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COMPRESSIONAL WAVE TRANSLATING DEVICE

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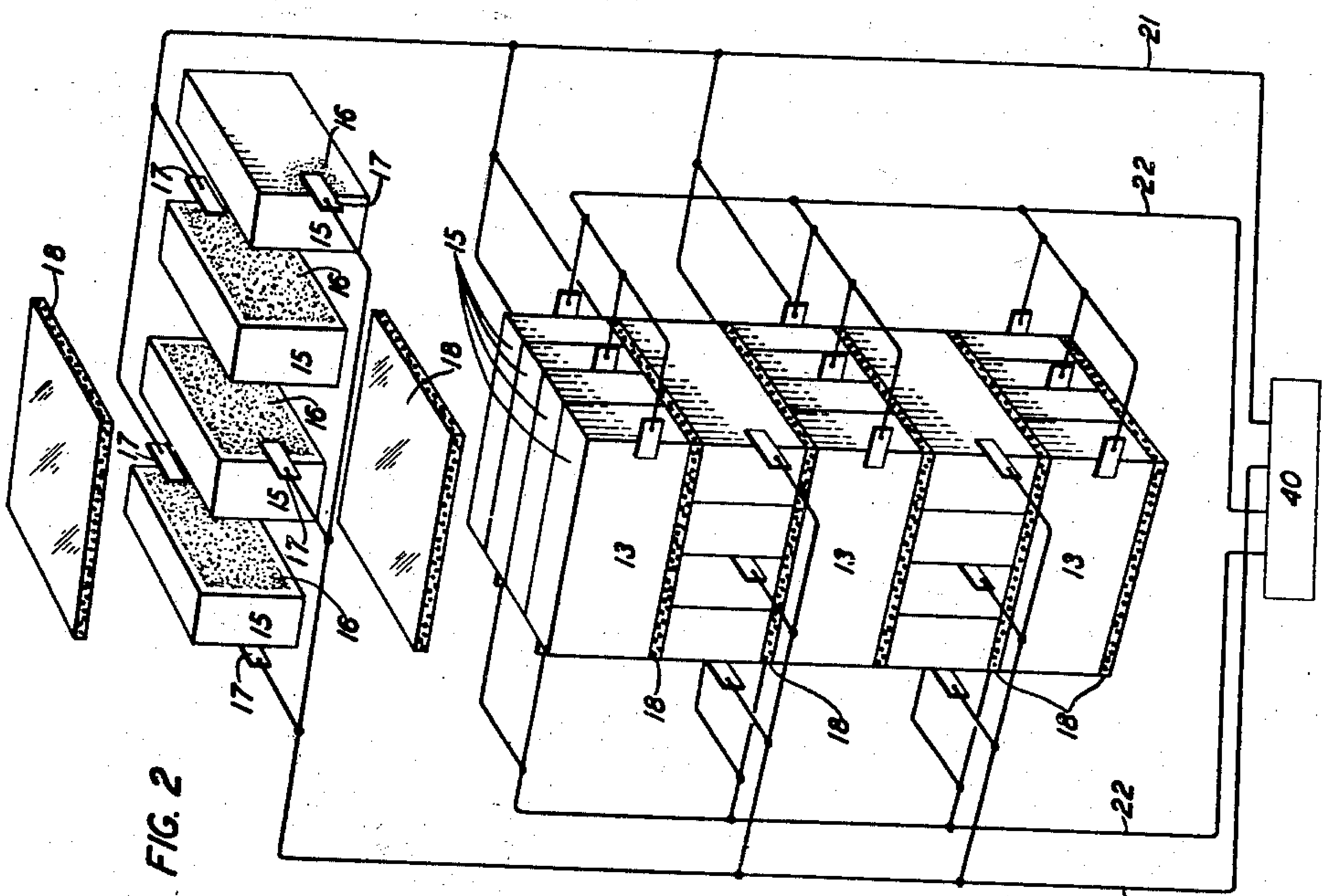

