In the latter medium it travels about 1,100 ft. per second. An illustration of the fact that time is required for sound to travel from one place to another is shown by a steam whistle at a distance of several hundred yards. If it be observed when blown, it will be noticed that the "steam"* can be seen coming from the whistle a considerable length of time before the sound of the whistle is heard. Sounds of all frequencies, or pitches, travel at the same speed. The speed at which sound travels divided by the frequency gives the wave length of the sound wave.

A knowledge of wave length is necessary for the proper construction and location of baffle boards and horns in theatres.

Speech.—The sounds of speech are divided into two classes, vowels and consonants. The vowel sounds are used in the pronunciation of the letters *a*, *e*, *i*, *o*, *u*, and sometimes *y*, in the formation of words.

These letters are also used in combination to indicate other vowel sounds. The pitch frequencies of the vowel sounds in male voices range from 110 cycles to 140 cycles. For female voices the range is from 230 to 270 cycles. The characteristic frequencies, or overtones of the vowel sounds, however, reach frequencies of 3,300 cycles. So important are these overtones that the pitch frequency can be entirely eliminated without noticeably changing the sound sensation produced on the human ear. The full range of frequencies used in vowel sounds is from 110 cycles to 4,800 cycles.

The pitch frequency of the vowel sounds are produced when air is blown through the vocal cords.

The vocal cords are two muscular ledges in the air passage of the throat. When these muscles are taut there is a narrow slit between them, which sets the air passing through into oscillation. The sound produced by the vocal cords is changed by the cavities of the mouth.

The shapes of the cavities continuously change as a person speaks, making it possible for him to produce a wide variety of sounds, all of very nearly the same pitch frequency.

*NOTE.—***The white cloud** seen issuing from a steam whistle usually called "steam," is not steam but a fog of minute liquid particles produced by ***condensation***. The term is misused above simply for convenience. Steam is invisible.

Consonant sounds are usually produced without the aid of the vocal cords.

Most of these sounds are produced by the lips and teeth, as in the pronunciation of *th*, *s*, and *f*. The range of frequencies covered by consonant sounds is from 200 to 8,000 cycles, but most consonant sounds have frequencies of less than 6,000 cycles.

Hearing.—The actual mechanism of hearing is not very well understood, but certain facts regarding the ability of the ear to register sounds of various frequencies has been determined very accurately.

The range of frequencies which the average person can hear is from about 20 cycles to 17,000 cycles, but a comparatively large amount of sound energy is required before the ear can detect sound of extremely low or extremely high frequencies.

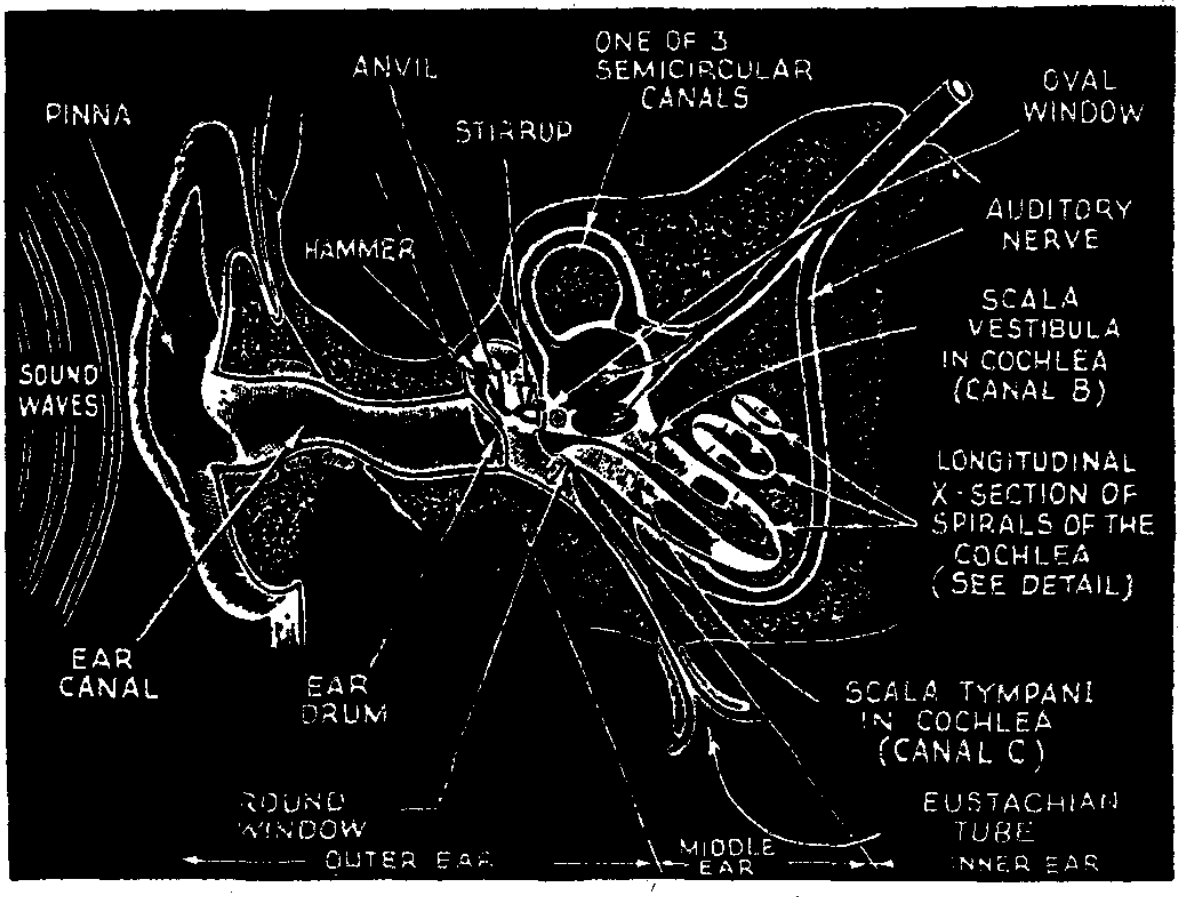

FIG. 14.—**Internal Structure of the Human Ear.**

The ear is most sensitive to frequencies between 500 cycles and 7,000 cycles; also, the ear is most sensitive to changes of pitch and changes of intensity of sound in this same band of frequencies.

NOTE.—***Woman s speech*** in general is more difficult to interpret than man's. This may be due in part to the fact that woman's speech has only one half as many tones as man's, so that the membrane of hearing is not disturbed in as many places. It may be inferred therefore that the nerve fibres do not carry as much data to the brain for interpretation. The greatest differences occur in the case of the more difficult consonant sounds. In woman's speech these sounds are not only fainter but require a higher frequency range for interpretation. A range of from 3,000 to 6,000 cycles for man's voice corresponds roughly to a range of from 5,000 to 8,000 cycles for woman's voice. Since the ear is less sensitive in the latter range and the sounds are initially fainter, their difficulty of interpretation is greater.

NOTE.—When sounds containing a number of tones are increased in loudness, the lower tones in the sound deafen the auditor to the higher tones. This deafening or masking effect becomes very marked when the sound pressure of the lower tones is greater than twenty sensation units. In the case of speech, this effect impairs the interpretation of the higher pitched sounds. The best loudness for the interpretation of speech corresponds to a sound pressure between 0 and 20 sensation units. If the sound pressure be less than this, the fainter sounds are inaudible. If the sound pressure be greater, the masking effects impair the interpretation of these sounds.