THE NEW STANDARD VOLUME INDICATOR AND REFERENCE LEVEL

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THE volume indicators in use, until recently, differed widely as to type and characteristics; method of calibration and use; and the values of the reference level on which the calibration was effected. The type and characteristics of instruments used included: rms or quasi-peak; "slow, medium or high speed"; half or full wave rectification and critically or under-damped meter movement. The reference levels on which calibration was effected included: 10^{-9}, 1, 6, 10, 12.5 and 50 milliwatts in 500 or 600 ohms. The possibility of confusion and misunderstanding which resulted when two different groups attempted to correlate measurements on the same circuit is obvious in view of the many variables.

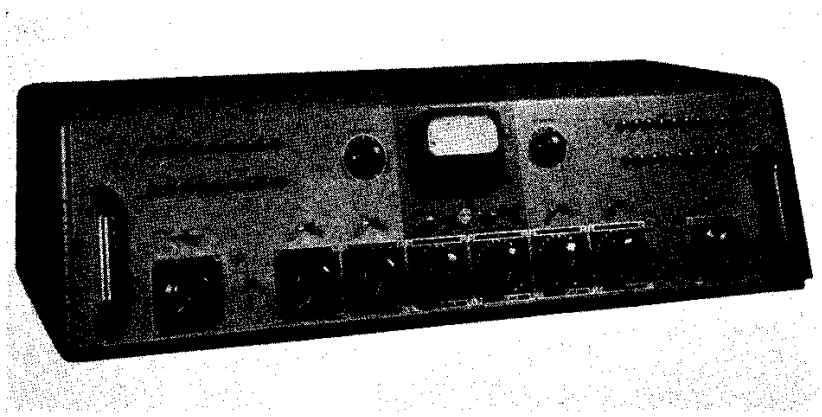
Uses of Volume Indicator

Radio broadcast service, involving the inter-connection of many radio stations by means of telephone circuits, necessitates the almost continual use of volume indicators, not only for controlling volume but in a supervisory manner to insure the transmission of the proper program level and to isolate circuit irregularities. Volume indicators used in this manner may be located at points in the circuit separated by distances ranging from a mile or less to two or three thousand miles. The usual procedure to determine any circuit irregularity is to check "peaks" between the various points in the circuit. Under normal circumstances the indications of identical full wave rms instruments located at different points, properly adjusted as to sensitivity, should all produce the same "simultaneous" indications throughout the circuit. Until the present time the instruments in the majority of broadcast stations usually differed widely from those in the various associated telephone companies as to characteristics, calibration and interpretation of the indications. As the instruments differed, exact correlation was not possible; consequently arguments and misunderstandings resulted when attempts were made to adjust level discrepancies or to determine what level should be transmitted to or received from telephone circuits.

The Bell Telephone Laboratories, the Columbia Broadcasting System and the National Broadcasting Company have participated in a cooperative investigation to determine the type and characteristics of a volume indicator which would meet the various theoretical, practical and economic requirements and the value of a reference level and a standard of impedance to use as a basis for the calibration of the instrument. An agreement was announced Dec. 16, 1938, involving a volume indicator exemplified by the Weston Type 30 instrument and a calibration at the maximum marking point for program peaks based on 1 milliwatt in 600 ohms.

The characteristics of the new instrument are briefly as follows:*

1. The meter responds to the r m s value (approximately) of the impressed voltage and contains a full wave copper oxide rectifier within its case.
2. The total resistance of the instrument and the external resistor (of 3600 ohms) is 7500 ohms.
3. The sensitivity of the instrument is such that a deflection to the 100 division mark is obtained when connected across a sinusoidal voltage of 1.228.
4. The pointer movement is almost critically damped with an "overshoot" of between 1½ and 3%; the pointer is deflected from the "at rest" position to 99% of the steady value, 0.3 seconds (±10%) after the sudden application of 1.228 volts.
5. The distortion introduced by the connection of the instrument and its series resistor across a 600 ohm circuit is less than that equivalent to 0.3% (arithmetic sum of harmonics).
6. The instrument sensitivity is uniform within 0.2 db of the 1000 cycle value over the frequency range from 35 to 10,000 cycles and within 0.5 db over



Showing the use of the vu meter in the RCA 76-B1 Consolette.

*A more complete description will be found in "Electronics," February, 1939; "A New Standard Volume Indicator and Reference Level," H. A. Affel; H. A. Chinn and R. M. Morris and in the Proceedings of the I R E, January, 1940; "The New Standard Volume Indicator and Reference Level," D. K. Gannet; H. A. Chinn, and R. M. Morris.

the frequency range from 25 to 15,000 cycles.

