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Davis

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[54] **ULTRASONIC RIGID HORN ASSEMBLY**

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[73] Assignee: **Dukane Corporation**, St. Charles, Ill.

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[21] Appl. No.: **515,504**

Related U.S. Patent Documents

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[51] **Int. Cl.**[2] **B23K 1/06**; B23K 5/20

[58] **Field of Search** 228/1; 29/470.1, 470.3; 310/26; 156/73.1, 73.2, 73.3, 73.4, 73.5, 73.6

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Primary Examiner—Ronald J. Shore
Attorney, Agent, or Firm—Robert L. Kahn

[57] **ABSTRACT**

A versatile rigid horn assembly for distributing ultrasonic energy from at least one source to a plurality of spaced work areas is provided. This rigid horn assembly includes an elongated tool holder having an input region at one end and an output region at the other end. The tool holder is a horn of suitable metal and will have a length of at least one acoustic half wavelength, or any desired number of integral half wavelengths. Secured to and extending from the output end are rigid tool members, each of which is a horn and has a length of at least one acoustical half wavelength. Tool members may have lengths of integral half wavelengths, it being understood that tool members need not necessarily be of the same shape or length. The drawings illustrate various arrangements of tool members. The output end of a tool holder has means permitting attachment of a plurality of tool members, the means being arranged so that one or more various tool members may be disposed to provide different tool member patterns. The means for attaching a tool member to a tool holder includes threaded metal members each of which may be a threaded stud extending into a tapped recess in the tool holder or elongated bolts each having an enlarged head disposed in bores extending longitudinally of the tool holder and having an interior shouldered part for each bore.

Alternatively, a tool member may include an integral threaded boss, or the tool holder and tools may be of brazable material and secured by brazing.

