cycle length, rather than from any direct effect of frequency per se. Quantitatively, the effect of halving duration is to double the difference between the absolute threshold and the baseline.

However, it is not clear that duration alone can account for the entire frequency effect in sinusoidal stimulation. At frequencies sufficiently high that the baseline current is a negligible fraction of that required to reach absolute threshold, doubling frequency should double threshold. Schwarz (*2*) found this to occur in the range from 1 kcy to 4–16 kcy/sec (the upper limit depending on certain other parameters), but at higher frequencies (for example, 32 and 64 kcy/sec) thresholds were significantly higher than would be predicted. This might result either from physiological factors such as altered distribution of stimulus current in the tissues, or from increased loss in the stimulating apparatus at high frequencies.

It is of interest that the curves of the present experiment indicate a chronaxie of about 0.2 msec, a value typical of that obtained from A-fibers. Uttal (*5*), reporting an experiment involving the effects of ischemia on thresholds for single electrical pulses applied to the forearm, also concluded that A-fibers were involved in electrical cutaneous sensory stimulation. However, neither experiment necessarily means that "nerve" as opposed to "receptor" is invariably the site of such stimulation. In view of the evidence marshalled by Weddell (*6*) against any necessary morphological distinction between cutaneous sensory nerve and receptor, a more cautious interpretation is indicated. Certain characteristics of the response to electrical stimulation of the "touch" system have been ascertained. It remains to be seen whether the other cutaneous qualities differ in the way in which they respond to changes in stimulus current parameters (*7*).

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The Molecular Formula Generalized in Terms of Cyclic Elements of Structure

The molecular formulas for all ordinary covalent substances may be generalized in terms of the number of cyclic elements of structure in the molecules according to Eq. 1:

$$\rho = 1 + \tfrac{1}{2}\, \Sigma n_v(v-2) \qquad (1)$$

where ρ is the total number of rings and multiple bonds in the molecule (that is, *cyclic structures*), n_v is the number of atoms of covalence v, and the sum is taken over all the v's. The term *cyclic structures* may be used to include both rings and multiple bonds if the latter are considered to be (as they are, indeed, logically, generically, and stereochemically) two-membered rings.

For most organic and inorganic covalent substances, this reduces to Eq. 2:

$$\rho = 1 + \tfrac{1}{2}(2n_{\mathrm{C}} + n_{\mathrm{N,P}} - n_{\mathrm{H},X}) \qquad (2)$$

where n_{C} is the number of carbon atoms in the molecule, $n_{\mathrm{N,P}}$ is the total number of nitrogen and phosphorus atoms, and $n_{\mathrm{H},X}$ is the total number of univalent atoms; hydrogen, halogen, and so forth. The terms for oxygen and any dicovalent element obviously disappear. Equation 2 can, of course, be stated also as

$$\rho = 1 + \tfrac{1}{2}(2n_{\mathrm{IV}} + n_{\mathrm{V}} - n_{\mathrm{I,VII}}),$$

where the subscripts refer to the numbers of the main groups in the Periodic Table.

The single term for all nitrogen atoms regardless of their oxidation numbers or their formal valence numbers follows from the consideration that the cyclic structures containing nitrogen ordinarily involve the three nonpolar bonds and not the additional coordinate bonds present in the higher oxidation state (compare nitroso and nitro groups). Similar considerations apply to the coordinate valencies in oxidized sulfur and phosphorus, but if in these atoms an expanded covalency involving, for example, ten electrons is visualized, the terms $2n_{\mathrm{S}}$ and $3n_{\mathrm{P}}$ would be indicated in Eq. 2.

Electrovalent radicals can be accommodated by reference to their covalent analogs, the free acids and bases; for quaternary nitrogen the term $3n_{\mathrm{N^+}}$ based on an empirical pentavalence, applies.

These equations have practical utility in that the number of cyclic structures is given directly by substituting in Eq. 2 the subscripts in the molecular formula —for example, bromine, $Br_2 = \mathit{0}$; cholesterol, $C_{27}H_{46}O = \mathit{5}$; hexamethylene tetramine, $C_6H_{12}N_4 = \mathit{3}$; nitric acid, $HNO_3 = \mathit{1}$; nitrogen, $N_2 = \mathit{2}$; nitroglycerine, $C_3H_5N_3O_6 = \mathit{3}$; penicillin G, $C_{16}H_{17}N_2O_4SNa = \mathit{9}$; phosphorus sulfoxide, $P_4O_6S_4 = \mathit{3}$; phosphorus vapor, $P_4 = \mathit{3}$; streptomycin, $C_{21}H_{39}O_{12}N_7 = \mathit{6}$; strychnine, $C_{21}H_{22}N_2O_2 = \mathit{12}$. It is generally accepted tacitly that in counting the number of cyclic structures in a polycyclic system no cyclic structure is counted if it is made up entirely of elements of other cyclic structures which themselves have been counted. That is, decahydronaphthalene, cyclohexene epoxide, acetylene, and nitrogen contain only two cyclic structures each, and tetrahedral molecules, such as P_4, hexamethylenetetramine, P_4O_6, P_4O_{10}, As_4O_6, and $P_4O_6S_4$, contain only three (not four) cyclic structures.

Equation 2 reduces further to the familiar general formulas for the various homologous series of organic compounds if the restrictions which define the series are introduced into it. For example, for the acyclic saturated hydrocarbons (alkanes, paraffins), introducing $\rho = 0$ and dropping terms other than those for C and H gives $n_{\mathrm{H}} = 2n_{\mathrm{C}} + 2$. Similarly, for the homologous amino monocarboxylic acids, introducing $\rho = 1$ and $n_{\mathrm{N}} = 1$ ($n_{\mathrm{oxygen}} = 2$), gives $n_{\mathrm{H}} = 2n_{\mathrm{C}} + 1$ ($n_{\mathrm{oxygen}} = 2$).

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