POTABLE WATER FROM THE SEA

IN Dr. Whitney's most interesting and stimulating article, "Accomplishments and Future of the Physical Sciences,"[1] he makes an allusion to Francis Bacon's "New Atlantis." We quote Dr. Whitney in part: ". . . the accidentally discovered island, in his popular story, made use of such unheard-of advantages as horseless carriages, sailless ships, submarines, human wings, etc. He apparently exhausted himself by his suggestions of desirable but undiscovered things. But no one can exceed his number even now. It is so difficult to think in terms remote from experience. There were over twenty widely different predictions and all but one have been realized. That one seems simple. It is a filter to take potable water from the ocean. That this has eluded research so long does not make it insoluble, but it indicates limits to describing the impossible."

It is interesting to note that even this last prediction—a filter to produce potable water from the sea—has been realized. An article by Adams and Holmes[2] describes filters of two types of synthetic resins which have the ability to take up positive and negative ions, respectively. Sea water filtered first through one and then the other can thus be reduced to a potable saline content. Manufacturing costs have limited the use of such filters to laboratory scale installations up to the present time or at least up to a few weeks ago.

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[1] SCIENCE, 84: 211.

[2] *Jour. Soc. Chem. Ind.*, 54: 1 T.

SPECIAL ARTICLES

ELECTRON MOTION IN A PLASMA

IN a plasma the principal force acting on the electrons is the coulomb force arising wherever the equality of electron and positive ion density is disturbed. This force has been considered by Tonks and Langmuir[1] and made the basis of their theory of plasma electron oscillations. However, there is also another force, namely, that due to electron gas pressure gradients, which may be of considerable importance.

An equation for electron motion has been developed by the writer which is more general than previous ones, in that this latter force is not neglected.[2] The resulting expression for the one-dimensional case is

$$\frac{d^2\xi}{dt^2}+\frac{4\pi ne^2}{m}\xi=\frac{kT}{m}\frac{d^2\xi}{dx^2}, \tag{1}$$

where ξ is electron displacement, n electron density, T is electron gas temperature and x the equilibrium electron position. This indicates that the gas is capable of executing free oscillations of a series of frequencies given by

$$f_i=\sqrt{\frac{kT}{\lambda_i^2 m}+\frac{ne^2}{\pi m}}. \tag{2}$$

The lower limit $(ne^2/\pi m)^{1/2}$ corresponds to the Tonks-Langmuir value, while the other frequencies depend upon the possible standing waves which may exist.

If $T=0$, or $\lambda=\infty$, the equation reduces to the Tonks-Langmuir equation, which is to be expected, since in either case no pressure gradients would exist. If $e=0$ (uncharged particles) we get the equation for sound wave propagation, the electron gas behaving like a normal uncharged gas, in which pressure is the only acting force. If $d\xi/dt=0$, the equation yields the Debye-Hückel expression for the variation of potential near a charged plane in a plasma under equilibrium conditions.

The above theory offers an explanation of the observed variation of oscillation frequency with electron gas temperature. From the above expression (2) for frequency it is evident that an increase in temperature causes an increase in frequency. The value of λ, the wave-length in the plasma, which must be chosen to give quantitative agreement, turns out to be of the correct order of magnitude.

The Tonks and Langmuir theory predicted that harmonic disturbances would be propagated in the plasma with zero group velocity. However, if electron pressure be considered this is no longer true. The group velocity is found to be

$$G=\left(\frac{kT}{m}\right)^{1/2}\left(1-\frac{4\pi ne^2}{mp^2}\right)^{1/2};$$

and the phase velocity,

$$V=\left(\frac{kT}{m}\right)^{1/2}\left(1-\frac{4\pi ne^2}{mp^2}\right)^{-1/2},$$

where p is the frequency of the wave. These expressions are identical with the corresponding well-known ones for radio waves except that the quantity $(kT/m)^{1/2}$ replaces the velocity of light c.

Thus a high frequency electrical disturbance in a plasma produces two types of waves: first, a radio wave and second, an electronic wave, described by equation (1). The ratio of their velocities is $\frac{c}{(kT/m)^{1/2}}$, which is approximately the ratio of the

[1] L. Tonks and I. Langmuir, *Phys. Rev.*, 33: 195, 1929.

[2] E. G. Linder, *Phys. Rev.*, 49: 753, 1936.

speed of light to the speed of sound in a gas at a temperature T and consisting of particles of mass m.

