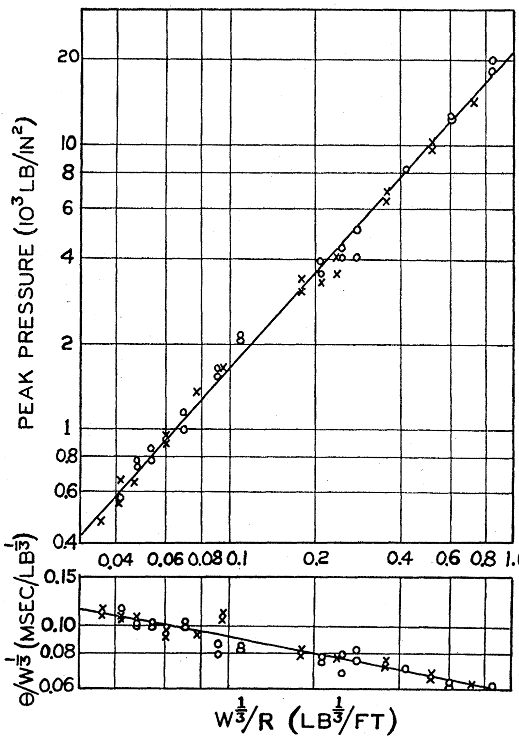

FIG. 1. Peak pressure and reduced time constant for spherical TNT charges of weight W at a distance R. Circles are for 76-lb. charges, crosses for 48-lb. charges.

obtained, or two-thirds the value of 240 lb./in.^{2} which would be realized if the decay were as the inverse first power of the distance. The time constant θ expressing the duration of the pressure is found to increase by nearly a factor of two from 0.50 m sec. at 20 ft. to 0.90 m sec. at 500 ft.

The large differences from the behavior for acoustic waves have been confirmed by so many measurements under widely different conditions that there can be little doubt of their reality. As an example, there may be cited the results of a series of measurements with spherical charges containing 48 and 76 lb. of TNT and at distances from 7 to 100 ft. The peak pressure is found to be a single valued function of the ratio $W^{1/3}/R$, where W is the weight of explosive and R the distance, as shown in the plot of peak pressure against $W^{1/3}/R$ on a double logarithmic scale in Fig. 1. The slope of the best straight line fitting these data is 1.13 and hence the peak pressure varies approximately as $R^{-1.13}$ for the pressure range of these data. The reduced time constant $\theta/W^{1/3}$ should also be a single valued function of $W^{1/3}/R$ (a result of the principle of similarity derivable from the hydrodynamical equations for shock waves), and this is shown by the lower curve of Fig. 1. Although the data have some scatter, they show very definitely the increase in duration of the shock front at greater distances (smaller values of $W^{1/3}/R$).

A very direct indication of the broadening in profile of the shock wave and dissipation at the steep front can also be seen by examination of pressure-time curves which have small bumps or discontinuities behind the front. As the distance increases, the bumps at higher pressure are found to be increasingly far in advance of those in later, lower pressure regions and also are increasingly close to the front. This progression toward, and dissipation at, the front are just what the increasing velocity of sound with pressure leads one to expect, as found for example by the approximate analysis of Osborne and Taylor for plane waves and the more detailed propagation theory of Kirkwood and Bethe[3] for spherical waves.

The failure of Osborne and Taylor to observe the broadening of the shock wave is thus surprising, as the results mentioned here and many others confirm the effect for larger charges and demonstrate the principle of similarity for scaling results to different charge weights and distances. The small quantities of explosive used by these workers do, however, make precise measurement difficult because of the very short durations of the pressure wave, the problem being much less difficult in this respect if larger charges are used.

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** Now at Brown University, Providence, Rhode Island.
[1] M. F. Osborne and A. H. Taylor, Phys. Rev. **70**, 322 (1946).
[2] Established at the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts under OSRD contract OEMsr-569 and under contract with the Bureau of Ordnance, U. S. Navy.
[3] J. G. Kirkwood and H. A. Bethe, "The pressure wave produced by an underwater explosion" I, OSRD Report 588 (available as photostat or microfilm copies from Office of the Publication Board, U. S. Department of Commerce, Washington).

Nuclear Electrostatic Generator

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ELECTROSTATIC generators in which a high voltage is produced by charging a collector by means of high energy particles from a radioactive material have been discussed in several recent articles. Among them is the letter of P. H. Miller[1] who proposed the use of polonium, and suggested that it could be produced from bismuth in a chain reacting pile. There is also the article by M. L. Pool,[2] and that by I. A. Lobanev and A. P. Beliakov.[3] The latter authors state that a nuclear generator was constructed which delivered currents of 10^{-10} to 10^{-9} ampere. The earliest publication on this topic with which the present writer is familiar, is that of H. G. J. Moseley[4] entitled "The Attainment of High Potentials by the Use of Radium," which appeared in 1913. It describes a device yielding potentials of about 150,000 volts.

