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Cunningham

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[54] **MOUNTING MEANS AND METHOD FOR VIBRATION MEMBER**

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[73] Assignee: **Branson Ultrasonics Corporation**, Danbury, Conn.

[21] Appl. No.: **507,053**

[22] Filed: **Jul. 25, 1995**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 194,108, Feb. 9, 1994, Pat. No. 5,443,240.

[51] **Int. Cl.**^{6} **F16M 3/00**

[52] **U.S. Cl.** **248/638**; 228/1.1; 248/568; 310/345

[58] **Field of Search** 248/638, 676, 248/637, 568, 569; 310/322, 323, 345, 26; 156/73.1; 228/1.1

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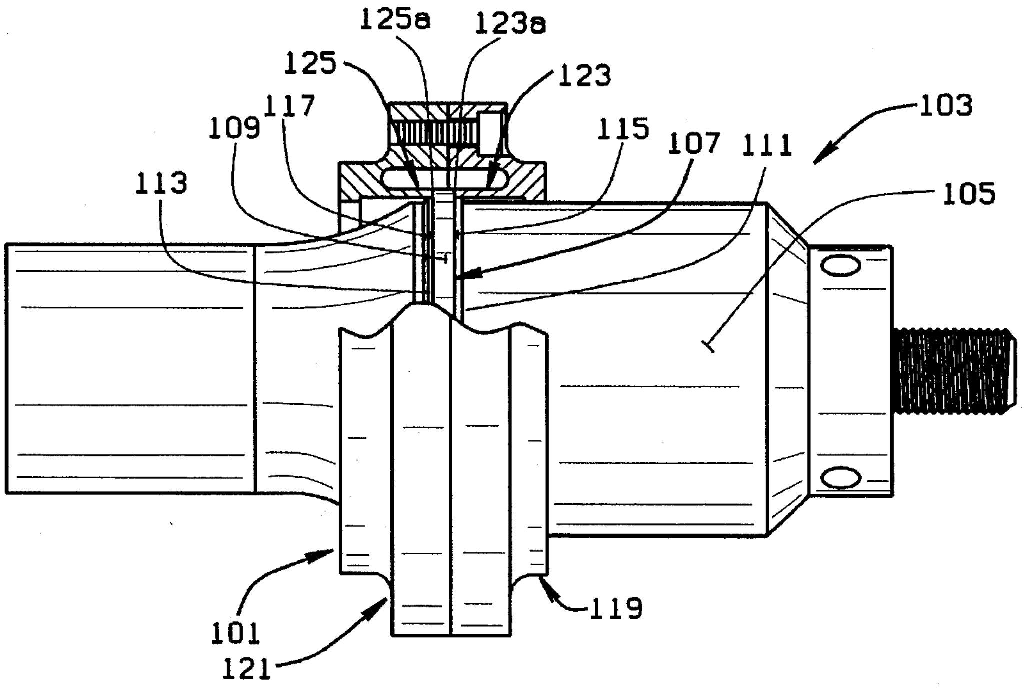
Primary Examiner—Ramon O. Ramirez
Attorney, Agent, or Firm—Polster, Lieder, Woodruff & Lucchesi

[57] **ABSTRACT**

A mount for a vibratory member, such as an elongate half wavelength resonator, includes a pair of cylindrical flexural tubes, each tube coupled with one end to the nodal region of the member and the other end of each tube coupled to a stationary member. The axial length and the thickness of the tubes are selected to enable the tubes to flex radially responsive to the substantially radial vibrations manifest at the nodal region of the member so as to decouple the vibrations of the member from the stationary member. A method of decoupling a vibration member from its stationary mount is also described.

