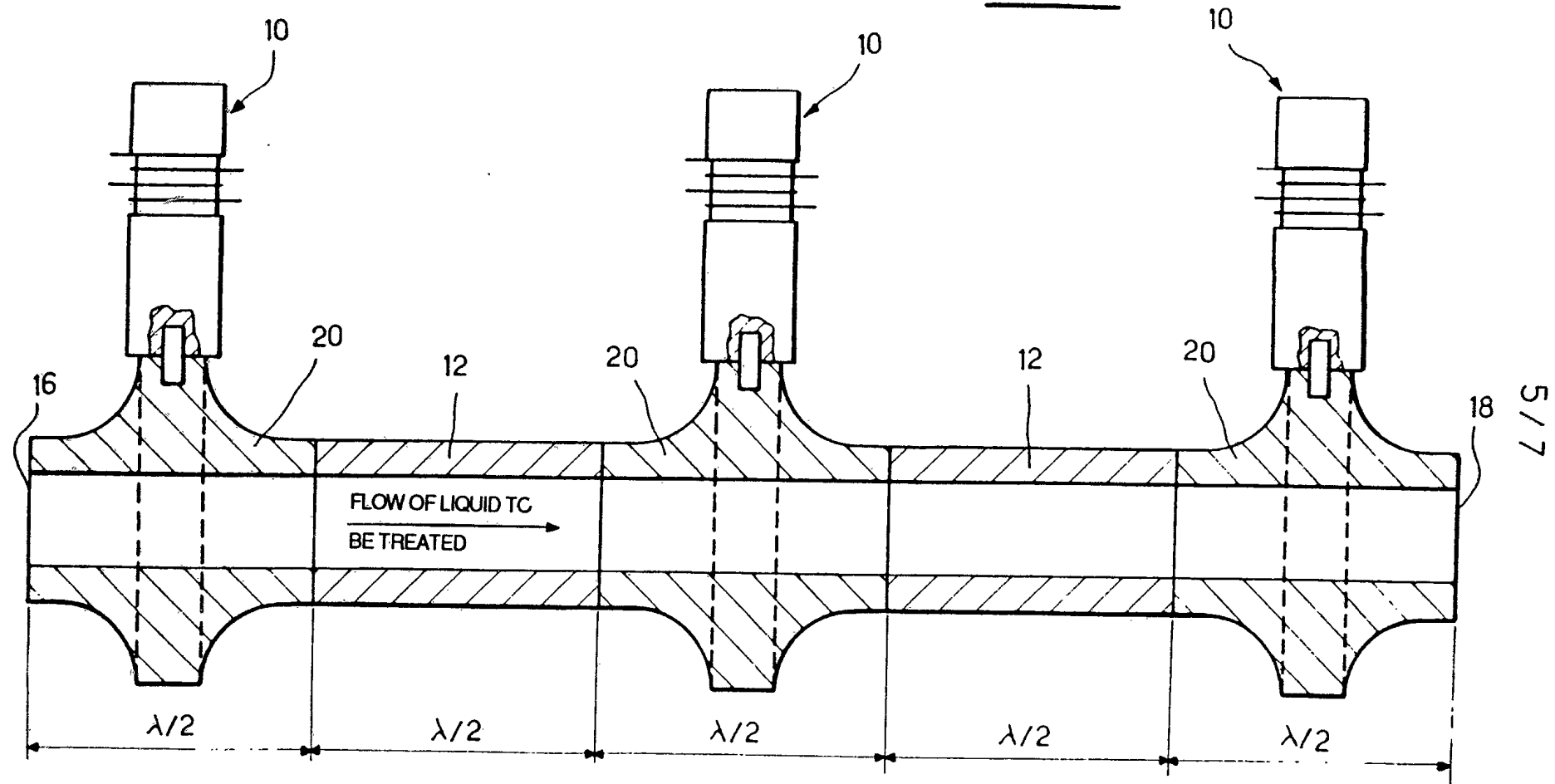


FIG. 6A