6 Claims, 16 Drawing Figures

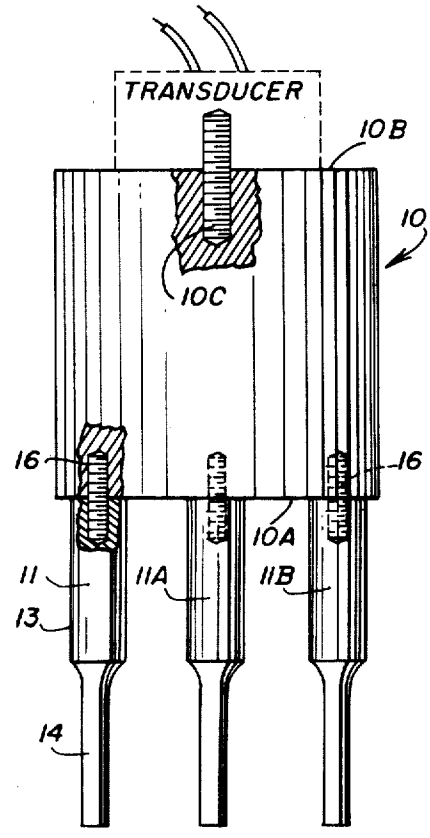


FIG. 1

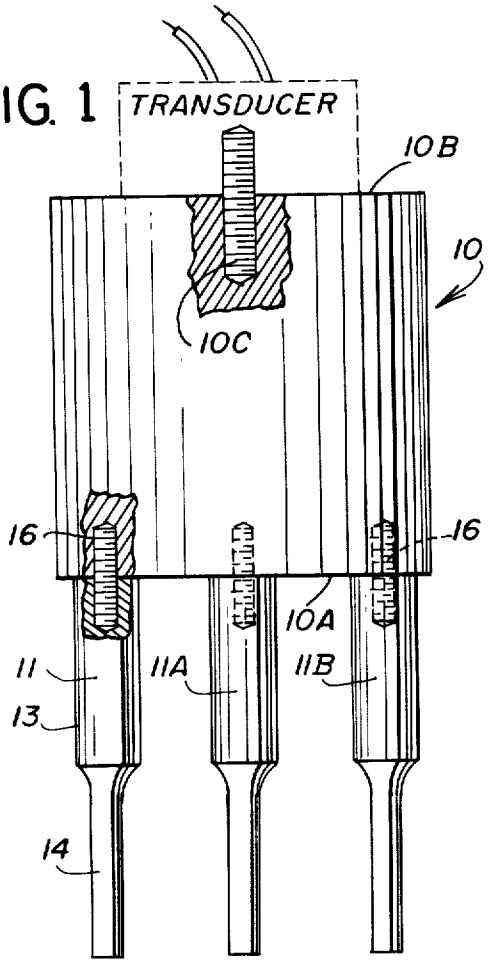


FIG. 2

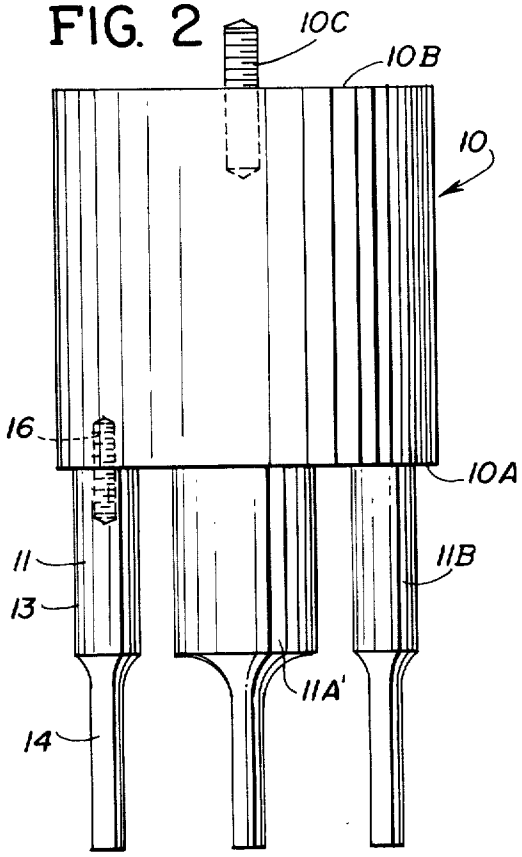


FIG. 1A

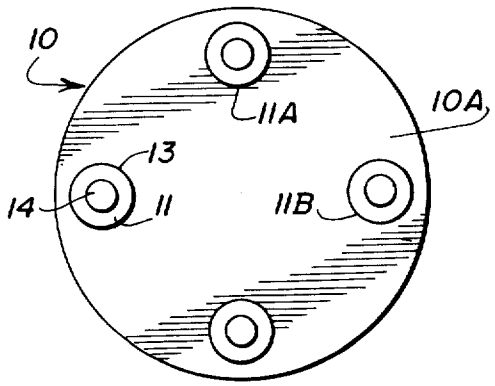


FIG. 2A

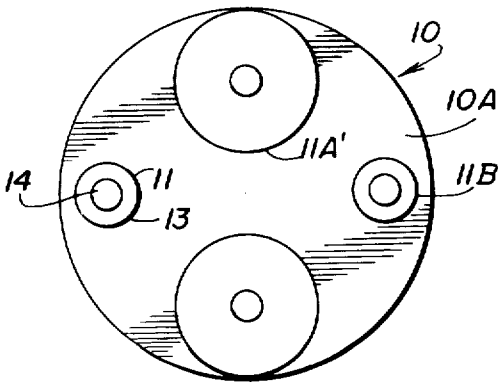


FIG. 3

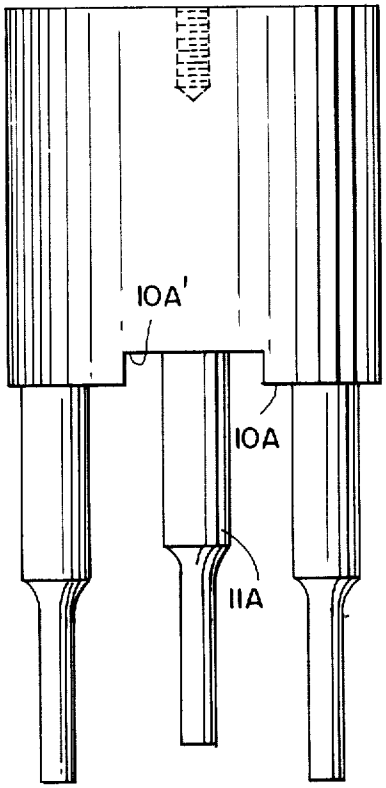


FIG. 4

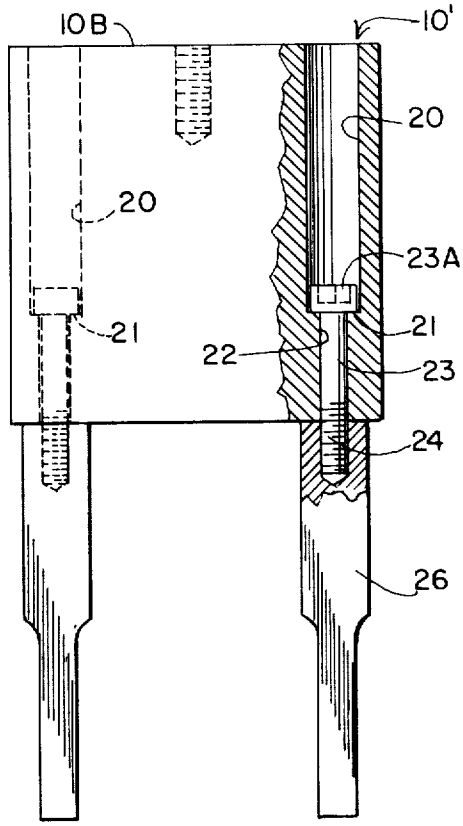


