

within several meters of the discharge tube, the transitions took place so rapidly as to generate oscillations of a frequency of the order of 250,000. As much as 66 percent of the d.c. energy was converted into these high frequency oscillations. Several rather paradoxical demonstrations are described in the papers referred to above. For example, a miniature incandescent lamp in series with the discharge tube glows more brightly when the discharge is taking place than when the electrodes are short-circuited, although in the latter case a d.c. ammeter indicates a larger current.

The effect was independent of the material of the anode, and could be obtained to a greater or less extent with cathodes of metals ranging all the way from soft solder to Ag or Pt, and even with carbon. Oscillations ceased with currents above 0.8 amp.

With an a.c. 60-cycle supply the effect could also be observed, although not so well. In this connection attention may be called to a paper by Plesse³ who found what appears to be the same high frequency glow-arc transitions with an a.c. supply.

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¹ H. Y. Fan, *Phys. Rev.* **55**, 769 (1939).

² W. G. Cady and G. W. Vinal, *Am. J. Sci.* **28**, 89 (1909) and *Physik. Zeits.* **10**, 569 (1909); W. G. Cady, *Am. J. Sci.* **28**, 239 (1909) and *Physik. Zeits.* **10**, 623 (1909). This work is discussed in the book by K. W. Wagner, *Der Lichtbogen als Wechselstromerzeuger* (Leipzig, 1910).

³ H. Plesse, *Ann. d. Physik*, **22**, 473 (1935). A somewhat similar phenomenon in the spark discharge is recorded by H. Kaiser and A. Wallraff, *Zeits. f. Physik* **112**, 215 (1939).

Initial Performance of the 60-Inch Cyclotron of the William H. Crocker Radiation Laboratory, University of California

During the past few weeks, we have been engaged in the adjustments of the 60-inch cyclotron of the William H. Crocker Radiation Laboratory, and at this time we wish to report its initial performance.

As is always fruitful in first turning on a cyclotron, we looked for resonance in the first instance by placing a Geiger counter nearby. With hydrogen, proton resonance was found close to the expected value of magnet current, and we proceeded to build up the intensity of the resonance effect by adjusting the magnetic field with shims. Following this adjustment, the beam to the target was observed and further shimming yielded 25 microamperes at eight-million volt protons. Probe measurements indicated about 100 microamperes circulating within the dees.

Next the hydrogen was replaced with deuterium at a pressure about one-tenth that normally used in our 37-inch cyclotron, and the procedure of adjustment was repeated. Again resonance of deuterons was first observed with a

Geiger counter and shims were used to build up the effect. Indeed, the radiation intensity almost immediately obtained in this way, even with but one-tenth of the normal deuterium pressure, exceeded that ever obtained from the 37-inch cyclotron. At this juncture the high energy deuteron beam was looked for by detecting ionization in the air outside an aluminum target window. The beam was immediately found, and adjustments proceeded until ten microamperes to the target itself was obtained. The deuterons were observed to emerge from the target window and to penetrate the air for a distance of more than $1\frac{1}{2}$ meters, indicating the energy to be in the neighborhood of 16 million volts, a value consistent with the frequency and the geometry. Under the circumstances, as is well known, replacing the deuterium with helium would result in a beam of 38 million volt alpha-particles. Dependence of the deuteron beam on the adjustments shows that very large currents are obtainable, perhaps as large as can conveniently be used. It is perhaps noteworthy also that this very high energy deuteron beam is obtained with an oscillator input of only 60 kilowatts. We therefore see no difficulties in the way of producing with the present equipment 25 million volt deuterons and 50 million volt alpha-particles, and moreover we are convinced that much higher energies could be obtained from a cyclotron of larger dimensions.

We wish to take this opportunity to express our profound gratitude to many individuals and organizations who have made these developments possible. In the first place we are indebted to the late Mr. Francis P. Garvan and to Mr. William H. Buffum of the Chemical Foundation, who provided the initial funds for the cyclotron construction, and to the late Mr. William H. Crocker, who provided for the laboratory building. We are equally indebted to the Rockefeller Foundation and the National Advisory Cancer Council for continued support which has made possible the rapid development of the work. We also are deeply appreciative of the important part our laboratory colleagues are having in this work; for all of our associates have been actively interested and have contributed in large measure to the development of the 60-inch cyclotron; and we are likewise appreciative of the invaluable help of the staff of the shop.

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