Early History of the Evolution of the Volume Indicator

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The invention of the vacuum tube had one of its first commercial applications in the telephone industry. This group realized the enormous potential for long distance telephones and developed amplifiers then known as repeaters. These repeaters were needed to compensate for the loss in speech power over cables and open wire. To measure this loss and evaluate the amplification needed to compensate for this loss, the "mile of standard cable" was used. This reference was an artificial line having a resistance of 88 ohms and capacitance of 54 nanofarads per loop mile. These values correspond to those in 1 mile of 19 gauge telephone cable. This loss is equivalent to the minimum change in level that a normal person can detect. Also, at this time, the reference power was defined as the output from a then-standard telephone set connected to a common battery central office by a line of zero resistance. This power provided the necessary reference for loss and gain rating of electrical power.

The instrument to measure the level of speech power was called a “volume indicator”. The device consisted of an amplifier-detector working into a direct-current meter, and was calibrated in “miles of standard cable”. Where telephone circuits were part of the system as they were in the Harding presidential inaugural address and Armistice Day celebration in 1921, the volume indicators were used at various repeater stations feeding the cities hooked up to the telephone networks as well as at the amplifier-loudspeaker points in several cities across the continent.

I. W. Green and J.P. Maxfield published a paper [1] in which they used the “mile of standard cable” as the unit to measure and plot the loss and gain in the entire system from microphone to loudspeaker systems. For example, the output of the standard (Wente) condenser microphone was rated as 65 miles below the reference power. The amplifiers were rated in gain or amplification factor in miles.

The Western Electric Company in 1922 supplied a broadcast transmitter and speech amplification system. The volume indicator was also calibrated in terms of miles of standard cable. The Western Electric 518 volume indicator was used to monitor the speech power required to adequately modulate this 500 watt transmitter.

W. H. Martin presented and published [2] a paper on the transmission unit and telephone transmission reference systems. It was a discussion of a “transmission unit” selected as more suitable for general telephone work than the “mile of standard cable” unit.

Martin wrote:

> The “transmission unit” (abbreviated TU) has been chosen so that two amounts of power differ by one transmission unit when they are in the ratio of 10^{1}, and any two amounts of power differ by N units when they are in the ratio of $10^{N(0.1)}$. The number of transmission units N corresponding to the ratio of any two powers P_1 and P_2, is then the common logarithm (logarithm to the base 10) of the ratio P_1/P_2 divided by 0.1. This may be written $N = 10 \log_{10} P_1/P_2$. Since N is a logarithmic function of the power ratio, any two numbers of units, N_1 and N_2, corresponding respectively to two ratios, P_a/P_b and P_c/P_d, may be added and the result $N_1 + N_2$, will correspond to the product of ratios, $P_a/P_b \times P_c/P_d$.
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> In other words, the transmission unit is a logarithmic measure of power ratio and is numerically equal to $\log 10^{0.1}$ [= 1.259...]

The “TU” also eliminated the problems associated with the mile of standard cable (which had been used for 20 years) which included [frequency response] distortion due to its inherent inductance and capacitance. The “TU” could then be independent of frequency so that the “TU” could be used to rate power ratios at any frequency. The sound power changes which can be detected by the ear are of the order of that corresponding to the “mile of standard cable”. The properties of the “TU” made it available in other fields and not restricted to telephone circuits.

The Western Electric Company manufactured a Type 203 volume indicator which was extensively used beginning in 1928 by most facilities needing such an instrument. Motion picture sound recording equipment, phonograph recording equipment and broadcasters were principal users. The reference voltage was 1.73 volts across a circuit of 500 ohms impedance and corresponded to a power of 6 milliwatts.

In 1929, a logarithmic unit called the “bel” was adopted as an international unit of power level on telephone and acoustical uses. For practical purposes, a unit which is one tenth of a bel is more convenient. The smaller unit is called the decibel, dB. It replaced the “TU”. It has extensive use in communication and all acoustical fields at this time.

In 1934, the Western Electric Company developed the Type 700A volume indicator [3] . This unit was an improvement over the Type 203 unit, and the Type 700A was supplied for use in new speech input equipment for radio broadcasting. It used a heater type vacuum tube. The dynamic characteristics of the meter were designed to give steady state deflection of the needle in approximately 0.2 seconds. The extreme range of levels was -25 dB to +45 dB. The reference voltage was again 1.73 volts across 500 ohms with a 1000 Hz sine wave.

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[1] Opus posthumous. Submitted to the AES Journal in 1984, for a planned issue on volume indicators that never materialized. Scanned and edited 2006-08, J. McKnight.

During the period of 1930...1940, several different volume indicators were used. In an effort to more properly monitor levels with respect to 100% modulation of broadcast transmitters, overload points of amplifiers and recording devices, peak reading instruments were used with varying opinions about their utility. Other so-called rms meters with varying ballistic characteristics were also in use. Many types of scales were available and the reference deflections of 100% modulation were marked at various positions with respect to the full scale reading and scales had various background colors.

This great array of variables led to confusion and a lack of understanding when an attempt was made to correlate measurements between groups.

A new standard volume indicator and reference power was published by H. A. Chin, D. K. Gannett and R. M. Morris [4] in 1940. It was adopted by the Bell system, broadcasting companies, and recording facilities.

The reading of the volume indicator is 0 vu when it is connected to a 600 ohm resistance in which is flowing 1 milliwatt of sine wave power at 1000 Hz. (Practical volume indicators do not actually have such a range.)

The volume indicator employs a direct current galvanometer with a full wave copper oxide rectifier mounted within its case. The scale contains both vu and percentage markings. The color of the scale is deep cream.

The meter case is 4.5 inches square. This meter because of its increased size has a scale that contributes to ease of reading and lack of eye strain in observing it over long periods.

As of this date, several different methods are being used in the recording, broadcasting and telephone industries. LED (light emitting devices) are used which may indicate peak or average levels, some having a switch to have both on the same meter. Both the standard “vu” meter and the LED types are used on recording and sound reinforcement consoles. The broadcast group to a larger extent use the vu meter.

REFERENCES

[1] I. W. Green and J.P. Maxfield, *Jour. American Institute of Electrical Engineers*, Vol. 452, pp. 64-75, 1923.

[2] W. H. Martin, “The Transmission Unit and Telephone Transmission Reference Systems”. *Jour. of the American Institute of Electrical Engineers*, Vol. 43 (XL III) Nr. 6, pp 797...801, June 1924.

[3] *Bell Labs Record* Vol. 13, 1934, December.

[4] H. A. Chin, D. K. Gannett and R. M. Morris, “A New Standard Volume Indicator and Reference Level”, *Proc. IRE*, 1940 Jan , pp. 1-17