8 Claims, 4 Drawing Sheets



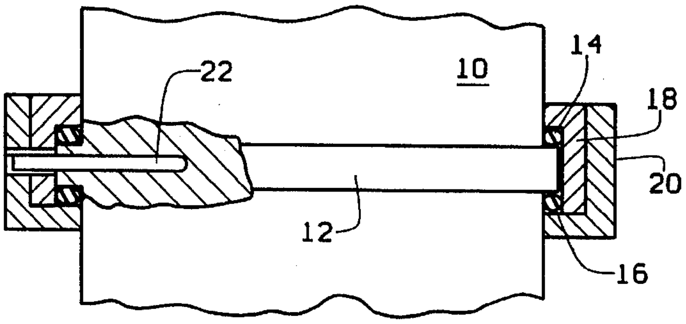


FIG. 1
PRIOR ART

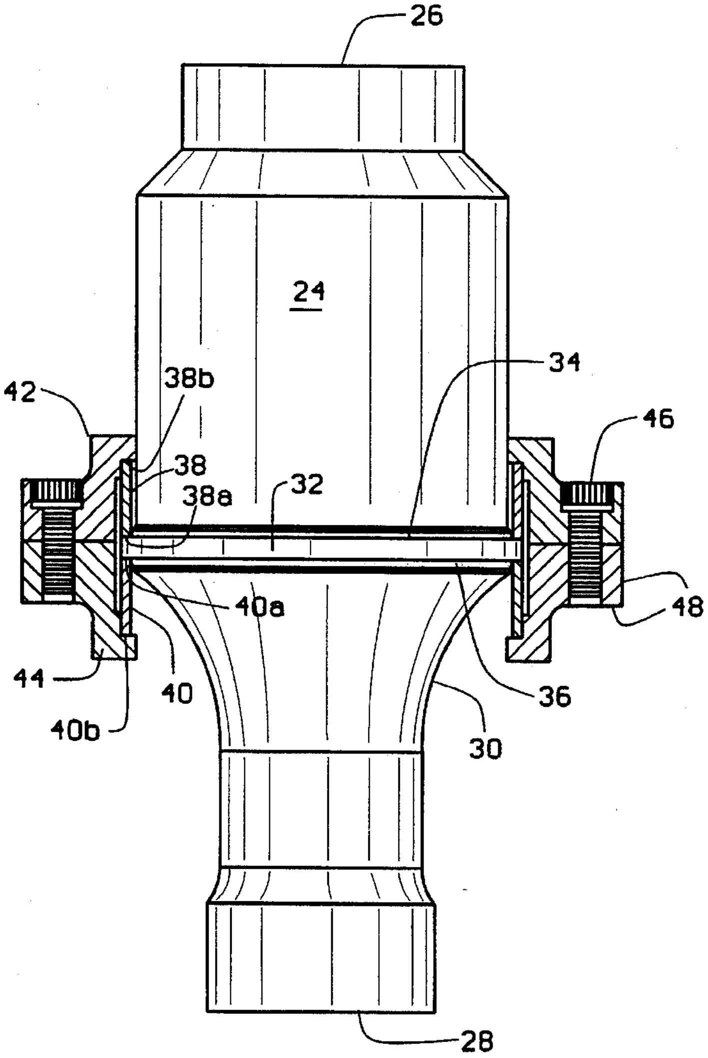


FIG. 2

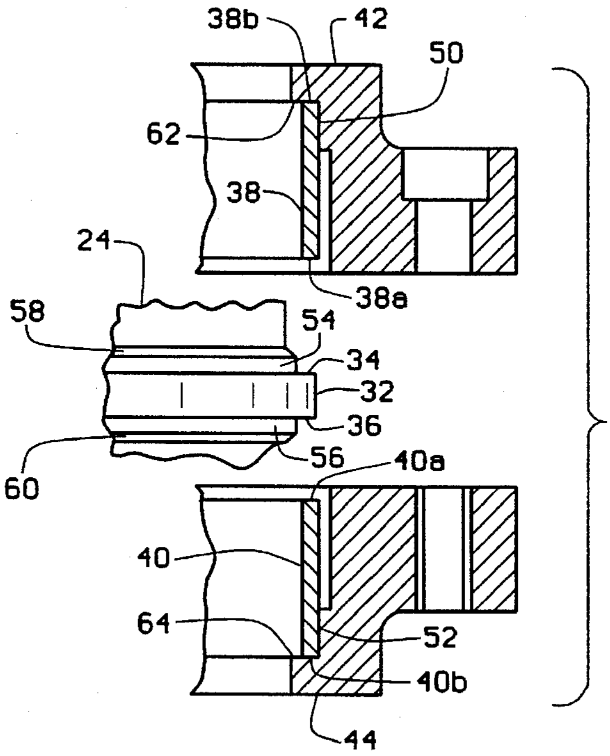

38b
42
50
62
38
24
38a
58
54
34
32
36
56
60
40a
40
64
52
40b
44

FIG. 3

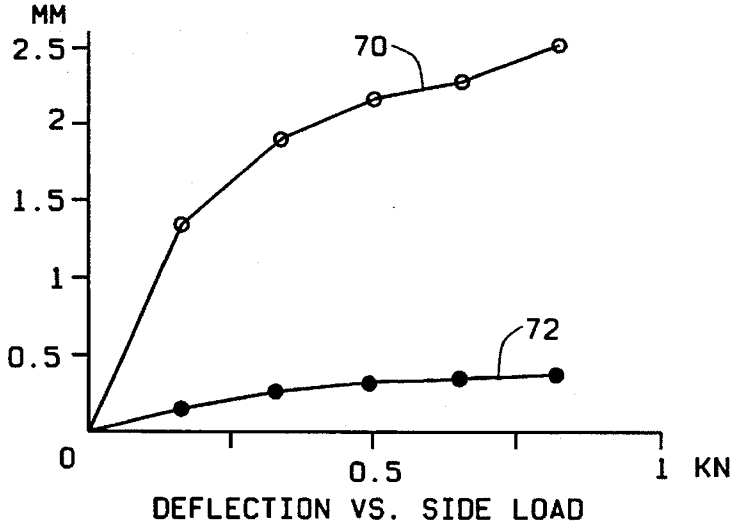
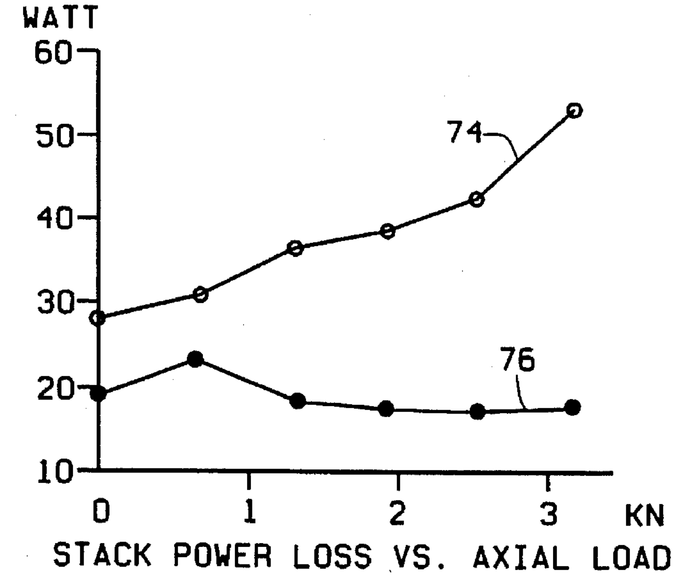
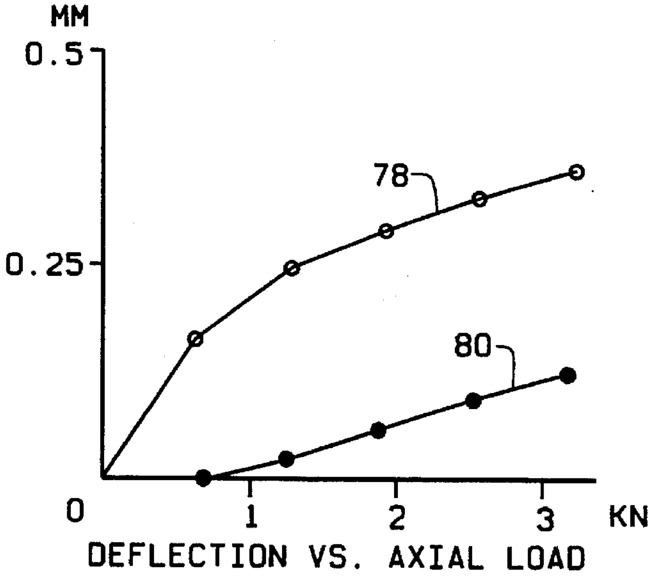

