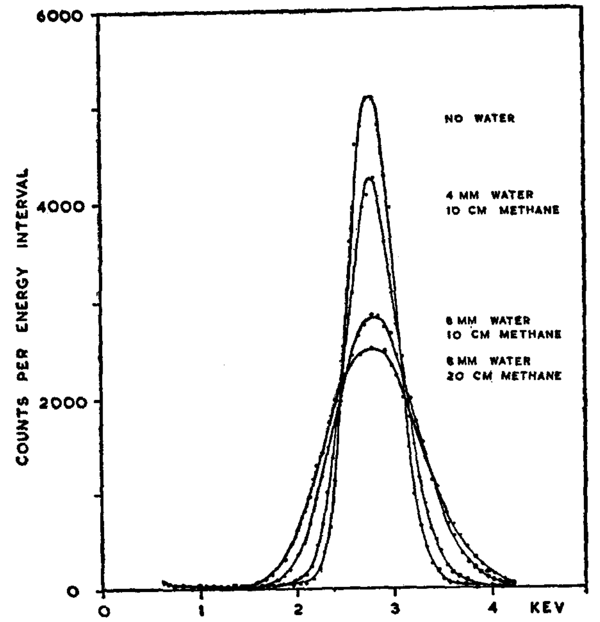

FIG. 1. Spectrum of A^{37} *K* peak obtained in a proportional counter of diameter 10 cm with different pressures of water vapor and methane.

and also to statistical fluctuations in attachment. The curves show that although energy resolution deteriorates as water is added, the pulses would all be counted provided the bias on the scaler were low enough.

The pulse spectra in the region of the *L* peak showed similar broadening. The measurements extended down to 50 ev and indicated the absence of spurious pulses.

The conclusion that activity measurements are not affected by the presence of water was verified independently by taking the counting rate from a solid C^{14} source mounted inside the counter facing the wall at different pressures of water vapor.

However, when tritiated water was being measured, the observed activity decreased with time as shown in Fig. 2. This may be explained by adsorption of the source on the wall of the counter, the effective counting geometry changing from 4π to approximately 2π in the process. The curve shown was obtained with a brass counter, but similar decays were observed in external cathode counters made of soda glass, glass treated with a water repellent silicone, and polythene. After pumping out, an activity of about 1% of the initial counting rate remained in the counters.

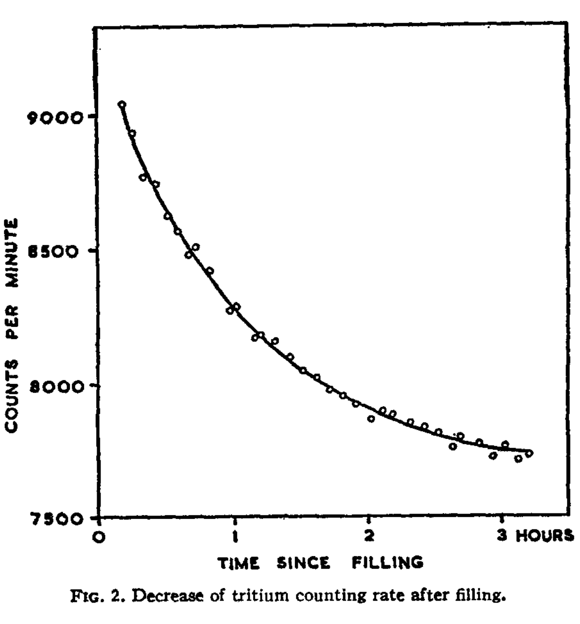

FIG. 2. Decrease of tritium counting rate after filling.

The deposition of the source on the wall involves complex adsorption phenomena which depend on the previous history of the surface and also tritium-hydrogen exchange effects. Mere extrapolation to find the initial activity cannot give the correct value for the source strength.

We would like to thank Dr. S. C. Curran for his encouragement and valuable discussions. This work was begun following a request by R. C. Hawkings of Chalk River for an independent assay of a standard source.

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[1] E. B. Butler, Nature 176, 1262 (1955).
[2] J. F. Cameron, Nature 176, 1264 (1955).
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[4] N. E. Bradbury and H. E. Tatel, J. Chem. Phys. 2, 835 (1934).