7. The instrument scale is approximately linear with voltage and the markings are on a cream yellow scale card to reduce eye strain and fatigue. The "voltage" markings are from 0 to 100 in black numerals above the pointer arc. The corresponding vu markings, with the 0 vu mark at the 100 division mark (70% full scale), are in red numerals below the pointer arc. The arc above the 100 division mark is a broad red band providing an upper margin of 3 db above the reference point.

From a study of the fundamental considerations involved, it may appear that an instrument responding to the peak or crest value of the program wave—that portion which causes distortion—would be more satisfactory than an r m s instrument. However, the results of a series of cooperative and individual tests, that began in 1935 and were in progress until December 1938 show that, on the average, within a range of about 1 db, neither the quasi-peak nor the r m s type of instrument of the design finally determined upon, exhibited any marked superiority as regards indicating aural distortion.

Phase Distortion

It was found, furthermore, that the phase distortion on program circuits, some of which are only a few miles in length, may be such that considerable discrepancies are obtained from the use of quasi-peak-indicating instruments even when the distortion is not aurally detectable. Since telephone circuits are almost always involved, even though they are only from a remote point to the studio or from the studios to the transmitter site, errors of this type would be inevitable in practice if a peak instrument were used. A full-wave r m s type is not, of course, subject to these errors.

Still another consideration was the fact that the instrument must be suitable for use at both fixed and field locations if complete standardization is to be accomplished. The use of a quasi-peak reading instrument which, at present, involves a number of tubes and an associated power supply was not considered feasible in portable equipment, particularly in view of the fact that no great benefit was to be derived from its adoption.

Under these circumstances and also since it is essential that the instrument be relatively inexpensive in order that its general adoption is not hampered by economic considerations, an r m s type of instrument of the type described, has been determined upon.

New V I Scale

Both vu* and percent voltage markings are incorporated on the new instrument scale. The need for the former in wire line transmission is obvious, but the philosophy which led to the inclusion of the latter requires explanation. It is evident, assuming a linear system, that the voltage scale is directly proportional to percentage modulation. If the system is adjusted for complete modulation for a deflection to the 100% mark, then subsequent indications will on the average show the degree of modulation under actual operating conditions. In the interest of best operation, it may be desirable, of course, to adjust the system for somewhat less than complete modulation when the 100% indication is reached. The use of the new instrument will in no way reduce the desirability of a limiter amplifier at the transmitter, as the indications of the new instrument will, in any event, show the "percentage utilization of the channel."

Standard Reference Level

The adoption of the new volume indicator will not permit full-realization of all the advantages of proper correlation unless the manner of use and calibration of the instrument by each user are identical. The first step in this direction was an agreement upon a standard reference level to replace the numerous "zero" or reference levels now in use. As already mentioned, this problem was given a great deal of consideration and agreement was finally reached on a one milliwatt standard.

A standard reference level based on one milliwatt has much to commend itself, as compared with former reference levels, some of which seem to have just "happened" into being. The value of one milliwatt was chosen because it is: (a) a unit quantity and readily applicable to a decimal system, (b) a "preferred" number, (c) related to the "watt" by the "preferred" factor* of 10^{-3}, (d) it results in positive values for the majority of transmission levels encountered in practice at the present time and (e) it was found to be the one value to which general and perhaps international agreement is possible.

Although the reference level is a unit of power, the devices employed for measurement are in general some form of volt-meter, consequently a standardized value of impedance is desirable. The extent to which existing plants were standardized, the values of impedance in use and future trends as to impedance values for various circuits were all regarded as important considerations in this problem. The usual broadcast plant employs several different impedances, consequently, the value of "standard impedance" selected is in a sense nominal and largely for the purpose of specifying a voltage sensitivity in the calibration of the instrument. The telephone company has standardized on a value of 600 ohms and expended their plants to such an extent that the selection of any other value is impractical in view of the extensive changes in plant equipment which would be involved. Consequently, a value of 600 ohms was adopted as the standard impedance.

Calibration

Theoretically, the new instrument is calibrated in such manner that a deflection to the 100 division mark (or 0 vu mark) is produced when the instrument is connected across a 600 ohm resistor in which one milliwatt or "sinusoidal" power is being dissi-

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*vu—numerically equal to the number of db above (or below) the new reference level based on 1 mw.

*A. Van Dyck, "Preferred Numbers," Proc. I R E, Vol. 24, pp. 159-179 (1936)

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pated. This value corresponds to a voltage across the resistor of a 0.775 volts, r m s. The standard instruments are not sufficiently sensitive to indicate this value directly.* Measurements and calibration at the 100 mark (or 0 vu mark) must be effected, in practice, as a volume level of +4 vu or higher. (See Figure 1).

