June 6, 1950 A. J. GALE 2,510,811

PIEZOELECTRIC CRYSTAL

Filed May 7, 1945

Fig. 1.

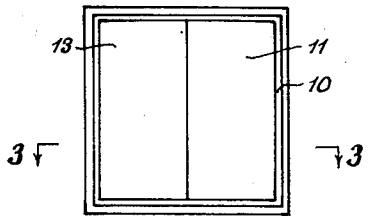


Fig. 2.

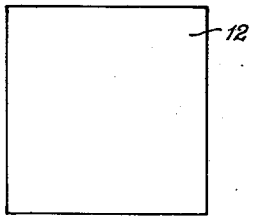


Fig. 3.

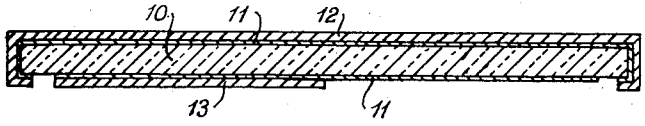
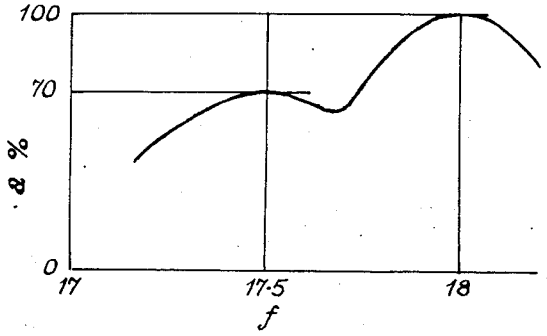


Fig. 4.



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PIEZOELECTRIC CRYSTAL

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Patent expires December 8, 1962

14 Claims. (Cl. 171—327)

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This invention relates to piezo-electric crystals suitable for generating mechanical supersonic waves in fluids, and for other uses.

The object of this invention is to provide a method of treating a piezo-electric crystal so as to broaden its frequency response and to provide a piezo-electric crystal having a relatively broad frequency response.

The addition to the opposed surfaces of a piezo-electric crystal of relatively thick layers of metal, acting as electrodes, has the effect of broadening the frequency response and at the same time lowering the frequency at which the maximum response occurs.

According to this invention, at least one of the faces of the crystal is coated with a layer of metal, the thickness of this metal layer at one portion of the face being different from its thickness at another portion of the face. In this way a response curve is obtained which is a combination of the response curves of the individual portions considered separately. Thus, by coating, for example, half of the crystal on each of the opposed faces with a thin layer of metal and the other half with a thick layer, a repsonse curve is obtained which is the algebraic sum of the response curves of each half taken separately; and the thicker the thick layer is made, the farther the shift of the point of maximum frequency response and the more the broadening of the overall response.

The crystal may have a thin silver layer chemically deposited on its face followed by an additional layer of metal, e. g. also silver, electrolytically deposited over part of said face.

One way of carrying the invention into practice will be described by way of example with reference to the accompanying diagrammatic drawings, in which:

Fig. 1 is an elevation of the front face of a crystal treated in accordance with the invention,

Fig. 2 is an elevation of the back of the same crystal,

Fig. 3 is a section on a larger scale, taken on the line 3—3 in Fig. 1, and

Fig. 4 is a graph showing the relationship of amplitude of oscillation a to frequency f of this crystal.

The crystal 10 shown in Figs. 1, 2 and 3 may be about 1 cm. by 1 cm. and 0.016 cm. thick. An initial coating of silver is made chemically in known manner by deposition from an ammoniacal solution of silver nitrate reduced by means of glucose. The required thickening is then secured by electrolytic deposition where required. On the back and edges of the crystal,

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a copper coating 12 is electrolytically deposited on the initial silver layer 11, while one-half of the separate area of the initial silver layer 11 on the face is thickened by electrically depositing a silver coating 13. This thick silver coating may be followed by a layer of electrolytically deposited copper.

It is thought that the most useful range of thickness for the silver layer 13 is between a few molecules and 0.0001 in.; and owing to the difficulty of determining this thickness directly, it is found most convenient to obtain any desired result by a process of trial and error, with recognition of the fact that loading the crystal with the metal coating will reduce the amplitude of oscillation, broaden the response curve and lower the frequency of maximum response of the part of the crystal so coated.

