The results concerning the latitude dependence of the delayed coincidences registered at 30,000 feet with absorber are summarized in Table I. The last line of the table contains the ratio ("latitude ratio," I/I_0) between the value of N obtained at each latitude and near the equator (9° North). Curve a in Fig. 1 represents these data. The results concerning the anticoincidences are graphically represented in the same way (namely, as latitude ratio I/I_0) by the points of curve b, curve c, which represents the latitude dependence of the X component, is obtained, through Eqs. (1) and (2), from the other two curves. If the X particles were protons, they should have a momentum of about 1 Bev/c to penetrate the 15 cm Pb interposed between counters A and B. A latitude ratio of 2.8 between the highest latitude and the equator for protons of such a momentum seems to be reasonable if compared with the latitude dependence recently observed for "stars"[2] and for small "bursts."[3] Further arguments which support the view that the X component is made up essentially of protons will be given in a future paper.

* Supported by the joint program of the ONR and the AEC.
** On leave from the University of Rome, Italy.
*** A small correction for the spurious delayed coincidences produced in the first channel by the spontaneous lags of counters C has been introduced on the basis of measurements taken in flight without absorber. A detailed account of all corrections introduced will be given in a complete report of this research.

[1] M. Conversi, Phys. Rev. 76, 311 (1949).
[2] Lord, Schein, and Vidale, Phys. Rev. 76, 171 (1949).
[3] J. A. Simpson, private communication.

Electron Gun Emission and X-Ray Output for Three Betatrons

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In a recent publication[1] a new theory was presented for the process of capture of electrons in the betatron. In an attempt to check this theory, measurements were made on three different betatrons of x-ray output *versus* electron emission from the gun. The results are interesting because of the great differences between curves plotted for different machines and because of the change of the shape of the curves with gun voltage. In one respect all the curves confirm qualitatively an important point of the theory namely for the greater portion of the curves the x-ray output varies as the gun electron emission current to a power larger than one.

All x-ray measurements were referred to Victoreen thimbles in one-eighth inch lead jackets and special checks were made on the location of the x-ray beam by means of films at different distances in order to exclude errors from stray electrons. The direct readings were taken on x-ray ionization chamber monitors calibrated with the Victoreen instrument.

In all three machines the magnetic field varies inversely proportional to the three-quarters power of the radius over most of the region between gun and target.

The curves shown at the left in Fig. 1 were taken on the 100-Mev betatron[2] which operates at 60 cycles per second and has a pumped vacuum tube. The orbit diameter is 66 inches, the free vacuum space is 3.4 inches high by 4.6 inches wide, corresponding respectively to relative apertures of 0.052 and 0.07. An improved electron gun with a barium aluminate cathode was used. During its long life of more than one thousand hours the x-ray output had dropped from 2300 roentgens per minute at 1 meter to the present figures principally on account of reduced spark over potential. The voltage pulse is a half-sine wave of 10 microsecond duration.

The curves in the middle of Fig. 1 were taken on the 50-Mev biased betatron[3] operating at 180 cycles per second with a sealed off vacuum tube. The orbit diameter is 23 inches, the free vacuum space is 1.63 in.×2.21 in. corresponding to relative apertures of 0.071 and 0.096 respectively. The gun has an improved focusing

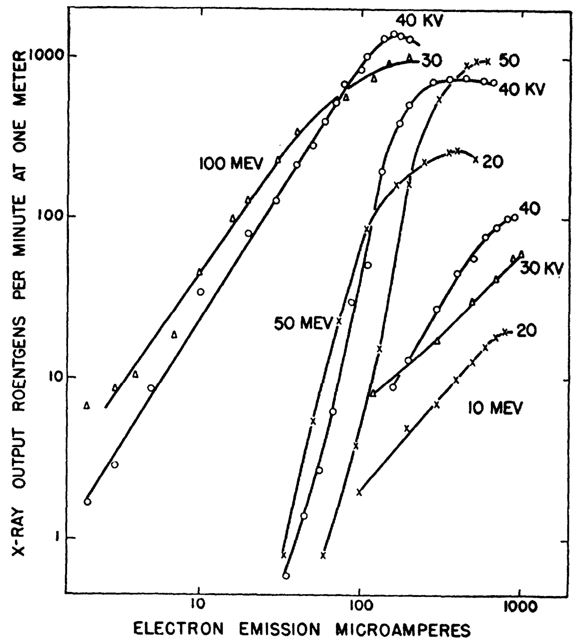

FIG. 1. Logarithmic plot of x-ray output *versus* electron gun emission for a 100-Mev, a 50-Mev and a 10-Mev betatron, at different gun voltages ranging from 20 to 50 kilovolts.

cup with a conventional coiled tungsten filament and a fourth electrode of adjustable potential which permits directional adjustment of the beam. The voltage pulse wave form is very nearly a half-sine wave of 5 microsecond base width.

