June 24, 1930. A. McL. NICOLSON 1,766,043

INTERNALLY CLAMPED COMPOSITE PIEZO ELECTRIC TORSION DEVICE

Filed Dec. 20, 1926

Fig. 1

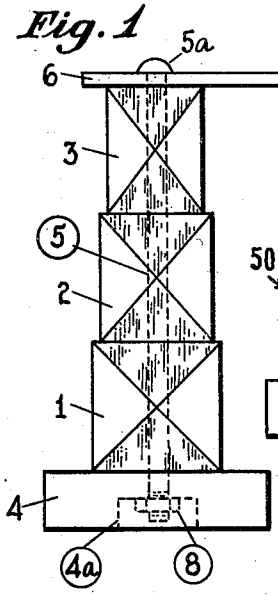


Fig. 5

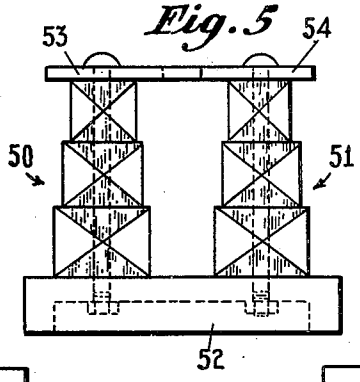


Fig. 2

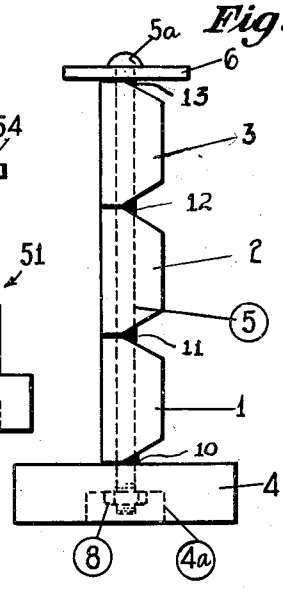


Fig. 3

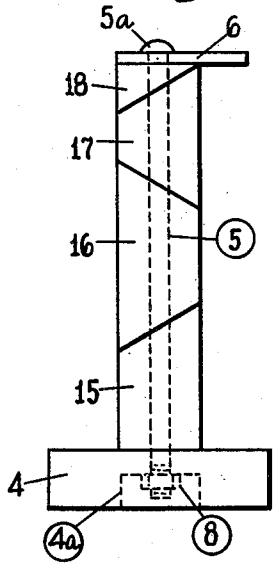


Fig. 4

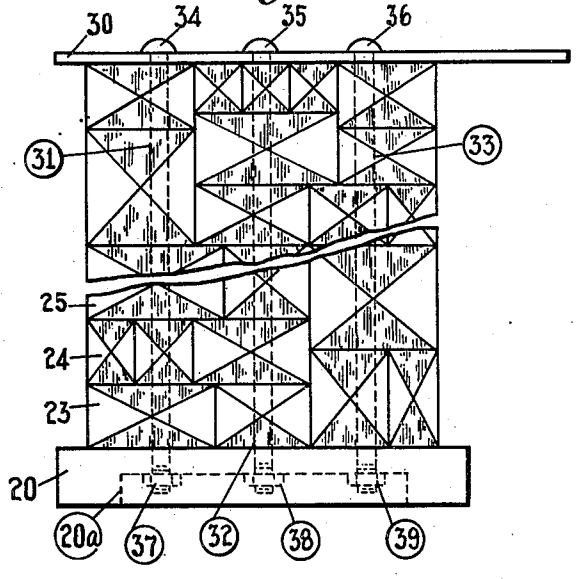
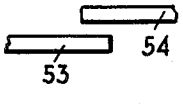


Fig. 6



Fig. 7



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UNITED STATES PATENT OFFICE

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INTERNALLY-CLAMPED COMPOSITE PIEZO-ELECTRIC TORSION DEVICE

Application filed December 20, 1926. Serial No. 155,900.

This invention relates to piezo-electric crystal devices, more particularly adapted and arranged to be utilized in connection with electric circuits, and to a method of producing the same. It has been known for some time that crystals of certain substances, such as Rochelle salt, quartz, tourmaline, and the like, produce an electro-motive force if subjected to physical stress or movement, and conversely, produce physical stresses or movement in response to the impression of an electro-motive force upon them.

Such crystals are capable of wide use and application in the electrical arts, and particularly in those arts which deal with the generation, transmission, and utilization of alternating currents or potentials, whether of audible frequency or of the highest radio frequency.

In my Patent No. 1,495,429 issued May 27, 1924, I have shown that Rochelle salt piezo electric crystals may be used in the generation of electrical oscillations.

