Feb. 10, 1970 P. A. BURGO ET AL 3,495,104

ULTRASONIC TRANSDUCER

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FIG. 1

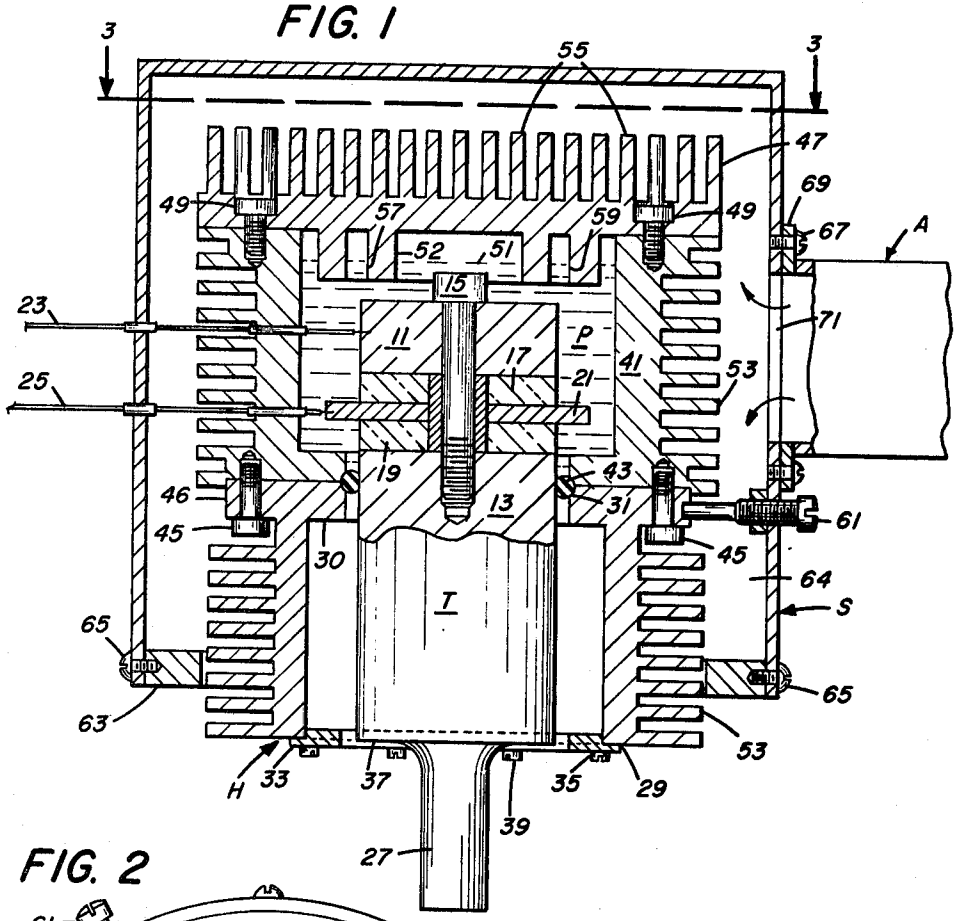
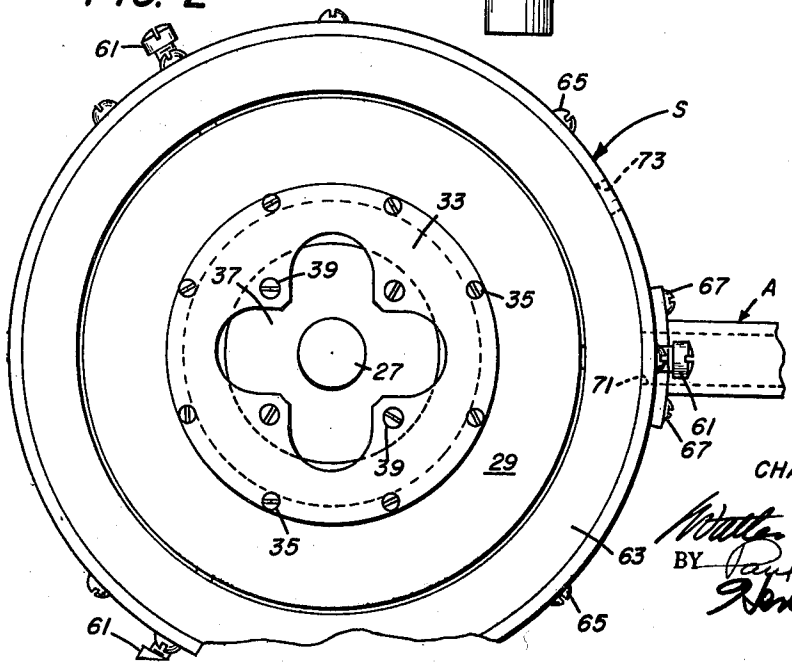