On the right in Fig. 1 are shown the data obtained with an industrial 10-Mev betatron operating at 1920 cycles per second. The orbit diameter is 10.5 in.; the free vacuum space is 1.7 in. ×2.33 in. with consequent relative apertures of 0.16 and 0.22. The tube is sealed off and has an electron gun like the one in the 50-Mev biased betatron. The gun voltage pulse has a waveform with a base of 6 microseconds and a flat top of 2 microseconds.

The steepest slopes of the curves as drawn are in descending order of gun voltage for the 100-Mev machine 1.6 and 1.45, for the 50-Mev machine 5.7, 5.0, and 4.3, and for the 10-Mev machine 1.7, 1.1, and 1.2. For all three machines the maximum x-ray output obtainable with excess emission available at a given gun voltage varies very nearly as the 1.25 power of the gun voltage.

[1] D. W. Kerst, Phys. Rev. 74, 503 (1948).
[2] W. F. Westendorp and E. E. Charlton, J. App. Phys. 16, 581 (1945).
[3] W. F. Westendorp, J. App. Phys. 16, 657 (1945); Phys. Rev. 71, 271 (1947).

The Superconducting Torus

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June 10, 1949

A RECENT exact solution of the electrodynamic behavior of a superconducting torus by one of the authors,[1] presents the opportunity of discussing the effect of changes in torus dimensions on the hysteresis loop obtained by magnetic cycling.

Figure 1 is the hysteresis loop to be expected for a superconducting torus with s, the ratio of mean radius of toroidal ring to radius of toroidal wire, equal to four. Shoenberg[2] in studying the properties of a superconducting torus used a torus for which $s=4$. Within experimental error his results are in agreement with Fig. 1.

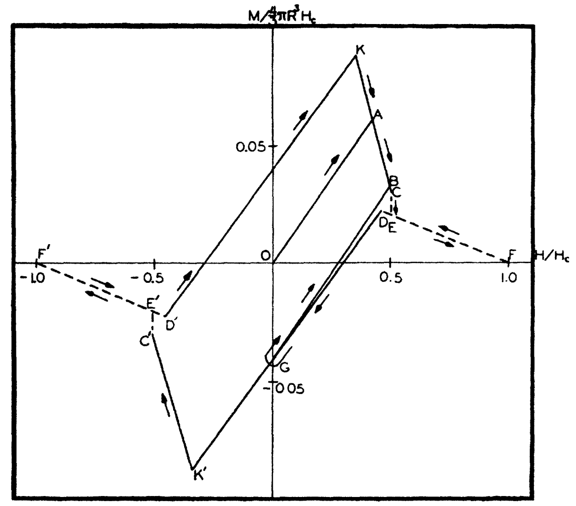

FIG. 1. Behavior of a torus ($s=4$) in a magnetic cycle. The symbols used are: M, magnetic moment; R, mean radius of ring; H_c, critical magnetic field; H, applied field.

Experiments with tori for which the geometrical factor s ranged in value from 6 to 33 have been conducted by McLennan *et al.*,[3] Schubnikow and Chotkewitsch,[4] and Grassmann and Eicke.[5] Their experimental data are in reasonable agreement with the theoretical formulas.[1] Thus it is felt that the interpretation of the hysteresis loop as outlined by Shoenberg[6] is essentially correct.

All investigations to date have been performed using tori for which s is relatively large. Of interest is the departures to be expected for the case of thick tori. Figure 2 is the hysteresis loop expected to be obtained upon the magnetic cycling of a superconducting torus for which $s=1.4$. Of immediate note are: (1) The increase in the value of H/H_c for the point C at which the torus, in increasing field, enters the intermediate state. The usually quoted value of $H/H_c=\frac{1}{2}$ for the point C is correct only for very large values of s. (2) The large increase in current change occurring (C to E) when the torus passes from the superconducting state to the intermediate state. (3) The large decrease in H/H_c (E to D) for which the torus again becomes superconducting in decreasing field.