In the past, difficulties have been encountered in the use of comparatively large crystals and crystals of unusual shapes, whether natural or grown. It has been found difficult to obtain and maintain large crystals in the case of crystals made by growth from a solution of the mother liquor, such as Rochelle salt crystals. The large crystals, as will be understood, require more time to grow than the small ones, and moreover, they seem to be considerably more fragile and tend to develop cracks and flaws even before the crystals have been effectively cured and hardened.

In the case of natural crystals, such as quartz and tourmaline, etc., it is clear that the difficulty and expense of preparing crystals increases greatly with the size, and the liability of accidental injury in the use of the crystal is much greater.

In my copending application entitled "Composite piezo-electric crystal device" Serial No. 155,898, filed December 20, 1926, I have described and shown a composite piezo-electric device, and a method of producing the same from a plurality or multiplicity of component piezo-electric crystals physically secured into a single entity and arranged so that the piezo-electric effects of the individual component crystals may be integrated.

In my copending cases entitled "Composite piezo-electric torsion device" and "Composite piezo-electric device," Serial Nos. 155,899 and 155,898, respectively, filed December 20, 1926, I have shown and described a composite piezo-electric device arranged and adapted particularly for torsional vibration, and also a method of producing the same by assembling the component piezo-electric crystals into a single physical entity in such manner that torsional piezo-electric vibrations of the individual component crystals may be integrated. The invention forming the subject matter of this application relates to a composite piezo-electric device arranged and adapted particularly for torsional vibration, and a method of producing the same, by mechanically clamping together into a single entity a plurality of component piezo-electric crystals, and more specifically, by the use of an internal elastic and preferably metallic mechanical clamp adapted to engage the component crystals and hold them in a single physical entity.

The various orientation of crystals with respect to each other may be utilized. For example, each component piezo electric crystal may be made up of a plurality of smaller piezo electrically active pieces cemented together into a unitary structure. Care must be exercised in properly aligning the smaller piezo electrically active pieces so that the piezo electric effects of the pieces are added. The construction of large piezo electric crystals in which a plurality of small piezo electrically active crystals are cemented together is more particularly described and claimed in my application Serial No. 155,899 filed December 20, 1926, entitled "Orientation of component crystals in composite piezo-electric devices."

It is an object of this invention to provide a composite piezo-electric crystal particularly adapted for torsional vibration, and a method of producing the same, whereby the composite crystal may be quickly and easily disassembled into its components, with the

object of inspecting, and if necessary, replacing any individual component crystal.

It is a further object of this invention to provide a composite piezo-electric crystal particularly adapted for torsional vibration, and a method of producing the same, without the use of cement, liquid binder, or the like.

It is a further object of this invention to provide a composite piezo-electric crystal particularly adapted for torsional vibration, and a method of producing the same, whereby the component crystals are held under compression which may be adjusted to the desired value.

The features of novelty which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention, itself, however, both as to its fundamental principles and as to its practical application, will best be understood by reference to the specification and accompanying drawing, in which

Fig. 1 is a front elevation of a composite piezo-electric device according to my invention.

Fig. 2 is a side elevation thereof.

Fig. 3 is a side elevation of a modified form thereof.

Fig. 4 is a front elevation of a still further modified form utilizing a larger number of component piezo-electric crystals and a plurality of clamping members.

Fig. 5 is a front elevation of an additional form of piezo-electric device according to my invention, and

Figs. 6 and 7 are details of one form of my invention.

In accordance with my invention, I select a plurality of piezo-electric crystals to be assembled into a composite device. The selection is preferably made by choosing crystals which are chemically and optically similar. For example, I may select a number of quartz crystals, being careful to separate the crystals of dextro asymmetry from those of laevo asymmetry. The composite piezo-electric device may be constructed of either of the components, but it is preferable to use in any one assembly only crystals of the same asymmetry, as otherwise the mechanical vibrations of the one class will be mechanically 180° out of phase with those of the other class, which will interfere with the proper functioning of the device, and may even cause its destruction.

In the case of other hemihedral crystals which occur only in right-handed or left-handed forms, such for example as Rochelle salt, it is not necessary to separate the forms.

After the component crystals have been selected, I may then proceed to form an opening through each of the component crystals, parallel to the *c*-axis, and preferably symmetrically disposed within the crystal, in any suitable way, as for example, by drilling, or by cutting the crystal, fluting it, and cementing the parts together again. After the crystals have been selected and provided with the openings as described, I may then proceed to build up a composite structure by providing an elastic, preferably metallic, member adapted to withstand sufficient tension to place the crystals under the desired compression. A base plate will preferably be provided, adapted to receive and secure one end of the elastic member.