MM
2.5
2
1.5
1
0.5
0
0.5
1 KN
70
72
DEFLECTION VS. SIDE LOAD

FIG. 4



STACK POWER LOSS VS. AXIAL LOAD

FIG. 5



DEFLECTION VS. AXIAL LOAD

FIG. 6

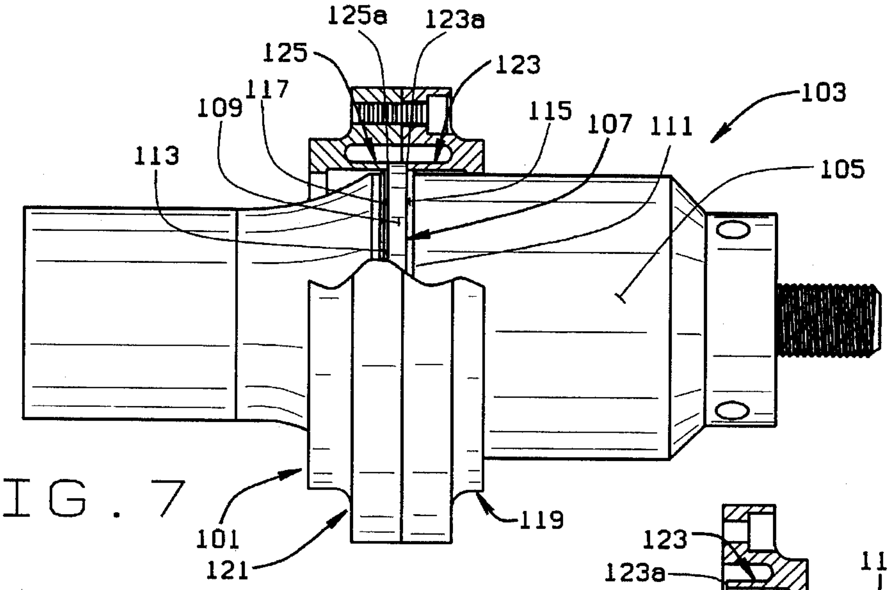


FIG. 7

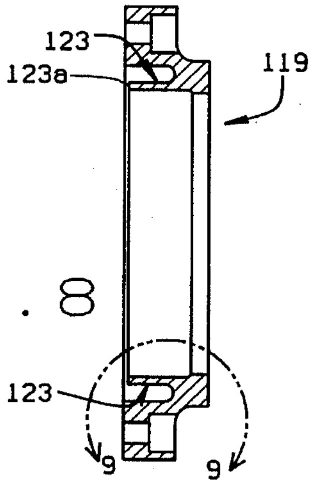


FIG. 8

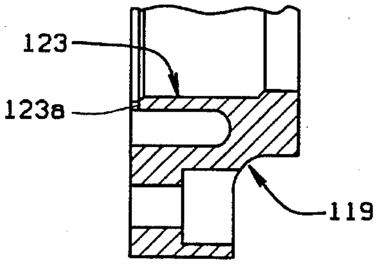


FIG. 9

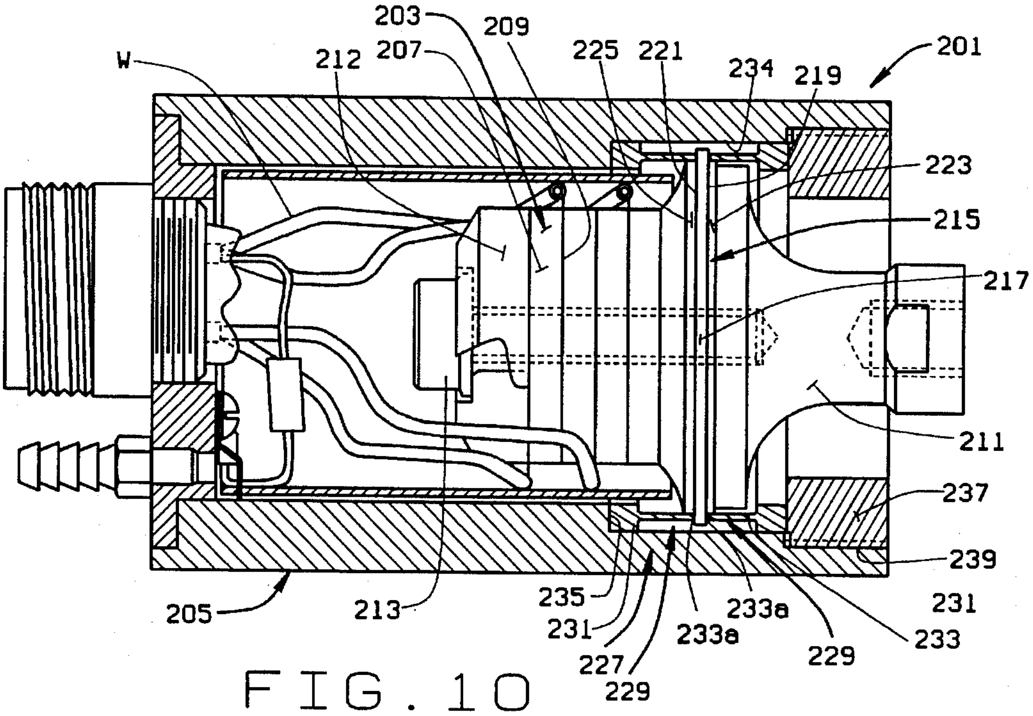


FIG. 10

MOUNTING MEANS AND METHOD FOR VIBRATION MEMBER

CROSS-REFERENCE TO A RELATED APPLICATION

This is a continuation-in-part application of U.S. patent application No. 08/194,108, filed Feb. 9, 1994, now U.S. Pat. No. 5,443,240.

BACKGROUND OF THE INVENTION

This invention relates to mounting means for high frequency vibration members and, more specifically, refers to mounting means for solid resonators, also known as mechanical impedance transformers, sonotrodes, horns, tools, concentrators, couplers and the like, used for coupling high frequency vibrations in the sonic or ultrasonic frequency range to a workplace. The vibrations are used for joining thermoplastic pans, welding metal parts, abrasive slurry machining of glass or ceramic workpieces and the like. The construction and use of these vibration members is well known and fully described in "Ultrasonic Engineering" (book) by Julian R. Frederick, John Wiley & Sons, New York, N.Y. (1965), pp. 89–103.

The mounting means for a vibration member must be designed to substantially decouple the vibrations of the vibration member, which, when operative, is resonant as a one-half wavelength resonator for high frequency vibrations of predetermined frequency traveling longitudinally therethrough, from the mounting means without impairing the operation of the vibration member. Absent such decoupling, there is a loss of vibratory energy and the transmission of vibrations to mounting means and to other parts of a machine where the existence of vibrations is highly undesirable.

Mounting the vibration member to a stationary support is effected most commonly by providing support means which engage the vibration member at a nodal region or an antinodal region present in the vibration member when the high frequency vibrations are transmitted through the member along its longitudinal axis from a radially disposed input surface at one end to a radially disposed output surface at the other end. Under those conditions and assuming