Invented by
Donald R. Culp
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Witnessed and understood
Walter G. Finch
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MEANS FOR IMPROVING TRANSDUCER PERFORMANCE BY USING A MODIFIED TAIL MASS

PURPOSE

The purpose of this design is to improve the performance of a sonic/ultrasonic transducer by using a modified tail mass that properly distributes the static clamp pressure across the ceramics.

CURRENT ART

A typical transducer design is shown in figure 1. The transducer is designed to resonate parallel to its axis at ultrasonic frequencies, typically between 10 kHz and 100 kHz, although lower or higher frequencies are possible. The ceramics (whose number and location may vary, depending on the transducer design) are clamped between a tail mass and a head mass by a stack bolt. The stack bolt applies a static compressive pressure to the ceramics. This static compressive pressure keeps the ceramics from breaking when the transducer vibrates. The head mass and tail mass may have different shapes, depending on the design requirements. For simplicity, these are shown as cylinders of constant outside diameter.

One of the problems of this design is that the static pressure distribution across the ceramics is very nonuniform. One cause of this problem is that the head of the stack bolt has a small diameter compared to the ceramics. When the stack bolt is tightened, most is the static compressive pressure is applied at the inside diameter of the ceramics, while relatively little pressure is available at the outside diameter of the ceramics. (See figure 2, where the results were determined by finite element analysis.)

When the ceramic pressure distribution is not uniform, the ceramics are not properly supported. This can cause problems when the transducer vibrates. The power loss may increase, especially if there are any flexural vibrations that excite the transducer. (Such flexural vibrations are often caused by a poorly designed horn.) Also, the ceramics may slip or break.

DESCRIPTION OF IMPROVED TRANSDUCER DESIGN

The above problem can be corrected by redesigning the tail mass so that the bolt load is more evenly applied to the ceramics. Figure 3 shows one possible arrangement. In figure 3, the tail mass has been divided into two pieces: tail mass washer #1 and tail mass washer #2. A flange exists between the two washers. The purpose of the flange is to apply the pressure from the stack bolt to the middle of washer #2, and thence to the center of the ceramic interface area.

In figure 3, the position and dimensions of the flange are approximate. The thickness of the flange has been exaggerated.

Advantages

The improved pressure distribution across the tail mass/ceramic interface is shown in figure 2. This should reduce the power loss and improve the transducer performance when flexure is present.

Ramifications

In figure 3, the stack bolt shoulder is shown flush with the back of washer #1. If necessary, the head could be recessed into a counterbore in washer #1. Other shapes for the washers are possible.

The stack bolt could be replaced by a stud which is threaded at both ends. Then tail mass washer #1 could have an internal thread that would engage the stud (i.e., tail mass washer #1 would act like a nut).

The two tail mass washers could be machined as a single unit, although this would probably be more difficult than making them as separate units. However, a single unit might be advantageous, since it would reduce the number of transducer pieces by one and prevent galling or other problems at the interface between the washers.

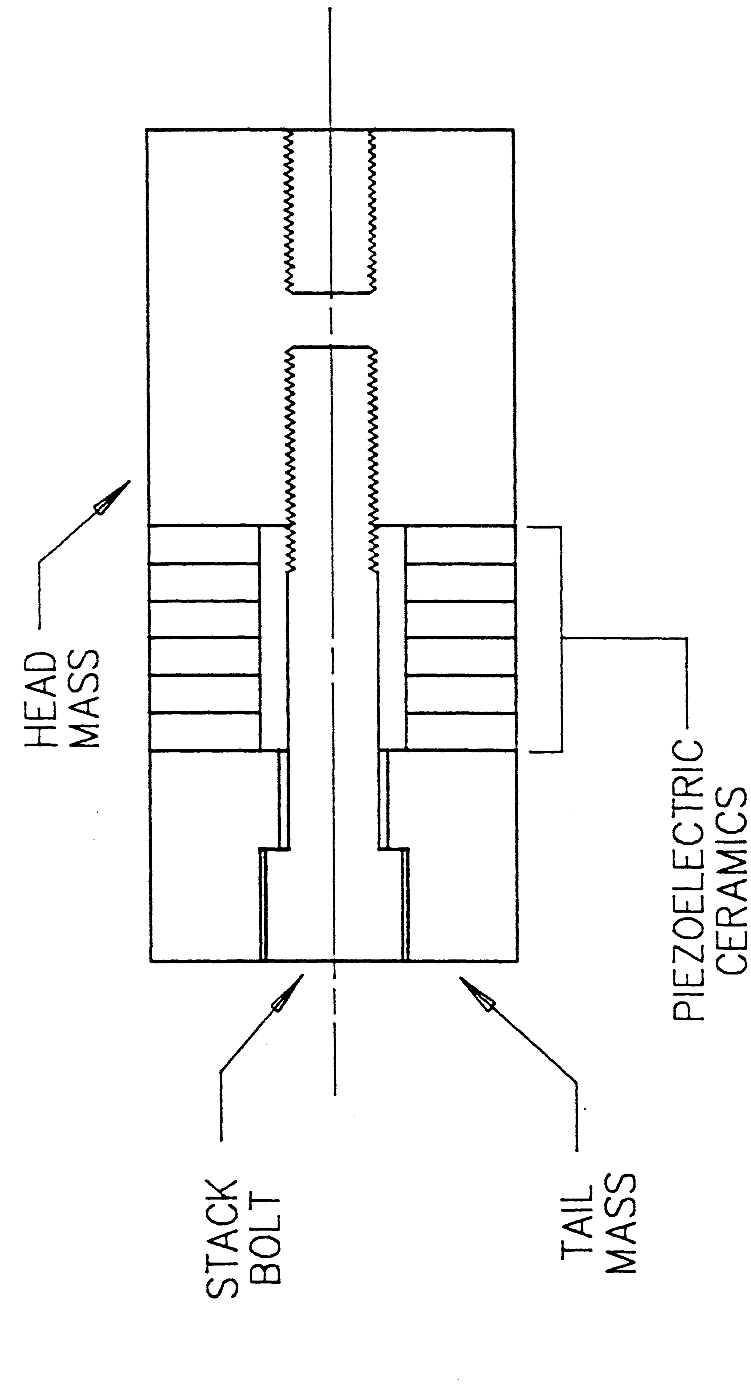
The flange of washer #1 could, instead, be part of washer #2, or it could be an independent piece.

