Notes on audio-frequency measurements

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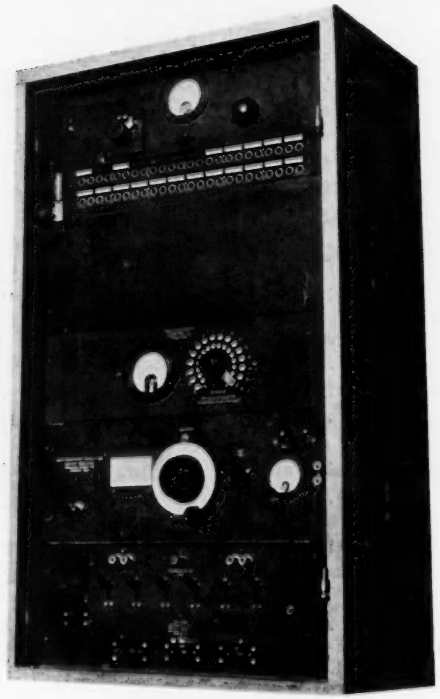

Portable equipment for making gain frequency measurements on studio field units and theater sound equipment

THE importance of maintaining recording equipment of a studio in perfect condition is apparent to anyone having an appreciation of production schedules. To properly maintain such a system, it is very desirable to test the equipment on some definite schedule since experience has shown that such testing insures a uniform product without costly delays and inconvenience. The gain-frequency method of testing such equipment is very rapid, reliable and the apparatus used for making these tests can be assembled from standard units which are available.

In order to measure the gain of equipment at the various frequencies which pass through the system, an oscillator, gain set or attenuator, a volume indicator or power level device and the necessary switching keys are required. The amplifier and associated circuits to be measured are connected between the send and receive terminals of the gain-set. A tone of the desired frequency from the oscillator is applied to the attenuator input and the loss of the attenuator is set at the expected gain of the system. When the measuring device is transferred from the input of the attenuator to the output of the amplifier and the level is the same, the loss in the attenuator is equal to the gain of the amplifier provided the impedances of the amplifier are the same as that of the gain-set. When these impedances are not identical to those of the gain-set, repeating coils or transformers of the proper ratio are employed.

The equipment shown is the complete equipment necessary to make these tests. It is built in portable form so that it may be conveniently used to test field units and theater reproducing equipment. The lower panel consists of the input attenuators, keys, volume control and output termination for the equipment under test. The next panel above is a frequency oscillator. At the extreme top is a power amplifier which has a gain of 20 db. and a carrying capacity of plus 10 db. or 60 milliwatts. The volume control is placed between the oscillator output and amplifier input. Above the oscillator is a power level indicator. Above this is the impedance matching coils and the jacks. The connections to all pieces of equipment appear on individual jacks.

Power level indicator

In detail the attenuator unit consists of a General Radio type 552, 500-ohm H type, 30 db. network with 1.5 db. per step, one 40 db. fixed unit, and a 10 db. 500-200-ohm unit to be used when 200-ohm loads are measured. The attenuators are arranged on keys in such a manner that any combination of units can be used depending upon the impedance and loss required. The terminating resistance on the output is 500 ohms and the power level indicator is arranged on a double throw double pole switch to compare input and output.

It is customary to measure power level in voice transmission lines by observing the voltage across the line. This is an indication of the power when the impedance of the line is shown. A common impedance of such lines is 500 ohms. The power level is usually wanted in decibels from some standard reference level, such as six milliwatts. For these reasons the power level indicator is calibrated to read in decibe's above and below a six milliwatt reference level on a 500-ohm line. The sensitivity of the General Radio level indicator is such that it will read from a minus ten to a plus six decibel level. The scale of the meter is calibrated in 2 decibel steps through this range. A curve is supplied which gives the correction to be applied for lines of other impedances.

In order to increase the upper range of the instrument, a calibrated resistive multiplier is inserted between the input terminals and the rectifier and meter elements. The multiplier is so designed that the input impedance of the indicator is constant regardless of the multiplier setting. By means of the multiplier the upper range of the instru-

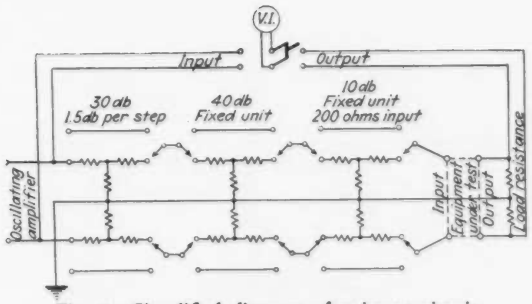

Fig. 1—Simplified diagram of gain set circuit to obtain power level in decibels

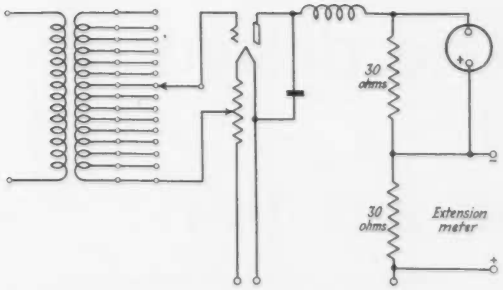

Fig. 2—Schematic diagram of volume indicator circuit showing connections for extension meter

ment is increased to 36 decibels in 2 decibel steps.

