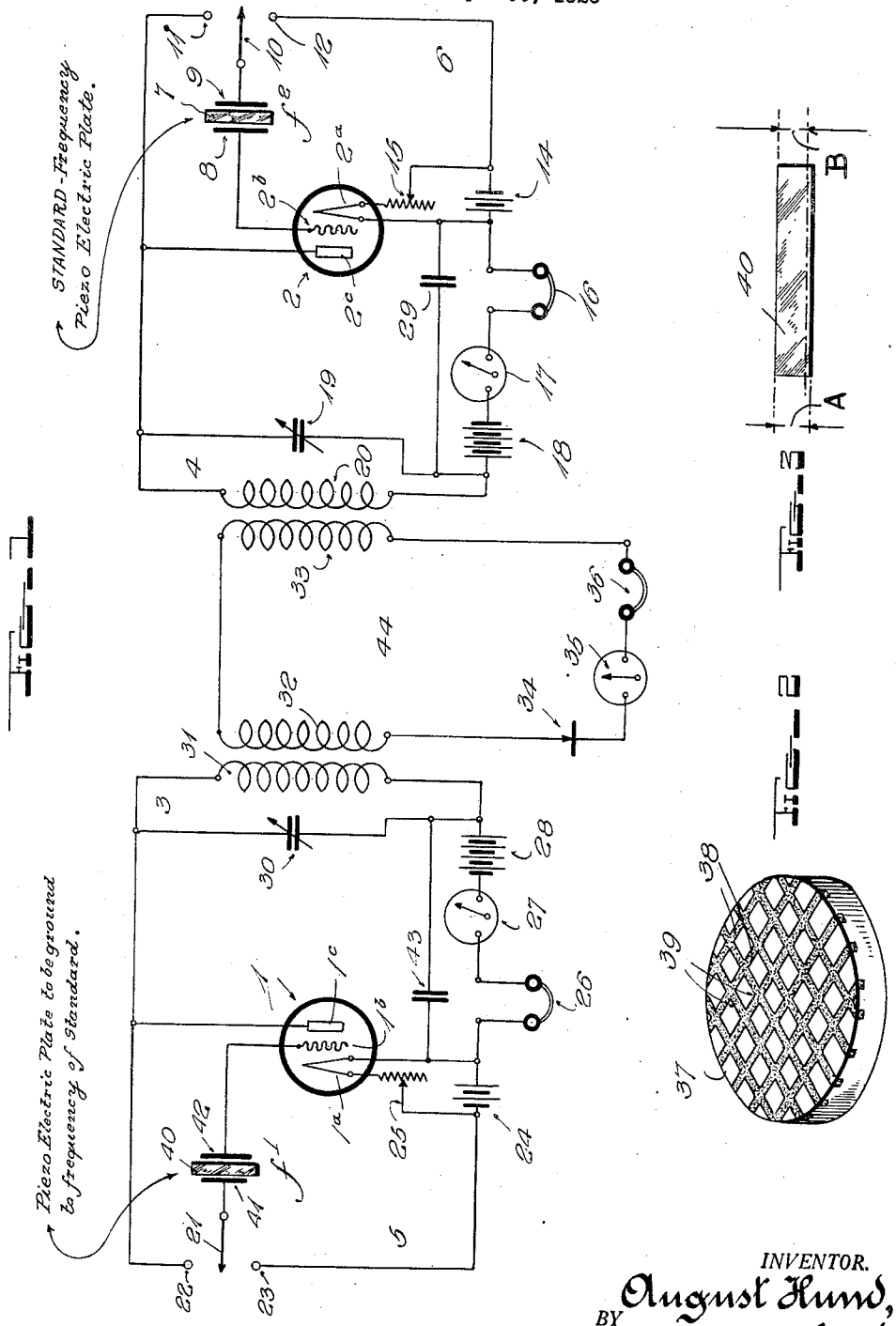
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METHOD OF PREPARING PIEZO ELECTRIC PLATES

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METHOD OF PREPARING PIEZO-ELECTRIC PLATES.

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My invention relates broadly to piezo electricity and more particularly to methods for preparing piezo electric plates for commercial use.