Experimental Test of the Fixed Field Alternating Gradient Principle of Particle Accelerator Design*

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(Received June 28, 1956)

THE possibility of accelerating particles in an annular ring machine with a magnetic guide field which is constant in time,[1] using alternating gradient focusing, has been verified by the achievement of an accelerated beam in an electron model. This model[2] (Fig. 1) uses the simplest method of achieving alternating gradient focusing with a fixed guide field, the so-called radial sector method, in which the median plane field at any azimuth is of the form $H=H_0(r/r_0)^k$, but has opposite sign in successive magnets. The value of k for this model is 3.36. The positive field magnets are longer than the negative field magnets to bend the electrons around the machine; this, with the positive k, makes the focusing of the radial betatron oscillations stronger than that of the vertical oscillations. With the small number of sectors of this machine, eight, some vertical focusing and radial defocusing is provided by the magnet edges.

Electrons are betatron-accelerated at 40 volts per turn from 25 kev to 400 kev, the average orbit radius going from 36 cm to 52 cm during the acceleration. Accelerated beam is obtained both with a pulsed current injector and a continuous current injector. In the first case the accelerated beam, detected at the outside edge of the machine both by collected charge on a probe and by x-rays, appears as a pulse delayed 160 μsec from injection. Halving the betatron accelerating voltage doubles the delay time, corresponding then to about 20 000 revolutions of the electrons. A pulsed expander is used to pull the electrons away from the injector, although appreciable beam is obtained without the expander. Using continuous current injection, accelerated beam is observed to come out over 600 μsec of the 2000-μsec period of one betatron cycle. It is rather surprising that any beam is obtained with continuous injection, without any expander, since the electrons must make 25 revolutions before they gain enough energy from the betatron flux to pull the orbit away from the injector, a longer survival time than calculated for this machine.

The frequencies of the radial and vertical betatron oscillations have been measured both statically, using pin holes and a ZnS screen,[3] and dynamically with the accelerated beam, using rf excitation of the betatron oscillations.[4] The results are essentially

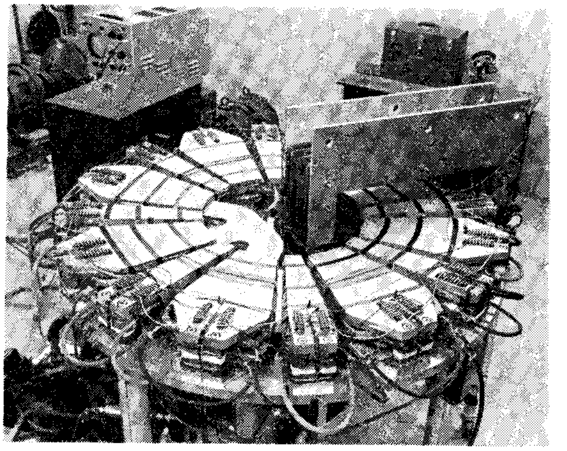

FIG. 1. Electron model used to test the fixed field alternating gradient principle.

the same by both methods. The static measurements indicate a small amount of nonlinearity in the betatron oscillations; the dynamical measurements show that ν_r and ν_z, the number of radial and vertical betatron oscillations around the machine, are independent of orbit radius, checking the scaling design of the machine. By varying the ratio of the currents in the positive and negative field magnets, and by changing the field index k with extra windings, it is possible to vary both ν_r and ν_z. The frequency region surveyed is $2.5<\nu_r<3$ and $1.5<\nu_z<2.5$. Accelerated beam is found for all ν's investigated except near the resonance regions, in particular the integral, half-integral, and unstable third-integral ($\nu_r=8/3$) regions. The stop bands are wide on the integral resonance, very narrow on the others. As yet, no systematic search has been made for sum, difference, or higher order resonances.

We wish to acknowledge the contributions to this project of many other members of the Midwestern Universities Research Association. We want to give special thanks to C. H. Pruett of Indiana University for his valuable technical assistance, F. T. Cole of the University of Iowa for the theoretical design calculations, and D. W. Kerst of the University of Illinois for his continued interest, contributions, and support.

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* Supported by the National Science Foundation and the Office of Naval Research.

