

crete required to reduce intensities to a half value. It was found that the effectiveness of this shielding material provides a saving in floor space that more than offsets the slight additional cost of the special concrete. E.C.

Magnetite Concrete for Radiation Shielding. By E. Creutz and K. Downes. *J. Appl. Phys.* 20: 1236, December, 1949.

Ferromagnetic Crystals

Much of our knowledge of the solid state of matter depends on the study of the properties of single crystals. Research on crystal structure, elasticity, piezoelectricity (fundamental and applied), and ferromagnetism, to mention only a few examples, has depended on the successful growing of crystals to a size larger than that occurring in natural or technical materials. The technique described in this article is directed toward the growing of ferromagnetic crystals, which have already been used for investigating magnetic domains, magnetic anisotropy, elastic constants, and the damping of elastic vibrations. It is believed that the methods of growing, orienting, and cutting metal crystals of rather high melting point (1400 to 1600°C), as described in this paper, will prove helpful to investigators in other laboratories. The many requests for these crystals, received at the Bell Laboratories and not fulfilled because the crystals were not available, show that they are desired in an increasing number of investigations. Work on elastic constants and neutron diffraction, as well as on various ferromagnetic phenomena, could be carried forward more rapidly if more ferromagnetic crystals were available. R.M.B.

Growing and Processing Single Crystals of Magnetic Metals. By J. G. Walker, H. J. Williams, and R. M. Bozorth. *Rev. Sci. Inst.* 20: 947, December, 1949.

Electric Breakdown

Pure single crystals subjected to an intense electric field under carefully controlled conditions break down at characteristic minimum field strengths (about 10^6 volts per centimeter). The breakdown takes the form of a thin conducting channel which suddenly and rapidly punctures the crystal. Although the breakdown paths lie along definite crystallographic directions, the breakdown field strengths are, surprisingly, found to be independent of the relative orientation of the applied field and the crystallographic axes.

It has been suggested by A. von Hippel that the breakdown process results when the applied field is capable of accelerating the few electrons in the conduction band to such energies that they are able to ionize the negative ions of the crystal by collision. The population of the conduction band then builds up locally in the form of an avalanche, which melts the crystal and produces a breakdown path.

The frictional drag on the electron, which determines the breakdown field strength, is exerted by the interaction of the electron with the vibrational modes of the crystal. This interaction is computed for ionic crystals by an adaptation of a method developed by H. Fröhlich. The drag is greatest for very slow electrons, which therefore determine the breakdown strength. These slow electrons

interact only with vibrational modes of long wavelength, which are insensitive to direction. The fast electrons, however, interact with the direction sensitive modes having wavelengths comparable to the distance between atoms, thus producing the direction sensitivity of the observed breakdown paths. The computed breakdown field strengths are also in good agreement with experiment. H.C.

Electric Breakdown in Ion Crystals. By Herbert Callen. *Phys. Rev.* 76: 1394, November 1, 1949.

Ultrafast

Voltage impulses may be helpful, among their other uses, in studying the starting characteristics of physical phenomena which they themselves have initiated. The electric breakdown of solids and gases at atmospheric and higher pressures has been particularly challenging over the years, for instance, because the starting times involved can be so extremely short, being in some cases less than 5×10^{-10} seconds. It was necessary, in exploring the problem, to produce and measure twenty kilovolt impulses arising in times of less than 10^{-9} seconds. The techniques of working with such fast impulses posed many new problems, for these transients may have frequency components over the range from 10 to 3000 megacycles per second, which requires extremely broadband ultrahigh-frequency circuits. These impulses have thus been called ultrahigh-speed impulses.

The method used for producing these short impulses has been to arrange a spark gap containing 600 pounds per square inch of nitrogen along the center conductor of a coaxial transmission line. The use of the transmission line as a connection has the advantage that lead inductances and capacitances are made to look like a pure resistance. The impulses have been measured with the micro-oscilloscope through a voltage divider. The knotty problem of a voltage divider was solved only by abandoning lumped circuits altogether and using instead two concentric coaxial transmission lines, the ratio of whose characteristic impedances gives the desired divider ratio. By these means voltage impulses have been produced and measured with rise times as small as 4×10^{-10} seconds. R.C.F.

Production and Measurement of Ultrahigh-speed Impulses. By R. C. Fletcher. *Rev. Sci. Inst.* 20: 861, December, 1949.

Conductivity at Microwave Frequencies

If a high frequency electric field is applied to an ionized gas, the resulting oscillatory motion of the free electrons will give rise to an alternating current. At very low gas pressures the inertia of the electrons causes this current to lag ninety degrees behind the electric field; as the pressure, and hence the density, is increased, frequent collisions of electrons with gas atoms will produce an energy loss which must be supplied by a component of current in phase with the field. This behavior may be described by assigning a complex conductivity to the ionized gas whose real and imaginary components correspond to the in-phase and out-of-phase current components. A knowledge of this conductivity is necessary in the analysis of ionosphere problems and in several phases of microwave work, such