FIG. 2



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FIG. 3

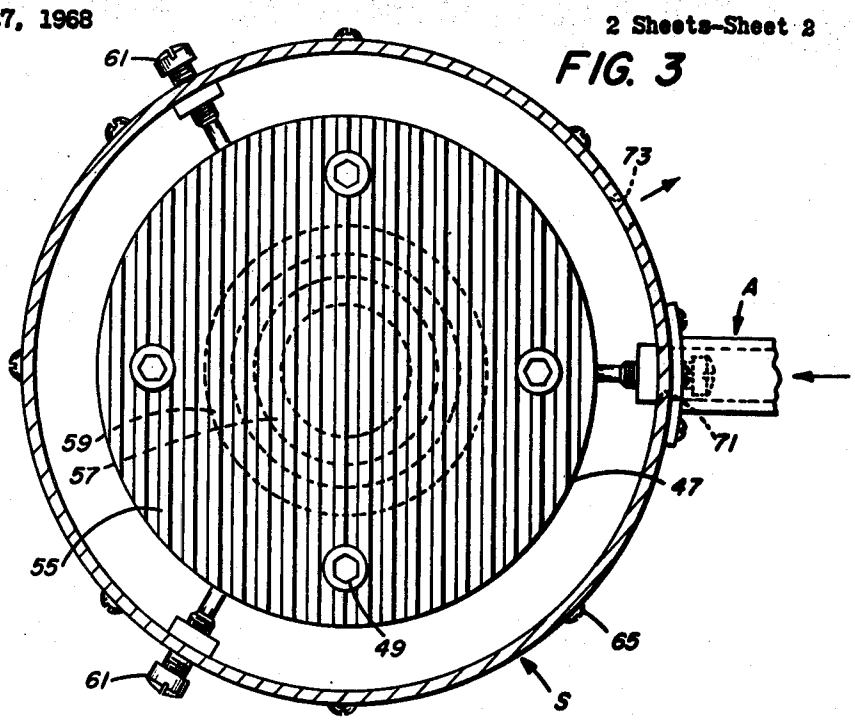
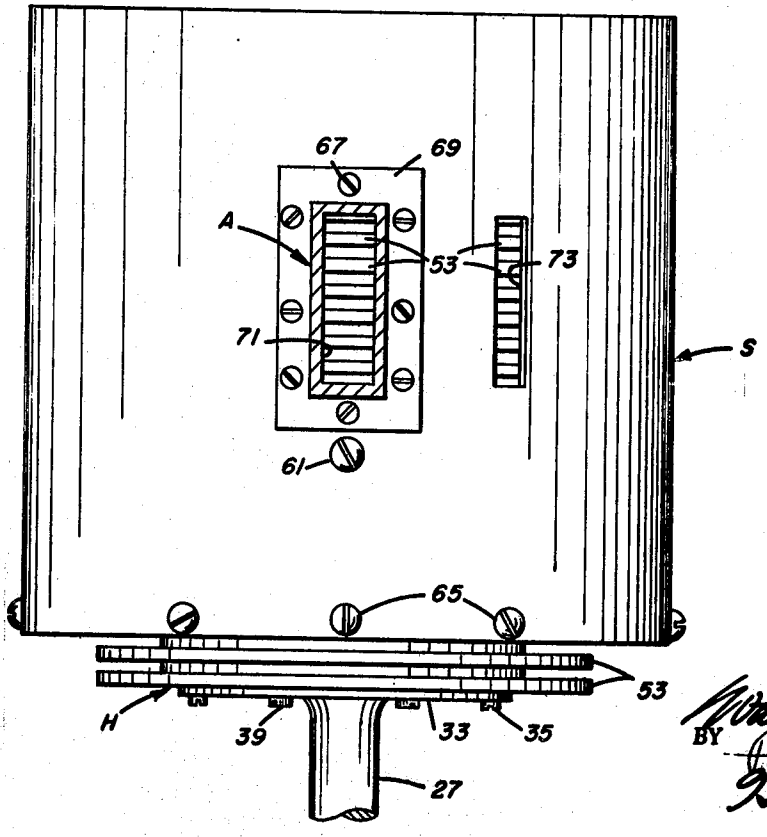


