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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

Letter
Circular
LC 186

(November 20, 1925)

SPECIFICATIONS FOR PORTABLE PIEZO OSCILLATOR,

BUREAU OF STANDARDS TYPE N.

This device is a type which was originally designed by the Bureau of Standards for use by the radio inspectors of this Department. It is useful as a frequency standard, for the calibration of frequency meters, and as an aid in maintaining constant frequency of transmitting stations. The specifications are in a form suitable for use by a manufacturer. It is estimated that the device can be manufactured for approximately $100 to $130 plus the cost of the quartz plate, which may be somewhere from $10 to $30. The user will have to provide in addition a pair of headphones, 4 No.6 dry cells (or a 6-volt storage battery), 4 B-batteries (each 22 1/2 volts), and one electron tube, UV-201A or equivalent.

The Bureau of Standards has made no investigation of the possible existence of patents covering any of the features of these specifications, and takes no responsibility for their freedom from patent infringement.

Determination of Quartz Plate Frequencies.- The quartz plate, or the complete piezo oscillator, should not be sent to the Bureau of Standards for calibration. In general, the apparatus should be sent to a commercial standardizing laboratory, or, the user may determine the frequencies by comparison with the Bureau's standard frequency signals. The Bureau will furnish upon application a schedule of its standard frequency signal transmissions and a pamphlet (Letter Circular 171) which includes directions for the use of harmonics in obtaining desired frequency values from any particular known frequency. In some special cases, as for instance where the piezo oscillator is to be used in a transmitting station to maintain the station frequency constant, the Bureau may make the frequency determination; but arrangements should always be made by correspondence before sending any material to the Bureau; see below, last paragraph under "Use in Transmitting Stations."

Use in Calibrating Frequency Meters.- For use in the calibration of most frequency meters (wavemeters), it is convenient to use with the piezo oscillator an auxiliary generator of radio-frequency current. Specifications for such an auxiliary generator are available in Bureau of Standards Letter Circular No.187, "Specifications for Portable Auxiliary Generator, Bureau of Standards Type O." Directions for the use of the apparatus are given in Bureau of Standards Letter Circular No.183, "Directions for Use of the Piezo Oscillator and Auxiliary Generator for Calibration of a Radio Frequency Meter." As explained in that Letter

Circular, this combination of apparatus gives a remarkably convenient and rapid means of calibrating any frequency meter throughout the whole frequency range from 18 kilocycles to 10,000 kilocycles (17,000 to 30 meters).

Use in Transmitting Stations.- An important application of the piezo oscillator is its use in a transmitting station as a constant-frequency comparison standard. Reference is not made here to so-called crystal control or piezo control of station frequency, in which the output of a piezo oscillator is amplified by a power amplifier, the power amplifier in turn feeding into the antenna. Piezo control would require material modification in the transmitting apparatus at most stations. Use of a piezo oscillator as a frequency indicator or comparison standard, however, requires no alteration in the apparatus whatever. Such use is particularly valuable and important in broadcasting stations. A station using this device might be called a "crystal checked" station, in contradistinction from a "crystal controlled" station.

These specifications call for a quartz plate whose fundamental frequencies are approximately 75, 105, and 450 kilocycles per second. Most of the specifications will apply when the quartz plate is made for other frequencies, some changes being necessary in the dimensions of the quartz plate holder, the quartz plate itself, and the two coil windings. For use in broadcast stations, the quartz plate should be cut to a thickness in millimeters approximately equal to 2700 divided by the station frequency in kilocycles, instead of the thickness of 6 millimeters specified herein.

When a piezo oscillator is thus intended as a station frequency standard, the Bureau of Standards will, if requested, make the final adjustment of the quartz plate to the station's licensed frequency; the fee for this is $20.00. The quartz plate should be cut to give a frequency approximately 1% lower than the station frequency; this will enable the Bureau to adjust to the exact frequency by reducing the thickness of the plate. The Bureau may refuse to undertake any work on a quartz plate which does not operate readily or which is appreciably more than 1% below the station's licensed frequency.

General Design.- The piezo oscillator is a simple electron tube apparatus, with an inductance shunted by a variable capacity in the plate circuit. The inductance is provided by either of two detachable coils. Provision is made for the connection of the quartz plate between the grid and filament or between grid and plate. The function of the quartz plate is to control the frequency of the current in the tube circuits in accordance with the frequency of a mechanical vibration of the quartz plate.

The various parts of the outfit, scheme of connections, etc., are shown on the drawings, which are considered as parts of these specifications (see note at end hereof). Workmanship and materials throughout shall be of the best grade.

Connections, Etc.- Fig.1 gives a top view of the piezo oscillator showing: the knob of the filament rheostat (1); the dial of the variable condenser (2) which has a 6-to-1 slow-motion device; and the milliammeter (3) with a 0 to 5 milliampere scale for noting the plate current of the tube. The switch (13) is used for connecting the quartz plate either between the filament (F) and the grid or between the plate (P) and the grid. Terminals for a telephone receiver are provided in such a way that it is inserted in the plate circuit. Fig.2 is a side elevation of the apparatus.

Fig.7 gives the rear view of the panel with the necessary electrical connections. The plate terminal of the tube is in series with the two jacks (6) provided for either one of the two inductance coils. In parallel with the two jacks is the variable air condenser (3). In series with the two jacks are two binding posts for the B-battery with its positive pole next to the inductance coil. In series with it are another set of two binding posts for the telephone receiver. In series with them is a milliammeter (3) and the terminals leading to the A-battery of the tube. The positive terminal of the A-battery leads through a rheostat (1) of 6-to-10 ohms resistance to the positive terminal of the tube socket, while the negative terminal goes directly to the negative terminal of the socket and to the contact point marked F (see Fig.1). The contact point marked P connects to the plate terminal of the tube socket. The B-battery, the telephone receiver and the milliammeter are shunted by a mica condenser (4) of 0.01 μf. This is accomplished by connecting one terminal of this condenser to the positive terminal of the milliammeter while the other terminal of the mica condenser leads to the positive terminal provided for the B-battery.