a one-half wavelength resonator, there exists an antinodal region of the vibrations at the input surface and at the output surface, and a nodal region of the vibrations will be present at a region medially between the antinodal regions, the precise location of the nodal region being dependent on the mechanical configuration of the resonator. At the nodal region the vibrations appear as substantially radially directed vibrations.

Mounting means using flexible metallic elements engaging a vibration member at antinodal regions of the vibrations have been disclosed, for instance, in U.S. Pat. No. 3,752,380 entitled "Vibratory Welding Apparatus" issued to A. Shoh, dated Aug. 14, 1973. The disadvantage of that arrangement resides in the fact that the vibration member must be at least one full wavelength long.

Other mounting means coupled to a vibration member are shown in U.S. Pat. Nos. 2,891,178, 2,891,179 and 2,891,180 entitled "Support for Vibratory Devices", issued to W. C. Elmore, dated Jun. 16, 1959. These patents disclose various decoupling means engaging the vibration member at an antinodal region. The decoupling means comprise tuned elements one-half wavelength long. These mounts, because of their complexity and space requirements, have not found wide acceptance and are rarely present in commercial apparatus.

As a result of the above stated shortcomings, several mounts have been developed which support the vibration member at its nodal region. One current design, in wide use, provides the vibration member with a thin flange which protrudes radially from the nodal region of the vibration member. Elastomer "O"-rings are disposed on either side of the flange, all enclosed in a two-piece metallic annular ring, see U.S. Pat. No. 4,647,336 issued to J. D. Coener et al, dated Mar. 3, 1987. The elastomer "O"-rings serve to dampen the vibrations present at the nodal region of the vibration member with respect to the annular ring, which, in turn, is held stationary in a housing. However, this construction, although widely used, has several inherent problems. The "O"-rings are subject to wear and the elastic rings fail to provide the desired degree of rigidity for the vibration member in precision applications, specifically, the vibration member is subject to movement responsive to an axial or lateral force.

