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.

A. M. BUSWELL,
Chief, Illinois State Water Survey
UNIVERSITY OF ILLINOIS

[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

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

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

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

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.