FIG. 3A

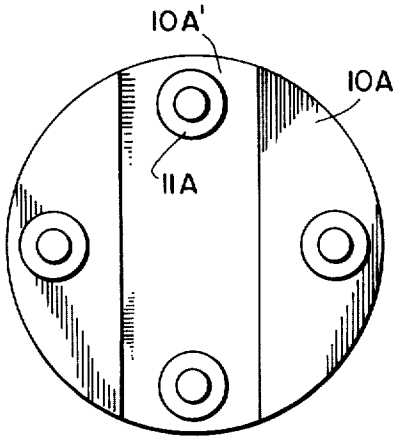


FIG. 4A

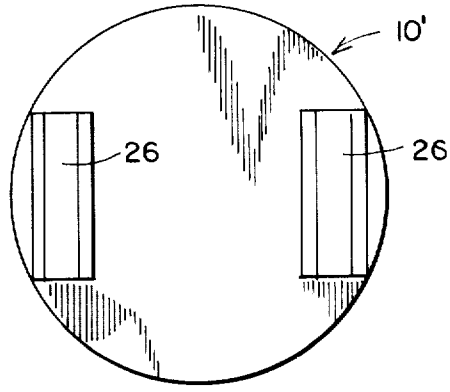


FIG. 5

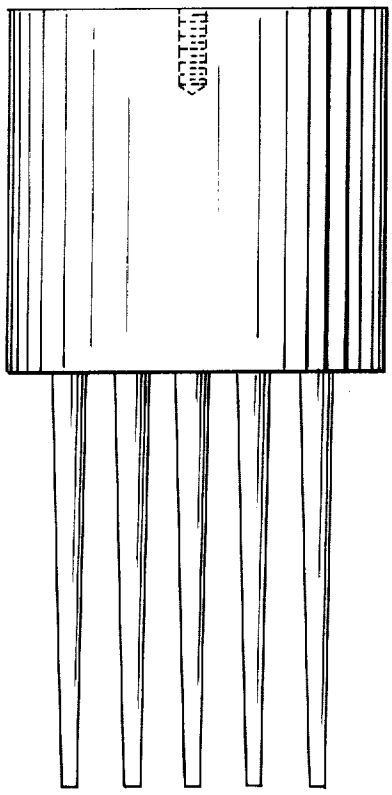


FIG. 6

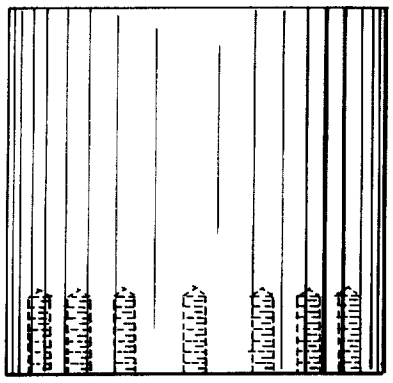


FIG. 6A

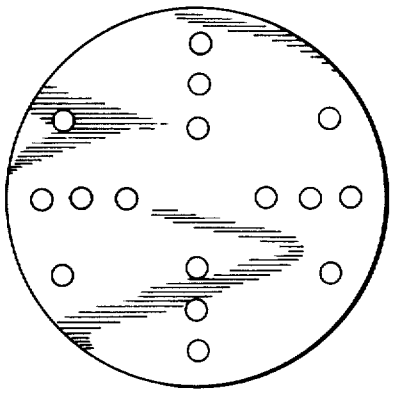


FIG. 8

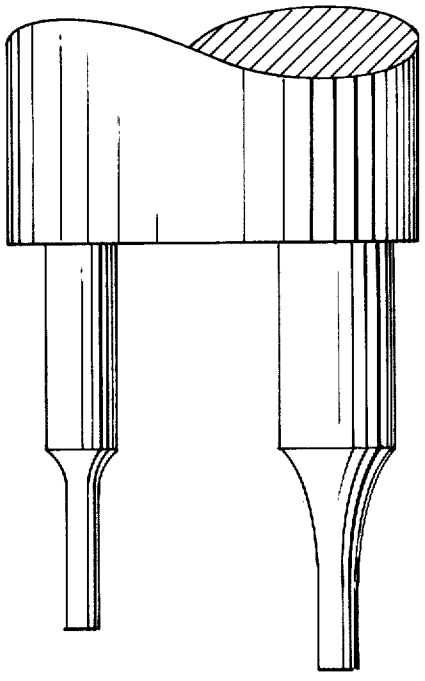
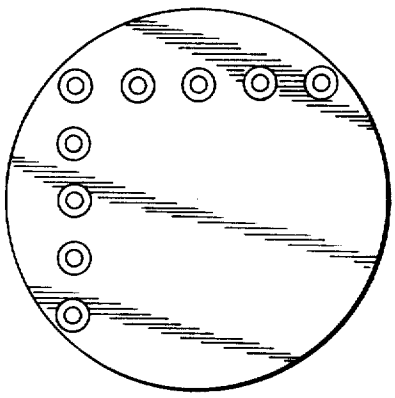