It will be noted that the philosophy employed in the majority of broadcasting studios in the calibration of volume indicators has been retained, viz.: the power required (or the voltage across the standardized impedance) to cause a deflection to the reference or "marking point" has also been use to designate the volume of program material.

An important advantage in the use of the new instrument is that, since they are all exactly similar, the various instruments on a circuit may be lined up with a 1000 c p s sinusoidal voltage with the assurance that they will then read alike on program waves.

A precaution to be observed in connection with the use of the new instrument is the fact that as available at present, it should not be mounted on a steel panel (except when specifically designed for this use). The deliberate, highly-damped characteristic of the instrument has been obtained by the use of a greater magnetic flux than is required in a normal instrument. Any loss of magnetic flux such as would occur through the shunting effect of a steel panel, prevents the development of the required characteristics. It is best, therefore, that magnetic materials be kept at least 2 inches away from the center of pointer rotation. It is further desirable that other instruments be located a similar distance to prevent interaction of the magnetic fields of the instruments.

*Instruments with a sensitivity of "0" vu are available from two manufacturers for use where the effect of temperature changes are not of great concern.

Terminology

The primary purpose of the instrument is to measure volume levels, although it is suitable for steady-state measurements. In the use of the new instrument, it is proposed to use a new term "vu" which is "numerically equal to the number of decibels above (or below) a one milliwatt reference level." This procedure will make it possible to avoid confusion with several existing standards for volume measurements.

It is emphasized that the designation of volume level in vu *implies measurement with the new standard instrument.* Previous types of volume indicators, even though recalibrated to a 1 milliwatt basis, in most instances will not give indications of program material corresponding to those of the new instrument.

The use of the new term will clarify the terminology used for expressing the performance of a piece of equipment or of an entire system. For example, in the past, it has been the practice to specify the performance of equipment by stating its (a) input level, (b) output level, (c) gain and (d) signal-to-noise ratio—all in decibels. In the case of (a) and (b) "decibels above a reference level of X milliwatts" is implied while in (c) and (d) pure ratios are involved. The use of the new term "vu" obviates this inconsistency since the term immediately implies measurements with the new standard instrument referred to a 1 milliwatt reference level.

Thus it should be borne in mind that the term "vu" implies an absolute volume level and where ratios are involved, the term decibels is to be used as in the past. For instance, the gain or loss of a system, a program line or a piece of apparatus is expressed in "db" as is a signal-to-noise ratio or a response-frequency characteristic. Volume levels, on the other hand, are expressed in "vu" since absolute quantities based on the use of the new instrument are involved.

(To Be Continued)

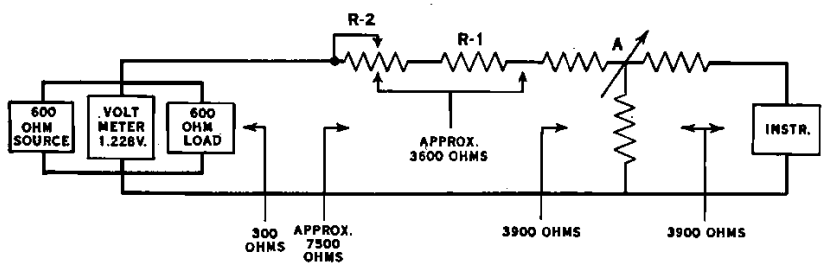

Fig. 1. Schematic showing method of calibration of the Standard Volume indicator.
R_2 is about 800 ohms and is adjustable to compensate for variations in deflection of the instrument.
R_1 is usually a portion of the adjustable attenuator A.
A is an adjustable 3900-3900 ohm attenuator for adjustment of sensitivity.

WEST COAST FACSIMILE DEMONSTRATION

A recent demonstration of Facsimile was given at Sherman Clay & Co., in San Francisco, jointly sponsored by NBC and the Leo J. Meyberg Co.

One of the large windows in the Sherman Clay store was used for the scanner and the display type Facsimile receivers while the home receiver was placed in an adjoining window. Large groups were attracted to the display which was in operation from 10:30 to 5:00 P. M. daily.

A wide variety of material was used to show the flexibility of the Facsimile equipment. Publicity shots of NBC stars were used and news flashes were sent from the NBC news room every hour.

Lectures were delivered on RCA Facsimile, it's operation, it's uses and future possibilities.

A NEW TREATMENT FOR DEAFNESS

Dr. Christian Volf, Danish physicist, has developed a snythetic sound treatment for many types of chronic deafness. Snythetic sounds whose frequencies are scientifically controlled have been placed on records and effectively exercise the tiny muscles of the inner ear.