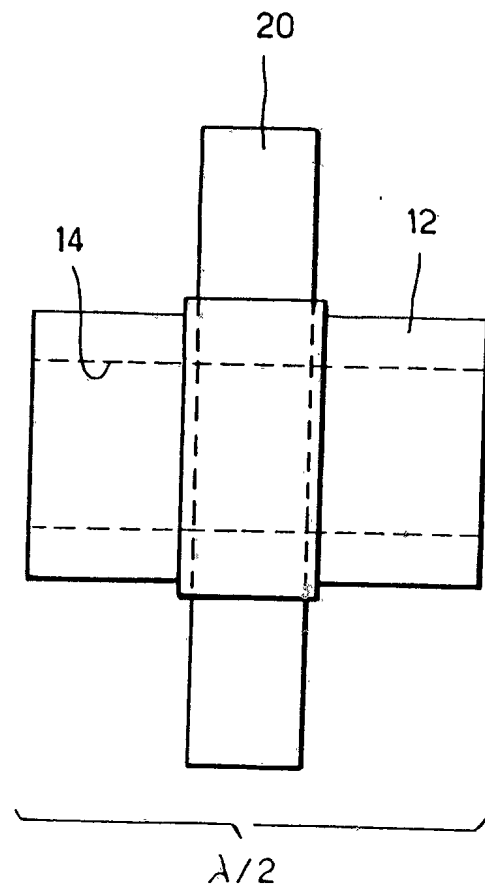


FIG. 6B

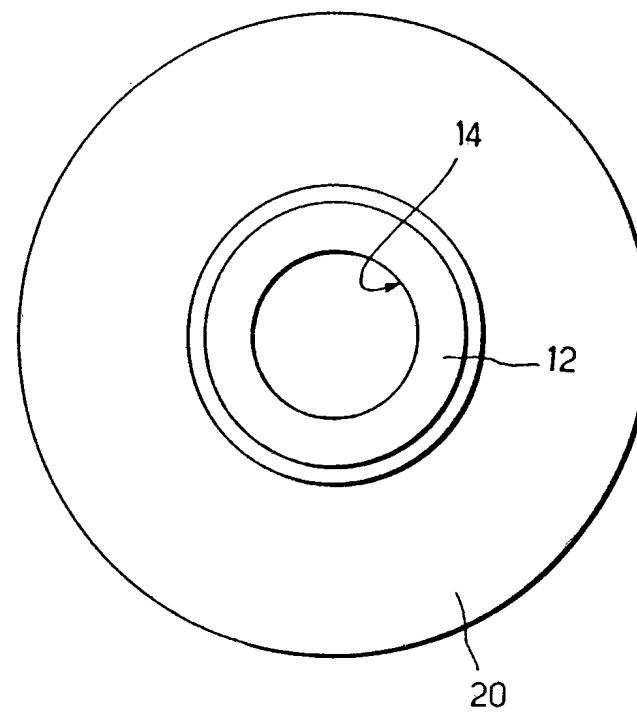
