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B. MATTHIAS

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ROCHELLE SALT RESONATOR

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Fig. 1.

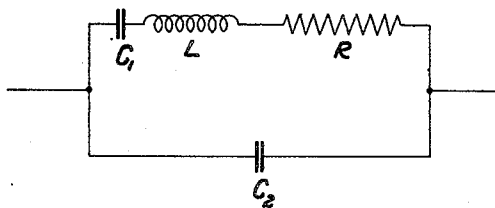


Fig. 2.

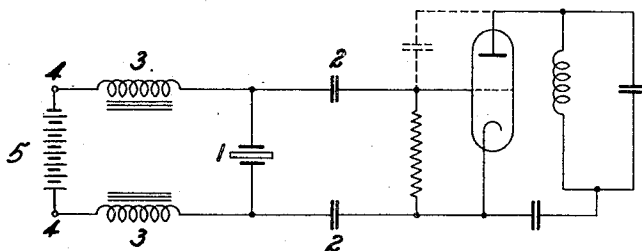
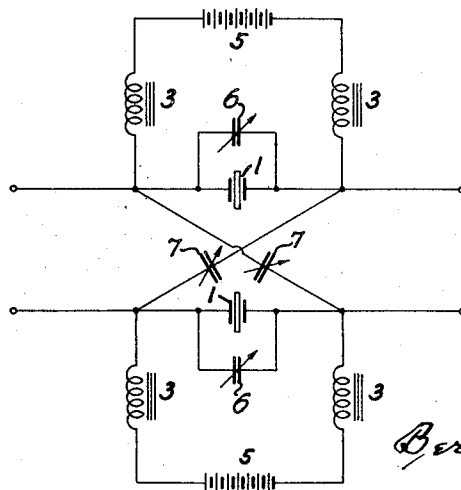


Fig. 3.



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ROCHELLE SALT RESONATOR

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The invention relates to oscillation circuits and more particularly to methods of and circuit arrangements for controlling the frequency of the oscillation circuit through the use of piezo-electric crystals.

It is known that by means of the piezo-electric effect crystals can be excited at their resonance frequency and used to stabilize high frequency electrical oscillations in oscillation circuits. Up to the present quartz crystals have preferably been used for this purpose, although it is also known to use crystals of Rochelle salt in their place. It is also known to apply a direct voltage to such a Rochelle crystal in order to change its resonance frequency. The practical application of Rochelle crystals is, however, greatly handicapped by the large damping. This is primarily a drawback as regards generator circuits because it is impossible to obtain a sharp and stable frequency. Filters with such crystals are not very selective.

A Rochelle electric crystal which is caused to oscillate can be regarded as the equivalent of an electrical oscillation circuit, which according to Fig. 1 consists of two capacitances C_1 and C_2 , an inductance L and an ohmic resistance R . This oscillation circuit possesses the disadvantage that the resonance frequency is not sharply defined and the dielectric losses are high. It is already known that the resonance frequency can be varied by applying a direct voltage to both faces of the crystals. This dependence of the resonance frequency on the applied direct voltage exists over the range within which the polarisation of the crystal shows a hysteresis character as a function of the voltage applied to both faces; that is to say the dependence exists up to field strengths of about 900 v/cm. If the field strength is increased still further another phenomenon occurs, namely for this range the electrical losses are much smaller than in the range where the polarisation has a hysteresis character. By applying a direct voltage the crystal becomes deformed. Therefore conversely by means of deformation it is possible to cause the hysteresis character of the polarisation to disappear practically. With these electrical or mechanical influences the piezo modulus remains at a value of about the same order of magnitude.

The present invention thus consists of an oscillation circuit for high frequency electrical oscillations whose frequency is controlled by at least one Rochelle electric crystal, the invention being characterised by the feature that means are provided whereby the operating point is lo-

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cated in a range within which the polarisation of the Rochelle electric crystal is practically a definite function of the voltage applied to both faces of the crystal.

Objects of the invention are to improve the selectivity or sharpness of tuning of oscillation circuits which include Rochelle salt crystals, the increased selectivity being obtained through new methods of and circuit arrangements for reducing the dielectric losses in the crystals. Objects are to provide oscillation circuits of the type including Rochelle salt crystals which are pre-loaded or polarized electrically and/or mechanically substantially to eliminate the hysteresis character of the known electrical polarization corresponding to biasing electrical fields of the order of up to about 900 volts per centimeter. Other objects are to provide methods of and apparatus for adjusting the frequency of an oscillation circuit which is frequency stabilized by a Rochelle salt crystal pre-loaded to such a degree that the resonant frequency of the circuit is substantially independent of small changes in polarizing voltages applied to the crystal to pre-load the same.

