LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the eighteenth of the preceding month, for the second issue, the third of the month. Because of the late closing dates for the section no proof can be shown to authors. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Communications should not in general exceed 600 words in length.

Visible Radiation Produced by Electrons Moving in a Medium with Velocities Exceeding that of Light

In a note published in 1934[1] as well as in the subsequent publications[2-4] the present author reported his discovery of feeble visible radiation emitted by pure liquids under the action of fast electrons (β-particles of radioactive elements or Compton electrons liberated in liquids in the process of scattering of γ-rays). This radiation was a novel phenomenon, which could not be identified with any of the kinds of luminescence then known as the theory of luminescence failed to account for a number of unusual properties (insensitiveness to the action of quenching agents, anomalous polarization, marked spacial asymmetry, etc.) exhibited by the radiation in question. In 1934 the earliest results obtained in the experiments with γ-rays led S. I. Wawilow[5] to interpret the radiation observed as a result of the retardation of the Compton electrons liberated in liquids by γ-rays. A comprehensive quantitative theory subsequently advanced by I. M. Frank and I. E. Tamm[6] afforded an exhaustive interpretation of all the peculiarities of the new phenomenon, including its most remarkable characteristic —the asymmetry.

According to their theory, an electron moving in a medium of refractive index n with a velocity exceeding that of light in the same medium ($\beta > 1/n$) is liable to emit light which must be propagated in a direction forming an angle θ with the path of the electron, this angle being determined by the equation:

$$\cos\theta = 1/\beta n, \qquad (1)$$

where β is the ratio of the electron velocity to that of light in vacuum.

A successful experimental verification of formula (1) was only performed with water[4] for which, at the moment

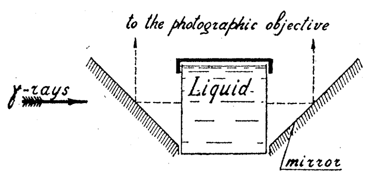

FIG. 1. Arrangement of apparatus.

of publication of the above theory, data were already available which had been obtained by visual observations by the method of quenching.[7, 8]

We recently performed additional experiments in which the intensity of radiation was recorded photographically, the records being taken simultaneously for all the angles θ lying in a plane passing through the primary electron

(a)

(b)

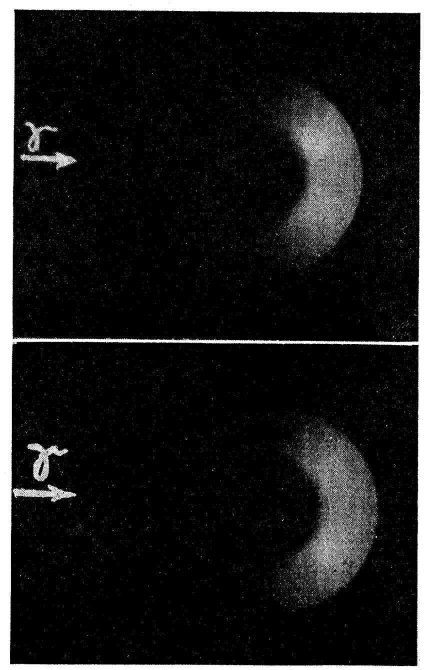

FIG. 2. Photographs showing asymmetry of luminescence. (a) water. $n = 1.337$; (b) benzene, $n = 1.513$.

beam. The liquid was placed in a cylindrical glass vessel with very thin walls, and the light emitted by the liquid was reflected by a conical mirror in an upward direction to the object glass of a photographic camera as indicated in Fig. 1. An approximately parallel beam of γ-rays, filtered through a 3-mm lead plate, fell on the liquid horizontally. The γ-radiation used was equivalent to that of 794 mg of radium. The considerable thickness of the lead screen, the large aperture of the object glass (f : 1.4) and the long exposure (72 hours) ensured sufficient distinctness of the photographs.

The latter were obtained for ten different liquids. Two of the photographs taken (positive) are represented in Fig. 2. An examination of these photographs leads to the following conclusions:

(1) In all the pure liquids investigated the radiation propagates mainly in the onward direction of the primary beam, the blackening of the negatives being only visible on part of the annular circle.

(2) The area of the blackened sector increases with the

refractive index of the liquids (see Fig. 2: (a) $n=1.337$ for water and (b) $n=1.513$ for benzene).

(3) Each photograph exhibits two diffuse but clearly visible maxima of blackening, which are symmetrical with respect to the primary beam. Their angular spacing increases with the refractive index of the liquids, and, to a first approximation, agrees with the values which might be expected according to Eq. (1). The absence of distinct maxima of blackening is undoubtedly associated with the difference in energy of the Compton electrons liberated from the molecules of the liquids by γ-rays, with the nonparallelism of these electrons and with the fact that the energy of each electron, moving in a liquid, gradually changes from the initial energy to zero.

All the results obtained are in good agreement with I. M. Frank and I. E. Tamm's theory of the coherent radiation of electrons moving in a medium.[6]

P. A. Čerenkov

The Physical Institute of the Academy of Sciences of U.S.S.R.,
Moscow,
June 15, 1937.

