April 5, 1949. A. C. KELLER 2,466,112

COMPRESSIONAL WAVE TRANSLATING DEVICE

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FIG. 1

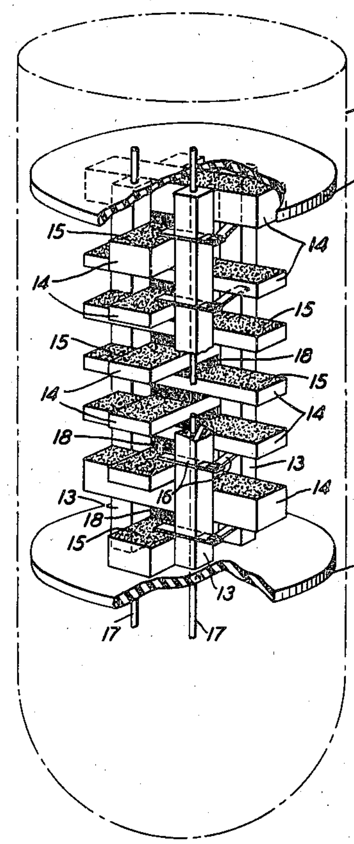


FIG. 3

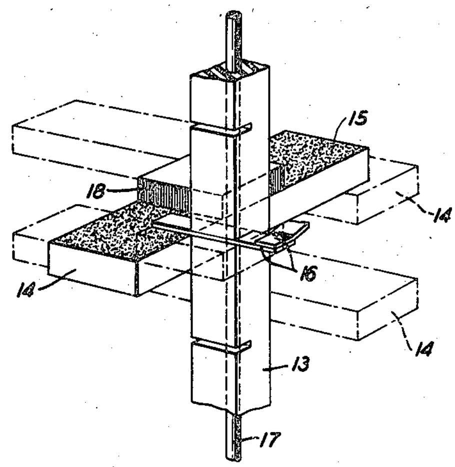


FIG. 2

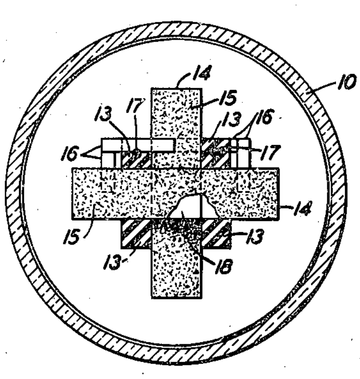
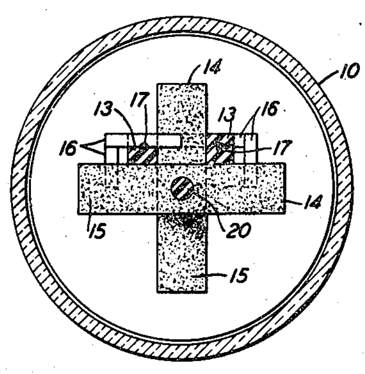


FIG. 4



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COMPRESSIONAL WAVE TRANSLATING DEVICE

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This invention relates to compressional wave translating devices and more particularly to piezoelectric crystal type receivers and transmitters especially suitable for supersonic submarine signaling.

One object of this invention is to obtain, with a piezoelectric type device, a propagation and reception pattern or characteristic, highly discriminatory directionally in one direction and essentially non-discriminatory normal to this direction.

Another object of this invention is to simplify the construction of crystal array type compressional wave translating devices.

In one illustrative embodiment of this invention, a supersonic compressional wave device, suitable for use both as a transmitter and a receiver in submarine signaling equipment, comprises a linear array of piezoelectric crystals electrically in parallel, the crystals being in the form of rectangular blocks, and supports for mounting the crystals.

In accordance with one feature of this invention, the blocks constituting the array are divided into two or more groups, the blocks in the several groups being in interposed relation and the blocks in each group extending at an angle to the others. In one construction, the crystal blocks are mounted in superposed centrally aligned relation with adjacent blocks extending at right angles to one another so that the array comprises two groups of alternately arranged crystal blocks in quadrature.

In accordance with another feature of this invention, the crystal blocks are mounted in stacked relation and are held in position laterally by guiding means engaging the blocks.

The invention and the above-noted and other 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 an elevational view in perspective of a submarine signaling device illustrative of one embodiment of this invention, the housing for the crystal array being shown in phantom;

Fig. 2 is a cross-sectional view of the device illustrated in Fig. 1;

Fig. 3 is a detail perspective view of one of the crystal blocks and the electrodes and leading-in conductors therefor; and

Fig. 4 is a cross-sectional view of a modification of the device illustrated in Figs. 1 and 2.

Referring now to the drawing, the submarine signaling device illustrated in Figs. 1 to 3 comprises a fluid-tight housing **10** highly transparent to supersonic wave energy and having a filling of a viscous fluid, such as castor oil, having substantially the same impedance to transmission of wave energy as sea water. Mounted within the housing is a supporting frame including end members **11** and **12**, for example discs of insulating material, and a plurality of insulating guide for positioning posts **13**, for example four posts arranged at the corners of a square as shown in Fig. 2, secured to the end discs **11** and **12**.

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Positioned by and between the guide posts **13** are a plurality of similar piezoelectric crystals **14**, which may be advantageously 45-degree Y-cut rectangular Rochelle crystal blocks. Each block is of a length substantially equal to one-half wave-length of the frequency at which the device is to be operated, if single frequency operation is intended, or to one-half wave-length of the highest frequency to be translated if the device is intended for operation within a predetermined band of frequencies, and is of such thickness that the center to center spacing of adjacent blocks is less than one-half wave-length of the intended operating frequency or of the highest frequency in the band to be translated.