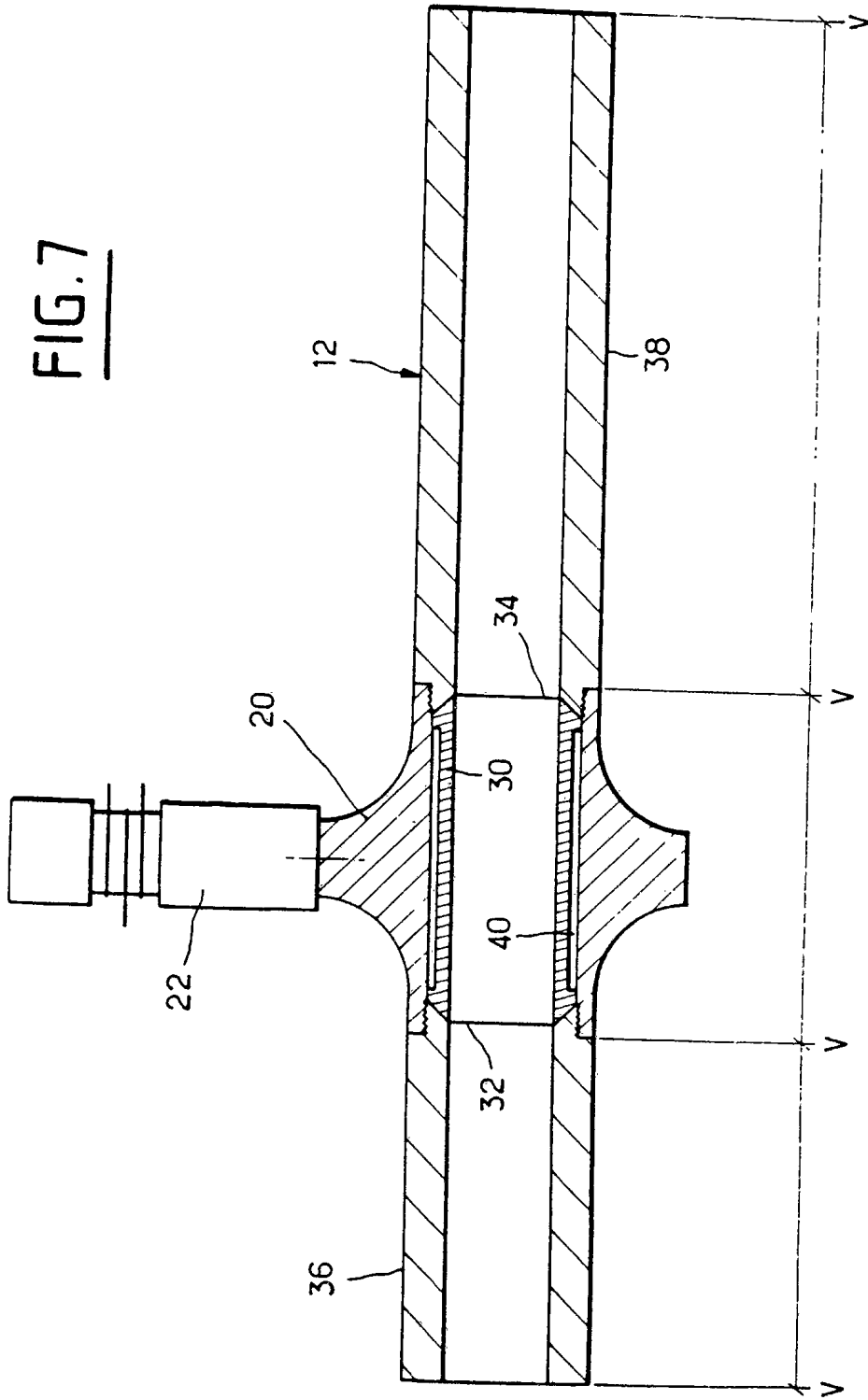