[1] Čerenkov, C. R. Ac. Sci. U.S.S.R. **8**, 451 (1934).
[2] Čerenkov, C. R. Ac. Sci. U.S.S.R. **12** (3), 413 (1936).
[3] Čerenkov, C. R. Ac. Sci. U.S.S.R. **14**, 102 (1937).
[4] Čerenkov, C. R. Ac. Sci. U.S.S.R. **14**, 105 (1937).
[5] Wawilow, C. R. Ac. Sci. U.S.S.R. **8**, 457 (1934).
[6] Frank and Tamm, C. R. Ac. Sci. U.S.S.R. **14**, 109 (1937).
[7] Bull. Ac. Sci. U.S.S.R. No. 7, 919 (1933).
[8] E. Brumberg and S. Wawilow, C. R. Ac. Sci. U.S.S.R. **3**, 405 (1934)

Maximum Voltage of Wisconsin Electrostatic Generator as a Function of Air Pressure

The large electrostatic generator developed at this laboratory[1] has been in use for more than a year and during regular operation some information was obtained regarding the maximum generator voltage as a function of air pressure in the enclosing tank. This information was very limited, however, since during regular operation the pressure is generally kept at 115 lb. (100-lb. gauge pressure) and when making tests on apparatus atmospheric pressure was used.

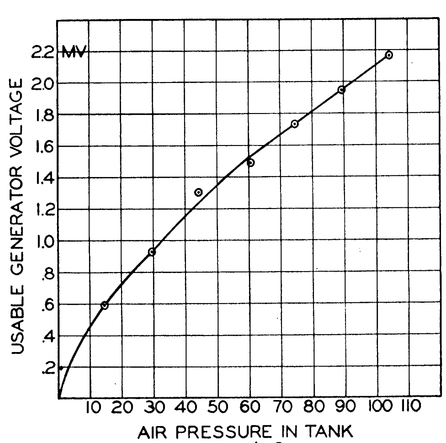

Fig. 1. Curve showing maximum usable generator voltage as a function of air pressure in the enclosing tank. Air pressure is given in lb./in², absolute (not above atmospheric).

To determine the maximum usable voltage over the entire pressure range, a test run was recently made giving the data shown in Fig. 1. The maximum voltage was found to be somewhat indefinite at all air pressures, since a region of voltage instability exists in which the generator will run steadily except for an occasional spark, the average interval between sparks decreasing as the voltage is increased. During the first 15 minutes of running the maximum voltage generally shows a very appreciable increase with time. This increase may, however, depend more on the number of sparks that pass than on the length of running time. To determine the maximum usable generator voltage corresponding to each of the air pressures indicated in Fig. 1, the performance of the generator was studied at each value of the pressure chosen. The voltage values plotted are voltages for which the time interval between sparks was approximately 3 minutes after the generator had been run 15 minutes. A time interval of 3 minutes between sparks is too short for good running conditions, but this criterion was adopted during the test run in order to get consistent data in a reasonable length of time.

The sparks pass radially from the high potential electrode to the tank wall. They do no damage and after a spark has passed the voltage rises to its former steady value in approximately 10 seconds. At air pressures up to about 95 lb. (80-lb. gauge pressure) the generator voltage is always limited by this radial sparking, but at higher pressures the limit is sometimes determined by sparking down the charging belts. This is caused by excessive charging current on the belts, and can only be eliminated by decreasing current drain from the generator and hence allowing a decrease in the charging current. Generally, when the belts fail, an increase in tank pressure gives a decrease in usable voltage. When the data shown in Fig. 1 were taken the corona gaps along the accelerating tube were set too close for voltages above 2200 kv. Their high current drain necessitated high charging currents, and when the tank pressure was increased to 115 lb. sparking along the belts limited the usable voltage to approximately 2100 kv. This value was not plotted in Fig. 1, since a voltage limitation due to sparking along the belts is not characteristic of the generator operating under good conditions.

No explanation has been found for the nonlinearity of the curve of Fig. 1 in the region of low air pressures. At pressures above 45 lb. the curve is very nearly linear with a slope somewhat greater than had been expected.

From a consideration of these results it seems that higher air pressure may be of value for a generator of this type providing that the limitations due to sparking along charging belts and insulating supports can be avoided.

R. G. Herb
E. J. Bernet

University of Wisconsin,
Madison, Wisconsin,
July 23, 1937.

[1] R. G. Herb, D. B. Parkinson, D. W. Kerst, Phys. Rev. **51**, 75 (1937).

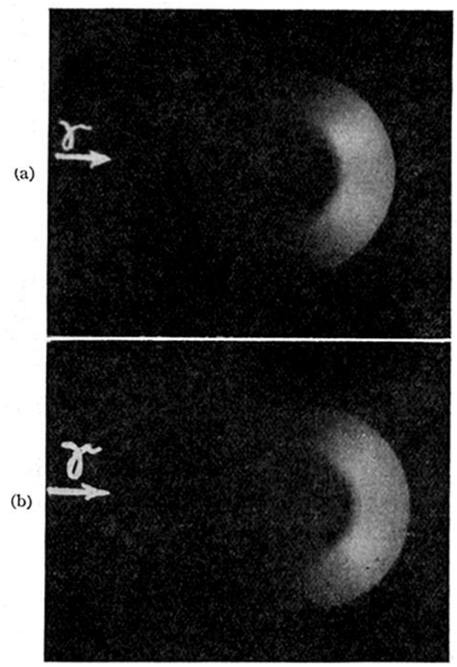

FIG. 2. Photographs showing asymmetry of luminescence. (a) water· $n = 1.337$; (b) benzene, $n = 1.513$.