

Nov. 14, 1967

J. DORY

3,352,376

STACK OF FOILS USED AS AN ACOUSTIC RELAY

Filed June 28, 1965

2 Sheets-Sheet 1

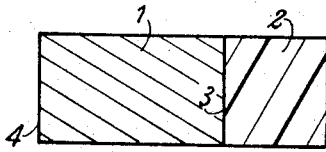


Fig. 1

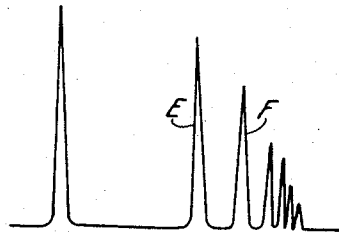


Fig. 2

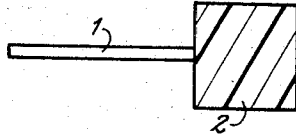


Fig. 3

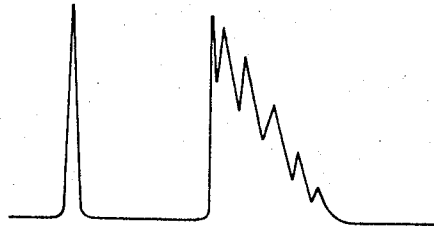


Fig. 4

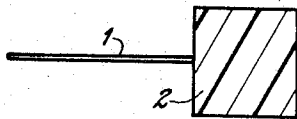


Fig. 5

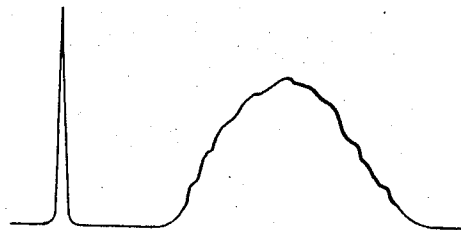


Fig. 6

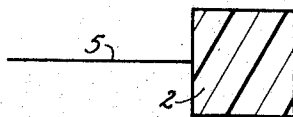


Fig. 7

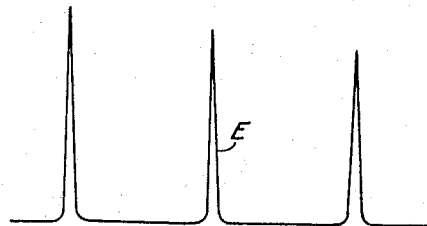


Fig. 8

Inventor
Jacques Dory
By *Cushman, Darby & Cushman*
Attorneys

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J. DORY

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2 Sheets-Sheet 2

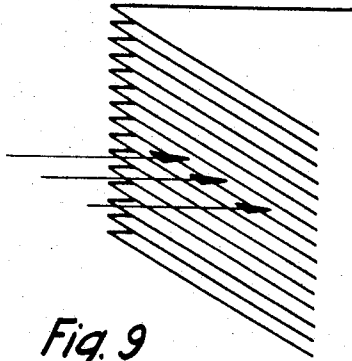


Fig. 9

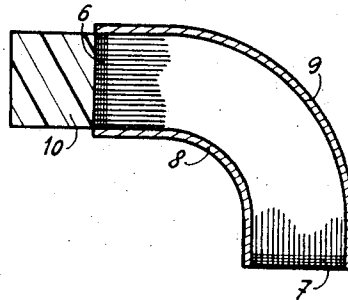


Fig. 10

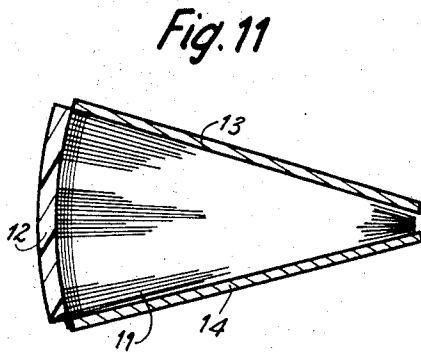


Fig. 11

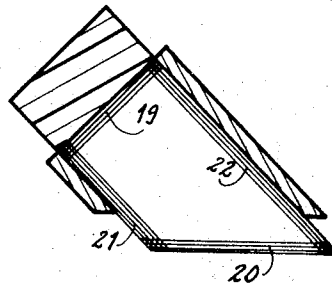


Fig. 12

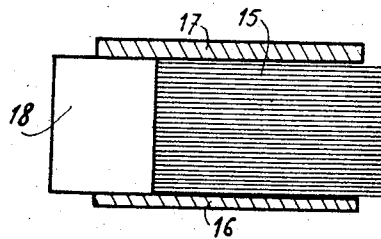


Fig. 13

By *Jacques Dory* Inventor
Cushman, Darby & Cushman Attorneys

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STACK OF FOILS USED AS AN
ACOUSTIC RELAYJacques Dory, Paris, France, assignor to Corporation
Realisations Ultrasoniques

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980,446, Patent 1,411,069

5 Claims. (Cl. 181—.5)

ABSTRACT OF THE DISCLOSURE

The invention is broadly concerned with acoustic coupling devices for transmitting vibrations from an electro-acoustic transducer to a medium to be acted on by the vibrations.