The composite device may then be built up by placing the crystals one after another, upon the elastic member by passing the same through the hole in the crystal. After a sufficient number of the component crystals have been mounted on the elastic member to provide the desired size of composite device, a suitable compression-carrying member such as a metallic plate may be mounted upon the elastic member bearing against the uppermost crystal, and the desired compressive force exerted upon the device by means of a suitable nut which may be formed to engage threads on the elastic member.

The component crystals when arranged as described, will be lined up in a line parallel to the *c*-axis of the crystals.

It may be found desirable, in the case where a considerable number of crystals are to be used, to provide a plurality of elastic members spaced at various points with respect to the composite crystal, whereby a more uniform distribution of the stresses may be effected. It may also be found desirable to provide a plurality of composite devices on the same base and so arranged as to work each with the other.

The central clamping bolt may be used as an internal electrode, if desired.

Also, for the purpose of mechanically reinforcing the crystals at the points of mechanical contact, metallic reinforcing plates may be arranged upon the crystals, which plates may also be utilized as electrodes if desired. As an alternative, the crystal or salient portions thereof may be reinforced by the application of a coating of "melt" thereto.

Referring now more particularly to Fig. 1, 1, 2 and 3 designate separate component piezo-electric crystals. A base plate 4 is provided having a depression 4^a on the underside adapted to permit the mounting of a nut therein, as will hereinafter be explained. Each of the crystals is provided with an opening, extending through the crystal parallel to the *c*-axis, and preferably symmetrically disposed with reference to the crystal. This opening may be formed by drilling through the crystal with a drill of the proper size, or it may be formed by sawing through the crystal parallel to the *c*-axis, and cutting corresponding grooves in the thus exposed crystal surfaces, after which the two parts of the crystal are cemented together for ex-

ample by means of Rochelle salt "cement," consisting of Rochelle salt from which about one fourth of the water has been removed, or "melt," comprising Rochelle salt fused at a temperature controlled according to the amount of water of crystallization it is desired to retain in the "melt."

A corresponding opening is provided through the base plate 4, and a cap or stress distributing member 6 is provided, also having a hole formed therein, and being of a suitable configuration to rest upon the outer surface of crystal 3 and distribute the stress uniformly over the surface thereof. An elastic securing member or tie rod 5, preferably of metal, and having a head 6 formed on one end, and having suitable threads on the other end, is provided, of the proper diameter to pass through the holes in the crystals and base plate.

The cap or stress distributing member 6, which may be provided with an extension for the purpose of mechanically coupling the crystal to a load or to a source of energy, is placed upon the tie rod 5, after which crystals 3, 2, and 1, are placed thereon. Finally, the base plate is placed thereon, and a suitable nut 8 run down depression 4ª, the cooperation of which with the threads on the tie rods permits placing the desired amount of compression upon the crystals.

Suitable electrodes (not shown) will be provided at the proper poles on each of the individual crystals for impressing electromotive forces upon the individual crystals, or for drawing therefrom the charges generated by vibration of the crystal device. As an example of a suitable electrode construction, the tie rod 5 may constitute a common internal electrode, and individual girdle electrodes in the form of a belt of metal foil or gauze may be applied to each crystal around the exterior thereof, all of which girdle electrodes may be connected together. The crystal device so constituted, is ready for use, and will function, either as a generator or as a motor. That is to say, an electro-motive force may be impressed upon the device, which will be converted into torsional vibrations of the crystal such that one end of the device tends to rotate with respect to the other end, or physical stresses may be applied to the crystal device tending to rotate one end in a plane normal to the *c*-axis, in order to produce fluctuations of electro-motive force corresponding thereto.

Referring now to Fig. 2, I have shown the manner of reinforcing the component crystals against mechanical stress. In this instance, 10, 11, 12 and 13 designate solidified coatings of "cement" or "melt", the former comprising Rochelle salt from which about one fourth of the water has been removed, and the later comprising Rochelle salt heated to a temperature controlled in accordance with the amount of water it is desired to retain in the salt. These coatings may be spread adjacent the junctures of the crystals by means of a brush while in a semi-fluid state or otherwise applied to the salient points or planes of the crystals to build up a reinforcing structure, and allowed to harden before the crystals are assembled. If necessary, the crystals may then be ground to remove excess material and leave smoothly fitting cooperating faces.

Also, metallic plates of the proper shape to rest upon a large crystal area may be used, which may form end electrodes for the component crystals.

Referring now to Fig. 3, I have shown a composite piezo-electric device assembled in a similar manner from crystals 15, 16 and 17, of still different shape. In this instance a filler block 18 may be provided under the cap 6 for the purpose of distributing the stress uniformly over the upper surface of crystal 17.

Referring now to Fig. 4, I have shown a modification in which a relatively larger number of crystals are utilized, arranged in lines parallel to the *c*-axes and also in lines normal thereto, and in which a plurality of tie rods are utilized. In this figure, 20 designates a suitable base plate, provided with a recess 20ª in the under side.

