Aug. 13, 1946. W. D. GOODALE, JR., ET AL 2,405,605

SIGNAL TRANSLATING DEVICE

Filed Sept. 2, 1943

FIG. 1

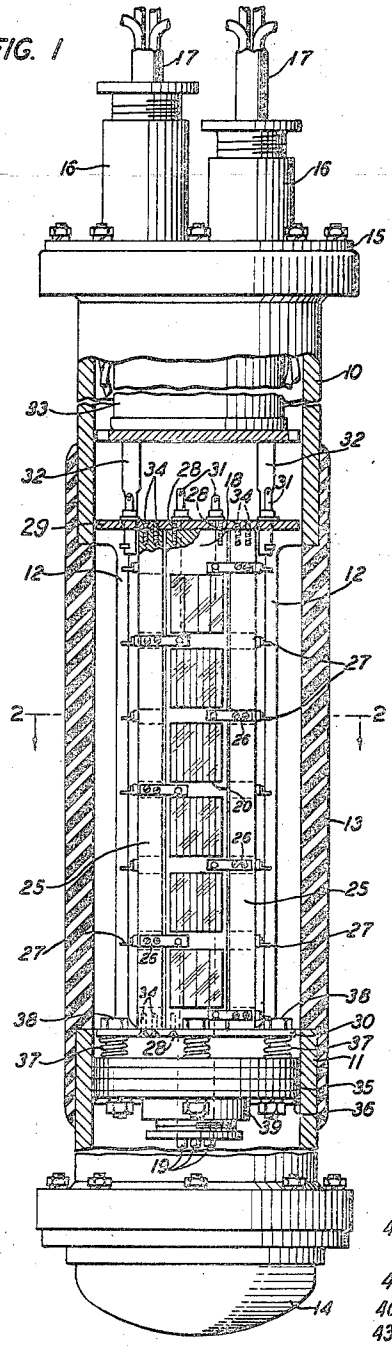


FIG. 2

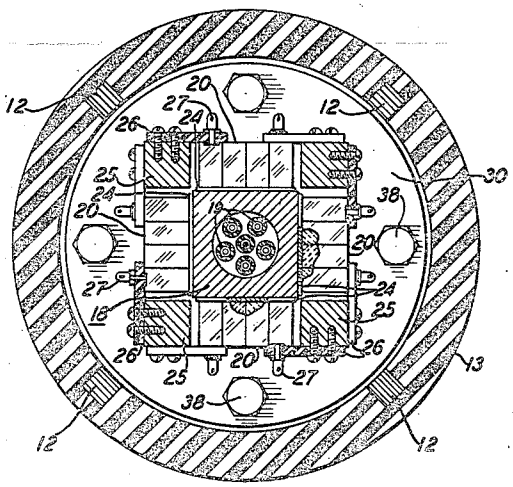
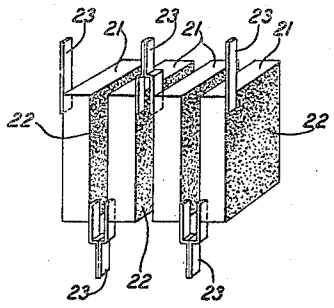


FIG. 3



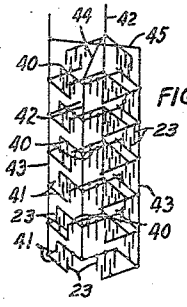


FIG. 4

INVENTORS:
W. D. GOODALE, JR.
F. F. ROMANOW

BY Walter C. Kiesel

ATTORNEY

Patented Aug. 13, 1946 2,405,605

UNITED STATES PATENT OFFICE

2,405,605

SIGNAL TRANSLATING DEVICE

Walter D. Goodale, Jr., Convent Station, and Frank F. Romanow, Summit, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application September 2, 1943, Serial No. 500,914

5 Claims. (Cl. 177—386)

1

This invention relates to signal translating devices and more particularly to submarine signal projectors of the piezoelectric crystal type.