The instant invention more particularly relates to a coupling device which is adapted for transmitting ultrasonic pulses without adding undesirable "wall effect" echoes thereto.

The said coupling device essentially consists of a multi-layer stack of foils along which the vibrations are transmitted from one end of the stack to the other, in a direction parallel to the foils.

Elastic pulses, especially ultra-sounds, produced for example by a piezo-electric transducer and used for control of metallic parts, have to be often transmitted, between the transducer and the part to be controlled, through components wherein they propagate and which have the function, either to introduce a delaying or a dampening action or to concentrate the ultra-sonic energy in a determined region, or to modify the incident angle (prism), or to match impedances, these functions being just given as a mere illustration.

These components above referred to, that will be designated hereafter under the name of "acoustic relays," it being understood that this designation has to be interpreted in a very extensive manner, generally are shaped as solid blocks and their lateral dimensions, or their dimensions in a plane perpendicular to the direction of propagation, are much greater than the wave length of the ultra-sounds propagated therein.

Under these conditions, as will be explained in detail hereinafter, the "relay" adds undesirable pulses termed "wall effect" echoes, which follow each pulse to be transmitted and appear very detrimental particularly in the case of control of parts.

It is an object of the present invention to provide an acoustical relay wherein the elastic pulses propagate without producing "wall-effect" echoes.

According to the convention, an acoustical relay essentially consists of a multi-layer stack of thin plates or foils assembled only by their terminal edges, the latter being located at the input and output of the ultra-sounds which penetrate and come out of each plate through a terminal edge.

This and other objects of the invention will become more clearly apparent with the help of the following description.

In the appended drawing:

FIGURE 1 illustrates the driving, by means of an electro-acoustic transducer, of a metallic plate, the thickness of which is approximately equal to a great number of wave lengths;

FIGURE 2 shows the waveform of the ultra-sonic pulses collected at the output of the plate illustrated in FIG. 1;

FIGURE 3 illustrates the driving of a plate, the thickness of which is approximately equal to a small number of wave lengths;

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FIGURE 4 shows the waveform of the ultra-sonic pulses which are collected at the output of the plate of FIG. 3;

FIGURE 5 illustrates the driving of a plate, the thickness of which is about one wave length and

FIGURE 6, the waveform of the corresponding pulses;

FIGURE 7 illustrates the driving of a plate, the thickness of which is much smaller than the wave length and

FIGURE 8, the waveform of the corresponding pulses;

FIGURE 9 shows a set of superposed very thin foils driven by ultra-sound through one edge thereof;

FIGURE 10 shows a longitudinal section of an acoustical relay according to the invention;

FIGURE 11 represents a concentrator of ultrasonic energy, and

FIGURES 12 and 13 represent an acoustical prism.

Referring more particularly now to FIGURES 1, 3 and 5, there is shown a plate 1, made of a copper or aluminium for example, the terminal face 3 of which is in contact with an electro-acoustical transducer 2. When the latter is driven by a generator of electrical pulses, not shown, it provides ultrasonic pulses which penetrate into plate 1 through the above mentioned terminal face 3, propagate in the plate and are reflected against the opposite terminal face 4 and, then, reaching back transducer 2. The latter transmits to a receiver equipment, not shown, the echoes, the waveform of which is represented in FIG. 2.

The useful echo is the bottom echo E. It is seen that the latter is followed by a succession of undesirable echoes, of decreasing amplitude, called "wall effect echoes," such as F.

FIGS. 3 and 4 show that the various echoes tend to overlap as the plate thickness decreases. In the cases of FIGS. 5 and 6, they have completely overlapped.

In the above disclosed embodiments of the relay, face 3 acts both as an input and as an output, and the transducer acts both as an emitter and as a receiver.

Similar results would be obtained by placing a transmitter transducer in contact with face 3, and a receiver transducer in contact with face 4, the transmitter pulse itself, being therefore substituted for the bottom echo.

As another example, the thickness of the plate may be about a centimeter—in the case of FIGURE 1—for ultra-sounds having a frequency of 5 mHz. (corresponding to a wave length of 1.2 mm.).