As shown in Fig. 1, advantageously, for reasons to be pointed out hereinafter, the two crystal blocks at each end of the array may be of twice the thickness of the remaining blocks. The several blocks are centrally aligned and engaged and positioned laterally by the guide posts **13**. Adjacent crystal blocks are arranged at right angles to one another, thus providing an array composed of two groups of crystals in space quadrature.

As shown clearly in Fig. 3, each of the crystals **14** is provided on opposite faces, the upper and lower faces in Fig. 1, with electrodes **15** which may be, for example, coatings of gold evaporated onto these faces, and leading-in conductors **16**, for example, gold-plated foil strips, are secured to each of the electrodes **15**. The foil strips **16** extend into slots in two of the guide posts **13**, the conductors from juxtaposed faces of adjacent electrodes being connected together so that these faces are at the same potential, whereby capacitance effects between crystals are minimized.

All of the crystal blocks may be connected in parallel electrically, as by the conductors **17**, the blocks being oriented, of course, so that all the crystals respond in the same manner to either compressional waves incident thereon or potentials impressed between the electrodes **15**, so that the output of the blocks is cumulative.

Adjacent crystal blocks are insulatingly spaced from each other by separators 18, such as thin strips or blocks of ceramic having a low dielectric constant. The separators are secured to the blocks as by an adhesive also having a low dielectric constant.

As is known, an array of piezoelectric crystals is highly directional in the direction of its length; that is, the array is highly sensitive to waves incident thereon normal to its length and is but poorly sensitive to waves incident thereon at angles to this normal. This directivity, which obtains, of course, for both propagation and reception, is enhanced by making the end crystal blocks double the thickness of the intermediate blocks.

It will be noted that the crystal array provides surfaces exposed to the wave conveying medium for all directions of propagation or reception of wave energy. The groups of crystals, because of their arrangement and symmetry with respect to the longitudinal axis of the array provide a substantially circular propagation and reception pattern concentric with this axis so that although, as noted hereinabove, the array is sharply directive in the direction of the longitudinal axis of the array it is essentially non-directional about this axis, i. e., it is equally sensitive in all directions normal to this axis.

It will be appreciated that the crystal array is facilely constructable and can be fabricated readily as a rugged unit for mounting in the housing 10. Inasmuch as the guide posts 13 merely engage the crystal blocks and the several crystals are interconnected mechanically only by the separators 18, the mechanical restraint to vibration of the crystals in response to either electrical or mechanical forces impressed thereupon is small and is localized in the region of the stress or vibrational antinodes of the crystal blocks. Hence, high sensitivity and translating efficiency are realized.

In the device illustrated in Fig. 4, the crystal blocks 14 are constructed, arranged and connected mechanically and electrically in the same manner as in the device shown in Figs. 1 to 3. However, each block is provided with a central aperture in which an insulating guide or positioning member 20 is fitted, and only two guide posts 13 are provided. These posts 13 may be omitted, if desired, and the leading-in conductors 16 brought out to conductors 17 located in the positions of the posts 13 shown in Fig. 4.

The sensitivity and directional pattern of the device will be dependent upon the compressional wave energy transmission characteristics of the housing 10. In a particularly advantageous construction, the housing may be fabricated of an expanded metal frame having a covering of thin sheet steel, as described in my Patent 2,417,829, granted March 25, 1947, which is characterized by high transparency to supersonic compressional wave energy and substantially no variation of transmission characteristic with angle of incidence of the waves thereon. Other materials may be employed for the housing, such as a cellulose acetone butyrate plastic known commercially as "Tenite II" and a laminated molded wood impregnated with a phenolic condensation product known commercially as "Impreg."

Although specific embodiments of this invention have been illustrated and described, it will be understood that they are but illustrative and that various modifications may be made therein. For example, although in the device described hereinabove, two groups of crystals in quadrature are employed, three groups of crystals at an angle of 60 degrees to one another may be utilized. Other modifications may be made without departing from the scope and spirit of the invention as defined by the appended claims.

What is claimed is:

1. A compressional wave translating device comprising a plurality of rectangular, longitudinally vibratile, piezoelectric crystal blocks arrayed in spaced superposed relation with adjacent blocks extending at right angles to each other, insulating spacer means between adjacent blocks, and substantially parallel, laterally spaced insulating guide posts extending longitudinally of the array of blocks and slidably engaging the sides of said blocks to maintain the angular relation thereof.

2. A compressional wave translating device comprising an insulating support structure including an end member and four parallel guide posts extending from said end member and arranged at the corners of a square, two groups of rectangular piezoelectric crystal blocks arrayed in superposed relation above said end member, said blocks extending between and being positioned laterally in alignment by said guide posts, the crystal blocks of one group extending at right angles to those of the other and the blocks of the two groups being alternately positioned, and means mechanically coupling adjacent blocks to one another adjacent the centers thereof.

3. A submarine signaling device comprising a plurality of rectangular piezoelectric crystal blocks of the same length arrayed in superposed, centrally aligned relation with alternate crystal blocks extending at right angles to the other blocks, the length of said blocks being substantially one-half wave-length of a predetermined frequency and adjacent blocks being spaced a distance, center-to-center, less than one-half said wave-length, means mechanically coupling adjacent blocks at the center portions thereof, positioning means laterally adjacent and engaging said blocks, and means electrically connecting said blocks in parallel, said coupling means constituting the only vibration restraining mechanical interconnection between said blocks.

4. A compressional wave translating device comprising a housing transparent to compressional wave energy, an array of longitudinally vibratile, rectangular, piezoelectric crystal blocks mounted in spaced superposed relation within said housing and spaced from the inner wall thereof, all of said blocks being of a length substantially equal to one half wavelength of a preassigned frequency and adjacent blocks extending at right angles to one another, and means for mechanically interconnecting said blocks solely adjacent the centers thereof.

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