In order to overcome the above stated problem, metallic nodal mounts have been developed which provide greater rigidity. However, the designs now in use exhibit significant disadvantages. In one design, the vibration member and the metallic decoupling flange are made from a single piece of material, requiring intricate and expensive machining operations. Another design uses a single circular "L"-shaped cross sectioned decoupling flange which also is machined from bar stock and occupies a rather large amount of space. In addition, in this other design the fastening of the vibration member, due to the design of the decoupling flange, takes place away from the nodal region.

SUMMARY OF THE INVENTION

The present invention discloses a compact and simple metallic mounting means for a vibration member. The vibration member is provided at its nodal region with a radially extending cylindrical flange. Clamping means surround the vibration member. A pair of cylindrical flexure tubes is provided, each tube secured by a press fit with one of its ends to one respective side of the flange, and the other end of such tube secured by a press fit to the clamping means, which comprises two halves axially secured to one another. Additionally, both clamping halves have respective radial surfaces for urging each tube against a respective seating surface disposed on the flange. The cylindrical tubes have a wall thickness and axial length dimensioned for enabling the tubes to flex radially as the vibration member undergoes its radial vibrations in the nodal region. Therefore, the tubes decouple the vibrations of the member from the clamping means which are supported in a stationary housing.

One of the principal objects of this invention is the provision of a new and improved mounting means for a vibration member.

Another principal object of this invention is the provision of a new and improved solid mounting means for a vibration member, specifically a vibration member adapted to be resonant as a one-half wavelength resonator.

Another important object of this invention is the provision of a metallic mounting means coupled to a vibration member at its nodal region, the member exhibiting such nodal region when rendered resonant at a predetermined frequency.

A further object of this invention is the provision of a mounting means for a vibratory member adapted to be resonant as a one-half wavelength resonator, the mounting means including a pair of cylindrical tubes for decoupling the vibrations manifest at the nodal region of the member from substantially stationary clamping means surrounding the vibratory member.

Another and further object of this invention is the provision of a metallic and solid mounting means for a vibration member engaging such member at its nodal region, the mounting means being characterized by simplicity of construction and low cost.

Still another and further object of this invention is the provision of a nodal mount for a vibration member, the mount exhibiting greater rigidity and having a lower power loss than prior art means using elastic rings for decoupling vibrations.

Further and still other objects of this invention will become more clearly apparent from the following description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational view, partly in section, of a typical prior art mounting means in wide use;

FIG. **2** is an elevational view, partly in section, of the improved mounting means forming the present invention;

FIG. **3** is an exploded view of parts shown in FIG. **2**;

FIG. **4** is a graph showing deflection vs. side load for the prior art design per FIG. **1** and the improved mount depicted in FIG. **2**;

FIG. **5** is a graph showing stack power loss vs. axial load for the prior art mount and the improved mount;

FIG. **6** is a graph showing deflection vs. axial load for the prior art mount and the improved nodal mount construction disclosed herein;

FIG. **7** is an elevational view, partly in section, of another embodiment of the improved mounting means forming the present invention;

FIG. **8** is a cross-sectional view of one of the mounting means shown in FIG. **7** illustrating an integral cylindrical tube which engages a cylindrical flange on an ultrasonic vibration member so as to decouple the vibrations of the vibration member from the clamping rings which in turn are supported by a stationary support;

FIG. **9** in an enlarged view of the clamping ring and the integral tube taken along line **9—9** of FIG. **8**; and

FIG. **10** is a cross-sectional view of an electroacoustic transducer assembly having a vibration member mounted within its stationary support by means of the improved mounting means of the present invention.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The mounting means described hereafter is particularly suited for mounting an elongated resonator, dimensioned to be resonant as a one-half wavelength resonator when high frequency vibrations of predetermined frequency traverse such resonator longitudinally, at its nodal region of longitudinal vibrations. In a typical industrial apparatus, the predetermined frequency is in the ultrasonic range, for instance 20 KHz, and the apparatus includes a stack of three vibration members, namely an electroacoustic transducer assembly for converting applied electrical high frequency energy to mechanical vibrations, an intermediate coupler, also known as "booster horn", for receiving the vibrations from the converter and coupling them at the same amplitude or increased amplitude to an output horn, tool, sonotrode, etc., which couples the vibrations to a workpiece. In order to be operative, all members of the stack are dimensioned to be resonant at the predetermined frequency. The booster horn, aside from functioning as a mechanical impedance transformer, also serves in most cases as a means for supporting the stack in a stationary housing. The following description describes the mounting means in connection with a booster horn, although the invention is applicable also to other vibration members of a similar nature.

Referring now to the drawing figures and in particular to FIG. **1**, there is shown a widely used prior an mounting means. Numeral **10** denotes the body of a typical booster horn, made from aluminum or titanium, which is provided at its nodal region of longitudinal vibrations with a radially extending flange **12**. Elastomer "O"-rings **14** and **16** are provided, one ring on either side of the flange **12**, and both the rings and the flange are enclosed within a set of "L"-shaped annular metal rings **18** and **20** which are secured to one another by a set of radial pins **22**. The elastomer rings serve to decouple the vibrations of the vibration member (booster horn) from the surrounding support rings **18** and **20** which, in turn, are inserted into and supported by a circular groove disposed in a larger housing, not shown.