In the case of FIGURE 3, the thickness of metal plate 5 will be about 2 to 3 mm. and, in the case of FIGURE 5, one mm.

In the case of FIGURE 7, however, the metallic foil 5 will be 0.1 mm. thick, which corresponds to $\frac{1}{10}$ of the wave length, these values being merely illustrative.

Under such conditions, one may observe that echo E is not followed by any "wall effect" echo and is perfectly pure.

The invention relies on the discovery of the fact that this result is also obtained if a plurality of very thin plates or foils are assembled, as shown in FIGURE 9, and driven through their terminal edge by ultra-sounds parallel to their plane surface, as shown in FIGURE 9, on the condition however that these foils are not assembled with the help of an ultra-sound conductive medium such as a liquid, i.e., the foils are acoustically insulated from each other.

However, these foils may be stuck at their ends 6 and 7, as shown in FIG. 10, without modifying this result: portions of surface stuck have to be relatively small to prevent excessive dampening of the ultra-sounds. Had the whole surface of the foils been stuck, however all of the ultrasonic energy would be absorbed.

Therefore, in the same manner, one may produce—by sticking sufficient portions of foils area—dampening

elements which present the remarkable advantage of having an acoustical impedance of about the same value as that of the piezo-electric crystal to be dampened. Such dampeners are, therefore, better than the plastic blocks, currently used for this purpose, which have a much lower acoustical impedance.

In practice, foils are assembled between two flanges 8 and 9, in order to obtain a rigid assembly. For example, a few hundred of foils are assembled, to obtain a relay of normal thickness, which may be connected easily to a driving transducer 10.

This relay may depart from a rectangular shape and have a generally curved profile as shown in FIGURE 10. Thus curved profile does not affect transmission of the ultra-sounds and may be convenient.

FIGURE 11 shows an ultrasonic energy concentrator, composed of a multilayer foil assembly of decreasing thickness, separated by decreasing intervals in order to constitute a bundle, the foils being stuck at their terminal edges. The thicker edge is fixed to a cupel 12. Flanges 13 and 14 enable one to obtain a rigid assembly.

FIGURES 12 and 13 show an acoustical prism obtained from stacked foils arranged between two flanges 16 and 17. The piezo-electric transducer 18 is inserted between the prolongation of the flanges away from the foils bundle. The latter is stuck at its terminal edges 15 in the same way as for the above disclosed embodiments. In addition, lateral edges 21 and 22 are glued, which has the effect of cancelling some of the parasitic echoes that would be produced by reflection on these edges (the sticking of the lateral edges could be used for acoustical relays according to the invention other than prisms).

According to the fact that propagation of ultra-sounds through the above disclosed acoustical prism is slower than in the case of an acoustical prism of prior art, made with the help of a block of material, the refractive index is therefore higher.

On the other hand, the prism according to the invention may be obtained with the help of an electro-conductive metal, which will simplify the electric circuit of the testing system, the relay being used as one of the electrodes of the piezo-electric transducer.

It is to be understood that the above disclosed applications of the invention are by no ways limitative and that many modifications could be devised without departing from the spirit and scope of the invention, as defined in the appended claims.

What I claim is:

1. In an acoustic coupling for transmitting acoustic,

particularly ultrasonic, vibrations from one element to another, the improvement comprising:

a multi-layer stack of foils having input terminal edges adapted to receive from said one element vibrations to be transmitted;

means extending in one direction for rigidly mounting said foils to extend in said one direction;

said foils being fixedly secured together at least at said terminal edges and being acoustically insulated one from the next over at least a substantial portion of their surfaces to cause the said received vibrations to be transmitted substantially solely within said foils along the length thereof; and

the thickness of each of said foil being substantially smaller than the wavelength of the vibrations to be transmitted to obtain only pure echoes by preventing wall effect echoes in any said foil.

2. A coupling as in claim 1 wherein said foils are fixedly secured together by means for adhering them together only at the marginal parts thereof at which the vibrations leave and enter the coupling.

3. A coupling as in claim 1 including a transmitter, as said one element, adjacent said input terminal edges for applying said vibrations thereto.

4. A coupling as in claim 1 for use as a concentrator of ultrasonic vibrations wherein the spacing between the foils decreases from the said terminal edges to form a tapered stack.

5. A coupling as in claim 1 wherein the foils are of gradually reduced length and are stacked with their said terminal edges aligned perpendicular to said length to cause the opposite edges thereof to be inclined relative to the perpendicular.

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RODNEY D. BENNETT, *Primary Examiner*.

BENJAMIN A. BORCHELT, SAMUEL FEINBERG,
Examiners.

M. F. HUBLER, *Assistant Examiner*.