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, in a signal translating device, a response pattern substantially non-directional with respect to a prescribed axis. More specifically, one object of the invention is to obtain, in a supersonic submarine signal projector, a directional pattern which is substantially circular about one axis of the device and sharply directional normal to this axis whereby a narrow annular signal beam is propogated by the device.

Another object of this invention is to increase the power of volume ratio of submarine signaling devices of the piezoelectric crystal type.

Still another object of this invention is to realize, with a supersonic submarine signal projector, a substantially uniform output in one plane, for example normal to the longitudinal axis of the projector, and also a large radiating or propagating surface whereby high power outputs without substantial distortion are obtained.

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

In one illustrative embodiment of this invention, a supersonic submarine signal projector comprises a housing having a cylindrical wall portion highly transparent to supersonic compressional wave energy and an elongated multielement signal translating unit within the housing and adapted to propagate compressional wave signals normal to the longitudinal axis of the unit. The housing is filled with a fluid having substantially the same characteristics as sea water for the transmission of compressional wave energy.

In accordance with one feature of this invention, the signal translating unit comprises four similar groups or arrays of piezoelectric crystals arranged in quadature about and extending parallel to the longitudinal axis of the unit, and the crystals of the several groups are so constructed and arranged that when the crystals are energized in parallel and in phase the directional pattern of the unit is substantially uniform about the axis noted. In a particularly advantageous construction, the crystals of each group or array are graded as to power, in the direction of the longitudinal axis thereof whereby each array and

2

the several arrays in common have very poor transmission at all angles to the axis except in the vicinity of the plane normal to the axis.

In accordance with another feature of this invention, all of the crystals of the several arrays are mounted upon a common support extending between the arrays. For example, this support may be a post of square cross-section and the crytsals are secured to the longitudinal faces of the post.

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 of a submarine signaling device illustrative of one embodiment of this invention, portions of the casing or housing being broken away to show the projector assembly more clearly;

Fig. 2 is a cross-sectional view of the projector taken along plane 2—2 of Fig. 1;

Fig. 3 is an exploded perspective view of one of the crystal assemblies included in the projector illustrated in Figs. 1 and 2; and

Fig. 4 is a wiring diagram illustrating the electrical connection of the crystals.

Referring now to the drawing, the submarine signaling device illustrated therein comprises an elongated cylindrical casing including end portions 10 and 11 connected by a plurality of parallel bars or posts 12, and a sonically transparent intermediate portion or window 13 secured in water-tight relation to the end portions 10 and 11. The end portions 10 and 11 and connecting bars or posts 12 are of a rigid material and may be fabricated as a unitary structure as by casting or from a tube of such material, for example a metal such as steel. The window 13 is of a material, such as a commercially available type of rubber, having substantially the same density and impedance to the transmission of supersonic compressional wave energy as sea water, vulcanized to the end portions 10 and 11 and to the bars 12. One end of the cylindrical casing is closed by a dished cover member 14 of a material, for example the same as the window material, having substantially the same density and impedance to the transmission of supersonic compressional wave energy as sea water. The other end of the casing is closed by a cover 15 provided with tubulatures 16 through which rubber jacketed conductors 17 for establishing electrical connection with the apparatus mounted within the casing extend, suitable glands or pack-

ing, not shown, being provided to form a watertight joint between the conductors 17 and the tubulatures 16.

Mounted within the casing adjacent the cover member 14 is a supersonic signal detector or receiver, not shown, which may be of the construction disclosed in the application, Serial No. 479,084, filed March 13, 1943, of Thomas J. Pope. A suitable transformer, not shown, may be provided in association with the detector or receiver.