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BRAIN POTENTIALS IN CHILDREN AND ADULTS

AN attempt has been made to compare the spontaneous electrical activity of the brain in normal adult subjects with that in children from infancy to adulthood. Using a standardized procedure,[1] both in the placement of the electrodes and in the conduct of the experiments, brain potentials were recorded from 54 adults (40 men and 14 women) ranging in age from 18 to 64, and from more than 100 children of from 1 month to 16 years of age. Significant differences in the frequency and pattern of the potential oscillations were observed, but the frequency variations of the so-called alpha waves in relation to age is the main purpose of this report.

Records were obtained from over the occipital areas of the brain, while the subjects were relaxed and at rest in a dark and relatively sound-proof room, which was electrically shielded. The position of the electrodes was determined by actual measurement with respect to certain anatomical landmarks. A comparison of these measurements with x-rays of the skulls which are available for all children and with the brain and x-rays of the skulls of child and adult cadavers has indicated that the electrodes were usually just posterior to the parieto-occipital fossa.

Wide differences in frequency of the waves were observed between the records of children and adults. Table I gives the average and range of frequency for each age group. The frequency of the large rhythmic waves of the adult records ranged from 8 to 12 per second as has generally been reported by others, without significant age differences. The average frequency for the men was 10.2 per second, whereas that for the women was 11 per second.

TABLE I

No. of subjects	Age	Average frequency	Range
1	1 mo.		
2	2 mos.		
7	3 "		
1	4 "	3.8	3.5– 4.0
2	5 "	4.6	4.0– 5.0
4	6 "	4.7	4.0– 5.5
2	7 "	4.8	4.5– 5.0
1	9 "	4.8	4.5– 5.0
1	13 "	5.5	5.0– 6.0
1	18 "	5.8	5.0– 6.5
8	2 yr.	6.3	5.0– 8.0
3	3 "	8.3	7.0– 9.5
14	4 "	8.3	7.0–12.0
5	5 "	8.1	6.5– 9.5
10	6 "	8.8	7.5–10.0
5	7 "	9.0	7.0–11.0
3	8 "	10.3	9.0–12.5
4	9 "	9.4	8.5–11.0
4	10 "	11.2	9.0–14.0
13	11 "	10.8	8.5–13.0
10	12 "	10.9	8.5–13.0
7	13 "	10.3	9.0–11.0
1	14 "	10.5	9.5–11.0
2	15 "	10.3	9.5–12.0
54	adults	10.4	8.0–12.0

[1] Apparatus, procedure and additional results will be discussed in detail elsewhere.

The records obtained from children of 1 and 2 months of age showed occasional waves of the magnitude of alpha waves but of irregular size and shape and never in rhythmic sequence. The records from 7 babies of 3 months of age were essentially similar and showed mainly gross and irregular variations of potential, with often a complete absence of electrical activity except for the small oscillations (presumably beta waves) at frequencies ranging from 25 to 40 per second. In a few of the records from 3 of the 3-months-old children there were occasional evidences of waves of rhythmic character, that is, a series of 3 or 4 waves in rhythmic sequence occurring at a frequency of 3 to 4 per second. It appears that this occasional rhythmic activity is the forerunner of the clear and more persistent rhythms which have been observed in the records of these same children when examined at intervals of 1 to 3 months later.

Table I shows the gradual increase in the frequency of the waves with age from 4 months of age upward until the adult frequency level is reached at about 8 to 10 years of age. From 10 to 12 years of age the frequency is higher than that of the adult average.

These observations lead us to conclude that rhythmic (alpha) waves first become manifest between the age of 3 and 6 months, and probably in most infants at or shortly after 3 months of age. In view of the fact that children begin to perceive objects and follow them across the visual field at about this same time, it appears that the onset of the rhythmic waves may be associated with the development of functional activity in certain parts of the visual area from over which our records were obtained.

No satisfactory explanation has yet been found for the beginning of the rhythmic waves around 3 months of age or for the increase in frequency of the waves with age in children, but the consistent and somewhat uniform upward trend of the frequency until the adult level is reached at 8 to 10 years of age suggests a developmental process of some sort. Whether myelinization of projection fibers or some other growth process is concerned can not be hazarded. The rise in frequency in children from 10 to 12 years of age to a value above the average for the adult group appears to be significant and may be related to some of the many physiological changes which are believed to occur at this age.

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