FIG. 2

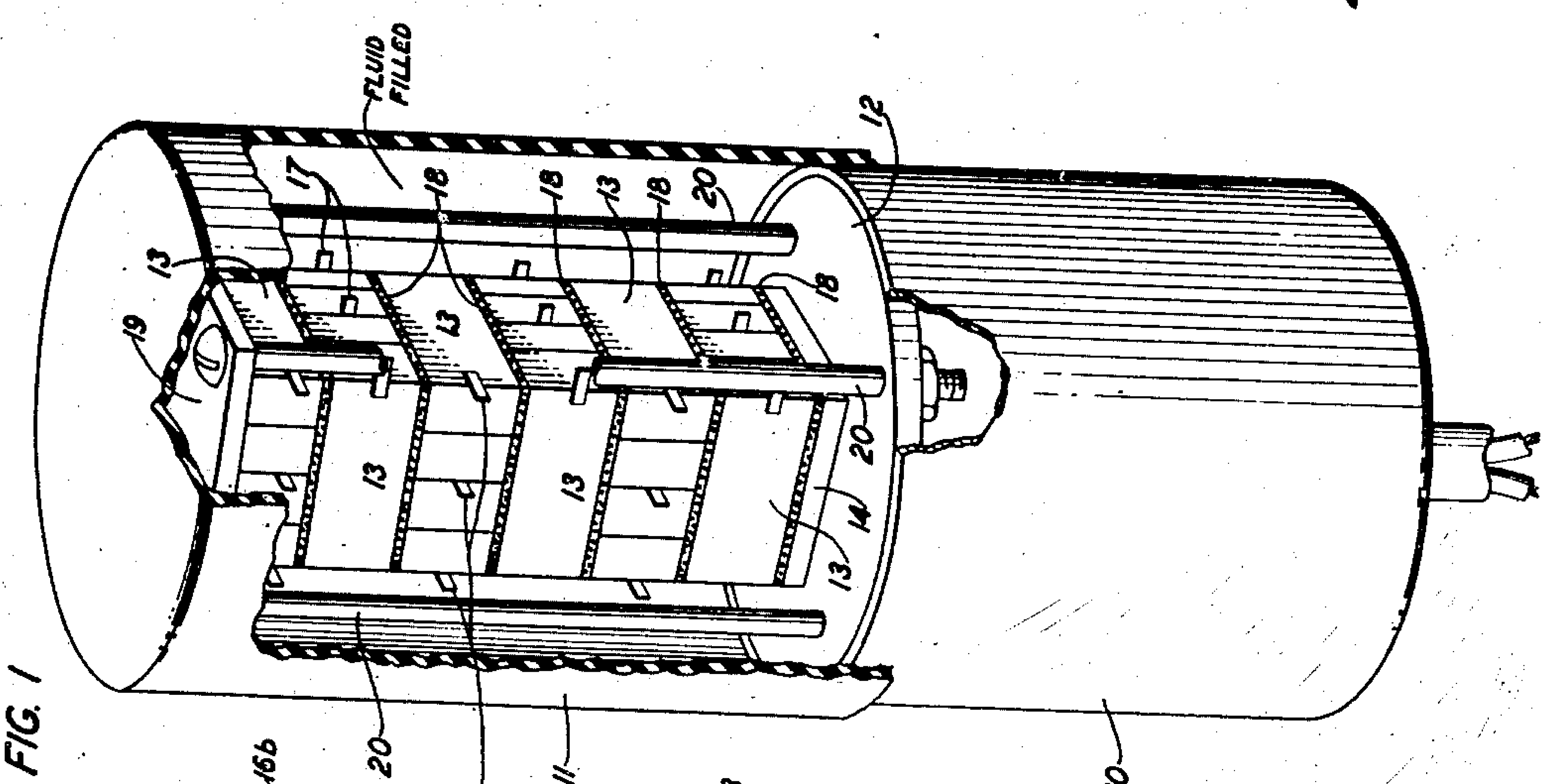

FIG. 1

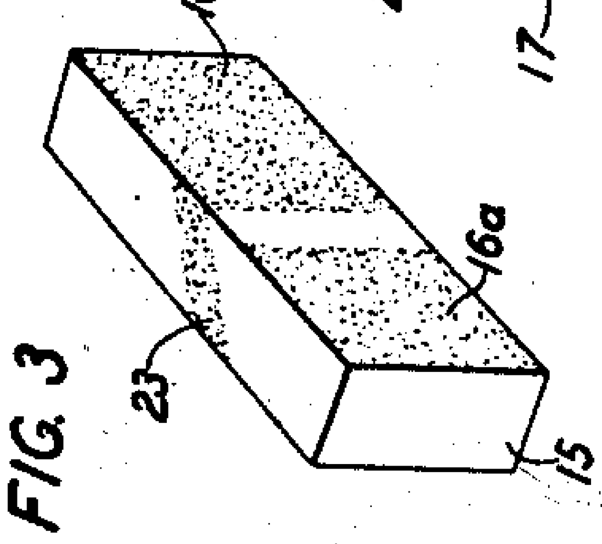

FIG. 3

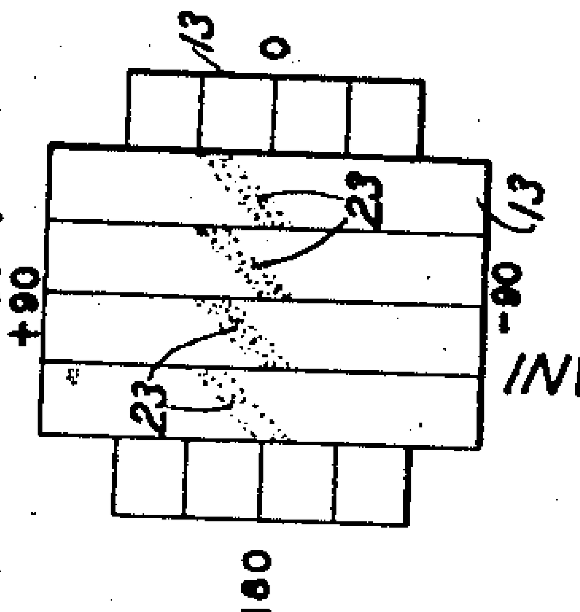

FIG. 4

INVENTORS W. D. GOODALE, JR.
T. J. POPE

BY

Walter C. Kiesel

ATTORNEY

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COMPRESSIONAL WAVE TRANSLATING DEVICE

Walter D. Goodale, Jr., Convent, and Thomas J. Pope, East Orange, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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11 Claims. (Cl. 177—386)

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This invention relates to compressional wave translating devices and more particularly to supersonic projectors for submarine signaling systems.

The present invention is an improvement upon that disclosed in the copending application Serial No 470,808, filed December 31, 1942, of Arthur C. Keller.

One object of this invention is to obtain a substantially circular directional propagating pattern for a supersonic projector, whereby the projector will propagate signals with substantially uniform intensity in all directions about an axis thereof and will propagate relatively little along this axis.

Another object of this invention is to increase the power capacity of supersonic submarine signaling devices of the piezoelectric type.

A further object of this invention is to simplify and facilitate the construction of high power submarine signaling devices.

In one illustrative embodiment of this invention, a supersonic submarine signaling device comprises a housing transparent to compressional wave energy and filled with an air-free fluid having substantially the same transmission characteristics for supersonic compressional wave energy as sea water, and a piezoelectric translating unit within the housing and immersed in the fluid filling therein.

In accordance with one feature of this invention, the translating unit comprises an array of substantially identical piezoelectric elements of square cross-section mounted in superposed aligned relation and adjacent elements having their mechanical axes at right angles to one another so that adjacent units vibrate at right angles to one another in response to electrical signals impressed thereon.