The example shown in Figs. 1 to 3, after the treatment by which only the thin initial silver coating 11 was applied to the face had a peak amplitude of oscillation at 18.0 megacycles/sec. After the addition of the thick silver coating, in the portion loaded with the thick layer the peak amplitude occurred at a frequency lowered by 0.5 megacycles/sec. and the amplitude was 30% lower, the crystal as a whole having the overall response curve shown in Fig. 4.

By depositing layers of metal of suitable different thicknesses over different portions of suitable area of the crystal, a wide variety of frequency-response curves may be obtained, such as curves having a conventional band-pass characteristic, or curves having a substantially flat top over a certain frequency range with substantially zero response to frequencies outside that range.

The coating may consist of metals other than silver, for example sputtered aluminium may be used; but it is preferred to start with a layer of chemically deposited silver, which can be readily deposited on a non-conducting crystal surface.

I claim:

1. A method of broadening the frequency response of a piezo-electric crystal, which comprises coating at least one of the faces of the crystal with a layer of metal, the thickness of said layer at one portion of said face being different from its thickness at another portion of said face.

2. A method of broadening the frequency response of a piezo-electric crystal which comprises chemically depositing a thin silver layer on at least one of the faces of the crystal and

thereafter electrolytically depositing an additional thickness of metal over only a part of said face.

3. A piezo-electric crystal having on at least one of its faces a thin coating of silver formed by chemical deposition, and over only a part of said coating an additional layer of metal formed by electrolytic deposition.

4. A method of broadening the frequency response of a piezo-electric crystal which comprises chemically depositing a thin silver layer on at least one of the faces of the crystal and thereafter electrolytically depositing an additional thickness of silver over only a part of said face.

5. A piezo-electric crystal having on at least one of its faces a coating of silver which on one part of said face is relatively thin and formed by chemical deposition and which over another part of said face is composed of an under layer formed by chemical deposition and an upper layer formed by electrolytic deposition.

6. A method of broadening the frequency response of a piezo-electric crystal which comprises chemically depositing a thin silver layer on at least one of the faces of the crystal, thereafter electrolytically depositing an additional thickness of silver over part of said face, and thereafter electrolytically depositing an additional thickness of metal over part of said face.

7. A piezo-electric crystal having on at least one of its faces a coating of silver which on one part of said face is relatively thin and formed by chemical deposition, which over another part of said face is composed of an under layer formed by chemical deposition and an upper layer formed by electrolytic deposition and which over at least part of said upper layer is composed of a surface layer of copper formed by electrolytic deposition.

8. A piezo-electric crystal having a relatively broad frequency response and having on its back and its edges a continuous coating of silver composed of a chemically deposited under layer and an electrolytically deposited upper layer, and over its face a continuous coating of silver separated from the first-mentioned coating, said face coating being composed of a chemically deposited relatively thin under layer and an upper electrolytically deposited layer over only part of said thin under layer.

9. A method of broadening the frequency response of a piezo-electric crystal which comprises chemically depositing a thin layer of metal on at least one of the faces of the crystal and thereafter electrolytically depositing an additional thickness of metal over only a part of said face.

10. A method of broadening the frequency response of a piezo-electric crystal which comprises the steps of depositing a thin metallic mechanical loading layer on at least one of the faces of the crystal and thereafter depositing an additional metallic mechanical loading layer over only a part of said face.

11. A piezo-electric crystal having on at least one of its faces a thin metallic mechanical loading member, and an additional metallic mechanical loading member superimposed over only a part of said first loading member.

12. A piezo-electric crystal having a thin metallic mechanical load of substantially uniform thickness on at least one of its faces and a second metallic mechanical load of substantially uniform thickness superimposed over only a part of said first load.

13. A piezo-electric crystal having a mechanical loading layer of metal on one of its faces, the layer being of uniform thickness over a first part of said face and being of greater thickness over a second part of said face.

14. A piezo-electric crystal having a mechanical loading coating of metal on one of its faces, the coating being of uniform thickness over a first part of said face and being of uniform thickness greater than said first-recited thickness over a second part of said face.

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