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(71) Applicant(s)
FFR IntelP Limited
(Incorporated in the United Kingdom)
Regency House, 33 Wood Street,
BARNETT, Hertfordshire, EN5 4BE,
United Kingdom

(72) Inventor(s)
Francis Frederick Hamilton Rawson

(74) Agent and/or Address for Service
Forrester Ketley & Co
Chamberlain House, Paradise Place,
BIRMINGHAM, B3 3HP, United Kingdom

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H4J JDK
B5K K3A6

(56) Documents Cited

GB 2091632 A	GB 1524924 A
GB 1232128 A	GB 1182597 A
US 5159838 A	US 3400340 A

(58) Field of Search
UK CL (Edition T) H4J JDK
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Other: ONLINE: WPI, EPODOC, JAPIO

(54) Abstract Title
Forged ultrasonic amplifier, horn, resonator or sonotrode

(57) A method of making an ultrasonic amplifier horn, resonator or sonotrode comprises shaping the ultrasonic amplifier by forging. This means that an amplifier with a complex shape can be forged in one piece preventing weaknesses at the joins between different sections of the amplifier.

The device may be made of titanium. In a further embodiment (fig 2) a plurality of horns are manufactured as one device.

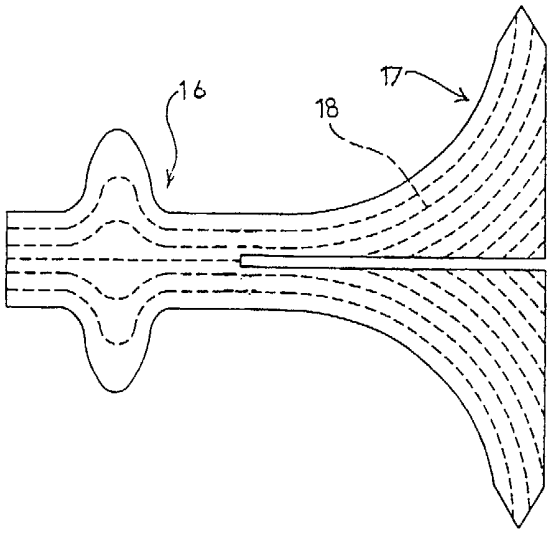

FIG 1b

GB 2 378 346 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

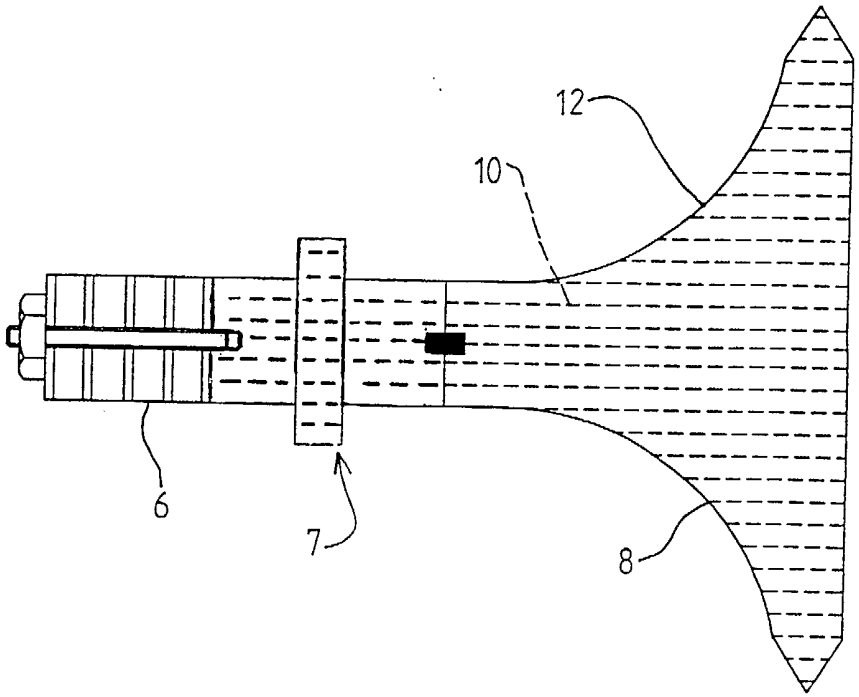

FIG 1a

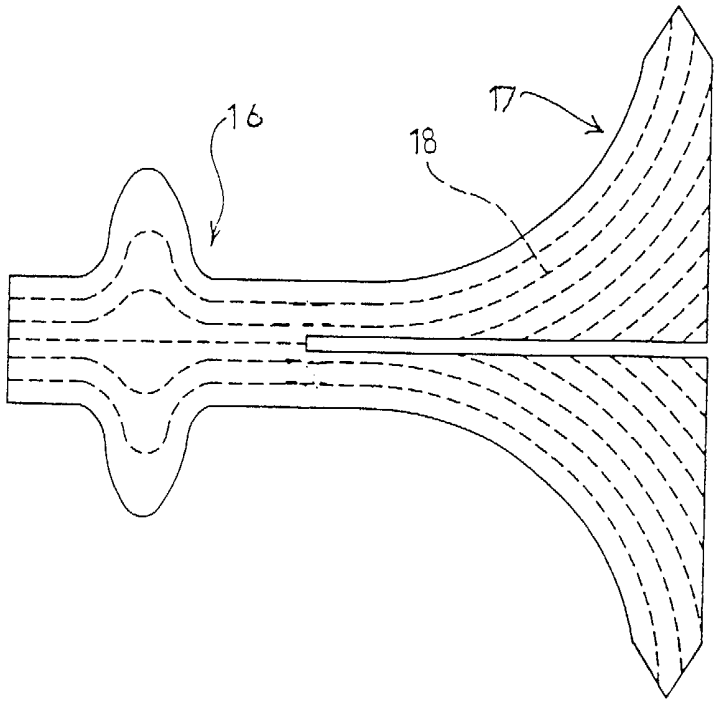

FIG 1b

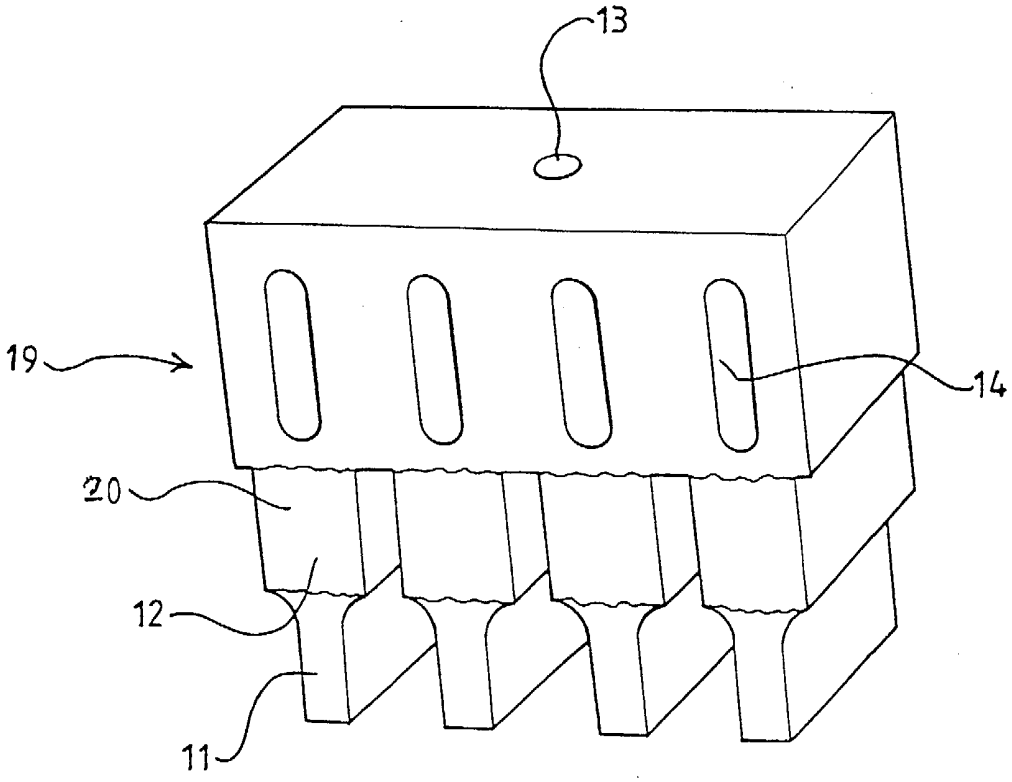

FIG 2

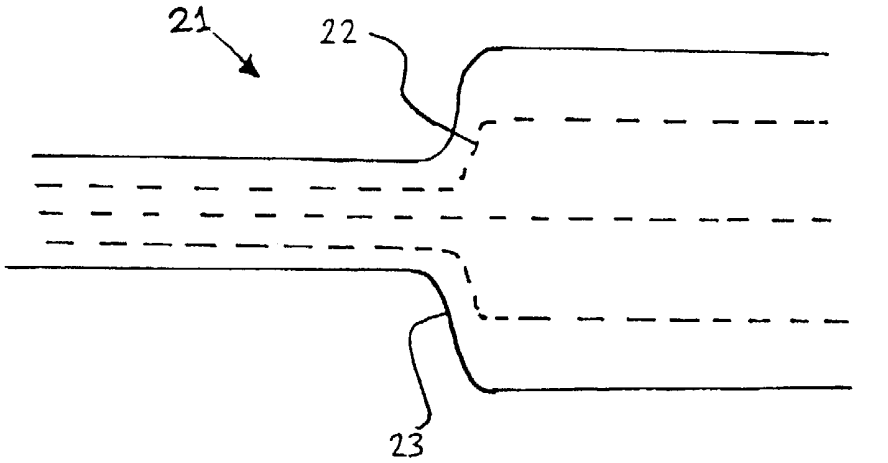

FIG 3

PATENTS ACT 1977

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Title: Ultrasonic Amplifier

Description of Invention

This invention relates to ultrasonic amplifiers, in particular, but not exclusively to a method of making ultrasonic amplifiers or resonant horns or both.