In accordance with another feature of this invention, the several elements of the array are associated electrically in two groups, the elements of the two groups being in alternate relation, and the two groups are energized 90 degrees out of phase with one another whereby a substantially circular propagation pattern about the longitudinal axis of the array is obtained.

In accordance with a further feature of this invention, the several elements constituting the array are mounted in pile-up fashion upon a single support by common fastening elements, adjacent elements being spaced slightly by thin interposed sheets or layers of a material having small mechanical impedance.

The invention and the above-noted and other

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features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing, in which:

Fig. 1 is a perspective view of a submarine signaling device illustrative of one embodiment of the invention, portions of the housing and support therefor and one of the fastening elements being broken away to show details of construction;

Fig. 2 is a perspective view, partially exploded, of the piezoelectric crystal array included in the device shown in Fig. 1 and illustrating one manner in which the elements of the array may be energized; and

Figs. 3 and 4 are detail perspective and plan views, respectively, illustrating a modification of the crystal array shown in Figs. 1 and 2.

Referring now to the drawings, the device there illustrated is particularly adapted for operation as a compressional wave submarine projector at supersonic frequencies, for example frequencies of the order of 25 kilocycles per second. It comprises a water-tight casing 10 in which a transformer or other apparatus may be mounted and an elongated, cylindrical cup-shaped housing 11 sealed in water-tight relation to the casing 10 and of a material transparent to supersonic compressional wave energy and having substantially the same density and wave transmission velocity characteristic as sea water. In one form, the housing 11 may be of rubber having the characteristics noted and having its open end vulcanized to the casing 10.

