certain members of this group is apparent when one considers the fact that the virus of smallpox and that of cow-pox, while differing in certain important ways, are in reality to be considered modifications of the same virus, because they cross-immunize against each other. In other words there is not a specific difference between them, and this probably applies to other modified strains such as those of horse-pox, swine-pox, goat- and sheep-pox. It would therefore seem advisable to use not only a specific, but a subspecific or variety name for the corpuscles of such related strains. I would therefore propose the following terminology:

Borreliota variolae hominis: specific corpuscles of smallpox (Paschen bodies, elementary corpuscles).
Borreliota variolae bovis: specific corpuscles of vaccinia (Paschen bodies, elementary corpuscles).
Borreliota variolae equi: specific corpuscles of horse-pox.
Borreliota variolae porci: specific corpuscles of swine-pox.
Borreliota variolae ovium: specific corpuscles of sheep and goat-pox.
Borreliota mollusci: specific corpuscles of molluscum contagiosum (Lipschütz corpuscles).
Borreliota avium: specific corpuscles of fowl-pox (Borrel corpuscles).

The acceptance of such a nomenclature based upon adequate experimental data would do much to attract attention to this related group as a whole, and would obviate the great confusion of terms now in use such as Borrel bodies, Lipschütz granules, Paschen corpuscles, elementary bodies and so on. At the same time the probability that the specific granules in question represent micro-organismal etiological agents would be duly recognized.

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A CONTRIBUTION TO VOWEL THEORY[1]

Two main theories of vowel production have been advanced, namely, the harmonic or steady state theory and the inharmonic or transient theory. The harmonic theory, advocated mainly by Wheatstone, Helmholtz and D. C. Miller, holds that the vocal cords generate a complex wave having a fundamental and a large number of harmonics. A wave at its source will contain all the frequencies that it will ever contain. The so-called resonating cavities (pharynx, mouth, nasal cavities, paranasal sinuses) will act to magnify those frequencies of the wave near the resonating frequencies of the cavities, the amount of amplification depending upon the damping constant of the cavity. The reinforced frequency bands determine the vowel quality.

The inharmonic or cavity tone theory, advocated mainly by Dodart, Willis and Scripture, holds that the wave or series of puffs from the vocal cords acts only as an agent for exciting the transient frequencies that are characteristic of the resonating cavities. Certain frequencies in the wave need not be present in the source but may be added by the resonating chambers. According to this theory, the vocal cords emit puffs of air, each puff setting the air in the above cavities into vibration, resulting in the so-called "cavity tones." The frequency of a cavity tone is determined by the natural frequency of the cavity, and is not dependent on any frequency aspect of the exciting or cord tone. This vibration of the cavity tone soon diminishes until it is started anew by a second puff. Here, as with the harmonic theory, the vowel quality is dependent upon the natural frequencies and damping constants of the vocal cavities.[2] The findings reported in the present paper tend to add weight to the inharmonic or cavity tone theory.

In order to delimit sharply the problem the head and neck of a cadaver was used to furnish the so-called resonating cavities and a pure sine wave as the force to act on these cavities. Our specimens (two male) presented normally extensive sinuses and normal nasal, oral and pharyngeal cavities (determined by sectioning the head after completion of the experiment). The soft palate was so fixed as to present an opening into both the nasal and the oral cavity which were patent. Both specimens had teeth. The source of the sine wave was a General Radio low frequency oscillator Type 377–B, activating a high-grade head phone. The waves were conveyed to the larynx or directly to the microphone from the head phone by a rubber tube 90 cm long and with a lumen 5 mm in diameter. For studying and recording the waves a Jenkins and Adair C6 condenser microphone with one additional stage of high quality amplification and a Westinghouse oscillograph were used. For all frequencies scouted, 120, 200, 300, 400, 500, 600, 700, 800, 900, 1000 and 1200 $\sim$, the waves were studied first by holding the end of the tube carrying the sound directly in front of the microphone. With the exception of one frequency, 120 $\sim$, all frequencies presented sine waves. Secondly, the waves were studied by placing the nose and mouth of the cadaver directly in front of the microphone after the rubber tube had been inserted through the trachea, into the ventricle of the larynx, just above the level of the vocal cords. The head was suspended from the ceil-

[1] This paper reports a part of a larger research program suggested by the late Dr. Henry J. Prentiss, head of the department of anatomy, University of Iowa. The program is now being kindly supported by Dr. E. M. MacEwen, present head of the department of anatomy.

