partially penetrating well; this is a nonsteady state flow problem which has been encountered frequently and which is not treated in the available literature. Solution of the type of problems described and its systematic application has effectively contributed, and will do even more so in the near future, to improve the methods of exploitation of our natural oil resources, a necessary condition to meet the impressive rate of increasing consumption (12 to 15% per annum) of fuels in this country.

R6. Some Observations of Geomagnetic Micropulsations. H. J. DUFFUS, *Pacific Naval Laboratory, British Columbia,* (introduced by W. N. English).—The diurnal variation and the spatial and frequency distributions of the components of geomagnetic micropulsations are found to disagree qualitatively with all theories as to their origin. Being narrow band trains of sinusoidal waves with amplitudes of 0.01 to 10×10^{-5} gauss and periods of 1 to 500 sec they occupy the frequency range of electromagnetic background below that caused by thunderstorm activity and above that associated with sudden commencements and diurnal variations. Observations have been made simultaneously in Canada at Esquimalt, B.C., and Halifax, N.S. Three mutually perpendicular induction coils 15 ft in diameter are used with simple filters and dc amplifiers. The dirunal variation of activity during the daylight hours shows two maxima which are approximately equally spaced about local noon. The frequency distribution during the daylight hours shows frequencies between 0.5 and 1.0 cycle per minute to have maximum probability. This single maximum is at variance with the double maximum found by observers at Eskdalemuir in the U.K.

R7. Some New Linear-System Integral Transform Relations. MALCOLM K. BRACHMAN, *Independents' Geophysical Surveys Corporation,* AND J. ROSS MACDONALD, *Texas Instruments Inc.*—Earlier work[1–3] has shown that the Mellin transform is a powerful tool for treating lumped- or distributed-constant electrical or mechanical linear systems exhibiting dispersion. A useful new relation between the Mellin transforms of $G(\tau)$, the relaxation-time distribution function, and $\alpha(t)$, the indicial admittance or decay function, will be discussed. In addition, a new integral transform connecting $G(\tau)$ and $\alpha(t)$ will be treated together with direct relations between $G(\tau)$ and the real and imaginary parts of the system response function $Q(\omega)$. Laplace, Fourier, Mellin, and Hilbert transforms connecting the quantities characterizing a linear dispersive system will be summarized and their use illustrated. The utility of complex Dirac delta functions in such work also will be discussed.

[1] M. K. Brachman and J. R. Macdonald, Physica XX, 1266 (1954).
[2] M. K. Brachman, J. Appl. Phys. 26, 497 (1955).
[3] M. K. Brachman and J. R. Macdonald (submitted to J. Franklin Inst.).

R8. Phase Centers of Microwave Antennas. DAVID CARTER, *Convair.*—This paper is concerned with the location of the phase centers of microwave antennas. The inadequacy of conventional aperture theory for the accurate description of phase centers is discussed. Formulas are developed, and for numerical indications, calculations are made for paraboloidal reflectors of different f/D ratios and a class of primary patterns which provide an approximate representation of a great many common feeds. The results are presented in graphical form to provide useful design information and show the dependence of principal E- and H-plane phase center location on feed and dish parameters. Contrary to the prediction of aperture theory, it is shown that the phase centers of axially symmetric antennas are not in the aperture plane, but that they are dispersed about it.

R9. Apparatus for a New Magnetism Laboratory. CHARLES F. SQUIRE, *The Rice Institute.*—A 300-kw direct current generator, which is Diesel engine driven, has been installed by us for special research purposes. A small building just for the generator was designed to reduce vibration, and an exhaust to minimize noise and fumes was constructed. The electric control features are of interest to research physicists because they permit a wide range of very steady current in the magnet laboratory. The 4-ton flywheel on the Diesel engine assures steady speed and makes possible a great flexibility of output current and voltage. Our first big magnet was built by us at modest cost and is similar to the iron yoke type[1] now in wide use. Performance figures are given for the 2-in. pole gap, $5\frac{1}{2}$-in. pole diameter (Armco magnet iron), for power up to 75 kw. The special equipment for cryogenic studies are items fitted to our research needs. Finally, we discuss the design of our proposed 300-kw magnet. We acknowledge a grant from the Robert A. Welch Foundation. The Office of Naval Research has kindly made the big generator available for our use and we are indebted to several groups for technical advice.

[1] F. Bitter and F. E. Reed, Rev. Sci. Instr. 22, 171 (1951).

R10. Nuclear Paramagnetism of Liquid Helium-3.* H. E. RORSCHACH, JR., AND W. V. HOUSTON, *The Rice Institute.*—A new method of treating the nuclear excitations in a liquid has been developed to treat the problem of the Curie law deviation of liquid helium-3.[1] The excitation spectrum of the liquid is estimated from a treatment of the nuclear motion in a periodic potential. A band structure results which suggests that the single-particle spectrum consists of a single narrow band of Bloch-type states below a continuum. The susceptibility ratio χ/χ_c (where χ_c is the Curie value) can be calculated for this spectrum; the agreement with experiment is good below 0.4°K. Above 0.4°K, the theoretical curve falls below the experimental values. This deviation above 0.4°K can be understood in terms of the nuclear correlations, and a simple way of estimating the correlations will be described.

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[1] Fairbank, Ard, and Walters, Phys. Rev. 95, 566 (1954).

R11. On the Origin of the Lambda Transition in Liquid Helium. LOUIS GOLDSTEIN, *Los Alamos Scientific Laboratory.*—In recent work an indirect and qualitative proof has been presented on the kinetic energy origin of the lambda transition.[1] The proof is based on the temperature variation of the mean potential energy, per atom, exchange energy included, across the lambda point. Combining these calculated potential energies with the empirical liquid helium binding energies, we have obtained the approximate mean kinetic energies per liquid atom over a temperature interval containing the lambda point. The mean kinetic energy was found to exhibit a highly nonsymmetric cusp at the lambda point, with a sharply increasing branch, in the He II range, at the approach of transition temperature. This provides a quantitative sharpening of the proof for the kinetic energy origin of the lambda transition. In addition, the calculated mean kinetic energies directly demonstrate the existence of the very large zero-point kinetic energy of liquid helium over the explored liquid temperature range.

[1] L. Goldstein and J. Reekie, Phys. Rev. 98, 857 (1955).

R12. Experimental Thermal Conductivities of Gases and Gaseous Mixtures. J. M. DAVIDSON, *General Electric Company, Richland.*—The thermal conductivities of nitrogen, helium, carbon dioxide, neon, and their binary mixtures were determined at zero degrees centigrade relative to the best estimated value for air. The thermal conductivities of mixtures of helium-carbon dioxide at 100°C were also determined. The method used was an unsteady state determination using large concentric cylinders similar to that used by Winkleman. Empirical relationships between mole fraction and conductivity were determined where applicable and they agree with the experimental curves within 5%. The results of this