Coils.- Fig.8 gives details of the forms upon which the coils are wound. The forms are of material of the bakelite type. Two coils are required for the three frequencies of the quartz plate specified herein. The first coil is wound with 40 turns of No.26 AWG enameled wire with one serving of silk. The second coil is wound with three layers of the same size of wire having 54, 53 and 52 turns of wire on the successive layers. A binder such as collodion may be used on these coils to hold the turns in place. As shown, the windings terminate in special plugs, as furnished with General Radio Co. type 274, or equivalent.

Quartz Plate.- The quartz plate is a flat disk approximately 36 mm. in diameter and 6.0 mm. thick. It is not important that these dimensions be exact, but any departures from them will require corresponding changes in the quartz plate holder. See also

statement regarding quartz plates for other frequencies, in second paragraph of "Use in Transmitting Stations," above. It is important that the quartz plate be properly cut from the quartz crystal and that the two faces of the quartz plate be strictly parallel. The edges of the quartz plate are to be beveled slightly to reduce the possibility of small pieces chipping off. Quartz plates ground for use in piezo oscillators can be obtained from a number of optical shops.

Quartz Plate Holder.- The dimensions of the holder for the quartz plate, as shown in Fig.10, are for the specific size of quartz plate given in preceding paragraph. Corresponding changes must be made if a quartz plate of different size is used. The holder consists of a piece of material, (5) Sheet 3, of the bakelite type, 2 5/8" x 2 7/16" x 3/4", which is bored out to hold the quartz plate and one nickel-plated brass disk electrode (7). The other electrode (6) is also of nickel-plated brass. The bakelite block (5) should be bored out to such a depth that when the electrode (7) and quartz plate are in place, the upper electrode (6) will clear the quartz plate by about 0.2 mm. It is of great importance that the bread faces of the bakelite block (5) be strictly parallel, as this determines parallelism of the two metal electrodes (6) and (7) between which the quartz plate is placed. The terminals for connection of the holder to the circuit are special plugs, as furnished with General Radio Company type 274, or equivalent. The mounted quartz plate, i.e., plate and holder, after being assembled and found to be in working order, should not be opened, but considered as a unit.

Panel.- Fig.3 gives the details of the panel forming the top. It is of material of the bakelite type. It is 8 1/2 inches square and 1/4 inch thick. All apparatus is mounted either on its top or bottom. Fig.4 gives the detail construction of the terminal blocks into which the quartz plate holder fits. The panel (9) is held in place in the cabinet by four 8-32 machine screws countersunk in the four corners of the panel. The four machine screws fit into four brass blocks shown on Sheet No.1 at (7) and in Fig.5, each of which is held in place by two 8-32 machine screws countersunk through the sides of box.

Assembly.- The various parts must be securely fastened in position. All binding nuts must be tightened and soldered in position. All connecting wires must be bare and self supporting and of a size not less than No.12 AWG (B&S). All wire must be tinned or nickel-plated copper. No soldering flux showing acid reaction shall be used, and all excess flux must be removed.

Cabinet.- The apparatus shall be housed in a well-seasoned baywood or walnut box as indicated in Fig.6, which gives a general view of the box including the cover. The thickness of the material shall be 1/2 inch, and all joints shall preferably be dovetailed.

The cover provides space for the two plate coils and the quartz plate holder, mounted as shown in Fig.9. Each coil is held by two phosphor bronze strips, Fig.11. The quartz plate holder is held in a small wooden compartment, (4) Sheet 3, lined with felt. The cover shall be equipped with separable hinges (9). The top shall have a handle for carrying. Two spring clasps shall be provided to hold cover positively shut when instrument is carried. No lock with key shall be used. The under side of the cabinet shall be provided with four rubber shock absorbers.

Finish.- All exposed metal parts shall be heavily nickel-plated, bright finish, except some parts (milliammeter, etc.) which are finished in black. The cabinet shall be stained somewhat darker than the natural color of the wood used and given at least two coats of a satisfactory rubbing varnish.

Marking.- As indicated in Fig.1, the following is to be engraved on top of the panel:

"COIL" in the space between the coil jacks.

"A" and "6V" in the space between the corresponding binding posts, with a plus and a minus sign as indicated in drawing.

A curved arrow with the inscripts "ON" and "OFF" around the path of the pointer of the rheostat (1).

The letters F and P next to the two contact points of switch (13). The blind contact in the center has no inscript since it serves merely the purpose of keeping the sliding blade of switch (13) in the upper plane of the active contact points F and P.

"QUARTZ PLATE" in the space between the blocks (11).

"TEL." in the space between the terminals (5).

"B 80V" between the corresponding binding posts with a plus and a minus sign as indicated in the figure.

Note: The letters shown in Fig.7 which give the rear view of the panel are not to be engraved. They are placed on the drawing in order to make the diagram of connections clear.

A piezo oscillator made in accordance with these specifications may have engraved in a suitable space, "Piezo Oscillator, Bureau of Standards Type N," followed by the name of the maker.

Drawings.- Radio Nos. 1006A, B and C, giving Figs.1 to 11, may be obtained by anyone actually requiring them for construction of this device, upon application to the Bureau of Standards.

Department of Commerce, Washington, D.C.