[2] For a fuller discussion of vowel theories see H. Fletcher, "Speech and Hearing," 1929, Macmillan; and G. O. Russell, "The Vowel," 1928, Ohio State University Press.

ing by small wires in order to avoid the possible resonating effects which might come from supporting it on a table or platform.

For specimen No. 1 the sine waves of frequencies of 200 and 300 ~ and for specimen No. 2 the sine waves of frequencies 200, 500 and 900 ~ were altered in their passage through the specimen. Fig. 1 shows the

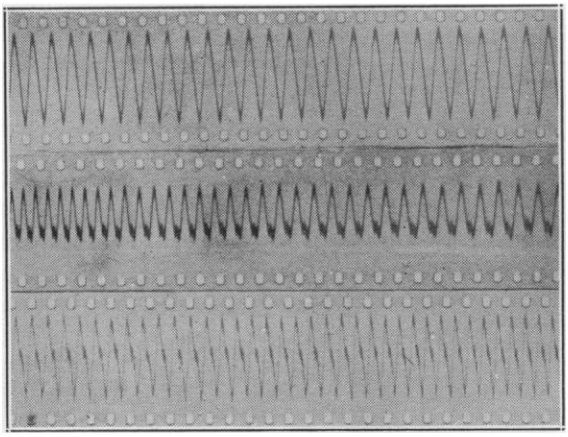

FIG. 1. Oscillogram of relatively pure sine waves (200 ~) led into the larynx of the cadaver. FIG. 2. Oscillogram of the waves emerging from the nose and mouth of the cadaver (specimen No. 2) when the waves depicted in Fig. 1 were being led into the cadaver's larynx. FIG. 3. Oscillogram of the waves emerging from the nose and mouth of the cadaver (specimen No. 1) when relatively pure sine waves of 300 ~ were being led into the cadaver's larynx.

relatively pure sine waves of a frequency of 200 ~ as they were taken directly from the end of the rubber tube. Fig. 2 shows the change produced in this frequency when the tube was inserted into the larynx of specimen No. 2. Fig. 3 shows the change produced in the sine waves of a frequency of 300 ~ by specimen No. 1.

There was a possibility that these changes might be due to the additional column of air imposed upon the vibrating diaphragm of the head phone by the cavities of the head and neck. This was tested by substituting a cardboard cylinder with a small input and output hole for the specimen. The waves emerging from this cylinder proved to be identical with those put into it. The possibility that these changes might be reflected waves was ruled out on the basis of the fact that all relationships between objects in the room were the same for the picking up of both the original input waves and those passing through the specimen. It appears that the alterations in the original waves emerging from the inserted tube occur during the passage of these waves through the cavities of the neck and head of the cadaver. Furthermore, the distortions are not a function of amplitude because the modified wave is smaller than the input wave.

With a more complicated original wave form, one might expect to obtain more striking structural changes in the waves as they emerge from the mouth and nose. We chose purposely the simple sine wave as the one to be modified, reasoning that any change produced in its form would be conclusive in regard to the point in question.

Because the recorded differences between the original waves and those emerging from the cadaver occur between the end of the inserted tube in the larynx and the nasal and oral openings, our results tend to support the cavity tone theory of vowel production. The resultant wave, being no longer pendular, must contain frequencies not present in the source and hence necessarily introduced by the cavities. Certain frequencies were not changed, probably because they did not excite the transient frequencies which were characteristic of the cavities. A close examination of the modified waves shows that a given wave may not be a perfect duplicate of its predecessor; *i.e.*, there is not absolute periodicity in the wave chain. This fits in well with Scripture's general conception of the inharmonic theory that each succeeding puff of air from the vocal cords changes the cavities' contents so that the cavities need not be exactly the same from puff to puff. If our input sine waves contained concealed harmonics, then our results are not so conclusive in favor of the inharmonic theory. However, it is thought that the waves emanating from the cadaver contained frequencies which were not present in the source.

It remains to attack the problem of vowel production with respect to both simple and more complicated input waves in relation to the condition, size and number of the so-called resonating chambers.

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