BROADCAST EQUIPMENT

PART V—AUDIO-FREQUENCY MEASUREMENTS

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IT has been shown that an attenuation equalizer is "a corrective network which is designed to make the absolute value of the transfer impedance, taken with respect to two chosen pairs of terminals, substantially constant for all frequencies within a desired range." (A.I.E.E. Standards) Our particular interest in this device is as applied to the audio-frequency program lines between the program origination points and the transmitting station. This of course includes all remote lines as well as the regular program wires.

Before using a line for program transmission, the necessary equalizer adjustments are made. An audio-frequency signal voltage of constant value and variable known frequencies is impressed across the line input and the level is measured at the termination with a volume indicator. Preliminary adjustments of the equalizer resistance are made at several of the most important frequencies, such as 1,000, 500, 100, 3,000, 5,000, 1,000 c.p.s., in that order. All these signals must be at very nearly the same predetermined level. Finer adjustments are then made until a flat characteristic is attained, thus insuring equal transmission of all frequencies throughout the required range.

For high-fidelity transmission and to satisfy good engineering practice, the entire broadcasting system must be substantially flat (i.e., within ±1 db) from 30 to 10,000 c.p.s. Although the program line is now assumed to be properly equalized, the over-all characteristic must take into consideration the remainder of the system as well, including the microphones, speech equipment, and transmitter. However, when frequency-run measurements are made, the microphone is excluded from the apparatus and the characteristic curves provided by the microphone manufacturer are employed.

The arrangement for a frequency run is illustrated in the block diagram of Fig. 1. The source of steady tone is an audio-frequency oscillator. For greatest accuracy, it is important that the harmonic content of the oscillator be of a very low order. The oscillator output is fed into the preliminary amplifier through a resistance network, for purposes of isolation and impedance-matching.

Before commencing the frequency run, it is necessary to ascertain that there is present neither regeneration caused by an unbalanced circuit nor R.F. feedback induced in the supplementary equipment assembled for this test. To verify the absence of regeneration due to an unbalanced circuit, after all equipment has been turned on and allowed to warm up, the transmitter is adjusted to its authorized carrier power and the gain controls and speech amplifiers are set at normal operating levels. The A.F. oscillator is set at about 10,000 c.p.s. at any convenient level. After a few moments, the oscillator and resistance network are removed from the circuit by opening switch S. If the line-amplifier volume indicator and the modulation-monitor meter indications do not fall to zero immediately, there is some regeneration present.

When testing for the presence of R.F. feedback, the audio oscillator remains in the circuit but its power is removed. The modulation-monitor and volume-indicator meters are again observed. Any erratic fluctuations or failure of these instruments to indicate zero is evidence of R.F. feedback. Furthermore, if the modulation system is a class-B amplifier, and its static plate current increases when the speech amplifiers are turned on and connected into the circuit, this is further proof of R.F. feedback. In this case, R.F. energy is being induced and rectified in one of the amplifiers, which in turn modulates the transmitter with the undesirable signal, at a frequency which is often beyond the upper limits of audibility.

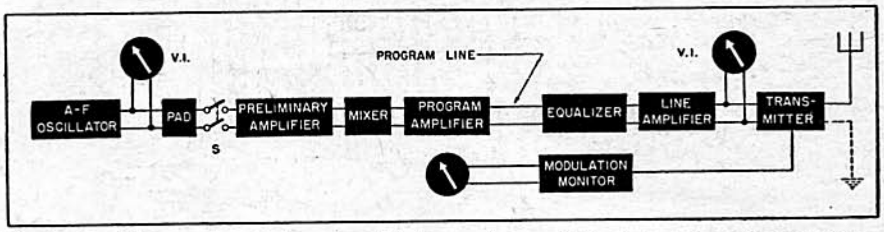

Fig. 1—Oscillator, pad, output and modulation meters as laid out to make a frequency run.

The following procedure should always be used after completing a new installation or when the over-all frequency characteristic is known to be non-linear and a precise determination of the deficiency is desired.

A reference frequency and percentage of modulation must first be established, such as 1,000 c.p.s. and 50% peak. These are desirable values, as the sensitivity of the human ear is maximum around 1,000 cycles, and a low percentage of modulation prevents any possible overloading, with its resultant harmonic distortion and increased meter readings. The transmitter should previously be carefully adjusted for symmetrical modulation. Nevertheless, as a further precaution, all calculations and plotting should be made with reference to the same modulation peak, whichever is chosen for the test.

