Sept. 6, 1955 F. P. BUNDY 2,717,319

METHOD AND APPARATUS FOR COOLING TRANSDUCERS

Filed May 27, 1954

Fig. 1.

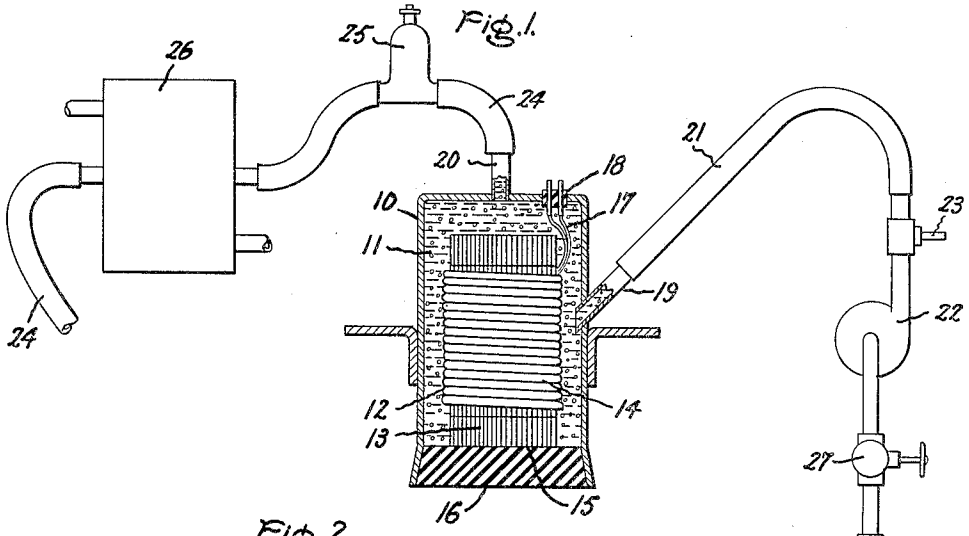


Fig. 2.

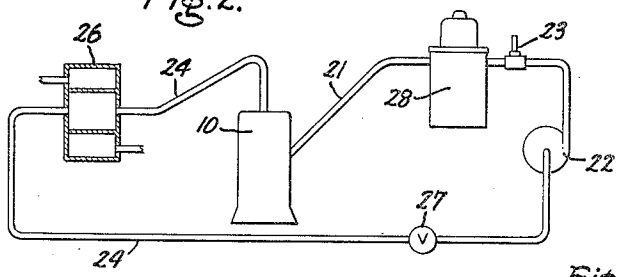


Fig. 3.

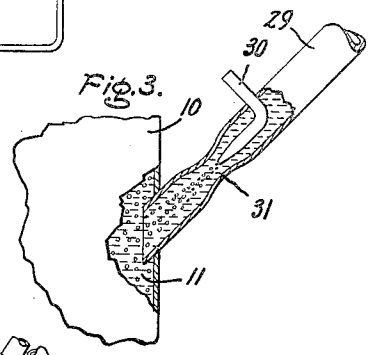
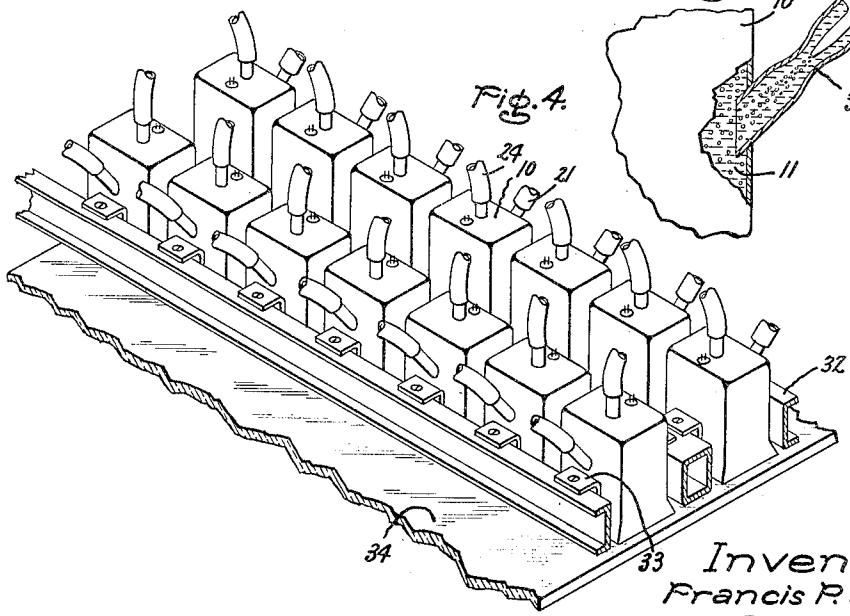


Fig. 4.