FIG. 4



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ULTRASONIC TRANSDUCER

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U.S. Cl. 310—9.1

14 Claims

ABSTRACT OF THE DISCLOSURE

An ultrasonic transducer which can be operated at a high frequency and high power input without overheating. Heat is conducted from the vibration generator, such as piezoelectric crystals or a magnetostrictive device, through a pool of heat conductive liquid to a housing having external projections of great surface area for dissipating heat.

An O-ring prevents leakage of liquid between the transducer and housing.

Cooling is further improved by surrounding the housing with a shroud, and blowing air through the space between the shroud and housing.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to a novel ultrasonic transducer construction having improved means for cooling the vibration generator.

Description of the prior art

Ultrasonic transducers wherein vibrations are produced electromechanically by energizing one or more piezoelectric crystals, or a magnetostrictive device, are well known. Such transducers have been used for actuating tools for drilling holes, welding together plastic sheets, and welding together the parts of thermoplastic devices.

Heat is generated within the transducer when the crystals or magnetostrictive elements are energized to produce the vibrations, and it is essential that this heat be dissipated so as to prevent the temperature from rising too high.

In the prior art, ultrasonic transducers have been cooled by air, either by static exposure of the external surfaces to the ambient air, or by blowing a stream of air over the external surfaces. In some instances such ultrasonic devices have been provided with external fins to enlarge the heat dissipating surface.

We have found that simple air cooling is not adequate for operating a transducer at a substantial power input for an extended period of time. For example, when operating a piezoelectric transducer at a frequency of about 40 kHz. with 150 watts input, the temperature rise exceeded 130° F. when operating continuously. It is apparent, therefore, that there was a need for an improved construction for overcoming this problem.

SUMMARY OF THE INVENTION

In accordance with the present invention, we have provided a novel ultarsonic transducer construction whereby a transducer operating at a frequency of 40 kHz. with a 150 watt input can be operated continuously for as long as 600 hours without the temperature exceeding 130° F. at the step of the horn.

Our novel ultrasonic transducer T comprises, in combination, a piezoelectric or magnetostrictive mechanism for electromechanically generating vibrations, which concurrently generates heat; a tool or horn coupled to the vibration generator and adapted to be vibrated thereby; a housing H surrounding the vibration generator and at least part of the tool; sealing means encircling the tool and engaging both the tool and the internal wall of the housing to prevent the passage of cooling fluid, while permitting vibration of the tool relative to the housing; and a pool P of heat-conductive liquid within the housing surrounding and in heat-conductive contact with the vibration generator for conducting generated heat to the housing.

The heat is thus conducted through the metal wall of the housing and is dissipated to the ambient atmosphere. Best results are obtained by surrounding the housing H with a shroud S and blowing air into and through the shroud in contact with the external wall of the housing H to conduct heat rapidly away. Advantageously, the external wall of the housing H is provided with a plurality of lateral projections providing a great surface area for the dissipation of heat.

The principles of the invention will be described more in detail below with reference to the accompanying drawings wherein:

FIG. 1 is a vertical sectional view through an ultrasonic transducer embodying the principles of the invention;

FIG. 2 is a bottom view of the transducer of FIG. 1;

FIG. 3 is a cross-sectional view of the transducer of FIG. 1 taken along the line 3—3; and

FIG. 4 is a side elevational view of the transducer of FIG. 1 as seen from the right.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the ultrasonic transducer T comprises a cylindrical assembly wherein a back body **11** and a front body **13** are connected together by a centrally-located bolt **15**, with a pair of piezoelectric crystals **17** and **19**, and an electrically conductive spacer **21** sandwiched between. Electrical conductors **23** and **25** are connected to the back body **11** and the spacer **21**, respectively, so as to energize the piezoelectric crystals to cause them to vibrate.

