and aggregates. The 21-cm absorption spectra will be investigated for accessible discrete radio sources. Studies relating to the spiral structure of our galaxy will be limited largely to regional surveys for small sections of the sky; we shall stress in these studies at all times the close interconnection that exists between radio and optical phenomena. Following Heesch's successful detection of 21-cm emission from the Coma cluster of galaxies, we shall attempt to study further 21-cm radiation from beyond our own galactic system, but in these studies we shall be limited to some extent by our electronic equipment, which was designed especially for high-resolution work in our own galaxy.

The new equipment is described in some detail in *Sky and Telescope* for July 1956, and an article is in press in *Nature*.

*Harvard College Observatory,
Cambridge, Mass.*

Burbidge, G. R. and Hoyle, F. Matter and anti-matter.

The implications of anti-matter, consisting of positrons and anti-protons, existing on a cosmic scale are discussed. It is shown from a consideration of the kinetic and magnetic energy of the interstellar gas clouds and from the energy of cosmic radiation that the ratio of anti-matter to ordinary matter in our Galaxy cannot exceed about 10^{-7} . The importance to radio astronomy of such a limit being attained is investigated. It appears that the intensities of radio emission from galactic and extragalactic sources may be quantitatively explained on this hypothesis. The relation of these ideas to cosmology is also briefly discussed.

*Mount Wilson and Palomar Observatories,
Carnegie Institution of Washington,
California Institute of Technology,
Pasadena, Calif.*

Byram, E. T., Chubb, T. A., Friedman, H. and Kupperian, J. E., Jr. Rocket observations of extraterrestrial far-ultraviolet radiation.

An experiment to survey the night-sky radiation in the far ultraviolet was attempted for the first time in Naval Research Laboratory Aerobee 25 flown from White Sands Proving Ground, New Mexico, at 2:00 a.m., MST on November 17, 1955. The rocket reached an altitude of 104 km. Collimated photon counters were used to cover the bands 1100Å to 1340Å and 1220Å to 1340Å. A strong diffuse response was observed

in the 1100Å to 1340Å detector which included the Lyman α line of hydrogen, 1216Å. The 1220Å to 1340Å tube detected discrete celestial sources. Of the region scanned by this tube the most significant responses were obtained in the Puppis-Vela region.

*Naval Research Laboratory,
Washington, D. C.*

Cameron, A. G. W. On the origin of the heavy elements.

The inverse correlation between the metal abundances and the ages of stars suggests that the elements have been formed in stellar interiors. An analysis of the cosmic abundances of nuclear isobars, and calculations relating to the growth of nuclide abundances by neutron capture, show that the following three mechanisms are necessary, and probably sufficient, to produce the observed cosmic abundances of the nuclides with mass number greater than 70.

(1) Neutron capture on a slow time-scale. When helium thermonuclear reactions commence in a hydrogen-exhausted stellar core, explosive instability forces an expansion of the core, probably accompanied by mixing between the core and envelope (Hoyle and Schwarzschild 1955). Further helium reactions then produce neutrons. These are initially captured predominantly by the iron abundance peak and eventually large abundances of certain heavy nuclides are produced. The mean time between neutron captures in a typical heavy nucleus is of the order of 10 to 100 years. The observed cosmic abundances correspond to the production and capture by heavy nuclides of about 18 neutrons per silicon nucleus initially present in the core.

(2) Neutron capture on a fast time-scale. It has been suggested (Hoyle 1946) that in supernovae a rapid implosion of the core is accompanied by a thermonuclear explosion in the envelope. If the hydrogen abundance in the envelope is comparable to the abundance of the products of advanced thermonuclear reactions, the explosion will rapidly exhaust the hydrogen and then produce very high fluxes of neutrons by exothermic (α, n) reactions. It has been suggested (G. R. Burbidge, F. Hoyle, E. M. Burbidge, R. F. Christy and W. A. Fowler, unpublished) that this is the mechanism involved in Type I supernova explosions. The mean time between neutron captures in a typical heavy nucleus will be of the order of a second, and the effects of closed neutron shells are reflected in