The impedance of the unit is 5,000 ohms which is high enough so that it absorbs a negligible amount of the available power. When used on a 500 ohm line, the bridging loss is only 0.4 decibel. The sensitivity is independent of frequency from 20 to 10,000 cycles, and the error in this range is usually less than 0.2 decibel.

The volume indicator

The commercial volume indicator used to indicate relative sound volumes in public address, broadcasting, and recording, is based on a reference volume of six milliwatts across a 500-ohm circuit. This means that for an input of six milliwatts at its input terminals, the meter in its plate circuit gives a mid scale reading which is indicated as zero. A reading of more than this value is a measure of power greater than six milliwatts and is called a plus level. A reading less than mid scale is called a minus level. The meter generally has 30 divisions which means that the reference is taken at 30 divisions. It has been found convenient to calibrate the meter only 2 db. each side of reference. Since the meter is calibrated logarithmically, it is easy to estimate other values, since the scale reading is an indication of voltage. Hence, a reading of two times 30 or 60 gives a voltage ratio of 2 or an increase of 6 db., also a reading of 15 divisions indicates a decrease of 6 db. from reference. Other points may be obtained from the decibel-voltage table. Readings above 30 divisions are not reliable since at this point the tube begins to draw grid current. When a volume indicator is calibrated on steady tone, 6 milliwatts will give a deflection on the meter of approximately 23 divisions. The reason for indicating a reference at 30 divisions is because music and speech indicate a peak voltage while a steady tone approximates an average value.

Sometimes it is not convenient to have the meter and the associated equipment of the volume indicator together. This can be remedied by extending the meter from the rest of the circuit as long as the loads have a small amount of resistance, not to exceed 2 ohms. In cases where it is desirable to have an extension meter as well as one with the equipment, an extension circuit can be provided, shown in Fig. 2.

In order to check the calibration of a volume indicator, the following method is used: With a single frequency sine wave from an oscillator, measure a definite volume into a 500-ohm circuit by means of a thermocouple, and obtain reference volume of 6 milliwatts. The 500-ohm load may be made up of a thermocouple with enough series resistance to make 500 ohms ($R_1 + R_2$) Fig. 3. The volume indicator bridged across this load with its dial set for reading reference volume, should then give a deflection on its meter of 23 divisions. To obtain reference volume a current of 3.46 milliamperes should flow through the 500-ohm load circuit. Since reference volume = .006 watts and $W = I^2R$

$$I = \sqrt{.006/600} = .00346 \text{ amperes}$$

If the voltage at reference volume across the 500-ohm load circuit = $500 \times .00346 = 1.73$ volts, the volume indicator bridged across a circuit in which there is an a.c. voltage across the volume indicator terminals of 1.73 volts (r.m.s.) and the volume indicator set for reading reference volume, its meter will give a reading of 23 divisions. Hence, either the voltage or current method may be used.

The principal error in volume indicators will be found to be the variation in characteristics of the tubes used in the circuit. Although the volume indicator is calibrated to read directly across a 500-ohm load, the instrument may be used across loads of other impedances by adding or subtracting the following correction term:

$$N = 10 \log_{10} 500/\text{load impedance}$$

A curve is plotted as shown in (Fig. 4) for various impedances.

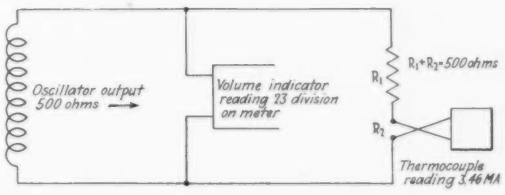

Fig. 3—Circuit used for calibrating volume indicator

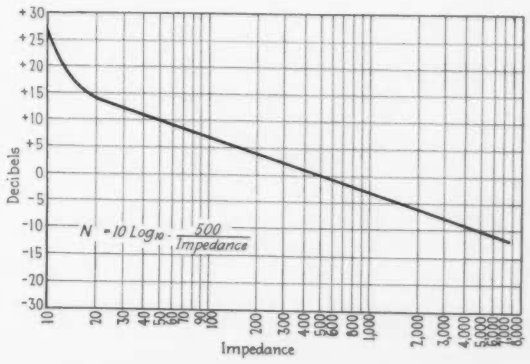

Fig. 4—Curve giving corrections in decibels to volume indicator readings when used across loads of other than 500 ohms impedance