When so energized, the vibrations are generated as a sine wave within the transducer and cause a tool or horn portion **27** of the transducer, which has substantially smaller diameter than the front body **13**, to vibrate in an amplified manner so as to impart the vibrations of its end surface to the work (such as overlapping thermoplastic sheets which are to be united).

The housing H enclosing the transducer T comprises a first sleeve **29** surrounding the front body **13** in spaced relation thereto and having an inturned annular flange **30** with half of an annular groove **31** in the upper interal surface thereof for receiving an O-ring. Sleeve **29** is connected to the transducer T by means of a transversely extending perforated mounting plate **33** secured to the bottom of sleeve **29** by a series of peripherally located screws **35**, and also connected to the step **37** of the front body **13** by a second series of peripherally located screws **39**. It is most advantageous for the step **37** to be at a node of the since wave so as to minimize transmission of vibrations from transducer T into housing H.

A second sleeve **41** surrounds the vibration generating devices **17** and **19** and the back body **11** in spaced relation thereto so as to provide annular space for the pool of heat transmitting liquid P. The lower internal corner is provided with the second half of the annular groove **31** which mates with the first half groove as described above and forms therewith a full annular groove, within which is positioned an O-ring **43** of rubber or other resilient material which encircles the tool and engages its surface to prevent the passage of liquid from the pool

P while permitting vibration of the tool relative to the housing H. Sleeves **29** and **41** are secured together by a series of peripherally located bolts **45** passing through bores in an external flange **46** of the sleeve **29**, and into mating bores in the sleeve **41**.

The housing H is completed by a cap **47** which rests upon and engages the top end of sleeve **41** and is secured thereto by a series of peripherally arranged bolts **49** which pass through bores in the cap and are threaded into the sleeve.

The space within sleeve **41** is provided with a pool P of heat conductive dielectric liquid such as mineral oil, or other heat stable liquid such as Dow Chemical Company's Dowtherm liquid diphenyl. Even water, preferably distilled, can be used when the temperature rise is not enough to boil the water. This pool extends above the top of the back body **11** to an upper surface or level **51** which is spaced a short distance below the internal surface of cap **47** so as to provide outage space for expansion of the liquid when heated, and also for the accumulation of any foam which is generated by vibrations of the transducer.

The efficiency of heat conduction from the transducer T through the pool of liquid P and the housing H to the ambient atmosphere is improved by providing the sleeves **29** and **41** with external laterally projecting annular fins **53**, by providing the cap **47** with external transverse parallel straight fins **55**, and by providing the inner surface of the cap **47** with a plurality of annular flanges **57** and **59** which project from the bottom of the cap down through the space **52** and into the liquid P.

While the foregoing construction provides excellent cooling and dissipation of the heat to the ambient atmosphere, the efficiency of cooling is still further improved by surrounding the housing H with a shroud S in the form of an inverted cup which fits over the housing and is spaced therefrom on both sides and the top. Shroud S is retained in position by a series of lateral set screws **61** which are mounted on the side walls of the shroud and bear against the outer surface of the sleeve **29**, with their inner ends being positioned within shallow bores to prevent longitudinal movement of the shroud. The open lower end of the shroud is essentially closed by an annular internally projecting flange **63** which is mounted on the shroud by a series of screws **65**. This construction makes it possible to apply the shroud S over the top of the housing H, mount it in position with the set screws **61**, and then apply the flange **63**.

Cooling air is blown into the cooling chamber **64** formed by the housing H and the shroud S by means of any air supply conduit A which is mounted on the side of the shroud by screws **67** extending through a flange **69**, and in register with an aperture **71**. Air circulates within the shroud and is discharged through a second aperture **73** in the side wall of the shroud as shown more clearly in FIG. 4.

For energizing the piezoelectric crystals **17** and **19**, an alternating electrical current of high frequency, such as 40 kHz. is supplied by a pair of conductors **23** and **25** through feed-through insulators in the side walls of the shroud S and the housing H, which provide seals against the leakage of liquid or gas from the apparatus.

The device described above is constructed of suitable heat-conducting metal (except for the crystals **17** and **19**). Among suitable metals are aluminum, copper, brass, titanium, stainless steel, and Monel metal. Some parts can be constructed of one metal and some of another.