Conventionally ultrasonic amplifiers are made from a metal alloy by machining one or more component parts from a solid metal bar or bars to the shape desired. The ultrasonic amplifier is then welded or bolted together, or to a further amplifier or a transducer, or both. The advantage of machining the metal is that a wide variety of shapes can be made, quickly, easily and relatively inexpensively. There is generally no need to use further finishing processes.

According to this invention a method of making an ultrasonic amplifier comprises shaping the ultrasonic amplifier by forging. An amplifier or horn with a complex shape or with a dimension that is a multiple of half wave lengths may thus be provided either as a single amplifier without joins, or as multiple amplifiers joined together.

This invention involves the recognition that a forging process, used to cause the metal alloy to flow into shape in a controlled manner, is conducive to causing the lattice or grain structure of the metal alloy to be more desirably aligned with the shape of the amplifier. This enhances the strength of the material in the aligned grain direction. When a similar shape is machined from a solid block, on the other hand, the lattice maintains the shape and alignment that it had as the block. Since the lattice of the forged amplifier may be appropriately shaped, the amplification may be more effective. Furthermore the device is likely to have enhanced fatigue strength, particularly at higher amplitudes of vibration.

The amount of machining necessary may be reduced, reducing the cost of such an amplifier. Additionally, far less scrap may be generated by a forging process than in machining the material from a solid block, which makes the ultrasonic amplifier considerably less expensive.

Preferably the method involves multiple forging operations. The method may also involve inspecting the amplifier and modifying subsequent operations accordingly.

The method may also involve finishing the ultrasonic amplifier by a machining operation. Techniques such as spark erosion, milling, turning or grinding may be used. These finishing techniques smooth the external surface of the amplifier. Preferably the method of forging used is drop forging.