One of the objects of my invention is to provide a method of grinding piezo electric plates accurately to a required frequency.

Another object of my invention is to provide a method of preparing a piezo electric plate by which the frequency of the plate may be compared with the frequency of a standard piezo electric plate and any number of piezo electric plates of substantially the same frequency produced.

Still another object of my invention is to provide a visual system for grinding piezo electric plates to an accuracy within 1/180th of a cycle and better, even though the desired frequency is of the order of 10^6 cycles per second or greater.

A further object of my invention is to provide a method of preparing piezo electric plates by which an audible indication may be obtained of the approach of the frequency of the piezo electric plate under preparation to the frequency of the standard plate with means for visually observing the final frequency of the plate with respect to the frequency of the standard plate.

Other and further objects of my invention will be understood from the following specification by reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic representation of the system which I employ for accurately grinding piezo electric plates to the frequency of a standard piezo electric plate; Fig. 2 is a perspective view of the grinding plate against which the piezo electric plates may be ground for cutting the plate to that thickness which will respond to the desired frequency; and Fig. 3 represents a piezo electric plate under treatment and illustrates in exaggerated form a portion of the plate which is removed in the grinding process for securing a piezo electric plate of desired frequency characteristics.

Where it is desired to secure oscillations from a piezo electric plate which are correct for instance within 1/180th of a cycle even though the desired frequency is of the order of 10^6 cycles per second or more, it is not possible to use the well-known standard frequency meter for determination of the frequency of the plate, for frequency meters do not have the resolving power to indicate such accurate settings. I have discovered that a beat method lends itself practically in preparing a piezo electric plate having desired frequencies. Piezo electric plates of extremely accurate and predetermined frequencies are becoming necessary in the art for the frequency characteristics of a piezo electric plate possess such constancy that the plates are used for many purposes. The constant frequency characteristics of piezo electric plates are such that the plates when arranged in properly designed electrical circuits may be used as a standard of time. A piezo electric pendulum may be provided where piezo electric plates are arranged to operate a slow motion indicator producing a beat which may be observed at recurring periods of time spaced by time intervals of one second where desired. Where the terminals of a communication system are arranged to cooperate with each other on a high frequency channel, it is extremely important that piezo electric plates which are used to control both terminals of the system be cut accurately to the same frequency.

Referring more particularly to the drawings, reference characters 1 and 2 illustrate electron tubes each having filament, grid and plate electrodes 1^a, 1^b and 1^c, and 2^a, 2^b and 2^c, respectively. The electron tubes are arranged each with separate output circuits 3 and 4 and with independent input circuits 5 and 6 respectively. In the input circuit of electron tube 2 I provide a piezo electric plate 7 of a standard frequency. The standard piezo electric plate is positioned between the metallic plates 8 and 9 and connected in the electron tube circuit by a switching device 10 which may make contact at 11 or 12 to position the piezo electric plate in shunt with the grid and plate electrodes or the grid and filament electrodes of the electron tube system. The cathode 2^a is heated from battery 14 through rheostat 15. The output circuit of the tube 2 includes the telephone headset 16, the meter 17 and high potential battery 18 which are shunted by the radio frequency by-pass condenser 29. A tuned circuit comprising inductance 20 and variable condenser 19 is

connected across the output of the electron tube 2 for adjusting the oscillatory system to the desired fundamental frequency of the standard piezo electric plate 7. In the input circuit of electron tube 1, I connect the piezo electric plate 40 which is to be accurately ground to the frequency of the standard piezo electric plate 7. The piezo electric plate 40 is initially ground to a thickness in accordance with the formulæ which I have set forth in more detail in the aforementioned application for Letters Patent which will bring the frequency of the plate to within approximately one-half of one per cent of the required accuracy.

In my aforesaid copending application I have determined that the following empirical laws govern the value of the frequency possessed by piezo electric plates cut in accordance with the principles set forth in the said application:

$$f_1=\frac{2715}{d}$$

$$f_2=\frac{3830}{d}$$

$$f_3=\frac{2870}{t}$$

Where f is the frequency in kilocycles (k. c.) per second; t is the thickness in millimeters (mm.); and d is the diameter of the disc expressed in millimeters (mm.)