FIG. 7

INTERNATIONAL SEARCH REPORT

International Application No PCT/FR 92/00029

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁵ B01J19/10; B01F3/00; B06B3/00; B01B19/00		
II. FIELDS SEARCHED		
Minimum Documentation Searched ?		
Classification System	Classification Symbols	
IPC ⁵	B01J; B01F; B01D; F26B; B06B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	WO,A,8 203 795 (BATELLE DEVELOPMENT CORPORATION) 11 November 1982 see abstract see page 3, line 19 - line 27 see page 4, line 12 - line 23 see page 6, line 31 - page 7, line 20 see page 12, line 11 - line 19 see page 13, line 1 - line 30 see figures 1,2,6	1-4, 7, 10,11
A	---	8
Y	US,A,4 074 152 (K.ASAI ET AL.) 14 February 1978 see abstract see column 1, line 7 - line 12 see column 2, line 17 - column 3, line 12 see column 5, line 65 - column 6, line 42 see column 27, line 45 - column 28, line 32 see figure 21A21B	1-4, 7, 10,11
	---	./.
* Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document 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 "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		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
27 April 1992 (27.04.92)	07 May 1992 (07.05.92)	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE		

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	WO,A,8 200 260 (SCM CORPORATION) 4 February 1982 see page 3, line 24 - page 4, line 34 see figures 1,2	1,2,10
Y	--- JAPANESE JOURNAL OF APPLIED PHYSICS, SUPPLEMENTS. Vol. 20, No. 20-3, 1981, TOKYO JA pages 169 - 172; K.ASAI ET AL.: "A NEW HOLLOW CYLINDRICAL ULTRASONIC WAVE RADIATOR" see page 169, right-hand column, paragraph 3- page 170, left-hand column, paragraph 1 see page 170, right-hand column, paragraph 2 see figures 1,2	7
A		1,3,4
A	--- US,A,4 392 380 (M.J.CAINES) 12 July 1983 see abstract see column 2, line 15 - line 54 see figure 1	4,6
A	--- FR,A,2 354 827 (MECASONIC) 13 January 1978 see page 1, line 1 - line 3 see page 1, line 27 - page 2, line 3 see page 2, line 13 - line 22 see figures 1,2 --- -----	1,3

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. FR 9200029
SA 56393**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international 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. 27/04/92

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-8203795	11-11-82	US-A- 4339247	13-07-82
		AU-B- 545870	01-08-85
		AU-A- 8391582	24-11-82
		CA-A- 1168992	12-06-84
		DE-A- 3278557	07-07-88
		EP-A, B 0077352	27-04-83
US-A-4074152	14-02-78	JP-A- 51078317	07-07-76
		JP-C- 1114371	29-09-82
		JP-A- 52026213	26-02-77
		JP-B- 57007792	12-02-82
		JP-A- 51040090	03-04-76
WO-A-8200260	04-02-82	US-A- 4347110	31-08-82
		SE-B- 451953	09-11-87
		SE-A- 8201461	09-03-82
US-A-4392380	12-07-83	None	
FR-A-2354827	13-01-78	DE-A- 2711305	22-12-77
		GB-A- 1524924	13-09-78

I. CLASSEMENT DE L'INVENTION (si plusieurs symboles de classification sont applicables, les indiquer tous) ?

Selon la classification internationale des brevets (CIB) ou à la fois selon la classification nationale et la CIB

CIB 5 B01J19/10; B01F3/00; B06B3/00; B01D19/00

II. DOMAINES SUR LESQUELS LA RECHERCHE A PORTEDocumentation minimale consultée⁸

Système de classification

Symboles de classification

CIB 5

B01J ;
B06B

B01F ;

B01D ;

F26B

Documentation consultée autre que la documentation minimale dans la mesure où de tels documents font partie des domaines sur lesquels la recherche a porté

III. DOCUMENTS CONSIDERES COMME PERTINENTS¹⁰

Catégorie ⁹	Identification des documents cités, avec indication, si nécessaire, ¹² des passages pertinents ¹³	No. des revendications visées ¹⁴
Y	WO,A,8 203 795 (BATELLE DEVELOPMENT CORPORATION) 11 Novembre 1982 voir abrégé voir page 3, ligne 19 - ligne 27 voir page 4, ligne 12 - ligne 23 voir page 6, ligne 31 - page 7, ligne 20 voir page 12, ligne 11 - ligne 19 voir page 13, ligne 1 - ligne 30 voir figures 1,2,6	1-4,7, 10,11
A	---	8
Y	US,A,4 074 152 (K.ASAI ET AL.) 14 Février 1978 voir abrégé voir colonne 1, ligne 7 - ligne 12 voir colonne 2, ligne 17 - colonne 3, ligne 12 voir colonne 5, ligne 65 - colonne 6, ligne 42 voir colonne 27, ligne 45 - colonne 28, ligne 32 voir figure 21A21B ---	1-4,7, 10,11
	---	---

⁹ Catégories spéciales de documents cités:¹¹^{"A"} document définissant l'état général de la technique, non considéré comme particulièrement pertinent^{"E"} document antérieur, mais publié à la date de dépôt international ou après cette date^{"L"} document pouvant jeter un doute sur une revendication de priorité ou cité pour déterminer la date de publication d'une autre citation ou pour une raison spéciale (telle qu'indiquée)^{"O"} document se référant à une divulgation orale, à un usage, à une exposition ou tous autres moyens^{"P"} document publié avant la date de dépôt international, mais postérieurement à la date de priorité revendiquée^{"T"} document ultérieur publié postérieurement à la date de dépôt international ou à la date de priorité et n'appartenant pas à l'état de la technique pertinent, mais cité pour comprendre le principe ou la théorie constituant la base de l'invention^{"X"} document particulièrement pertinent; l'invention revendiquée ne peut être considérée comme nouvelle ou comme impliquant une activité inventive^{"Y"} document particulièrement pertinent; l'invention revendiquée ne peut être considérée comme impliquant une activité inventive lorsque le document est associé à un ou plusieurs autres documents de même nature, cette combinaison étant évidente pour une personne du métier.^{"A"} document qui fait partie de la même famille de brevets**IV. CERTIFICATION**