Supported upon a plate 12 joined to the casing 10 at one end thereof is an array of piezoelectric crystal elements 13, the element 13 nearest the plate 12 being seated upon and spaced from the plate 12 by a block 14 seated on the plate. Each of the crystal elements 13, as shown clearly in Fig. 2, comprises a plurality, for example four, of similar rectangular piezoelectric slabs or blocks 15 secured together in face-to-face relation. The slabs or blocks 15 are of such dimensions that each element 13 is of square cross-section and the array provides, therefore, four equal area propagating surfaces in quadrature. Opposite faces of the slabs are provided with electrodes 16, such as electrically conductive coatings suitably applied to these faces, to which leading-in conductors 17, such as foil strips, are secured. The several slabs or blocks 15 constituting each element 13 have their mechanical axes parallel and have their electrical axes oriented so that the slabs or blocks vibrate in the same direction in response to signal voltages applied by way of the conductors 17 as described hereinafter.

The several elements 13 are mounted in superposed relation with adjacent elements spaced from one another by thin sheets or layers 18 of a flexible material having small mechanical impedance so that each element may vibrate substantially independently of the adjacent elements. As shown in the drawing, the slabs or blocks 15 of adjacent elements 13 extend at right angles to each other so that adjacent elements have their axes of expansion and contraction at right angles. All the elements 13, together with the block 14, are secured in common between the plate 12 and a clamping plate 19 by posts or bolts 20 connecting the plates 12 and 19 and disposed opposite the corners of the crystal array.

As illustrated in Fig. 2, advantageously the several elements 13 are associated electrically in two groups by conductors 21 and 22, which are connected to a suitable signal supply source 40 in such manner that the two groups of elements are energized 90 degrees out of phase and with the same amplitude.

The housing 11 is filled with a fluid, not shown, such for example as castor oil, having substantially the same transmission characteristics for supersonic compressional wave energy as sea water.

When the elements 13 are energized, as noted above, each of the elements vibrates in the direction normal to the major faces of the blocks or slabs thereof, the direction of vibration of the two groups of elements being at right angles. Hence, the array as a whole propagates compressional waves of substantially uniform intensity in all directions normal to the longitudinal axis of the array, that is, the directional pattern of the array is circular about the longitudinal axis of the array. The intensity of propagation along the axis is small so that the array is essentially non-directional parallel to this axis. Because of the sheets or layers 18, each element 13 vibrates substantially independently of the adjacent elements, as noted heretofore, so that interference between adjacent elements and, hence, distortion are eliminated. The block 14 spaces the element 13 seated thereon from the plate 12 and thus prevents interference by the plate with the waves propagated by this element.

In the construction illustrated in Figs. 3 and 4, the electrically conductive coatings upon each face of the crystal slabs or blocks 15 are divided to provide two electrodes 16*a* and 16*b* on each face, and diagonally opposite electrodes on the two faces of each slab or block are connected to one another as by conductive coating strips 23, one of which is shown in Fig. 3.

The elements 13 including blocks or slabs of the construction shown in Fig. 3 may be square or may be rectangular as illustrated in Fig. 4. The phase pattern resulting when the two groups of elements are energized 90 degrees out of phase with one another is indicated in the latter figure and constitutes in effect a continuous phase rotation resulting in non-directivity about the axis of the crystal array.

In a modification of the construction illustrated in Fig. 3, each crystal block or slab may be composed of two separate parts, the mechanical division corresponding to the electrical division of the conductive coatings into two parts.

It will be appreciated that the crystal array provides an efficient device of high power capacity and low impedance which is of relatively simple construction and may be constructed with facility. In a typical device, the array may be of the order of 4 inches long and each element 13 may be of the order of ⅝ inch on a side. When the slabs or blocks 15 are of Rochelle salt, the power capacity of a device of these dimensions is approximately 15 watts in a medium of castor oil.

It will be understood, of course, that arrays of different dimensions and composed of a greater or lesser number of elements 13 may be employed. It will be understood further that the particular device shown and described is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A compressional wave translating device comprising an elongated electromechanical translating unit of substantially square cross-section, said unit including a plurality of similar piezoelectric crystals in superposed relation and oriented so that the axes of expansion and contraction of adjacent crystals are in parallel planes and at right angles to one another and flexible means interposed between and spacing adjacent crystals.

