

not now further explain. But that there is a process of resolution gone through every one must know. When a band is playing every one notices the effects of several instruments at the same time, his observation being directed now to one group, now to another. So, also, we recognize very readily the voices of several people talking at the same time. In the second place I have to remark that a single musical sound is generally compounded of simple tones. Thus a note on a violin string, or the piano, is really a collection of tones of different pitches and intensities, embracing the fundamental and several harmonics. For example, on the piano, if *C* is sounded, an attentive ear perceives its octave and the fifth (*G*) above that. A violinist readily perceives when a note is played on the violin a much longer succession of harmonics. Now what is true of the note of the violin is true of the generality of musical sounds; and if we do not usually manifest the acoustician's powers of analyzing them, it is because no useful purpose would be served by our doing so. Indirectly, however, we do recognize the constituent tones of a note. *C* on the piano is different in quality from *C* on the violin only because the harmonic notes are not equally strong. One voice has a different quality from another for a similar reason. These differences in quality we recognize immediately, and, as that generally serves our purpose, it would be useless to enter on a process of analysis. An illustration will convey my meaning more clearly. In listening to several choirs in succession, suppose our object was simply to distinguish one from another. If this could be done without comparing sopranos in one with sopranos in the other, tenors with tenors, and so on, nothing would be gained by such a process of analysis. In order to tell Gilmore's band from the

performers of a country village, it is not necessary to dissect the performance of every member from the drummer boy upwards. So it is in ordinary cases where the ear does not exercise its analyzing powers. By an immediate deduction we recognize the qualities of different voices and instruments; and so the necessity for analysis does not exist. The composite character of sounds, however, is none the less a fact which can be established by synthesis and analysis. If, for example, a fundamental note and its harmonics are simultaneously produced on a series of forks, the former being loud and the latter feeble, the pitch still appears to be that of the fundamental, but the quality of the sound is changed, and the character of the change depends on the number and intensity of the accompanying harmonics. On the other hand all musical sounds, whatever their quality and origin, can be analyzed in various ways and shewn to be compounded, when not simple, of a fundamental and its harmonics. This fact can be established most satisfactorily with the aid of resonators. Thus, if appropriate resonators are applied in succession to the ear, the component tones of a voice emitting a low note can be discovered, and are found to embrace a long series of harmonics in addition to the fundamental. No more interesting example of voice analysis can be adduced than the method which has been employed to examine the vowel sounds. To apprehend the process it must be borne in mind that all vocal sounds are produced primarily in the *glottis* by the vibrations of the vocal chords, but that they only become speech in virtue of certain modifications imposed on them in the mouth. There they are formed into vowels, consonants, syllables, words. During the formation of the vowels the mouth cavity assumes definite