Positioned coaxially within the casing and substantially coextensive longitudinally with the window 13 is a supersonic signal projector which comprises a support or post 18 of square cross-section and provided with a longitudinal bore through which leading-in conductors 19 for the detector or receiver extend. The support or post 18 mounts four similar linear groups or arrays of piezoelectric crystal elements 20, the crystals of each group or array being supported from a corresponding face of the support or post as shown in Fig. 2. Each crystal element, as shown clearly in Fig. 3, comprises a group of similar slabs 21, for example 45-degree Y-cut Rochelle salt slabs, joined in face-to-face relation. Each slab is provided on its major faces with an electrode 22, for example a coating of gold or the like, to which a conductor 23 is secured. As shown in Fig. 3, opposing faces of adjacent slabs are connected together electrically. The slabs may be connected electrically in parallel and are oriented so that all the slabs of each element vibrate in phase, the axis of vibration being normal to the longitudinal axis of the support or post 18. Each crystal element is secured, as by cementing, to an insulating, e. g. ceramic, strip 24 secured, as by cementing to a face of the support or post 18.

Advantageously, as illustrated in Fig. 1, the several crystal elements 20 of each group or array are graded longitudinally as to power so that the propagation pattern of each array is highly directional, that is a concentrated signal beam of small included angle, propagated in the direction normal to the longitudinal axis of the crystal array is obtained. For example, the end elements in each array may be constituted of four slabs each and the intermediate elements may be constituted of a greater number of slabs, for example eight, whereby the intermediate crystal elements have lower impedance and greater power capacity than the end elements.

Extending adjacent the corners of the support or post 18 are four similar posts 25 of square cross-section, which mount insulating strips 26 carrying terminals 27 to which the conductors 23 are connected. The posts 25, which may be of metal for example, are of such lateral dimensions and are so positioned that the outer faces thereof are substantially coplanar with the radiating faces of the adjacent crystal arrays, as shown clearly in Fig. 2.

The post or support 18 has secured to its ends, as by screws 28, a pair of plates or discs 29 and 30 of slightly smaller diameter than the internal diameter of the end portions 10 and 11. The plate 29 carries terminals 31 which are connected to the terminals 27 by suitable conductors, not shown, and to which the conductors 32 leading from a transformer 33, or the detector conductors 19 are connected. The terminals 31 associated with the detector conductors 19 are connected also to the respective conductors 17, the connections being omitted from the drawing in the interest of clarity. The posts 25 also are secured to the discs or plates 29 and 30, as by

screws 34, to constitute a unitary assembly with the post 18, the crystals and the plates 29 and 30, insertable into the casing as a unit. This assembly may be supported resiliently within the casing as from a platform 35 secured to the end portion 11, for example by welding or soldering as indicated at 36. The plate 30 and platform 35 are spaced by resilient members such as helical springs 37 encompassing machine screws 38 threaded into the platform. The platform 35 may be formed with a hub 39 through which the conductors 19 extend, a suitable gland or packing being provided to form a fluid-tight seal between the conductors and the hub.

The casing is filled with an air-free fluid, for example a viscous liquid such as castor oil, to provide a continuous transmission path of uniform transmission characteristics between the projector and detector and the sea water surrounding the casing.

The crystal elements 20 of each group or array are connected electrically in parallel and the four groups or arrays also are adapted to be connected in parallel. The electrical connections are illustrated in Fig. 4. Specifically, as shown in this figure, corresponding conductors 23 of the several crystals are connected by tie wires 40 or 41 to suitable conductors 42 or 43 respectively, the two conductors 42 being tied together as shown at 44 and the two conductors 43 being associated similarly as shown at 45. In a particularly advantageous construction, the four groups or arrays are all driven or energized in phase. Because of the longitudinal grading, as to power, noted heretofore, there is obtained a concentrated signal beam perpendicular to the longitudinal axis of the projector, which has low side lobes; the narrowness of the main lobe being dependent upon the length of the arrays. In one construction, an array length of approximately six times the wavelength, in sea water, of the intended operating frequency, e. g. 32 kilocycles per second, of the device has been found to be satisfactory, the several crystals in each array being equally spaced.