2. A compressional wave translating device comprising a plurality of similar piezoelectric crystals in superposed aligned relation and defining an elongated electromechanical translating unit of substantially square cross-section, said crystals being vibratile normal to the axis of alignment thereof and adjacent crystals having their axes of vibration at right angles to one another, and spacer means having low mechanical impedance interposed between adjacent crystals.

3. A supersonic compressional wave projector comprising a linear array of similar piezoelectric elements of substantially square cross-section and having their corresponding faces coplanar, said elements being mounted in superposed relation with the axes of expansion and contraction of adjacent elements at right angles to one another, thin flexible sheet means interposed between and spacing adjacent elements, and means for electrically driving all of said elements to cause vibration thereof normal to the longitudinal axis of said array.

4. A supersonic compressional wave projector comprising an elongated electromechanical translating element including a plurality of similar rectangular piezoelectric crystals mounted for vibration in the longitudinal mode and in superposed relation and oriented so that the axes of expansion and contraction of adjacent crystals are at right angles to one another, means for electrically energizing one group of alternate crystals, and means for energizing the remainder of said crystals electrically at the same amplitude as and substantially 90 degrees out of phase with said group of alternate crystals.

5. A supersonic compressional wave projector comprising two groups of piezoelectric crystals mounted in superposed aligned relation with the crystals of one group in alternate relation to those of the other group and with the axes of expansion and contraction of the crystals of the two groups at right angles to one another, means having low mechanical impedance spacing adjacent crystals, and means for energizing said groups of crystals at the same amplitude and substantially 90 degrees out of phase.

6. A supersonic compressional wave projector comprising two groups of substantially square

piezoelectric crystals mounted in aligned superposed relation with the crystals of one group in alternate relation with and having their mechanical axes parallel and at right angles to the crystals of the other group, means of low mechanical impedance interposed between and spacing adjacent crystals, each of said crystals including a plurality of crystal slabs mechanically and electrically oriented to vibrate in phase, and means for energizing said groups of crystals at the same amplitude and substantially 90 degrees out of phase.

7. A compressional wave translating device comprising an array of similar, substantially square piezoelectric crystals mounted in aligned superposed relation with the axes of expansion and contraction of adjacent crystals at right angles to one another, flexible means interposed between and spaced adjacent crystals, a support adjacent one end of said array of crystals, and means clamping said crystals to one another and to said support.

8. A supersonic compressional wave projector comprising two groups of similar, substantially square piezoelectric elements in aligned superposed relation with the elements of the two groups in alternate relation, each of said elements including a plurality of slabs mechanically and electrically oriented to vibrate in phase, the axes of vibration of said groups being at right angles to one another, flexible means interposed between and spacing adjacent elements, a support, means securing said elements in alignment and to said support, and means for driving said groups of elements at the same amplitude and substantially 90 degrees out of phase.

9. A compressional wave signal translating device comprising two groups of piezoelectric elements mounted in superposed relation with the elements of one group in alternate relation with and having their axes of expansion and contraction at right angles to those of the elements of the other group, each of said elements including piezoelectric crystal slabs in face-to-face relation, two electrodes upon each face of each slab and extending from adjacent opposite ends thereof, means connecting diagonally opposite electrodes on the opposite faces of each slab, and means connected to said electrodes for energizing said groups at substantially the same amplitude and substantially 90 degrees out of phase.

10. A compressional wave signal translating device comprising two groups of electromechanical translating elements mounted in superposed relation with the elements of the two groups in alternate relation, each of said elements comprising a plurality of rectangular piezoelectric crystal slabs in face-to-face relation and the slabs of the two groups of elements being oriented so that the axes of expansion and contraction of the two groups are at right angles, and means for driving the portions of each slab on opposite sides of a transverse median plane thereof substantially 180 degrees out of phase and the elements of the two groups substantially 90 degrees out of phase.

11. A compressional wave signal translating device comprising an array of two similar groups of rectangular piezoelectric crystals, the crystals of the two groups being in alternate relation and having their axes of expansion and contraction at right angles, each crystal comprising a plurality of slabs mounted in face-to-face relation and oriented to vibrate in unison, two electrodes on each face of each slab and on opposite sides of the median line of the face, means connecting diagonally opposite electrodes on opposite faces of each slab, whereby each slab includes two sections electrically associated to vibrate substantially 180 degrees out of phase, the slabs of each crystal being oriented so that corresponding sections vibrate in phase, and means connected to said electrodes for energizing the two groups of crystals at substantially the same amplitude and 90 degrees out of phase.

WALTER D. GOODALE, JR.
THOMAS J. POPE.

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