It will be apparent that the prior art mounting means has inherent disadvantages with respect to stack rigidity arising from the elasticity of the "O"-rings, and that the latter rings are subject to aging and wear due to the dissipation of vibratory energy.

The improved, so-called rigid, nodal mount design is shown in FIGS. **2** and **3**. The booster horn **24**, an elongated round body, is provided with a radially disposed input surface **26** (shown in FIG. **2**) for being mechanically coupled to the output surface of an electroacoustic transducer assembly for receiving mechanical high frequency vibrations therefrom. The opposite radially disposed output surface **28** provides the vibrations to the input surface of a horn which, in turn, transmits the vibrations to a workpiece, see Frederick supra. The booster horn depicted has a gain section, generally identified by numeral **30**, for acting as a mechanical amplifier for the vibrations transmitted therethrough from the input surface **26** to the output surface **28**.

When vibrations of the predetermined frequency are transmitted, booster horn **24** is rendered resonant as a one-half wavelength resonator and a nodal region of such vibrations is manifest about medially between the antinodal regions present at the input surface **26** and output surface **28**, respectively. As stated heretofore, the precise location of the nodal region is dependent upon the configuration of the horn. As shown in FIG. **2**, an annular flange **32** protrudes radially from the nodal region of the horn. Each side of the flange **32** is provided with identical seating means **34** and **36** for receiving thereupon one end **38*a*, 40*a*** of a respective flexure tube **38** and **40**. The other end **38*b*, 40*b*** of each tube is seated in a respective half of clamping means **42** and **44**. A set of screws **46** secures the clamp halves to one another. The outer surfaces **48** of the clamp means are configured for being mounted within a circular groove of a larger housing, which thereby supports the member or a stack of resonators.

The distal ends of the tubes **38**, **40** have a press fit with the respective cylindrical surfaces **50** and **52** of the clamp rings **42**, **44**, see FIG. **3**. The seating means **34** and **36** are of the

"L" shaped configuration including cylindrical axially disposed surfaces **54** and **56** and the radial bearing surfaces **34**, **36**. The cylindric surfaces **54**, **56** of the seating means are spaced radially inwardly of the radial bearing surfaces **34**, **36** and extend axially therefrom. Preferably, the cylindric surfaces axially locate the ends of the tubes with respect to the bearing surfaces and are dimensioned to provide a close or press fit with the proximate ends of the tubes **38** and **40**. In order to effect the press fit, respective chamfered surfaces **58** and **60** are disposed on each side of the flange **32** for guiding the tubes upon the surfaces **54** and **56**.

The mounting means are assembled by pressing one end of a respective tube into one end of the clamping halves **42** and **44**. As stated, a press fit exists by virtue of surfaces **50** and **52** being machined to have a slightly smaller inside diameter than the outside diameter of the tubes. The clamp halves with tubes firmly pressed therein are then placed about the booster horn, see FIG. **3**, and closed upon one another by tightening screws **46**. The proximate ends of the tubes **38** and **40** are guided over the respective chamfered surfaces **58** and **60**, and pressed upon the abutting axial surfaces **54** and **56**, which have a slightly larger diameter than the inside diameter of the tubes **38** and **40**. The radial surfaces **60** and **62** of the respective clamp halves cause a force upon the associated tube, and as the screws are tightened, the tubes are urged to slide over the chamfered surfaces, the abutting cylindrical surfaces and onto the radial surfaces of the seating means **34** and **36**.

As a result of the press fit, the proximate ends **38*a***, **40*a*** of the tubes **38**, **40** are inhibited from undergoing relative motion with respect to the flange **32**, and the distal ends **38*b***, **40*b*** are inhibited from undergoing relative motion with respect to the clamping means **42**, **44**. The tubes **38**, **40**, in a typical case, are made from aluminum and have an axial length and wall thickness dimensioned to flex or yield radially for decoupling the vibrations manifest in the nodal region of the member from the substantially stationary clamping means. In a typical embodiment where the horn is dimensioned to be resonant at the ultrasonic frequency of 20 KHz, each tube has an axial length of 11.43 mm, an outer diameter of 55.4 mm, and a wall thickness of 1.29 mm. As is evident from FIGS. **2** and **3**, there is sufficient clearance between the midsection of the tubes and the clamping means to enable the tubes to flex radially as is required by the radial motion of the horn at its nodal region, thus effecting decoupling of the booster horn vibrations from the stationary clamping means.

The present construction has the advantage of simplicity. Importantly, however, the improved mount per FIG. **2** fits mechanically into the same housing as the prior art design per FIG. **1**. Therefore, there exists the capability of interchanging assemblies, which feature is of significance in obtaining improved performance from currently installed equipment.