FIG. 5A



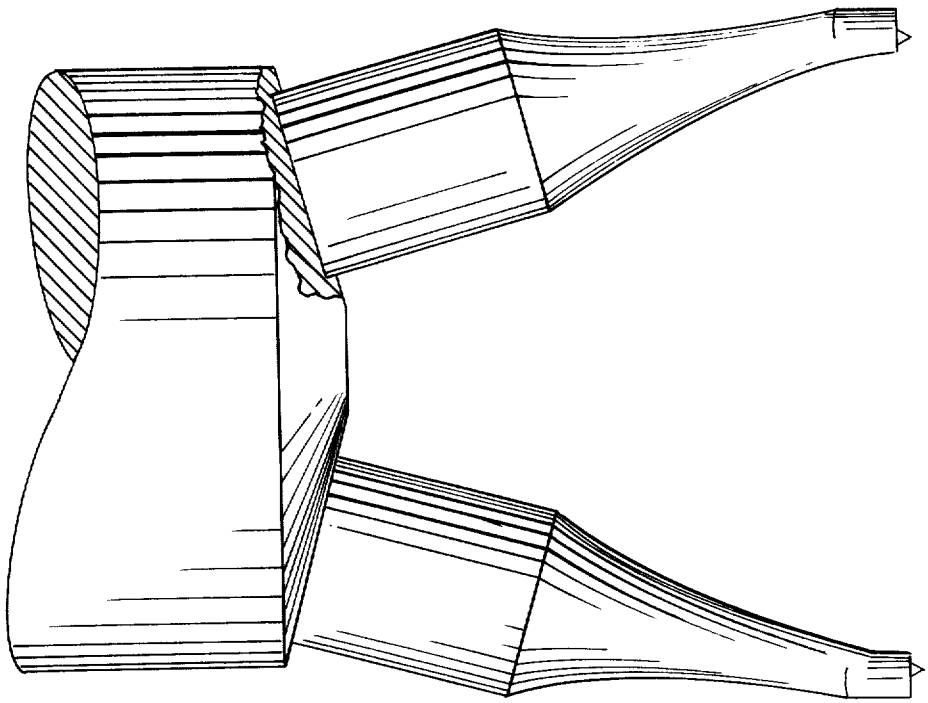


FIG. 7

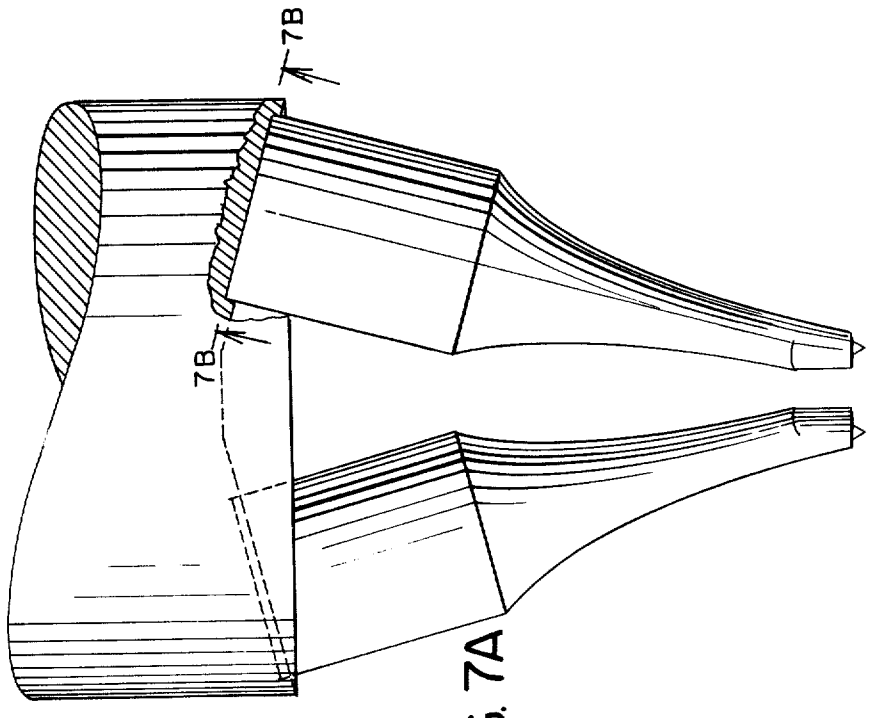


FIG. 7A

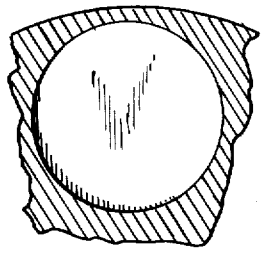


FIG. 7B

ULTRASONIC RIGID HORN ASSEMBLY

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

INTRODUCTION

This invention relates to an ultrasonic rigid horn assembly having enhanced functional adaptability for distributing ultrasonic energy from one or more sources to a plurality of tool members for application to various work areas. The invention particularly relates to applications of ultrasonics to plastics, such as welding, staking or inserting. As an example, welding may be accomplished by application of ultrasonic energy at predetermined work areas. In many instances, such work areas are disposed at spaced intervals in desired patterns for simultaneous treatment. The ultrasonic energy is directed to such spaced work areas to create simultaneously a pattern of weldments or other work.

It is not limited to plastics working, however, and may be useful where ultrasonic energy is required at discrete locations. Thus liquid at a number of locations may be cavitated.

It has been the practice to provide a unitary tool structure whose input is connected to a suitable source of ultrasonic acoustic energy and whose output is available at spaced sonic applicator regions on the tool. The sonic regions may assume a variety of forms, such as small separate circular or rectangular areas, all adapted to operate on the work piece and provide the desired effect at each of the sonic applicator regions. Inasmuch as the sonic applicator regions must be supplied with ultrasonic energy, the sonic wave transmission characteristics of a tool structure is determined in a substantial manner not only by the nature of the tool structure material (usually metal) but also by the longitudinal and transverse dimensions of the tool structure material. Such requirements involve shaping of a tool structure to obtain the required sonic tuning and vibration amplitude. It is, of course, well understood in this art that unless sonic energy is fed to every one of the spaced sonic energy applicator areas, that the desired action at the various regions to be operated upon may not occur.

As a rule, customer requirements with regard to number and spacing of sonic applicator regions in a tool structure differ greatly and may change even with changes only in dimensions and number and pattern of work areas.

In tool making for various customer requirements, the shaping of a tool to obtain desired operation often involves difficult machining operations to provide the desired shapes of the various parts of a tool. Frequently, such tools can not utilize surfaces of revolution in their manufacture. Consequently, the shaping of a tool may require difficult milling operations or even hand work. The various portions of a tool structure from the sonic input part to the respective individual sonic outputs must all have precise tuning and vibration amplitude characteristics.

The machining requirements for such tools are often made more expensive by the fact that the tool metals used in ultrasonic work may be special alloys, difficult

to machine, such as titanium or monel. Titanium, in particular, is very expensive as a raw material. In some instances, special thicknesses of metal plates for tool fabrication are required.

The resulting tool is useful for one particular job and rarely is adaptable for a different pattern of work areas. Consequently, any change in a work area pattern by customer's needs usually involves a complete change in tooling. Furthermore, tool metals may not have long life under conditions of rapid wear at working surfaces so that in many instances total tool renewal becomes necessary.

GENERAL REQUIREMENTS FOR TOOL STRUCTURE

The structure which couples ultrasonic energy from the acoustic source (piezoelectric or magnetostrictive transducer) to the material to be processed must satisfy several requirements:

1. Provide a sufficiently large output area to encompass the workpiece locations to be treated.
2. Provide whatever contours are necessary to provide concentration of sonic energy so that the required vibration amplitude will be available at the work locations.
3. The material must have sufficiently high strength to withstand high stresses present along the contoured sections.
4. The material must have sufficiently good wear resistance to withstand abrasion at the work faces.

According to prior art, structures are fabricated from one piece of metal and at least the first three of the above requirements must be met by this material. Unless the work areas can be provided with wear-resistant inserts, all four requirements must be met. In cases where a large work area must be handled, and high amplitude is required, this means that the structure (or horn) must be made of titanium or monel, materials which are both expensive as raw materials and difficult to machine.