The invention is particularly suitable for use where the metal alloy used is a titanium alloy. The cost of titanium makes use of this method particularly attractive.

The ultrasonic amplifier may have formations, such as holes or slots, which are formed in either the external or the internal surface of the ultrasonic amplifier, either as part of the forging process or the subsequent machining process or both.

This invention extends to an ultrasonic amplifier made according to any of the methods outlined above. It also extends to two such ultrasonic amplifiers which are joined together and which have metal lattices that are aligned across the region of the join. A plurality of such amplifiers, aligned at each join, may be provided.

Preferred embodiments of ultrasonic amplifiers, selected by way of example, will now be described, with reference to the following drawings in which:

FIGURE 1a shows schematically a side view of a conventional ultrasonic device;

FIGURE 1b shows schematically a side view of one embodiment of a one piece ultrasonic amplifier made by forging;

FIGURE 2 shows schematically a perspective view of a second embodiment of an ultrasonic amplifier made by forging; and

FIGURE 3 shows schematically a section view of a third embodiment of an ultrasonic amplifier made by forging.

Figure 1a shows schematically a side view of a conventional ultrasonic device comprising a transducer 6, a first amplifier 7 and a second amplifier 8 all made by machining. Both of the amplifiers 7, 8 are machined from a solid bar. The second amplifier 8 is designed to convert axial vibrations into radial vibrations, as described in GB 2 282 559 which the reader is referred to for further details of these aspects of construction.

The structure and alignment of the lattice, shown at 10 is still generally linear, it does not follow the contours of the curved sides 12 of the amplifier. The two amplifiers are simply bolted together.