The piezo electric plate 40 is positioned between metallic plates 41 and 42 which are connected between the grid electrode 1^b and the switch arm 21 arranged to move over contacts 22 and 23 for connecting the plate in shunt with the grid and plate or grid and filament electrodes. The cathode heating current is supplied from battery 24 under control of rheostat 25. The output circuit of tube 1 includes telephone receivers 26, the indicating meter 27 and high potential battery 28 shunted by condenser 43 for by-passing radio frequency oscillations. A tuned system comprising variable condenser 30 and inductance 31 is connected in the output circuit of tube 1 and adjusted to the frequency of the piezo electric plate 40. A third circuit 44 is coupled with the inductances 20 and 31 through inductances 33 and 32 respectively, and connected with a rectifier 34, a milliammeter 35, and telephone headset 36. The telephone headset 36 can indicate audible currents down to about 15 cycles per second, while the milliammeter 35 can show alternating current variations between zero and fifteen cycles. Where the piezo electric plate 40 is cut approximately to the required thickness the frequency thereof is lower than the frequency of the standard piezo electric plate 7. This will give rise to a beat frequency in circuit 44 which will give an audible indication in telephone headset 36 and a visual indication in the meter 35 in accordance with the expression:

$$f_I=f_{II}\pm f_B$$

where f_I is the frequency of the piezo electric plate 40 which is to be ground to the frequency of the standard piezo electric plate 7. f_{II} represents the frequency of the standard piezo electric plate 7 and f_B is the beat frequency in circuit 44. The piezo electric plate 40 should be cut a trifle over-size so that f_I is somewhat smaller than f_{II}. The difference in frequency between the plate 40 and the plate 7 will be observed both audibly in telephone headset 36 and visually by means of the meter 35. Where the difference is large the plate 40 is removed from its position between metallic plates 41 and 42 and passed over a grinding plate 37. The grinding plate 37 is provided with laterally and longitudinally extending grooves 38 and 39 which provide cutting faces between which a mixture of emery powder and water is provided. The plate 40 is returned to its position between the metallic plates 41 and 42 and a lower beat note is observed in the circuit 44. This beat note may approach closer and closer to fifteen cycles and then pass beyond aural ability to hear a tone in the telephone headset 36. The process of grinding is repeated until the visual beat indicator 35 moves to and fro. Three "to and fro" motions per second show that the frequency of the plate 40 is "off" by three cycles per second and one "to and fro" motion in one minute indicates that the beat frequency f_B is "off" by 1/60th of a cycle. This process of grinding extremely narrow surface cuts from the crystal 40 is carried on until a complete zero beat effect is obtained. In Fig. 3 I have represented the piezo electric plate 40 as having an original thickness A and a final thickness B when the proper frequency is obtained, but it will be realized that the difference in thickness which has been represented in the drawings has been greatly exaggerated for the normal grinding operation of the piezo electric plate against the grinding surface 37 consists in passing the piezo electric plate lightly over the grinding surface to remove an infinitesimal thickness of the surface of the plate. I may employ a modified method of fixing the frequency of a piezo electric plate with respect to a standard with a high degree of precision.

The necessity for piezo electric plates of exactly the same frequency characteristics will be more fully appreciated when their application to carrier wave signaling systems is considered. In these systems it is often desirable to suppress the carrier frequency from transmission. The carrier frequency however must be renewed or restored at the receiving station so that piezo electric plates

of identically the same frequency both at the transmitter and receiver enable the system to function practically. Numerous applications of piezo electric plates for the control of high frequency signaling systems have been discovered where plates of accurately predetermined frequencies are essential.

It will be understood that in taking the comparative observations the standard piezo electric plate and the plate which is to be ground will be maintained at substantially the same temperature to avoid any errors which might occur due to temperature differences. Appropriate means may be provided for maintaining the temperature of each plate constant.

While I have described my invention in certain preferred embodiments, I desire that it be understood that modifications may be made and that I intend no limitations upon the invention other than those imposed by the scope of the appended claims.