In some cases, it may be very difficult or impossible to provide the contours necessary to produce the vibration amplitude required at the work areas.

In the present invention, the requirements to be satisfied are divided between a tool holder horn and one or more rigid tool member horns which taken together make up a rigid horn assembly.

The new tool holder provides for locating the tool members at the necessary points across the area. It has relatively low stress situations, no location of wear, and may be made of cheap, easily machineable materials such as aluminum. It does not require elaborate contours to be generated.

The new tool members deliver the ultrasonic energy to the material being processed, and include whatever contours are required to produce the vibration amplitude necessary to do the work. Contours may be as elaborate as needed to give the required amplitude, high stress points may be present, and high wear conditions may be present at the work face. Special materials such as titanium 6Al–4V may be required, and these metals are both expensive and difficult to machine. The size of these tool members can be held to a minimum, proportionate to the input and output areas required to couple the energy, thus material costs and machining time are held down.

In practically all cases, at least part of the new tool member can be round in section so that full use may be

nade of contouring techniques to provide amplitude nagnification.

ADVANTAGE OF THE INVENTION

The present invention to be hereinafter described nakes possible an ultrasonic rigid horn assembly hav- ng enhanced functional adaptability, whose pattern of onic applicator work areas may usually be modified vithout requiring a completely new structure. For one hing, a great advantage of a rigid horn assembly em- iodying the present invention resides in the fact that he tool holder may be a body having flat or cylindrical nuter surfaces and is susceptible to accurate economi- :al machining. The sonic transmission characteristics of such new tool holder portion may be controlled ac- :urately and will remain unchanged throughout the 'arious tool transformations which the invention per- nits.

The new tool holder must be longitudinally resonant o a desired operating frequency range and has its out- ɔut end portion or has its entire body portion shaped or :onstructed in such a manner as to accommodate a de- iired number of or pattern of rigid tool members. These ool members similarly must be longitudinally resonant ind if more than one are used, are respectively adapted :o receive sonic energy from the tool holder and apply t to work areas. The number and pattern of tool mem- ɔer positioning may be changed easily without disturb- ng the tool holder design whose shape and dimensions are adapted to provide different patterns of work areas.

Each tool member is rigid and is individually attached to the tool holder to project from the output end thereof. The attaching means is adapted to be detachable and will include a threaded stud or bolt of suitably strong material, usually specially strong steel.

The attaching means itself may include tapped recesses or holes extending into the output end of the tool holder and/or longitudinal bores or holes extending parallel to the axis of the tool holder but laterally offset therefrom, such bores preferably each having an internal shoulder against which the enlarged head of a steel bolt may be seated. The tapped recesses or holes and- /or longitudinally disposed bores or holes may be disposed in any desired pattern so that any one or more tool members may be used in different patterns and spacing arrangements. In all cases, it is preferred to limit the number, spacing and depth of tapped recesses and/or longitudinal bores to minimize substantial changes in the sonic transmission characteristics such as resonance and internal reflections of the tool holder between the input and output thereof. It will generally be desirable to have the tool holder output area sufficiently great to accommodate a number of tool positions in a desired pattern. In all cases, however, the transverse tool holder dimensions must be chosen and proportioned with respect to the overall length to produce the desired longitudinal mode of acoustical resonance, with undesired modes minimized so that the tool members can produce the desired action on the work areas.

Another substantial advantage obtainable with the invention is the possibility of having tool members so inclined that their longitudinal axes are non-parallel to the tool holder axis by a small angle thus providing a working field which may be somewhat larger or somewhat smaller than the working field obtainable when the tool member and tool holder axes are parallel.

Other advantages will become apparent later with a more detailed description of the invention.

BRIEF DESCRIPTION OF DRAWINGS

The invention will be described in connection with the drawings wherein FIG. 1 is an elevation of a rigid horn assembly [embodying the present invention].

FIG. 1A is a bottom view showing the rigid horn assembly of FIG. 1 to illustrate a pattern of tool members.

FIG. 2 is an elevation of a modified form of rigid horn assembly wherein certain tool members are dimensioned differently to provide different vibration amplitudes.

FIG. 2A is a bottom view of the rigid horn assembly illustrated in FIG. 2 showing the arrangement of tool members.

FIG. 3 is an elevation of a still further modified form of the invention illustrating an arrangement of tool member tips at different levels.

FIG. 3A is a bottom view of the rigid horn assembly illustrated in FIG. 3.

FIG. 4 is an elevation of a still further modified form of rigid horn assembly, this showing different means for attaching tool members to the tool holder.

FIG. 4A is a bottom view of the tool member arrangement illustrated in FIG. 4.

FIG. 5 is an elevation of a [still further modified form of a rigid horn assembly embodying the present invention, this illustrating] linear arrangement of tool members.

FIG. 5A is a bottom view of the tool member arrangement of the structure illustrated in FIG. 5.

FIG. 6 is an elevation of a tool holder [embodying the present invention] showing a pattern of recesses for tool member attachment.

FIG. 6A is a bottom view showing the arrangement of recesses.

FIG. 7 is an elevation of a [still] further modified form of rigid horn assembly embodying the present invention, this illustrating tool members diverging at a slight angle to the tool holder axis rather than being parallel.

FIG. 7A shows a modification of the form of the invention illustrated in FIG. 7.

FIG. 7B is a detail of FIG. 7A on line 7B—7B.

FIG. 8 is a still further modified form of a rigid horn assembly embodying the present invention showing two tool members having different lengths, the two tool members having different contours to maintain equality of dimensions in acoustical half wavelengths.