The stack bolt and washer #1 could be combined into a single unit (i.e., a stack bolt with an over-large head). This design might have several disadvantages:

1. Because the head of the stack bolt would only make contact far from the shank of the stack bolt, this design would apply a large bending moment to the head of the stack bolt. This might cause failure at the junction between the bolt head and the bolt shank.

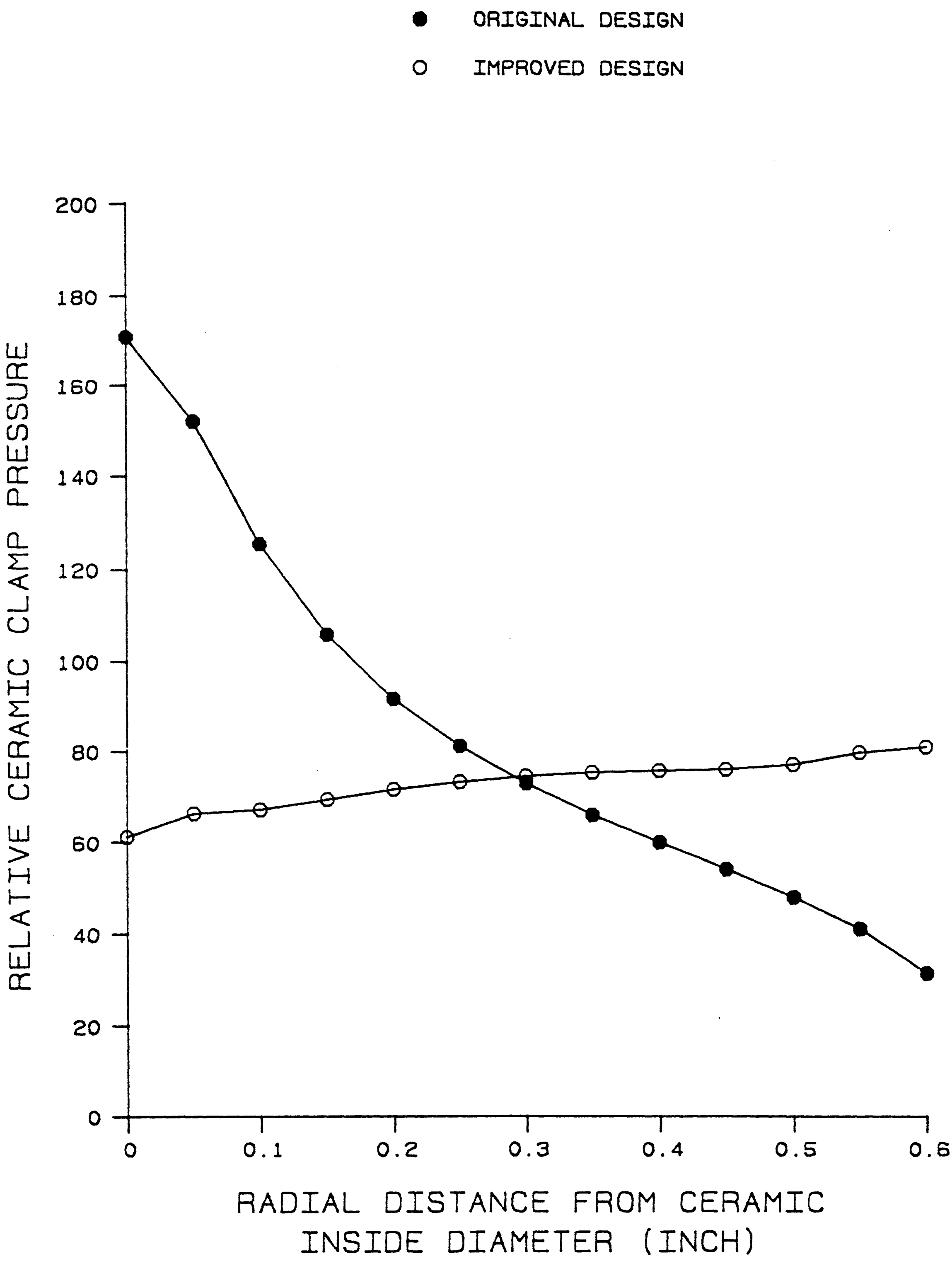
2. Depending on the transducer dimensions, this might require a specially manufactured stack bolt in order to achieve the required head configuration.