These and other objects and the advantages of the invention will be apparent from the following specification when taken with the accompanying drawing in which:

Fig. 1 is the equivalent circuit diagram of a Rochelle salt crystal; and

Figs. 2 and 3 are circuit diagrams of two oscillation circuits embodying the invention.

Two constructional examples of the invention are illustrated diagrammatically in Figs. 2 and 3 of the accompanying drawing, Fig. 2 showing a crystal-controlled transmitter and Fig. 3 an electric filter with two Rochelle crystals. In the arrangement shown in Fig. 2 the Rochelle electric crystal 1 is separated from the transmitter by the capacitances 2. In order to locate the operating point outside the aforementioned hysteresis region, so that the dielectric losses in the crystal are small, and so that a sharp resonance curve is obtained, a suitable direct voltage is applied to both faces. This is supplied to terminals 4 by a voltage source 5. The direct voltage source is separated from the crystal by the choke coils 3. These prevent high frequency power from escaping over the direct voltage source. The feed back from the anode to the grid circuit occurs over the grid-anode capacitance.

The dielectric losses not only depend on the initial voltage but also on the temperature. They attain a maximum value at the Curie points and

have a minimum value between these points.

It is therefore expedient to choose the operating point so that it lies in the region of this minimum value.

Fig. 3 shows how for example Rochelle electric crystals 1 are used in a filter arrangement of known type in which each crystal is shunted by a variable condenser 6 and the opposite faces of the crystals are cross-connected by variable condensers 7. By means of the direct voltage sources 5 the operating point on the Rochelle electric crystals is again located in a range where the losses practically disappear. The direct voltages 1 are separated from the crystals 1 by the high frequency blocking elements 3. If necessary the Rochelle electric crystals can also be separated from the rest of the high frequency arrangement.

In certain cases it may be an advantage to make the resonance frequency of the crystals variable, for instance so as to make the passing range of a filter variable. For this purpose the direct voltage should be varied in the hysteresis region, as already mentioned. It has, however, been determined that the resonance frequency also depends on the magnitude of the alternating voltage at the crystal surfaces, so that this voltage can also be employed for varying the frequency.

The dielectric losses are high when regulating with direct voltage. Furthermore the necessary alternating voltage alterations are much smaller than the corresponding direct voltage alterations. For this reason it is often an advantage to control the frequency with the alternating voltage. The alteration of the frequency as a function of the alternating voltage amplitude is a maximum when the temperature is so selected that the operating point lies in the region of one of the Curie points, it being particularly advantageous when it is in the region of the upper Curie point. Furthermore the temperature of the crystal can also be employed for slow changes in frequency, because the frequency follows a temperature-dependent course, whereby there is a minimum value at each Curie point and a maximum value between these points.

The direct voltage source for the elimination of the hysteresis losses can be obtained in several ways. Either a special direct voltage source can be provided, or the direct voltage is produced by extracting high frequency energy from the oscillation circuit and if necessary transforming it to a higher voltage and then rectifying it. In order to maintain the direct voltage exactly constant it is advisable to stabilize it.

If the frequency is to be kept as constant as possible, it is not only necessary to maintain the electrical values but also the temperature constant. Furthermore it is also an advantage to locate the operating point in a range where the resonance frequency changes as little as possible as a function of the temperature. For this pur-

pose the region of maximum frequency between both Curie points is especially favourable. It is, however, also possible to operate with the flattened parts at the Curie points. Furthermore in accordance with the present invention it has been recognized that by applying a field strength exceeding 1400 v./cm it is possible to achieve a considerable flattening of the resonance frequency curve as a function of the temperature, and the curve becomes still flatter if the alternating voltage is less than 0.1 volt.

The crystal becomes deformed when the direct voltage is applied. By means of this deformation it is therefore possible to make the hysteresis losses disappear. A favorable constructional form of the invention is therefore obtained when by deforming the Rochelle crystal, for instance by pressure, the operating point is located in a range where the polarisation of the crystal is practically a definite function of the voltage applied to both faces.

I claim:

1. An electrical high frequency oscillation circuit comprising at least one Rochelle salt crystal for controlling the frequency of the circuit, means for impressing an alternating current voltage upon the crystal, and a direct current source for establishing in the crystal an electrical field strength of the order of 1400 volts per centimeter.

2. In a filter, in combination, a circuit comprising a pair of conductors, a Rochelle electrical crystal in series with each conductor, and means polarizing said crystals to locate the operating points thereof outside the range within which the crystals exhibit a hysteresis characteristic as a function of the applied polarization, said polarizing means comprising a direct voltage source individual to each crystal and connected to impress a voltage across the opposite faces thereof.

3. The invention, as set forth in claim 2, wherein a high frequency blocking element is interposed between each voltage source and the crystal associated therewith.

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