DETAILED DESCRIPTION OF THE INVENTION

The [new] rigid horn assembly [embodying the present invention] consists essentially of tool holder **10** and one or more tool members **11, 11A, 11B,** etc. Tool holder **10** is preferably of metal having appropriate accoustical and strength properties and may, for example, be of certain grades of aluminum, titanium, or the like. As examples, an aluminum alloy 7075–T651 can be used. In case of titanium, an alloy known as 6Al–4V may be used.

Tool holder **10** has its length equal to an integral number of half wavelengths at the operating frequency to be used. As a rule, a single half wavelength may be used. For a five inch diameter tool holder of aluminum 7075–T651 for example, and using 20KHz, a length of 4.345 inches may be used. This length is an actual example and it is understood that different lots of mate-

rial may vary in acoustic properties, so the length may depart slightly from the value given. One common shape for tool holder **10** is cylindrical, although, a rectangular or polygonal shape may be used.

It is understood that the requirement for substantial area at output end **10A** of tool holder **10** is dictated by the desirability of having tool members in desired number and spacing carried at such end. Tool holder **10** is preferably proportioned so as to avoid change in vibration amplitude from the input end **10B** of tool holder **10** to the output end **10A.** End **10B** of tool holder **10** is adapted to be coupled to one or more sources of sonic energy. This is most simply accomplished by having tapped recess **10C** for each source extending into the tool holder and preferably symmetrically disposed with respect to the tool holder axis. In order to attach a source of sonic energy, a steel stud may be screwed into recess **10C**, the steel stud being strong enough to withstand the various stresses and strains to which it may be subjected. For example, a sonic generator of the piezoelectric or magnetostrictive type may be used, the output being directly coupled to tool holder **10** or through an intermediate resonant coupling member.

One or more tool members **11; 11A; 11B** etc. may be coupled to tool holder **10** at output face **10A.** Referring to tool member **11,** as an example, this consists of input portion **13** and reduced tool member portion **14** as an extension thereof. In the particular example given, tool member **11** as a whole will have an overall length of one-half wavelength with input portion **13** and tool member portion **14** being respectively one-quarter wavelength each. It is understood that the physical length of the entire tool member may be different from the physical length of tool holder **10** depending, of course, upon the nature and contour of the material used.

The designation of one-half wavelength for the overall tool member **11** is exemplary. It is understood that either the tool holder or the tool member, or both, may have one or more integral number of acoustical half wavelengths. In particular, the possibility of using tool members longer than one-half wavelength may be desirable. There is no particular arrangement or number of tool members necessary for use at the output part **10A** of the tool holder.

Referring to FIG. **1A,** it will be observed that a symmetrical arrangement of four tool members is provided. Each tool member is rigidly secured to tool holder **10** by means of threaded steel stud **16.** It is important that stud **16** be of a sufficiently strong material and properly dimensioned to withstand the vibratory stresses. Stud **16** may be integral with a tool member, if the tool is of sufficiently strong metal, such as titanium. The stud will in all cases extend into tapped recesses or holes in bottom face **10A** of tool holder **10.**

While four tool members are shown, it is not necessary that all tool members be used or be positioned in the tool holder. In fact, there is nothing magic about the number of tool members and the number may be as desired. This is also true of the pattern in which the tool member accommodating recesses are disposed. While the number and spacing of tool member accommodating recesses in face **10A** of tool holder **10** may vary within wide limits, it is essential that the volume of metal removed from all the recesses be small enough in comparison to the mass of the entire tool holder so that the general transmission characteristics of tool holder **10** for conducting sonic energy from face **10B** to face **10A** be unimpaired. Thus, if an excessively large num ber of tapped recesses is to be provided, it may be nec essary to compensate a change in transmission charac teristics by adjusting the length of the tool holder or th transverse dimensions of the tool holder or both.

No attempt is made to show the detailed structure c tool member portion **14** at the tip thereof since suc details are well known, depending upon the work effec to be created. It should be noted that the various toc members extending downwardly from tool holder 1 are rigid members and that the entire assembly of toc holder and tool members together with the source c sonic energy, such as transducer, may be handled i conventional fashion by supporting in a press so tha one or more tool members have their working end pressed against the work piece to be treated. The actua support of the entire assembly of transducer, toc holder **10** and the tool members, may be on the trans ducer, or on tool holder **10** or both. If the tool holder i to be supported, then a supporting nodal mount aroun the middle of tool holder **10** can be provided. At thi region of the tool holder, the longitudinal amplitude c the sonic energy is substantially zero. The same is tru for transducers so that mounts for the nodal regions c transducers and tool holders may be joined.

Referring now to FIG. **2,** the tool member is substar tially similar to that illustrated in FIG. **1** except tha tools **11A'** are shown as being of greater transvers area than **11** and **11B.** Such an arrangement permit greater amplitude to be delivered at the working end c the tool member as may be required in certain ir stances.

Referring now to FIG. **3,** output face **10A** has slotte portion **10A'** for accommodating tool members **11A** s long as the offset of slotted portion **10A** with respect t **10A** is small in terms of wavelength (as for example i the assumed case a difference of about one-quarter c an inch may be tolerated), the rigid horn assembly wi function generally satisfactorily. Such an arrangemer may be desirable where material to be worked upon re quires a stepped arrangement of tool member workin faces. As is illustrated in FIG. **3A,** slotted portion **10A** extends straight across the end face of tool holder **10.** is not necessary that slot **10A'** extend all the way acros and instead only one of the face members **11A** may b thus longitudinally offset.