FIGS. **4**, **5** and **6** depict the improved results obtained by the new mounting means disclosed heretofore. FIG. **4** shows the measurement on a stack as described heretofore of lateral deflection vs. side load. The deflection is measured in millimeters at the median or nodal area of an output horn and the load is measured in kilo-newtons. Curve **70** shows the "O"-ring assembly per FIG. **1**, whereas curve **72** shows the greatly reduced deflection achieved with the solid mount construction per FIG. **2**. FIG. **5** shows the stack electrical power loss vs. axial load. Curve **74** represents the measurements on the elastomer ring construction while curve **76** shows the much reduced power loss of the design per FIG. **2**. The large power loss per curve **74** is primarily due to an increase in stiffness of the "O"-rings. FIG. **6** depicts the deflection versus axial load. Once again, curve **78** relates to the resilient mount design, whereas curve **80** applies to the solid mount design shown in FIG. **2**. In all instances, the improvement achieved is significant.

Referring now to FIGS. **7**–**9**, another embodiment of the mounting means of the present invention is shown in its entirety at **101**. As shown in FIG. **7**, mounting means **101** is applied to an ultrasonic booster horn assembly, as is generally indicated at **103**. The booster horn assembly has a booster horn **105** which has an annular mounting flange **107** which extends radially outwardly from the body of the booster horn and which is located generally at the nodal region of the booster horn. Flange **107** has an outer cylindrical surface **109** which is generally coaxial with booster horn **105** and has oppositely facing annular seating surfaces **111** and **113** extending radially inwardly from outer cylindrical surface **109** toward the body of the booster horn. It will be noted that seating surfaces **111** and **113** face in opposite axial directions. Further, flange **107** has a pair of axial (cylindrical) seating surfaces or walls **115**, **117** which extend in axial direction from seating surfaces **111**, **113**. It will be appreciated that flange **107** on booster horn **105** is generally similar to flange **32** on booster horn **24** in construction and function and that bearing surfaces **111**, **113** and cylindric surfaces **115**, **117** have a construction and function similar to the surfaces **34**, **36** and **54**, **56** of flange **32** heretofore described.

Mounting means **101** comprises a pair of clamping rings **119**, **121**, generally similar to clamping means **42**, **44** described above in regard to FIGS. **2** and **3**. More specifically, clamping rings **119**, **121** each have a flexural tube, as indicated at **123**, **125**, each of which is integral with its respective clamping ring. That is, each flexural tube **123**, **125** is preferably machined from the same piece of metal as its respective clamping ring such that the flexural tube is cantilevered from a portion of the clamping ring. It will be appreciated that the flexural tubes **123**, **125** are the equivalent of tubes **38**, **40**, as above described, for vibrationally decoupling the booster horn **105** from its mount. Like tubes **38**, **40**, the free ends **123*a***, **125*a*** of tubes **123**, **125** have a press fit with the respective axial (or cylindrical) surfaces **115**, **117** of flange **107** such that no relative movement between the inner walls of the flexure tubes and the axial (or cylindric) surfaces **115**, **117** of the flange occurs. The clamping rings are forcefully drawn together by means of screws, similar to screws **46** as shown in FIG. **2**, such that the ends of the flexural tubes bear solidly against a respective bearing surface **111**, **113** of flange **107**.

It will be appreciated that since the other ends of the flexure tubes **123**, **125** are integral with their respective clamping rings **119**, **121**, the other ends of the tubes are prevented from undergoing relative movement relative to the clamping rings. Further, the length and thickness of the flexure tubes **123**, **125** is such that tubes flex or yield radially for decoupling the vibration manifest in the nodal region of booster horn **105** from the substantially stationary clamping members **119**, **121**.

Referring now to FIG. **10**, still another embodiment of the mounting means of the present invention is indicated in its entirety at **201** for mounting an electroacoustic transducer assembly, as generally indicated at **203**, within a stationary support housing or tube **205**. The electroacoustic transducer assembly has a stack of alternating piezoelectric disc members **207** and electrode discs **209** securely mounted between a front mass **211** and a rear mass **212** by a bolt **213**. The piezoelectric disc members are supplied with electrical power by means of wires W in the conventional manner. The front mass **211** of the electroacoustic transducer assembly further has a circumferential flange **215** located generally at the nodal region of the transducer assembly. The flange has an outer cylindrical surface **217**, radial bearing surfaces **219** and **221** extending radially inwardly of the flange and facing in opposite axial directions, and generally cylindric surfaces **223**, **225** which extend axially from the bearing surfaces **219** and **221**. Generally, flange **215** is similar in construction and function to flange **32** on booster horn **24** and to flange **107** on booster horn **105**.

In accordance with this invention, transducer assembly **203** is mounted within its stationary tube **205** by means, as generally indicated at **227**, for decoupling the transducer assembly **203** when resonant from its stationary tube or support **205**. More specifically, decoupling means **227** comprises a pair of decoupling rings, as indicated at **229**, each having a base ring **231** and an axially extending flexural tube **233** integral with the base ring. As shown in FIG. **10**, each flexural tube **233** has an inner cylindrical wall which, at its outer end, bears against a respective cylindric bearing surface **223** or **225** of flange **215**. Further, each flexural tube **233** has an outer end **233***a* which bears against a respective bearing surface **219**, **221**. The end **233***a* and the inner wall of flexural tube **233** fit snugly (preferably with a press fit) with a respective cylindric wall **223**, **225** on the flange so as to insure that there is no relative movement between the end of the flexural tube and the adjacent portion of booster horn **203**. It will be further understood that the outermost cylindric surface on base ring **231** of each decoupling ring **229** has a press fit within the inner cylindric surface **234** of stationary tube **205**. The innermost decoupling ring **229** is installed on a shoulder **235** provided within tube **205** with the end of the base ring **231** bearing solidly on the shoulder. A compression ring **237** is threaded into a threaded bore **239** provided in the end of tube **205** so as to forcibly compress the decoupling rings **229** between shoulder **235** on the tube **205** and to force the flexure tubes **233** of each of the decoupling rings into firm bearing engagement with the bearing surfaces **219**, **221** of flange **215**. Because of the close fit of the inner walls of the flexural tubes **233** against cylindric walls **223**, **225** of flange **215**, a press fit between the inner walls of the tubes and the cylindric walls of the flange is effected upon the forcible compression of the decoupling rings into tube **205**.

