Measurement of Non-Linearity Distortion

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Need for a Method Corresponding with Aural Judgment

DESPITE television, interest in sound-reproducing equipment was never greater. For evidence one has only to look at the advertisement pages of this journal. It can hardly be denied however that present practice in specifying the non-linearity of such equipment is unsatisfactory. Out of a considerable number of specifications that were examined, one of them stated the percentage total harmonic distortion at a mentioned power output at two frequencies (40 c/s and 2 kc/s), one gave the same information at a single frequency (1 kc/s), one gave a curve of " total distortion " against watts output (frequency not stated), six gave the " distortion " or " harmonic distortion " or " total harmonic distortion " at a stated output but no stated frequency, two were " undistorted " up to a stated output, and the remainder were even vaguer.

What is the information we really want? Presumably something that will tell us how much unpleasantness we may expect at the maximum output, or alternatively how much output is available up to the point at which unpleasantness does not exceed a specified amount.

The basic principles of this matter have been reviewed so recently by " Cathode Ray "[1] that the preliminaries can be abbreviated. As he says, unpleasantness is not measurable as such, so the only hope of obtaining quantitative information is to find some physical characteristic to which audible distortion is as nearly as possible proportional and measure that. There are of course various types of distortion. Of these, it can be assumed nowadays that frequency distortion can readily be brought under control. The other main type, to which the present discussion will be confined, is non-linearity. Unlike frequency distortion, the results of non-linearity in one unit of the audio chain cannot be compensated by opposite non-linearity in another.

Simple Methods

The problem is to observe and specify non-linearity so as to show how far it causes the reproduction to fall short of perfection. One common method is to apply a sinusoidal signal to the unit under test and to display the output waveform on an oscilloscope, using a linear time base. The fact that this is so often done can only be accounted for, surely, by the comparative ease of the procedure. The degree of distortion can be judged only by comparing what is seen with an invisible mental picture of a perfect sine wave, so the minimum that can be detected depends largely on the experience and skill of the observer and at best is not very small. A considerable improvement is to use a double-beam oscilloscope and compare
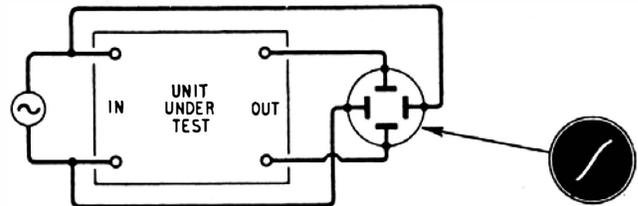

Fig. 1. In this c.r.o. method of measurement the cause rather than the effect of the distortion is seen—the non-linearity of the transfer characteristic.

the output waveform directly with the input, but even then the method is not sensitive enough for nearly linear units. It has its uses, but can hardly be classed as a method of measurement.

Another oscilloscope method is to display the transfer characteristic—the graph of instantaneous output against instantaneous input—by connecting as in Fig. 1. The ideal pattern is a perfectly straight diagonal line. One can much more easily judge departure from a straight line than from a sinusoid, and also more easily distinguish the nature of the distortion. But even so, the method is effective only for what would nowadays be considered comparatively gross distortion.

Need for a Single Figure

Obviously distortion shows up much more clearly if the comparatively large undistorted component of the output is removed. Both simple[2] and elaborate[3] arrangements have been described for filtering out the fundamental output and displaying the remainder—the distortion products—on the oscilloscope screen. This can be a most effective way of investigating distortion. But although distortion oscillograms are extremely informative to any one who can interpret them, for general purposes they have serious disadvantages. They cannot be communicated verbally. They are troublesome to reproduce accurately without photography. And they cannot readily be compared quantitatively with one another, nor enable the signal level to be set to a specific standard of distortion. So the need remains for some method yielding results that can be expressed numerically, preferably as a single figure.

Since the effect of non-linearity is to create signal components or products at frequencies not present in the original, the obvious solution is to compare the amplitudes of these products with that of either the whole output or the undistorted part of it. Stated in this way, the problem looks quite simple, but the more one examines it the more complicated and diffi-