What I claim and desire to secure by Letters Patent of the United States is as follows:—

1. In an apparatus for the preparation of piezo electric plates for the generation of predetermined frequencies, the combination of a pair of oscillatory circuits, a standard frequency piezo electric plate arranged to control the frequency of one of said oscillatory circuits, a piezo electric plate whose frequency is to be fixed arranged to control said other oscillator circuit, said last mentioned plate having an initial thickness corresponding to a frequency lower than the frequency of said standard plate, and an intermediate circuit coupled with each of said oscillator circuits and having means therein for indicating the difference between the frequencies of said standard piezo electric plate and said piezo electric plate whose frequency is to be fixed, said last mentioned piezo electric plate being capable of a reduction in thickness to the required dimension for the generation of oscillations equal in frequency to the oscillations generated by said standard piezo electric plate.

2. In a system for preparing piezo electric plates of predetermined frequency, the combination of a pair of oscillatory circuits, one of said circuits being controlled by a standard piezo electric plate of known frequency and the other of said oscillatory circuits being controlled by a piezo electric plate whose frequency is to be fixed, said last mentioned plate having an initial thickness corresponding to a frequency lower than the frequency of said standard plate, a third circuit coupled to said oscillatory circuits, and means in said third circuit for indicating the difference in frequency between said piezo electric plates, said last mentioned piezo electric plate being capable of a reduction to a thickness at which oscillations equal in frequency to the oscillations generated by said standard piezo electric plate are produced.

3. In a system for preparing piezo electric plates of predetermined frequency the combination of a pair of oscillatory circuits, one of said circuits being controlled by a standard piezo electric plate of known frequency and the other of said oscillatory circuits being controlled by a piezo electric plate whose frequency is to be fixed, said last mentioned plate having an initial thickness corresponding to a frequency lower than the frequency of said standard plate, a third circuit coupled with each of said oscillatory circuits, and means connected in said third circuit for both audibly and visually indicating the difference between the frequency of said last mentioned piezo electric plate and said standard piezo electric plate, said last mentioned piezo electric plate being capable of a dimensional reduction to a thickness at which oscillations equal in frequency to the oscillations of said standard piezo electric plate are produced.

4. In an apparatus for preparing piezo electric plates the combination of a pair of oscillatory circuits, one of said circuits being controlled by a standard piezo electric plate of known frequency, and the other of said circuits being controlled by a piezo electric plate whose frequency is to be determined, said last mentioned plate having an initial thickness corresponding to a frequency lower than the frequency of said standard plate, a third circuit coupled to each of said oscillator circuits, rectifying means connected in said third circuit, and visual and audible indicating means connected with said rectifying means, said audible indicating means being arranged to indicate the difference in frequency between said standard piezo electric plate and said last mentioned piezo electric plate through a given frequency range, and said visual indicating means being arranged to indicate the difference in frequency below the audible frequency range between said given frequency limit and zero, said last mentioned piezo electric plate being capable of a reduction to a thickness at which oscillations of a frequency corresponding to the frequency of the oscillations of said standard piezo electric plate may be produced.

5. A piezo electric apparatus comprising in combination a pair of oscillatory circuits, a standard piezo electric plate of known frequency arranged to control one of said oscillatory circuits, a piezo electric plate of slightly different frequency arranged to control said other oscillatory circuit, a third circuit coupled with each of said oscillatory circuits and having means therein for indicating the difference in frequency between said piezo electric plates.

6. In a piezo electric apparatus the com-

bination of a pair of electron tubes each having grid, filament and plate electrodes, input and output circuits for each of said tubes, interconnecting said electrodes, a standard piezo electric plate of known frequency arranged to be connected between the filament and grid or between the plate and grid of one of said electron tubes, a second piezo electric plate of slightly different frequency arranged to be connected between the filament and grid or between the plate and grid of said other electron tube for impressing upon each of said output circuits constant frequency oscillations of slightly different frequencies and a third circuit coupled with each of said output circuits and having means therein for observing the difference in frequency between said piezo electric plates.

In testimony whereof I affix my signature.

AUGUST HUND.