Date à laquelle la recherche internationale a été effectivement achevée

27 AVRIL 1992

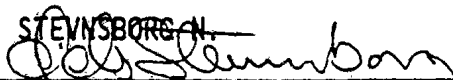
Date d'expédition du présent rapport de recherche internationale

07.05.92

Administration chargée de la recherche internationale

OFFICE EUROPEEN DES BREVETS

Signature du fonctionnaire autorisé

STEVNSBORG N.


III. DOCUMENTS CONSIDERES COMME PERTINENTS ¹⁴

(SUITE DES RENSEIGNEMENTS INDiques SUR LA
DEUXIEME FEUILLE)

Catégorie *	Identification des documents cités, ¹⁶ avec indication, si nécessaire des passages pertinents ¹⁷	No. des revendications visées ¹⁸
Y	WO,A,8 200 260 (SCM CORPORATION) 4 Février 1982 voir page 3, ligne 24 - page 4, ligne 34 voir figures 1,2 ---	1,2,10
Y	JAPANESE JOURNAL OF APPLIED PHYSICS, SUPPLEMENTS. vol. 20, no. 20-3, 1981, TOKYO JA pages 169 - 172; K.ASAI ET AL.: 'A NEW HOLLOW CYLINDRICAL ULTRASONIC WAVE RADIATOR' voir page 169, colonne de droite, alinéa 3 - page 170, colonne de gauche, alinéa 1 voir page 170, colonne de droite, alinéa 2 voir figures 1,2 ---	7
A	---	1,3,4
A	US,A,4 392 380 (M.J.CAINES) 12 Juillet 1983 voir abrégé voir colonne 2, ligne 15 - ligne 54 voir figure 1 ---	4,6
A	FR,A,2 354 827 (MECASONIC) 13 Janvier 1978 voir page 1, ligne 1 - ligne 3 voir page 1, ligne 27 - page 2, ligne 3 voir page 2, ligne 13 - ligne 22 voir figures 1,2 ---	1,3

**ANNEXE AU RAPPORT DE RECHERCHE INTERNATIONALE
RELATIF A LA DEMANDE INTERNATIONALE NO.**

FR 9200029
SA 56393

La présente annexe indique les membres de la famille de brevets relatifs aux documents brevets cités dans le rapport de recherche internationale visé ci-dessus.

Lesdits membres sont contenus au fichier informatique de l'Office européen des brevets à la date du

Les renseignements fournis sont donnés à titre indicatif et n'engagent pas la responsabilité de l'Office européen des brevets. 27/04/92

Document brevet cité au rapport de recherche	Date de publication	Membre(s) de la famille de brevet(s)	Date de publication
WO-A-8203795	11-11-82	US-A- 4339247	13-07-82
		AU-B- 545870	01-08-85
		AU-A- 8391582	24-11-82
		CA-A- 1168992	12-06-84
		DE-A- 3278557	07-07-88
		EP-A, B 0077352	27-04-83
US-A-4074152	14-02-78	JP-A- 51078317	07-07-76
		JP-C- 1114371	29-09-82
		JP-A- 52026213	26-02-77
		JP-B- 57007792	12-02-82
		JP-A- 51040090	03-04-76
WO-A-8200260	04-02-82	US-A- 4347110	31-08-82
		SE-B- 451953	09-11-87
		SE-A- 8201461	09-03-82
US-A-4392380	12-07-83	Aucun	
FR-A-2354827	13-01-78	DE-A- 2711305	22-12-77
		GB-A- 1524924	13-09-78