CONVENTIONAL DESIGN



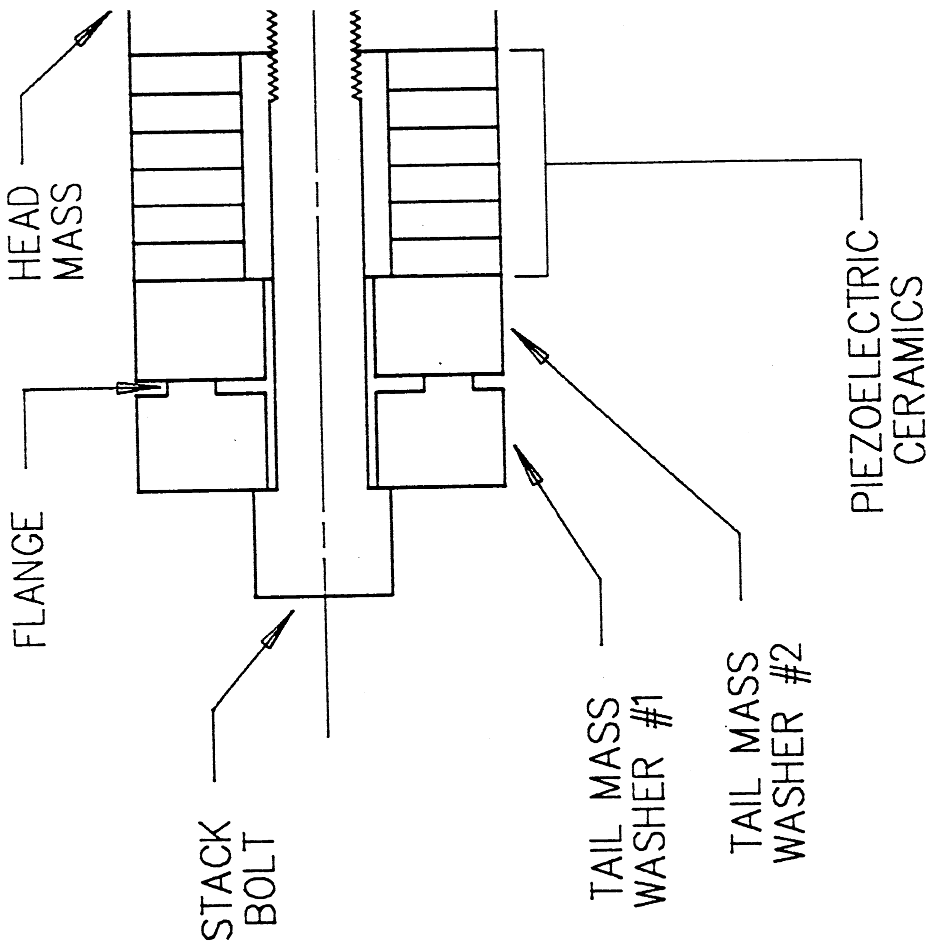
TYPICAL TRANSDUCER DESIGN
USING SINGLE TAIL MASS ELEMENT

Figure 1



STATIC PRESSURE DISTRIBUTION
ACROSS TRANSDUCER CERAMICS
AT TAIL-MASS/CERAMIC INTERFACE

Figure 2



IMPROVED TRANSDUCER DESIGN
USING MULTIPLE TAIL MASS ELEMENTS

Figure 3