Referring now to FIG. **4,** a different arrangement c tool member attachment to tool holder **10'** is illu trated. In this instance, instead of tapped recesses in th tool holder, there may be a pattern of passages or hol longitudinally of the tool holder and generally paralle to the axis but laterally offset therefrom. Such passage have enlarged bore portions **20** having shoulders **2** and reduced bore portions **22** extending longitudinal of tool holder **10'.** Bolts **23** having enlarged heads **23.** can extend as illustrated with threaded portions **24** e tending into and cooperating with threaded recesses i tool member **26.** Tool member **26** may have a suitab workable shape. As shown here, enlarged head **23A** bolt **23** is provided with a suitably shaped hex recess f engagement by a hex shaped rod to be used as wrench. The diameters of bores **20** and **22** and should **21** are all relatively proportioned so that each to member retaining bolt will not be excessively stresse Again as with tapped recesses or holes in the to holder previously described, it is essential that the nun ber of passages or holes **20** and **22** in a tool holder b such that the transmission characteristics of the enti

ol holder remain constant. In this particular modifi-
ıtion, it is clear that the volume of metal removed for
ıch tool member position is much greater than in the
'evious instances where only a blind tapped recess is
ed. However, the compensation for the removal of
etal may be readily provided by controlling the lateral
ıd longitudinal dimensions of the tool holder. The ar-
ngement of bolts as illustrated here in FIG. **4** is such
at access to the top face **10B** of tool holder **10'** is re-
ıired. In some instances, the mounting of the rigid
ɔrn assembly, transducer accessories various accefo-
:s may make access difficult. It is understood, there-
ɔm, that while the two arrangements illustrated in
G. **4** and FIGS. **1** to **3** for example with regard to tool
ember attachment to a tool holder are equivalent,
ıe may for certain purposes be more convenient than
e other.

Referring to FIG. **4A**, it will be noted that tool mem-
:r **26** has the top portion of rectangular shape. Either
ıe or two bolts **23** may be used for each tool member,
:pending upon requirements for a particular job. The
rangement of tool members in this particular tool
ɔlder may vary so that more or less than two tool
embers are used.

Referring to FIG. **5**, a modified tool member arrange-
ent, each of which may have a tapered shape, is illus-
ated. In this particular modification, as illustrated in
G. **5A**, two lines of tool members at right angles to
ıch other are illustrated. It is not necessary that every
ol member position be filled with a tool member and
is not even necessary that each tool member be of the
pered type.

Referring now to FIG. **6**, an arrangement of recesses
a tool holder is shown wherein such recesses which
e tapped are aligned along lines which extend in vari-
ıs directions making possible a large number of possi-
e tool member arrangements. It is understood that
is particular arrangement of recesses or holes may be
placed by through passages or holes in a tool holder
milar to FIG. **4**.

Referring now to FIG. **7**, a tool holder is illustrated
herein tool members have their axes disposed at a
ight angle to the tool holder axis. Thus, two or more
ol members may be arranged in this fashion, it being
ıderstood that the various angles at the output faces
the tool holder must be small.

By having the tool member axes inclined to be non-
ırallel to the tool holder axis, the totality of all work
ea patterns may be made smaller or larger than the
ıtire work area of parallel tool member arrangements.
In FIG. **7**, the rigid horn tool members diverge. In
IG. **7A**, the tool members converge. In both cases, the
ɔposing tool holder and tool member surfaces must be
ıt and true. Where the entire tool holder face is coni-
ıl, it is necessary to machine flat areas against which
tool member may fit, as suggested in FIG. **7B**. The
ol members may be bolted, brazed or welded in
ace.

In FIG. **7A**, the convergence of the tool members tips
ay require machining after tool members have been
t in place on a tool holder. This may involve shaping
ıe tool member tips to straighten out the working axis
ɔrmal to the work.

Referring now to FIG. **8**, an arrangement is shown
herein two differently dimensioned tool members are
ilized, one tool member being thicker and longer
ıan the other. This arrangement can be obtained by
ɔntrolling the nature of the contour for the tool. It is
understood, of course, that in each case each tool must
have a length equal to one or more integral half wave-
lengths.

In a broad sense, a tool holder and tool member may
each be considered as a horn so that an entire assembly
may be designated as a rigid horn assembly.

An entire assembly of tool holder and tool member
horns embodying the present invention is substantially
rigid at the tool member ends even though resilient
nodal mounting means for tool holder and/or trans-
ducer means are provided. Resilient mounts are desir-
able because of their efficiency.

What is claimed is:

[**1.** An ultra-sonic tool system for industrial process-
ing with acoustic energy, said system comprising an
elongated, straight, rigid, unitary tool holder of rigid
material having a longitudinal axis and a length of an
integral number of half-wave lengths at the operating
frequency, the transverse dimensions being so propor-
tioned to the length thereof as to minimize undesired
modes of transmission other than along the tool holder
length, said tool holder having only two ends shaped to
provide finished flat sonic energy input and output ar-
eas, the tool holder providing a common transmission
path for all sonic energy from the input to the output
thereof, threaded means at the input end for coupling
at least one source of sonic energy thereto; at least two,
elongated, rigid tool members laterally spaced from
each other rigidly secured directly to a sonic output
area of the tool holder, each tool member having at one
end a sonic input area conforming to a sonic tool
holder output area in the secured positions of the tool
holder and tool members, each tool member having a
sonic energy working output tip at its other end, the
tool holder output area being great enough to accom-
modate a plurality of laterally offset, secured tool mem-
bers arranged to create a desired pattern of work areas,
each tool member having a length of an integral num-
ber of half-wave lengths; whereby said tool holder ma-
terial may be selected on a basis of acoustic properties,
cost, and ease of machining and the tool member mate-
rial may be selected on a basis of acoustic properties
and toughness for working life, said tool holder and
tool members being each resonant to the acoustic en-
ergy so that efficient transmissions of sonic energy to
the work areas result, each tool member being suscepti-
ble to individual design with regard to tool member
contours, amplitude of sonic energy at a work area and
physical length of a tool member; the machining prob-
lem of the tool holder being distinct from any problem
of machining a tool member, said tool system being suf-
ficiently rigid so that it may be pressed against work
without accessories for guiding tool members.]