As with flexure tubes **38**, **40** and **123**, **125** described above, flexural tubes **233** are made of a suitable metal and have an axial length and wall thickness dimensioned to flex or yield radially for decoupling the vibration member (i.e., transducer assembly **203**) in the nodal region thereof from tube **205** and for enabling the flexural tubes to flex radially as is required by the radial motion of the transducer assembly at its nodal region, thus effecting decoupling of the booster horn vibrations from the stationary tube **205**. In short, decoupling means **227** is the equivalent of the decoupling means shown in FIGS. **2** and **3**, and the decoupling means shown in FIGS. **7–9**.

It will be understood that the mounting means **101** and **201** described in regard to FIGS. **7–9** and in FIG. **10**, respectively, operate generally in the manner and with the enhanced performance as the embodiments shown in FIGS. **2–6**.

While there have been described and illustrated preferred embodiments of the present invention, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the principle of the invention, which shall be limited only by the scope of the appended claims.

What is claimed is:

1. Mounting means for a vibration member dimensioned to be resonant as a resonator for vibrations of predetermined frequency traveling longitudinally therethrough, and when resonant exhibiting two respective antinodal regions and a nodal region of said vibrations, the improvement comprising:

a flange extending radially from said vibration member substantially at said nodal region thereof, said flange including bearing surfaces;

a pair of mounting rings surrounding said vibration member generally at the location of said flange, each of said mounting rings having a flexural tube integral therewith and extending axially therefrom, said flexural tube having an end bearing against one of said respective bearing surfaces of said flange such that relative movement between said end of said flexural tube and its respective said bearing surface is inhibited, said flexural tubes having an axial length and wall thickness dimensioned for enabling each tube to flex radially responsive to said member being resonant and thereby undergoing substantially radial motion at its nodal region; and

means for axially clamping said flexural tubes relative to said flange such that the ends of said flexural tubes bear against said bearing surfaces so as to decouple the vibrations of said vibration member from said means for clamping.

2. Mounting means as set forth in claim **1** further including a plurality of threaded members for forcefully drawing said mounting rings in axial direction toward one another so as to force the ends of said flexural tubes into forceful engagement with said bearing surfaces of said flange.

3. Mounting means as set forth in claim **1** wherein each said mounting ring includes a clamping portion spaced radially outwardly of said flexural tube with a gap between said flexural tube and said clamping portion.

4. Mounting means as set forth in claim **1** wherein said mounting rings mount said vibration member within a stationary member and decouple the vibrations of said vibration member from said stationary member, said stationary member having a shoulder therewithin, each said flexural tubes having a base ring integral therewith with the base ring of one of said flexural tubes bearing against said shoulder, and wherein said means for clamping comprises means for forcefully bearing against the base ring of said other flexural tube so as to force its flexural tube into engagement with its respective bearing surface and to in turn force said other bearing surface of said flange into bearing engagement with the end of said other flexure tube whose base ring is bears on said shoulder of said stationary member.

5. Mounting means as set forth in claim **4** wherein said means for bearing against the base ring of said other flexural tube is a ring axially threaded into said stationary member.

6. Mounting means as set forth in claim **1** wherein said vibration member is an electroacoustic transducer assembly.

7. A method of mounting a vibration member relative to a supporting member so as to decouple the vibrations of said vibration member from said supporting member, said vibration member being dimensioned for being resonant as a resonator for vibrations of predetermined frequency traveling longitudinally therethrough and, when resonant, having a nodal region of said vibrations, said vibration member having a flange substantially at said nodal region, said flange having surfaces for receiving thereupon a pair of flexural tubes extending axially in opposite direction from one another, said method comprising the steps of:

providing a pair of flexural tubes surrounding said vibration member generally at the location of said flange with an end of each of said flexural tubes engaging a respective one of said surfaces of said flange, said flexural tubes having an axial length and wall thickness so as to enable each tube to flex radially responsive to said vibration member being resonant; and

clamping said flexural tubes relative to said surfaces of said flange such as to substantially inhibit relative motion between said respective ends of said flexural tubes and said flange thereby to decouple the vibrations manifest at said flange from said supporting member.

8. The method as set forth in claim **7** wherein said flange has bearing surfaces that face in opposite axial directions of said vibration member and cylindrical location surfaces spaced radially inwardly from said bearing surfaces, each of said flexural tubes having an inner wall, wherein said step of clamping said flexural tubes to said surfaces comprises axially clamping each said flexural tubes to said flange with the end of each tube engaging its respective said bearing surface of said flange and with said inner wall of each tube having a press fit with its respective said cylindrical location surface.

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