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METHOD AND APPARATUS FOR COOLING TRANSDUCERS

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11 Claims. (Cl. 310—16)

This invention relates to transducers and specifically to a method and apparatus for cooling continuously operative high-power transducers.

High-power transducers, which are capable of continuous operation for a prolonged period of time, are desirable in such operations as the cleaning of plate glass and the tinning of aluminum. No serious cooling problem is encountered in low-power transducers nor in transducers to which high power is applied in short pulses with relatively long cooling periods between pulses. Under such operating conditions, layers or pads of cushioning material are cemented to the non-radiating surfaces of the transducer element. However, such materials are inherently good thermal insulators in that they impede the flow of heat from the transducer element. Conventional cushioning pads are unsuitable in those situations in which it is desirable to constantly operate a high-power transducer for a prolonged period.

Accordingly, it is an object of my invention to provide an improved high-power transducer structure in which a fluid coolant is employed.

It is another object of the invention to provide an improved high-power transducer structure in which a fluid coolant directly contacts the transducer element.

It is another object of the invention to provide an improved high-power transducer structure in which an acoustic cushioning fluid is the cooling medium.

It is a further object of the invention to provide a novel method of continuously cooling a continuously operative high-power transducer.

In carrying out my invention in one form, an aerated acoustic cushioning fluid is circulated in direct thermal contact with a transducer element to provide the cooling medium therefor.

These and various other objects, features and advantages of the invention will be better understood from the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a sectional view of an embodiment of my invention as applied to an individual transducer structure in which a fluid coolant is employed;

Fig. 2 is a diagrammatic view of a transducer structure with a modified fluid cooling system;

Fig. 3 is a partial sectional view of a transducer structure with a further modified fluid cooling system; and

Fig. 4 is a perspective view of a series of transducers such as those shown in Fig. 1 which are mounted in a staggered array for cleaning an extensive surface of glass.

Fig. 1 of the drawing discloses an individual transducer structure which comprises a liquid-tight housing **10** to define a chamber **11** wherein a transducer element **12** is mounted. The housing may also be of any suitable construction which will provide a fluid passage adjacent the element **12**. The transducer element **12** consists of a core **13** of a laminated magnetostrictive material which has windings **14** thereon. An active

vibrating face **15** of the core **13** is firmly bonded to a resilient face **16** to transmit compressional waves from the core **13** to a workpiece (not shown) outside the housing **10**. The face **16**, which may be composed of a suitable material, such as, for example, rubber or plastic will provide the bottom wall for this housing. A pair of wires **17** connect the windings **14** to an A. C. power source (not shown) through a sealed wire terminal **18** in the top wall of the housing **10**.

A cooling fluid inlet **19** and a fluid outlet **20** are provided in the side and top walls of the housing **10**, respectively. An inlet tube or circulation line **21** is connected to the fluid inlet **19** to circulate a cooling fluid from a centrifugal pump **22** to the interior of the chamber **11**. An inert gas, such as, for example, air is admitted to the fluid through a nozzle **23** from a gas source (not shown) for reasons to be described hereinbelow. An outlet tube or circulation line **24**, which has a gas vent **25** therein, is connected to the outlet **20** to remove the cooling fluid from the chamber **11**. A heat exchanger **26** is provided in the line **24** to remove the excess heat from the cooling fluid which heat may be transferred to a secondary fluid medium. If it is desired, the tube **24** may be connected to the pump **22** to form a circulatory passage for the cooling fluid. A valve **27** may also be provided in the line **24** to regulate the flow of the fluid to the pump **22**.

The cooling fluid is provided with a stable suspension of small inert gas bubbles to impart an acoustic cushioning property thereto thereby eliminating the conventional heat-insulating, cushioning pads which surround the non-radiating surfaces of the transducer element. The cooling fluid should be an electric non-conducting, non-corroding, non-damping and chemically stable liquid. Satisfactory materials, which fulfill these requirements, are transformer oils, and liquid dielectrics, such as, for example, pyranol.

In operation, the cooling fluid is circulated by the centrifugal pump **22** through the tube **21** and the inlet **19** into direct thermal contact with the transducer element **12** within the chamber **11**. The gas nozzle **23** provides a stable suspension of gas bubbles for the cooling fluid. After the fluid absorbs the heat from the transducer element, it passes through the outlet **20**, tube **24**, heat exchanger **26**, and regulating valve **27** to the inlet side of the pump **22**. The excess heat of the fluid is removed by the heat exchanger **26** while gas is permitted to escape through the vent **25**.