When operating the apparatus described above, the shroud S normally is clamped in a suitable holding device and then the apparatus is transported across the work to be treated, with the end of the horn **27** in contact therewith, so as to weld the parts together. Or the apparatus can be held stationary while the work to be welded is transported transversely in contact with the horn. The apparatus may also be held stationary while the work to be welded is held stationary.

Housing H, with or without shroud S, constitute novel subcombinations of our invention which are so constructed and arranged as to receive replacement transducers T. Such replacement may be necessary for repairs or when a horn **27** of different configuration is required.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected with the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

We claim:

1. An ultrasonic transducer comprising, in combination,

first means for electromechanically generating vibrations, and concurrently generating heat;

a tool coupled to said first means and adapted to be vibrated thereby;

a housing surrounding said first means and at least part of said tool, said housing having an internal wall spaced from said first means and said part of said tool, and also having an external wall for dissipating heat from said housing;

sealing means encircling said tool and engaging both said tool and said inernal wall, to prevent fluid passage while permitting vibration of said tool relative to said housing;

and a pool of heat-conductive liquid in said housing surrounding, and in heat conductive contact with, said first means for conducting generated heat from said first means to said housing.

2. An ultrasonic transducer in accordance with claim **1**, also comprising

second means for bringing cooling fluid into heat exchange relation with said external wall.

3. An ultrasonic transducer in accordance with claim **2**, wherein said second means comprises a shroud surrounding said housing in spaced relation thereto; and means for forcing cooling fluid though said shroud.

4. An ultrasonic transducer in accordance with claim **1** wherein said external wall comprises a plurality of projections providing great surface area for the dissipation of heat.

5. An ultrasonic transducer in accordance with claim **1**, also comprising mounting means connecting said housing to said tool at a nodal point of said tool.

6. An ultrasonic transducer in accordance with claim **1** wherein said sealing means is an O-ring, and wherein said internal wall has an annular recess carrying said O-ring.

7. An ultrasonic transducer in accordance with claim **1** wherein said pool of heat-conductive liquid has a top surface spaced from said internal wall to provide a space for expansion of liquid and for accumulation of foam.

8. An ultrasonic transducer in accordance with claim **7**, also comprising heat-conductive means projecting from said internal wall through said space into said pool of liquid.

9. An ultrasonic transducer in accordance with claim **1**, also comprising electrical conductor means leading from said first means through said pool and through said housing to the outside thereof; and

sealing means between said electrical conductor means and said housing for preventing the leakage of liquid from said pool.

10. An ultrasonic transducer in accordance with claim **1**:

(A) wherein said housing comprises

a first sleeve surrounding a portion of said tool remote from said first means, said first sleeve

having therein half of an annular groove for receiving an O-ring;

a second sleeve surrounding said first means and having a first end engaging the end of said first sleeve nearest said first means, said second sleeve having therein half of an annular groove mating with said first named half groove, and forming therewith a full annular groove for receiving an O-ring; and

a cap engaging the end of said second sleeve opposite said first end;

said first sleeve, second sleeve, and cap all having external projections for dissipating heat;

(B) wherein said sealing means is an O-ring carried in said groove;

(C) wherein said pool of heat-conductive liquid has a top surface spaced from said cap to provide space for expansion of liquid and for accumulation of foam;

(D) wherein said cap has heat-conductive means projecting from the internal surface thereof into said pool of liquid; and

(E) wherein said transducer also comprises mounting means connecting said first sleeve to said tool at a nodal point thereof.

11. A heat dissipating device for use with an ultrasonic transducer comprising

a hollow housing adapted to receive such a transducer, said housing having first and second ends, said first end being closed, the major portion of said housing having a relatively large internal diameter, the internal wall of said housing having a flange of smaller

diameter between said first and second ends thereof; and

annular sealing means carried by said flange adapted to engage the external wall of said transducer sealingly to provide a chamber for fluid between said flange and said closed first end.

12. A heat dissipating device in accordance with claim **11**, also comprising a shroud surrounding and mounted on said housing in spaced relation thereto; and

means for forcing cooling fluid through said shroud.

13. A heat dissipating device in accordance with claim **11**, also comprising mounting means carried by said housing adjacent said second end, adapted to be secured to such a transducer.

14. A heat dissipating device in accordance with claim **12**, also comprising a plurality of heat dissipating projections providing great surface area for the dissipation of heat.

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310—8.1, 8.3 ,26