A more effective axial to radial amplifier is shown in Figure 1b. The amplifier comprises a first amplifier 16 and a second amplifier 17, which are made from a single metal billet and thus aligned along their respective lattice structures or grains. The first amplifier 16 corresponds to a conventional booster flange, and the second amplifier 17 corresponds to a conventional flared horn. The two amplifiers 16, 17 are both manufactured by drop forging as a single piece. The drop forging process will be described below.

First a billet is cut from a metal bar. Two dies, each formed to shape a part of, usually half of, the amplifier are brought together repeatedly and rapidly. The amplifier is forged by a series of these operations which gradually change its shape. As the external shape of the metal is gradually deformed, so the lattice structure 18 of the metal gradually changes during the forging operations. When the forging operation is complete, the lattice structure 18 is

to an extent parallel to the flared sides 16 of the amplifier. The lattice or grain is aligned with the direction of vibration.

The device will, therefore, withstand higher amplitude vibrations enabling greater amplification to be achieved. The increased strength of the material enables it to resist fatigue. The device also has increased resistance to heat.

The scrap is then removed and the amplifier is finished to its required dimensional tolerances by machining. Grinding then takes place to produce a good surface finish.

The final, forged amplifier resonates along its lattice structure and so amplifies the ultrasonic vibrations far more effectively, especially at higher amplitudes of vibration. At the axial part of the transducer the lattice structure and the ultrasonic vibrations are in the axial plane whilst at the radial part of the amplifier the lattice structure and the ultrasonic vibrations are in the radial plane.

The amplifier may be forged in one piece and so weakness caused by joining multiple pieces is eliminated.

Since the billet deforms to the shape required only a small amount of excess titanium is needed, and the process is far less wasteful than conventional machining from a blank.

Figure 2 shows schematically a second embodiment of a forged amplifier 19. This amplifier 19 may be manufactured by a similar process to that outlined above. The figure illustrates the considerable amount of structure that may be impressed in the amplifier by drop forging, or by other forging processes. Probes 20 may be manufactured which have a thinner working end, or daughter horn, 11 than supporting end, or mother horn, 12. In addition holes 13 and slots 14 may be formed in the metal.

Figure 3 shows schematically a section view through a stepped amplifier 21 made by forging. The lattice or grain structure 22 of the amplifier follows the curve of the step 23.

The reader will appreciate that in ultrasonic amplifiers such as those described above the metal grain structure is controlled by the forging process. Many variations and improvements on the devices outlined will occur to the skilled reader, which are included in the scope of the invention outlined herein.

In the present specification "comprises" means "includes or consists of" and "comprising" means "including or consisting of".

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

Claims

1. A method of making an ultrasonic amplifier comprising shaping the ultrasonic amplifier by forging.

2. A method according to Claim 1 involving multiple forging operations.

3. A method according to any preceding claim involving finishing the ultrasonic amplifier by a machining operation.

4. A method according to any preceding claim in which the method of forging used is drop forging.

5. A method according to any preceding claim in which the metal alloy is a titanium alloy.

6. A method according to any preceding claim in which the ultrasonic amplifier has internal formations.

7. An ultrasonic amplifier made according to the method of any preceding claim.

8. A plurality of ultrasonic amplifiers, each made according to the method of any preceding claim which are joined together, and which have metal lattices that are desirably aligned across the region of each join.

9. A method of making an ultrasonic amplifier as hereinbefore described and as illustrated in the accompanying drawings.

10. An ultrasonic amplifier as hereinbefore described and as illustrated in the accompanying drawings.

11. A plurality of ultrasonic amplifiers as hereinbefore before described and as illustrated in the accompanying drawings.

12. Any novel feature or novel combination of features described herein and/or in the accompanying drawings.

INVESTOR IN PEOPLE

Application No:	GB 0119005.7	**Examiner:**	Peter Easterfield
Claims searched:	1 to 8	**Date of search:**	8 April 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H4J (JDK)

Int Cl (Ed.7): B06B 3/00, 3/02; B23K 20/10; B29C 65/08; G10K 11/02, 11/08, 11/26

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2091632 A	(BRANSON) see page 2 lines 19-20	5
Y	GB 1524924 A	(MECASONIC) see figs 3 & 4	6
Y	GB 1232128 A	(ERAPA) see the fig	6
Y	GB 1182597 A	(ES & A ROBINSON) see page 1 lines 85-87	5
X, Y	US 5159838 A	(LYNNWORTH) see column 8 lines 20-27 and column 13 line 66 to column 14 line 2	X: 1 Y: 5,6
X, Y	US 3400340 A	(PAPADAKIS) see column 6 lines 3-19	X: 1 Y: 5,6

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.