[1] K. R. Symon, Phys. Rev. **98**, 1152 (A) (1955).

[2] Terwilliger, Jones, Cole, and Kerst, Phys. Rev. **100**, 1246 (A) (1955); L. W. Jones and K. M. Terwilliger MURA Report—LWJ/KMT-5, 1956 (unpublished).

[3] L. W. Jones and K. M. Terwilliger, Phys. Rev. **100**, 1247 (A) (1955).

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Errata: Production and Use of High Transient Magnetic Fields. I

[Rev. Sci. Instr. **27**, 195 (1956)]

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(Received June 13, 1956)

ON page 195, second paragraph, accumulator-pulsed magnetic fields of the order of 100 000 gauss are attributed to P. Kapitza. The reference is to the Zeeman effect work of P. Kapitza and H. W. B. Skinner.[1] Kapitza earlier had reached 500 000 gauss in a millimeter coil by this method.[2]

Page 197, third paragraph, line 23, 4.5 per second should read one per 4.5 seconds. Page 198, third paragraph, line 8, several hundred degrees should read several thousand degrees.

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[1] P. Kapitza and H. W. B. Skinner, Proc. Roy. Soc. (London) **A109**, 227 (1925).

[2] P. Kapitza, Proc. Roy. Soc. (London) **A105**, 691 (1924).

Notes

BRIEF contributions in any field of instrumentation or technique within the scope of the Journal can be accorded earlier publication if submitted for this section. Contributions should in general not exceed 500 words.

Wide Range dc Ammeter for High Voltage Insulation Testing*

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(Received February 24, 1954; revised version June 11, 1956)

THE instrument comprises four series-connected low-range, direct-current ammeters, each of which is provided with a current-diverting circuit, which will carry all current above the full-scale current of the meter. A schematic diagram of the instrument appears in Fig. 1.

Overcurrents are diverted from each meter by means of a parallel-connected voltage regulator tube. This is made effective by connecting in series with each meter a sufficient amount of resistance so that when full-scale current is flowing through the meter the combined drop across meter and resistor will be equal to the operating voltage of the tube. Thus each diverter permits its meter to carry the entire current so long as full scale deflection is not reached. Above full scale current the meter remains at full scale deflection, all excess current being carried through the diverter. When the voltage across a voltage regulator tube is less than the operating voltage the current in it is much less than 0.1 microampere; thus its parallel connection does not influence the meter reading.

In order to protect the instrument from high overcurrents which might occur accompanying the failure of insulation, an

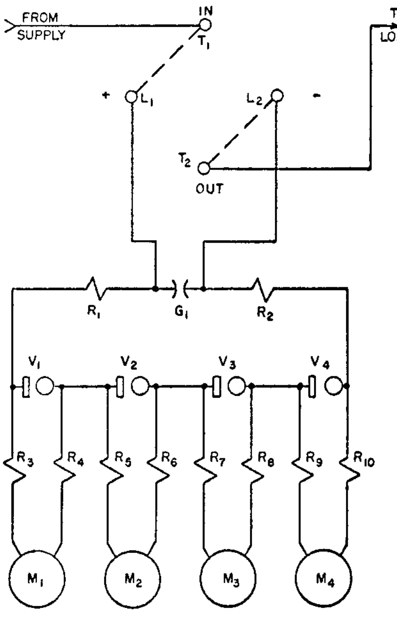

FIG. 1. Continuous reading direct-current ammeter. M_1—20-microampere dc ammeter. M_2—200-microampere dc ammeter. M_3—2-milliampere dc ammeter. M_4—20-milliampere dc ammeter. V_1, V_2, V_3, V_4—Voltage regulator tubes type OA3 (VR75). R_1R_2—10 000-ohm, 10-watt resistors. R_3R_4—1.8-megohm, 2-watt resistors. R_5R_6—0.18-megohm, 2-watt resistors. R_7R_8—18 000-ohm, 2-watt resistors. R_9R_{10}—1800-ohm, 2-watt resistors. G_1—protective gap (two layers of 3-mil tissue paper clamped between brass electrodes). Broken lines, T_1–L_1 and T_2–L_2 represent movable links which can be connected T_1–L_2 and T_2–L_1 to reverse polarity.