Interest in this type of device would seem to be justified by its enhanced possibilities in view of the now greatly increased availability of radioactive substances. Since any of the above articles were written, the list of materials obtainable from the Manhattan Project has been published, and it is evident that many more suitable materials are now available than were tried or suggested previously. For example, there is europium 154, caesium 134, and cobalt 60. These have half-lives of several years and are priced at approximately \$100 per Curie-year. Furthermore they are beta-ray emitters, and would therefore be more suitable than an alpha-ray emitter, such as polonium. because of the larger current (of the order of 100 times) obtainable per unit area due to the smaller absorption by the emitting substance. It seems likely that in the future the production of such materials will increase, so that they promise to be obtainable in quantities and at prices which make their use as electric voltage sources worthy of consideration from a practical standpoint.

Plans for constructing such a generator were made in this laboratory last year, and work is now progressing. It is hoped to exceed Moseley's results several-fold, with the help of the new supplies of radioactive materials, modern technique of high voltage insulation, and the use of shields to reduce the deleterious effects of secondary radiations.

Generators of this type offer a means for the direct conversion of nuclear energy into electrical energy. The practical realization of such conversion would seem to depend mainly upon a supply of suitable radioactive material, and probably (at least in the case of large power generators) upon the utilization of a controllable reaction, by means of which the emission of particles could be stopped and started at will.

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[4] H. G. J. Moseley, Proc. Roy. Soc. **A88**, 471 (1913).

Artificial Activities Produced in Europium and Holmium by Slow Neutron Bombardment*

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A NITRIC acid solution of Ho_2O_3 was irradiated with slow neutrons in an attempt to produce the 35-hour holmium activity reported in Seaborg's table.[1] An aliquot of this irradiated sample was placed on the filament source of a mass spectrograph. By operation of the spectrograph the holmium isotopes were separated according to mass and deposited on a photographic plate. After removal from the spectrograph this plate was placed face to face with another photographic plate, for convenience called a transfer plate. With the passage of time the radioactive decay particles emitted from the active isotope on the first plate gave rise to a developable image on the second plate. After development, the first plate showed the normal holmium spectrum, a strong line at mass 165 due to Ho, and a much weaker line at mass 181 due to HoO. The transfer plate showed a single weak line corresponding to mass 166 on the original plate. A decay curve of another aliquot of the irradiated sample counted for nine half-lives during the period of transfer showed that 96 percent of the activity recorded on the transfer plate decayed with a 27.5-hour half-life, and the remainder with a half-life of approximately 3 hours. Thus we may conclude that the artificial radioactive isotope of half-life 27.5 hours has a mass of 166. This is undoubtedly the same activity given in Seaborg's table as 35 hours. At present the 3-hour activity observed in the sample is ascribed to an impurity of dysprosium.

A nitric acid solution of Eu_2O_3 was irradiated with slow neutrons to produce the 9.2-hour and 5–8-year activities reported in Seaborg's table.[1] The mass of the 9.2-hour activity has been shown to be 152 by previous mass spectrographic analysis.[2] The irradiated sample was allowed to stand for two weeks in order that the 9.2-hour activity might decay. An aliquot of this sample was then run in the mass spectrograph, and a transfer plate was made. Development of the transfer plate showed two lines at masses 152 and 154. The deposit was allowed to stand for 4 months and a second transfer taken. The lines 152 and 154 appeared at the same relative strength as previously. This proved that the mass 152 line was not caused by the 9.2-hour activity of europium. Neither line 152 or 154 can be due to neodymium, illinium, samarium, or gadolinium since these elements emit copiously as NdO^+, IlO^+, SmO^+, and GdO^+ while europium emits only as Eu^+. Thus europium must have two long lived activities, one of mass 152 and one of mass 154, as well as the established 9.2 hour at mass 152. A magnetic investigation of the activities showed no detectable positron emission. Absorption curves showed at least two betas and one gamma. The energy of the gamma was 1.4 Mev.

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[1] G. T. Seaborg, Rev. Mod. Phys. **16**, 1 (1944).
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The Oscillator Concept in the Theory of Solids

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A RECENT problem has occasioned the question as to the role which the "bounded" linear oscillator might play in the theory of the specific heats of solids. As is well known, the Debye theory on closer comparison with experiment is in many cases more qualitatively than quantitatively correct, although the Debye specific heat function has certain of the required properties. Heretofore, all attempts to improve the status of theory (anomalies excepted) have been in the direction of obtaining more accurate frequency distributions in the manner of Born, Von Karman, Blackman, *et al.* The common ground of all these analyses has been the basic *a priori* assumption that the oscillator levels are given by $(n+\frac{1}{2})\hbar\omega$; i.e., the "ideal" or "Planck" oscillator.

We do not cavil at the "formal" use of the ideal oscillator in boson theory, but we do ask the question: How is it possible to obtain even qualitatively correct results using this model in the theory of solids? Although it is quite true that the probability amplitude is large only in and near the classical region, the quantizing condition is still the vanishing at infinity so that the amplitude is non-zero (in the strict sense) over a very large region. If, as is generally done, we take the somewhat literal picture of "material" oscillators then it would seem physically reasonable that