Fig. 2 discloses a modified cooling system for a transducer structure which employs a mechanical fluid agitator **28** to churn the cooling fluid. The agitation of the cooling fluid whips the gas, which is admitted through the nozzle **23** in the line **21**, into the cooling fluid in the form of a stable suspension of gas bubbles.

Fig. 3 discloses a further modified form of fluid cooling system for a transducer structure wherein the cooling fluid is circulated to the chamber **11** of the housing **10** through an inlet tube **29**. The inlet tube **29** is connected to the pump **22** in a similar manner to the tube **21** which is disclosed in Fig. 1. A gas injection jet **30** with a reversed L-shape is provided in the tube **29** to admit gas bubbles to the cooling fluid. The tube **29** is provided with a venturi **31** near the exit of the jet **30** to promote a stable gas suspension. The air injection jet **30** may also be used to circulate the cooling fluid thereby eliminating the pump **22**.

Fig. 4 shows a plurality of transducers of the type described above with reference to Fig. 1 which are mounted in a staggered array for cleaning extensive surfaces, such as, for example, plate glass or metal. The housings **10** are arranged in two staggered longitudinal rows between supporting beams **32** which may form

part of a frame member (not shown). Each housing **10** is mounted to its adjacent supporting beams **32** by means of angle brackets **33** which are suitably secured to both the housing and the support, such as, for example, by welding or by screws. The fluid inlet tubes **21** and outlet tubes **24** of the housing **10** may be connected to inlet and outlet manifolds, respectively.

A sheet of glass **34** which has a film of water thereon is passed underneath the resilient faces **16** of the housings **10**. The film of water, which is in contact with outer surfaces of the faces **16**, transmits vibrations from these faces to clean the glass surface. A plurality of rows of transducer structures may be provided rather than the two rows shown in Fig. 4.

As it will be apparent to those skilled in the art, the objects of my invention are attained by the use of an aerated, electric non-conducting and non-damping cooling fluid which is circulated in direct thermal contact with a transducer element.

While other modifications of this invention and variations of apparatus which may be employed within the scope of the invention have not been described, the invention is intended to include all such as may be embraced within the following claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for cooling a transducer having a transducer element, which comprises a housing to surround said element, and means for circulating an aerated acoustic cushioning fluid in said housing in direct thermal contact with said element.

2. Apparatus for cooling a transducer having a transducer element, which comprises a housing to surround said element, and an aerated acoustic cushioning fluid in said housing in direct thermal contact with said element.

3. Apparatus for cooling a transducer having a transducer element, which comprises a housing to surround said element, an aerated cushioning fluid in said housing in direct thermal contact with said element, and means to circulate said fluid.

4. A transducer comprising a housing defining a chamber, at least one transducer element within said housing, an electric non-conducting and non-damping cooling fluid within said chamber, means to aerate said fluid, and means to circulate said fluid through said chamber in direct thermal contact with said element.

5. A transducer comprising a housing defining a chamber, a transducer element within said housing, an electric non-conducting and non-damping cooling fluid within said chamber, and means to aerate and circulate said fluid through said chamber in direct thermal contact with said element.

6. A transducer comprising a housing defining a chamber, a transducer element arranged within said housing, inlet means to provide a passage to the interior of said chamber, outlet means to provide a passage from said chamber, and means for circulating an electric non-conducting and non-damping aerated cooling fluid through said inlet tube, said chamber in direct thermal contact with said elements, and said outlet tube.

7. A transducer comprising a housing defining a chamber, a transducer element arranged within said housing, an inlet tube to provide a passage to the interior of said chamber, an outlet tube to provide a passage from said chamber, an electric non-conducting and non-damping cooling fluid in said chamber in direct thermal contact with said element, said fluid having a stable suspension of inert gas bubbles therein, and means for circulating said fluid through said inlet tube, chamber and outlet tube.

8. The method of cooling a transducer having a transducer element which comprises aerating an electric non-conducting and non-damping fluid, and circulating said fluid in direct thermal contact with said transducer element.

9. The method of cooling a transducer having a transducer element which comprises agitating an electric non-conducting and non-damping fluid, incorporating a stable suspension of inert gas bubbles therein, and circulating said fluid in direct thermal contact with said transducer element.

10. The method of cooling a transducer having a transducer element and a housing which comprises aerating an electric non-conducting and non-damping fluid, and circulating said fluid through said housing in direct thermal contact with said transducer element.

11. The method of cooling a transducer having a transducer element and a housing which comprises agitating an electric non-conducting and non-damping fluid, incorporating a stable suspension of inert gas bubbles therein, and circulating said fluid through said housing in direct thermal contact with said transducer element.

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