The directional pattern of the projector about the longitudinal axis thereof is dependent primarily upon the transverse dimensions of the support or post 18 and the dimensions of the crystal elements 20. It has been found that these dimensions can be correlated to produce an essentially circular pattern about the longitudinal axis of the projector, when all the crystal elements are energized in parallel and in phase and that such correlation is general in terms of the wavelength, λ, in the medium of the intended operating frequency of the device. Specifically, it has been determined that in a device of the construction illustrated in Figs. 1 and 2 such a circular directional pattern is realized for the following dimensions:

Height of each crystal element 20, i. e., the dimension thereof normal to the longitudinal axis of the support or post 18, equal to substantially 0.32λ;

Width and length of each crystal element 20, i. e., the horizontal and vertical dimensions of the elements shown in Fig. 1, both equal to substantially $.70\lambda$; and

Width of each face of the post or support 18 equal to substantially 0.85λ.

The corner posts 25, as noted heretofore, are of square section and have their outer faces substantially coplanar with the radiating faces of the adjacent crystal elements.

In some cases, longitudinal resonant vibrations of the post or support 18 may occur. Such vibrations can be prevented by providing transverse slots or cuts, not shown, in the support or post, for example at planes intermediate the opposed sides of adjacent crystals in the arrays.

It will be noted that the projector construction described hereinabove constitutes a unitary, readily fabricable assembly which is characterized by a large power capacity and a large power capacity to size ratio. It will be noted further that the crystal arrays constitute a large proportion of the total volume of the projector so that a high space coefficient is obtained.

Although the invention has been described with particular reference to a supersonic signal projector, it will be understood that it may be embodied also in a signal detector or receiver. Also although the four crystal arrays have been described as operated in parallel whereby an essentially circular directional pattern is obtained, it will be understood that in some instances a lesser number of the groups may be operated in parallel, for example two opposite groups may be so operated to provide a bidirectional pattern or three of the groups may be so operated to produce a pattern corresponding approximately to a 270-degree portion of a circle.

It will be understood that the specific construction illustrated and described is but illustrative of the invention 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 supersonic submarine signaling device comprising a rigid post of square cross-section, and four similar groups of piezoelectric crystals, the crystals of each group being mounted in linear array upon a corresponding face of said post with the axis of the array parallel to the longitudinal axis of said post, the transverse dimensions of said post being equal to substantially 0.85λ and each of said crystals being of slightly less width than

said post and substantially 0.32λ high, λ being the wavelength of the operating frequency of said device.

2. A supersonic submarine signaling device in accordance with claim 1 wherein each of said crystals is substantially square and composed of a plurality of slabs of piezoelectric material oriented and electrically connected to vibrate in phase.

3. A supersonic submarine signaling device comprising a rigid, elongated support of square cross-section, four similar groups of piezoelectric crystals arranged in quadrature about said support, the crystals of each group being arranged in linear array parallel to the longitudinal axis of said support and being secured to a corresponding face of said support, all of the crystals in each array being of the same dimensions, substantially 0.70λ wide and 0.32λ high where λ is the wavelength of the operating frequency of the device, and the end crystals in each array having smaller power capacity than the intermediate crystals, each face of said support being substantially 0.85λ wide, and means for connecting all the crystals electrically in parallel.

4. A signal translating device comprising an elongated support of square cross-section, four parallel linear arrays of similar piezoelectric crystals, the crystals of each array being secured to a corresponding face of said support, leading-in conductors for each crystal, four posts mounted opposite the corners of said support and having their outer faces substantially coplanar with the outer faces of the adjacent crystals, and terminal members for said conductors carried by said posts.

5. A signal translating device in accordance with claim 4 wherein said support is substantially 0.85λ on each side and each of said crystals is substantially 0.32λ high and 0.70λ wide, λ being the wavelength of the operating frequency of the device.

WALTER D. GOODALE, JR.
FRANK F. ROMANOW.