[**2.** The construction according to claim **1** wherein
said tool holder has a plurality of holes extending from
at least one output area thereof inwardly toward the
input end thereof and wherein threaded means are pro-
vided for rigidly securing a tool member to said holder
at a desired hole.]

[**3.** The construction according to claim **2**, wherein
threaded metal studs for rigidly securing said tool mem-
bers to the output of said tool holder are provided.]

[**4.** The construction according to claim **2**, wherein
said tool holder has a plurality of longitudinal bores ex-
tending parallel to and laterally offset from the axis of
the tool holder, and a bolt for rigidly securing a tool
member to the tool holder at a bore.]

[5. The construction according to claim 1, wherein the tool holder is shaped so that the transverse dimensions remains substantially constant along the length of such holder.]

6. *An ultra-sonic tool system for industrial processing with acoustic energy, said system comprising an elongated, straight, rigid, unitary tool holder of rigid material having a longitudinal axis and a length of an intergral number of half-wave lengths at the operating frequency, the transverse dimensions being so proportioned to the length thereof as to minimize undesired modes of transmission other than along the tool holder length, said tool holder having only two ends shaped to provide finished flat sonic energy input and output areas, the tool holder providing a common transmission path for all sonic energy from the input to the output thereof, threaded means at the input end for coupling at least one source of sonic energy thereto; at least two, elongated, rigid tool members laterally spaced from each other each rigidly secured directly to a sonic output area of the tool holder, each tool member having at one end a sonic input area conforming to a sonic tool holder output area in the secured positions of the tool holder and tool members, each tool member having a sonic energy working output tip at its other end, the tool holder output area being great enough to accommodate a plurality of laterally offset secured tool members arranged to create a desired pattern of work areas, each tool member having a length of an integral number of half-wave lengths, said tool holder and tool members being each resonant to the acoustic energy so that efficient transmissions of sonic energy to the work areas result, each tool member being susceptible to individual design with regard to tool member contours, amplitude of sonic energy at a work area and physical length of a tool member, said tool system being sufficiently rigid so that it may be pressed against work without accessories for guiding tool members, at least one of said tool members having at least part of its length of a substantially different transverse dimension than corresponding parts of other tool members so that vibration amplitude differs from other tool members at the work areas.*

7. *An ultra-sonic tool system for industrial processing with acoustic energy, said system comprising an elongated, straight, rigid, unitary tool holder of rigid material having a longitudinal axis and a length of an integral number of half-wave lengths at the operating frequency, the transverse dimensions being so proportioned to the length thereof as to minimize undesired modes of transmission other than along the tool holder length, said tool holder having two ends shaped to provide finished flat sonic energy input and output areas, the tool holder providing a common transmission path for all sonic energy from the input to the output thereof, threaded means at the input end for coupling at least one source of sonic energy thereto; at least two, elongated, rigid tool members laterally spaced from each other rigidly secured directly to sonic output areas of the tool holder, each tool member having at one end a sonic input area conforming to a sonic tool holder output area in the secured positions of the tool holder and tool members, each tool member having a sonic energy working output tip at its other end, the tool holder output area being great enough to accommodate a plurality of laterally offset secured tool members arranged to create a desired pattern of work areas, each tool member having a length of an integral number of half-wave lengthss, said tool holder and tool members being each resonant to the acoustic energy so that efficient transmissions of sonic energy to the work areas result, each tool member being susceptible to individual design with regard to tool member contours, amplitude of sonic energy at a work area and physical length of a tool member, said tool system being sufficiently rigid so that it may be pressed against work without accessories for guiding tool members, at least one of said tool members having its working end at a level different from that of other tool members.*

8. *The system according to claim 7, wherein said tool holder has a portion of its output face at a level different from other portions so that even if similarly dimensioned tool members are used, the working ends of such tool members are at different levels, the difference in level at the output of the tool holder being small in comparison to the operating wavelength.*

9. *An ultra-sonic tool system for industrial processing with acoustic energy, said system comprising an elongated, straight, rigid, unitary tool holder of rigid material having a longitudinal axis and a length of an integral number of half-wave lengths at the operating frequency the transverse dimensions being so proportioned to the length thereof as to minimize undesired modes of transmission other than along the tool holder length, said tool holder having two ends shaped to provide finished flat sonic energy input and output areas, the tool holder providing a common transmission path for all sonic energy from the input to the output thereof, threaded means at the input end for coupling at least one source of sonic energy thereto; at least two, elongated, rigid tool members laterally spaced from each other rigidly secured directly to a sonic output area of the tool holder, each tool member having at one end a sonic input area conforming to a sonic tool holder output area in the secured positions of the tool holder and tool members, each tool member having a sonic energy working output tip at its other end, the tool holder output area being great enough to accommodate a plurality of laterally offset, secured tool members arranged to create a desired pattern of work areas, each tool member having a length of an integral number of half-wave lengths, said tool holder and tool members being each resonant to the acoustic energy so that efficient transmissions of sonic energy to the work areas result, each tool member being susceptible to individual design with regard to tool member contours, amplitude of sonic energy at a work area and physical length of a tool member, said tool system being sufficiently rigid so that it may be pressed against work without accessories for guiding tool members, at least two sonic flat output area portions of the tool holder lying in different non-parallel planes so that secured tool members have their respective lengths in non-parallel relation, the angular departure from parallelism being small.*

10. *The system according to claim 9, wherein the tool members converge.*

11. *The system according to claim 9, wherein the tool members diverge.*

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