The transmitter has now been adjusted to its regular operating power, and the audio oscillator is set at the 1,000-c.p.s. reference frequency at a convenient output level. The volume controls are then adjusted until the modulation-monitor meter reads 50% modulation. Thereafter, no further adjustments are to be made on any of the equipment, except that the audio-oscillator output is kept exactly the same for all frequencies. After adjustments at the ref-

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FREQUENCY RUN

DATE .... ( ) REGULAR ( ) EMERGENCY ( ) INTERCOMM TIME .... ( ) A.M. ( ) P.M.

FREQUENCY, CYCLES PER SECOND	LINE AMP. V.I. WHEN AUDIO OSC. V.I. READS ______	MODULATION MONITOR D.B. SCALE	
		POS. PEAK	NEG. PEAK
(reference) 1,000			
500			
100			
60			
30			
2,000			
3,000			
4,000			
5,000			
6,000			
8,000			
10,000			
(reference) 1,000			

REMARKS:

SIGNED: ....

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Fig. 2—Frequency checks are taken in the order shown above, and data is carefully tabulated.

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erence frequency have been made, a written record is made of the oscillator output, the indication of the line-amplifier volume indicator, and the indication of the secondary scale of the modulation-monitor meter, which is calibrated in decibels. This procedure is then repeated, as shown in the data sheet of Fig. 2, for the frequencies given, and in that order. The oscillator is readjusted to the reference frequency at the conclusion of the test, in order to verify the original readings and determine that no unexpected changes have occurred during the operation. Finally, the reading of the modulation monitor at the 1,000-c.p.s. frequency is taken as the reference level and the results obtained are plotted on semilogarithmic graph paper, as shown in Fig. 3.

Another method, practically the converse of that just described, does not appear to have any particular advantage, although it may be more convenient in some instances. The same precautions against regeneration are taken, and a reference frequency and modulation percentage are chosen as before. However, instead of keeping the oscillator output constant, it is varied so that the modulation-monitor meter indication is maintained at 50% throughout the range of frequencies specified in Fig. 2. The readings of the audio-oscillator volume indicator are then recorded and used for plotting the frequency characteristic curve. Thus, if at some frequency other than the 1,000-c.p.s. reference frequency, this volume indicator reads 1 decibel above the reference level, the overall response of the system is revealed as being down 1 db at that point.

It is quite obvious that equalization and frequency runs cannot be made during a station's regular program schedule. Any program modulation would nullify the results of the testing, and tone modulation would seriously interfere with the program. However, these necessary operations are provided for in the F.C.C. Rules and Regulations, which state: "The term 'experimental period' means that time between 12 midnight and local sunrise. This period may be used for experimental purposes in testing and maintaining apparatus by the licensee of any standard broadcast station on its assigned frequency and with its authorized power, provided no interference is caused to other stations maintaining a regular operating schedule within such period."

There are always at least two separate telephone lines between the main studios and the transmitter. This is most often the case with remotes as well. One line is the regular program wire, and may have an alternate for emergencies. The other is the intercommunication line or order wire. All of these lines are usually properly equalized, so that any one of them may be patched into the program circuit if necessary. If the lines are long, it is necessary to insert amplifiers known as "boosters" or "telephone repeaters" at intervals. The actual distance between repeaters depends upon individual circumstances, and is usually between 10 and 20 miles. All telephone lines and associated repeaters are furnished and maintained as a part of the service of the local Telephone Company. It should be understood that these are privately leased wires and do not go through a switchboard operator. They are considered as a part of the permanent installation and are not subject to tampering or interference. Although the telephone repeaters undergo a rigid schedule of inspection and servicing, they may occasionally be a source of distortion. If this is detected when making the daily frequency run, it should be immediately reported to the telephone company, so that the trouble may be remedied before air time.

The next installment will begin a discussion of the special requirements and operation of the line amplifier at the transmitting station.

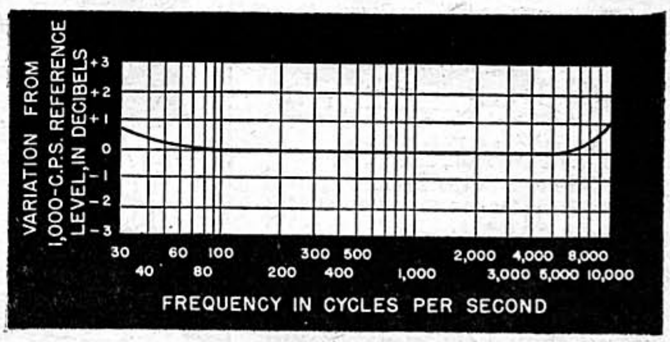

Fig. 3—Frequency characteristics of equalized line, as plotted from regular test run.