The crystals 23, 24, 25, etc., are built up and arranged in the manner dictated by the size, shape, and number of the various component crystals, with the *c*-axes parallel, so as to form a composite device of the size and shape desired. A cap member 30, of the proper size and shape to contact with the top surface of the composite crystal structure is provided, and the member 30 as well as the crystals and the base plate are provided with suitable openings permitting the passage of tie rods 31, 32 and 33, formed on their upper ends with heads 34, 35, and 36, and threaded on their lower ends to accommodate nuts 37, 38 and 39, by means of which the cap 30 may be drawn down upon the composite structure to place the desired compressive force upon the crystals.

Referring now to Fig. 5, I have shown a pair of composite crystal devices 50 and 51, which may be constructed in a manner similar to Figs. 1, 2, or 3, but mounted upon a single base plate 52 and provided with arms 53 and 54 extending toward each other. The arms may be in line with each other and with their adjacent ends slightly spaced from each other, as shown in Fig. 6, or they may be arranged parallel but laterally offset from each other with their adjacent ends slightly overlapping, as shown in Fig. 7, whereby a maximum motion may be produced in response to the impression of an E. M. F. upon the device, or a maximum charge may be developed by application of force to the arms.

The devices 50 and 51 will preferably be operated in parallel as a single unit and the necessary leads for this purpose will be provided.

While I have shown and described certain preferred embodiments of my invention, it is understood that modifications and changes may be made without departing from the spirit and scope of my invention, as will be understood by those skilled in the art.

I claim:

1. A composite piezo-electric Rochelle salt crystal adapted for torsional vibration comprising a plurality of component piezo-electric Rochelle salt crystals physically secured together with their *c*-axes parallel into a single entity by metallic clamping means passing internally through coincident bores in a plurality of said crystals, said crystals being so connected that piezo-electric torsional vibrations of said individual components may be integrated.

2. A composite piezo-electric Rochelle salt crystal adapted for torsional vibration comprising a plurality of substantially similar Rochelle salt piezo-electric crystals physically secured together with their *c*-axes parallel into a single entity by metallic clamping means passing internally through a plurality of said crystals, said crystals being so arranged that piezo-electric torsional vibrations of said individual components may be integrated.

3. A composite piezo-electric Rochelle salt crystal adapted for torsional vibration comprising a plurality of substantially similar piezo-electric Rochelle salt crystals physically secured together into a single entity, with their *c*-axes parallel by elastic clamping means passing internally through coincident bores in a plurality of said crystals, said crystals being so connected that piezo-electric torsional vibrations of said individual components may be integrated.

4. A composite piezo-electric Rochelle salt crystal adapted for torsional vibration comprising a plurality of substantially similar piezo-electric Rochelle salt crystals physically secured into a single entity, with their *c*-axes parallel and with a plurality of crystals in line parallel to said axis, by elastic clamping means passing internally through coincident bores in a plurality of said crystals, said crystals being so connected that piezo-electric torsional vibrations of said individual components may be integrated.

5. A composite piezo-electric Rochelle salt crystal adapted for torsional vibration comprising a plurality of substantially similar piezo-electric Rochelle salt crystals physically secured together into a single entity with their *c*-axes parallel and with a plurality of crystals in line parallel to said axis and normal thereto, by metallic clamping means passing internally through coincident bores in a plurality of said crystals, said crystals being so connected that piezo-electric torsional vibrations of said individual components may be integrated.

6. A composite piezo-electric device comprising a pluralitv of component piezo-electric crystals having torsionally vibrating characteristics and being physically secured in abutment end to end into a single entity by means passing through each of said crystals for maintaining said crystals in position, and separate means for mechanically reinforcing said component crystals against mechanical stress, said component piezo-electric crystals being arranged with a piezo electric axes parallel.

7. A composite piezo-electric device comprising a plurality of component piezo-electric crystals having torsionally vibrating characteristics and being physically secured in abutment end to end into a single entity, and means for mechanically reinforcing said component crystals against mechanical stress, said means comprising a metallic plate positioned upon one of said crystals at a point of mechanical stress, said component piezo electric crystals being arranged with their *c*-axes parallel.

8. A composite piezo-electric device comrising a plurality of component piezo-electric crystals having torsionally vibrating characteristics and being physically secured in abutment end to end into a single entity, and means for mechanically reinforcing said component crystals against mechanical stress, comprising a coating of reinforcing binder applied at the juncture part of said component crystals, said component piezo electric crystals being arranged with a piezo electric axis parallel so that the piezo electric effects of each of said component piezo electric crystals are additive.

In testimony whereof I hereunto affix my signature.

ALEXANDER McLEAN NICOLSON.