

March 24, 1928.

USE OF THE PIEZO OSCILLATOR IN RADIO BROADCASTING STATIONS.

General.

This Letter Circular considers one important application of the piezo oscillator, namely, its use in a broadcasting station for checking and assisting in the maintenance of a constant frequency close to the licensed value. This is not the same thing as automatic piezo control, in which the amplified output of a piezo oscillator is actually transmitted. The discussion herein is in two parts, viz., suggestions for the construction of a piezo oscillator and specific instructions for the particular use just mentioned. Information on construction of a piezo oscillator for general purposes is given in this Bureau's Letter Circular 246, "Specifications for portable piezo oscillator, Bureau of Standards Type N," which may be obtained upon request from the Bureau of Standards. The present Letter Circular describes certain modifications of that construction which render it somewhat simpler and less expensive. Other types of piezo oscillators are suitable for checking the frequency of a broadcasting station by the methods described in this Letter Circular.

Automatic piezo control, that is, a system in which the piezo oscillator is made a part of the transmitting circuits, eliminates the need of observation and adjustment. However, this condition may in itself constitute a disadvantage since in case of failure of the piezo control to function properly the trouble may not become known for a considerable time. The incorporation of automatic piezo control is elaborate and expensive. On the other hand, the use of the piezo oscillator as a separate device for checking is a very simple matter because no modifications whatever are required in the transmitting set.

The use of the piezo oscillator as a separate device for checking has been found by the Bureau of Standards to be useful and satisfactory, and has two distinct advantages over a frequency indicator, frequency meter, or any similar device which indicates the proper adjustment by maximum deflection of a needle moving over a scale. First, it is a particularly constant frequency standard. Second, the indication of a piezo oscillator is unaffected by fluctuations in the station's power or degree of modulation. For this reason it may be used to check the frequency of the broadcasting station with equal accuracy under all conditions of operation. A caution required in using the piezo oscillator, as compared to a device using a visual indicator, arises from the fact that some confusion may be caused by the production of beats from so-called fractional harmonics. This

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difficulty is overcome by familiarity with the use of the piezo oscillator and by securing an initial adjustment of the transmitting set giving approximately the required frequency.

Construction of Piezo Oscillator.

Almost any piezo oscillator will be satisfactory for this use. The type described in Letter Circular 246 is suitable, but it is preferable to construct it with the modifications listed below which simplify it for this purpose.

It is estimated that this piezo oscillator can be manufactured for approximately \$100 to \$120 plus the cost of the quartz plate which may be about \$25 to \$50. The Bureau of Standards does not manufacture or sell the piezo oscillator, the quartz plate, or any other device. 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.

Blueprint Sheet No.3 (with Letter Circular 246).- Make one coil form instead of two, also one pair of spring catches for holding coil in cover of cabinet instead of two pairs. (See Letter Circular 246, p.3, last paragraph). This coil form is wound with a single layer of No.24 AWG (B&S) double cotton covered wire. The approximate number of turns is determined by the frequency of the broadcasting station in which the piezo oscillator is to be used. If this frequency is below about 800 kilocycles, 40 turns are satisfactory; for frequencies higher than this, about 25 turns should be used. The turns specified assume the use of a 0.001 microfarad variable condenser (blueprint sheet No.1 accompanying LC246.)

Care and Operation of the Piezo Oscillator.

The quartz plate with its holder should be considered as a unit and the holder should not be opened. The frequency of a quartz plate may be changed by variations in temperature and circuit constants. Instruments are necessary to insure that the quartz plate is used with the same adjustments of the circuits as at the time of calibration. If an accuracy better than a few parts in 10,000 is desired, the quartz plate should be kept in a temperature-controlled cabinet. For use in stations of the higher frequencies, it may be advantageous to select a quartz plate which has a harmonic rather than a fundamental frequency of the proper value. Thus a quartz plate having a lower frequency, related to the licensed frequency of the broadcasting station by some simple ratio such as $1/4$, $1/3$, $1/2$, $3/2$, etc., would be used for checking the transmitted frequency. It has been found that a harmonic of the fundamental oscillation is usually satisfactory for this purpose. The condenser and coil of the piezo oscillator should be designed so as to include the fundamental frequency of the quartz plate that is to be employed

in checking the frequency of the transmitting station. For example, if the assigned frequency is 1000 kc and it is desired to use a quartz plate having a fundamental of 100 kc, the condenser and coil should be capable of tuning to 100 kc.

Dry batteries may be used to supply the necessary power to the piezo oscillator. It is very desirable that these be placed in a battery box with convenient connection terminals plainly marked which are connected to the piezo oscillator with flexible insulated leads. If a dry-cell A-battery is employed the filament rheostat should at all times be turned off when the piezo oscillator is not actually in use; otherwise frequent renewals will be necessary. The use of a storage A-battery is to be preferred. Failure of the piezo oscillator to operate may be due to defective A or B batteries or a defective tube. Occasionally trouble may be due to the quartz plate sticking in the holder and this may be overcome by shaking the holder slightly.

Use in Checking Frequency of Broadcasting Station.

After the quartz plate has been adjusted to the required frequency (see instructions in Letter Circular 246), the piezo oscillator is ready for use in checking the frequency of the station. The piezo oscillator is placed in the operating room in a convenient location for listening in the headphones and making the necessary frequency adjustment of the transmitting set. The most satisfactory location is determined by trial. If the piezo oscillator is too close to the source of power its operation may be unsteady as evidenced by jerking of the needle of the milliammeter; if too far away, a beat note of satisfactory intensity will not be obtained. If necessary, the leads to the headphones may be lengthened in order that the same observer may make the adjustment of the transmitting circuit while listening to the beat note in the phones of the piezo oscillator.

In the initial use it is very desirable that some form of frequency meter (wavemeter) be used to obtain an approximate frequency adjustment of the transmitting set and also to insure that the beat note obtained in the phones of the piezo oscillator is produced by the fundamental frequencies. After a little experience has been gained in the use of the piezo oscillator it should not be necessary to employ an auxiliary measuring instrument.

After making an approximate adjustment of the transmitting set to obtain a frequency differing by not more than about ten kilocycles per second from the piezo oscillator, a beat note will be heard in the phones of the piezo oscillator. This beat is caused by the interaction of the two frequencies. The frequency of the transmitting set is then adjusted in such a manner that the pitch of the beat note becomes lower and lower. The adjustment is carefully continued until zero beat is produced; that is, the condition where the beat is no longer audible in the headphones

of the piezo oscillator but reappears when the frequency of the transmitting set is increased or decreased slightly. This indicates that the transmitting set is very accurately adjusted to the frequency of the piezo oscillator. This condition should be checked at frequent intervals (e.g., every five minutes) by listening in the headphones to ascertain that a constant frequency is being maintained. Care should be taken to see that the piezo oscillator is generating at all times when the frequency of the transmitting set is being checked, otherwise it may appear that a zero beat adjustment is being maintained when actually the frequency of the transmitting set has shifted.

An amplifier and loudspeaker may be provided and the piezo oscillator operated continuously while the transmitting set is in operation. Any appreciable change in the frequency of the transmitting set will then be known at once and can be corrected immediately.



