# Directivity and the Acoustic Spectra of Brass Wind Instruments*

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(Received November 13, 1941)

INVESTIGATORS in musical acoustics have noted that a single-point harmonic analysis of the pressure wave radiating from a musical instrument is not an adequate physical expression of the instrument's acoustic output. For example, Northrop[1] has shown that the harmonic analysis of the pressure wave from an organ pipe changes significantly as the relative position of source and receiver is changed. Another example of such variation is shown in Fig. 1 where the harmonic analysis of a pressure wave is plotted as a function of angle for a cornet. The cornet was played mechanically by a device described in a previous paper,[2] and the analysis was made with a Hewlett-Packard 300A wave analyzer. The source and receiver were located on a framework built at the edge of a fourth story roof, and tests showed that this arrangement provided a free field essentially.

It is observed that for this high note, the intensity level of each harmonic decreases as the angle with the axis of the horn increases (180° represents the axis of the horn). Also the rate of decrease of intensity level becomes greater as the number of the harmonic increases so that the relative intensities of the harmonics depend upon angle. This would be anticipated from the greater directivity of the horn at higher frequencies. The distaste for high frequency sounds often expressed by listeners, combined with this high frequency directivity, gives an explanation for the unpleasant effect one notices when a brass instrument is pointed directly at him at close range. In open-air concerts, in large auditoriums or music halls, or in broadcast and recording of instrumental music, the direction which the player faces becomes important. Even for low tones the factor is significant for brass instruments, because their prominent high harmonics are directional.

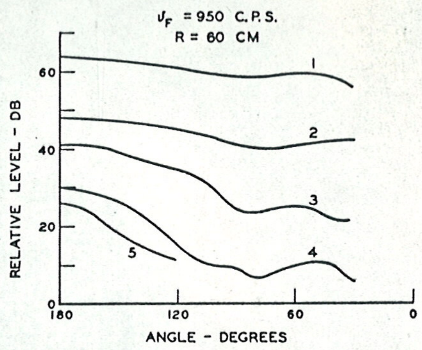

FIG. 1. Angular dependence of cornet tone analysis.

It is recognized that these directional properties are inherent in the instruments as long as conventional designs are used. It is not proposed that present instruments be redesigned to make them less directional, because such changes would alter the instruments so radically that the new instrument would probably sound very little like the older model. Rather it is the purpose of the author to present a method applicable to tests, classification, and standardization of instruments.

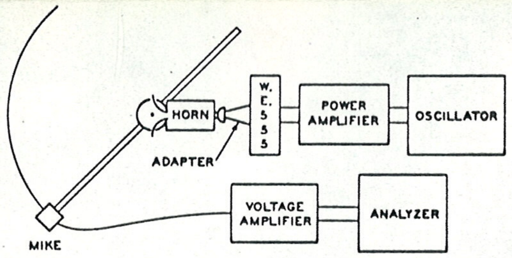

FIG. 2. Driver and pick-up system.

What a listener hears will depend upon his position relative to the instrument and the surroundings. What one desires in describing the sound spectrum of the instrument is a characteristic of the instrument itself. Probably an expression of the power output at each harmonic frequency would be the simplest single expression of acoustic output which would be

* This paper was presented at the Twenty-Sixth Meeting of the Acoustical Society of America in New York, October 25, 1941. It is the second of several which are based on the thesis submitted by the author in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Physics at the University of Illinois.
[1] P. A. Northrop, J. Acous. Soc. Am. 12, 90 (1940).
[2] D. W. Martin, J. Acous. Soc. Am. 12, 467A (1941).