These features suggest that tori having small values of s should be used when it is wished to study the intermediate state.

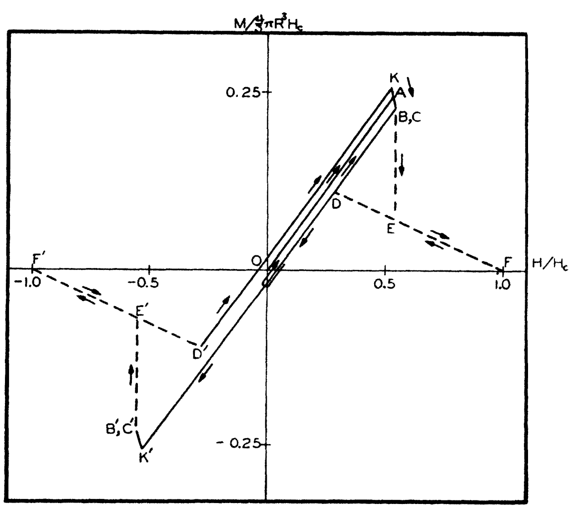

FIG. 2. Behavior of a torus ($s=1.4$) in a magnetic cycle. The symbols used have the same meaning as in Fig. 1.

On the other hand, tori of large s are more suitable for the determination of critical fields with minimum complication by the intermediate state. Along lines OA and KC, the material is completely superconducting[6] and since theoretically, the value of H/H_c at the point A is specified in terms of the geometry of the torus, a determination of the intersection point A would serve for the accurate determination of the critical field.

[1] J. de Launay, *Electrodynamics of a Superconducting Torus*, Naval Research Laboratory Technical Report No. P-3441, May 1949.
[2] D. Shoenberg, Proc. Roy. Soc. **155**, 712 (1936).
[3] McLennan, Allen, and Wilhelm, Phil. Mag. **14**, 168 (1932).
[4] L. W. Schubnikow and W. I. Chotkewitsch, Phys. Zeits. Sow. Union **10**, 231 (1936).
[5] P. Grassmann and H. Eicke, Phys. Zeits. **38**, 429 (1937).
[6] D. Shoenberg, *Superconductivity* (Cambridge University Press, London, 1938), Chapter IV.

An Observation of Non-Rayleigh Scattering of the Infra-Red Solar Spectrum by the Earth's Atmosphere

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June 13, 1949

WHILE engaged in the measurement of 10-micron ozonosphere radiation at Holloman Air Force Base, Alamogordo, New Mexico, in the spring of 1948,[1] the author chanced to observe the intense, scattered infra-red solar spectrum coming from the sky in the neighborhood of the sun.

It appears worthwhile to call attention to these observations because the relative intensities depart strikingly from the Rayleigh distribution.

Figure 1 compares a series of five consecutive observations of the sky-scattered, rock salt prismatic solar spectrum (*S*1, *S*2, *S*3, *S*4, *S*5), from 1 to 4 microns, with the spectrum of direct sunlight (*DO*) over the same wave-length interval.[2] The direct and the scattered spectra alike were recorded with a Perkin-Elmer spectrometer set at slit width $\frac{1}{2}$ mm. Further, they constitute a related

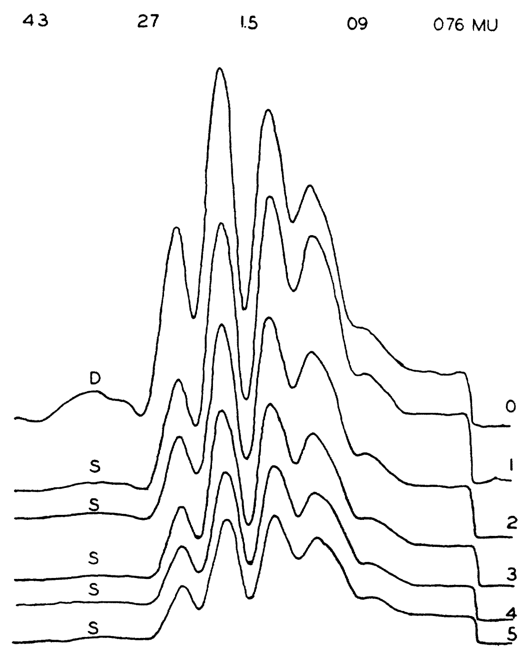

FIG. 1. Comparison of the near infra-red solar and sky spectra.