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**RADIATION EFFECTS INFORMATION CENTER
BATTELLE MEMORIAL INSTITUTE
505 King Avenue
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The Radiation Effects Information Center has been established at Battelle Memorial Institute by the United States Air Force to provide a means of placing radiation-effects data in the hands of designers and those conducting research and development. Access to the Center and to its reports is obtained through the Air Force. This report has been prepared pursuant to the provisions of Contract No. AF 33(657)-10085 [Continuation of AF 33(616)-7375], Task No. 738103, Project No. 7381 & 7634.

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Note: (1) The articles abstracted here represent a portion of those accessioned and extracted for the Radiation Effects Information Center Technical Information File during the period covered. The number at the top of each abstract is for the purpose of coordinate index term identification and internal control. Any questions or comments should be addressed to: Radiation Effects Information Center, Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio, Attention: E. N. Wyler; or Mr. Robert Merkle, ASRCM, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio.

(2) Unless otherwise noted, all references are unclassified.

(3) Reproduction of this document is authorized.

FACILITIES

18531

P. D. O'Brien

THE SANDIA PULSED REACTOR FACILITY

Sandia Corp., Albuquerque, N. M., SC 4737(M), Oct.,

1962, 30 pp

Avail: OTS

The Sandia Pulsed Reactor Facility (SPRF) is a laboratory facility specifically designed for radiation effects experiments which require an intense pulse of fast neutrons and gamma rays. The SPR, a bare, cylindrical, enriched-uranium assembly whose design is similar to that of the Los Alamos Scientific Laboratory's Godiva II, is normally operated in the heavily shielded reactor building, which incorporates a shielded pit into which the reactor may be lowered after operation. Modes of operation have ranged from delayed-critical power runs at levels up to 500 watts to superprompt-critical bursts with fission yields up to 2×10^{16} . A standard SPR burst, which produces a 110 C temperature rise in the fuel material, yields 2×10^{16} fissions. The measured characteristics of such a burst are as follows: (1) 50 μ sec pulse width at half maximum (41 μ sec at outdoor burst site), (2) 3×10^{16} leakage neutrons per burst, (3) 2×10^{20} fissions/sec peak fission rate, (4) 3×10^{20} neutrons/sec peak leakage rate, (5) radiation at point of closest experimental approach: 2.3×10^{13} neutrons/cm² integrated flux, 2.7×10^{17} neutrons/cm² sec peak flux, 5×10^3 rads (water) from γ 's, 6×10^7 rads (water)/sec from γ 's at peak, and $\sim 2 \times 10^{14}$ neutrons/cm² integrated flux, in the glory hole.

18532

K. G. Kerris, R. F. Hyneman, and J. E. Bjorkholm

STUDIES TO IMPROVE RADIATION SIMULATION TECHNIQUES

Hughes Aircraft Co., Ground Systems Group, Fullerton,

Calif., Jan. 15, 1963, First Annual Rpt., NONR-3481(00),

40 pp

A brief phenomenological description of the beam blow-up effect or pulse shortening in the microwave linear accelerator (LINAC) is presented. The speculation that positive charge formation and trapping is responsible for blow-up is presented and discussed. The theory that higher order electromagnetic modes cause beam blow-up is derived and discussed in great detail. The propagation of higher order TM modes in accelerators is investigated. Finally, experimental measurements of a coupling iris design which should destroy beam synchronism with deleterious r.f. modes are presented. It is concluded that beam blow-up is probably caused by excitation of the TM₁₁ mode. This undesirable interaction can possibly be suppressed by using a non rotationally symmetric iris design.

18533

Harold W. Giesler, Harry J. Reilly, and William A. Poley

LOW-POWER TESTS OF THE PLUM BROOK REACTORS

NASA Lewis Research Center, Cleveland, O., NASA-TN-D-1560,

Feb., 1963, Tech. Note, 50 pp

Avail: NASA, OTS

The initial criticality and subsequent low-power tests of the NASA Plum Brook Reactor core are described. The tests included initial criticality, measurement of cold clean excess and shutdown reactivity, control-rod worth calibrations, temperature coefficients, and neutron and gamma flux mapping of the core and the reflector.

18534

John P. Blewett, Brookhaven National Lab.
LINEAR ACCELERATORS FOR HIGH ENERGIES
Physics Today, 16, (1), Jan., 1963, pp 34-38

At a summer conference held at Brookhaven during the week of August 20, 1962, representatives from Brookhaven, Yale University, the Lawrence Radiation Laboratory, the Rutherford Laboratory, the Midwestern Universities Research Association, and CERN discussed studies of various aspects of linear-accelerator design now in progress.

MISCELLANEOUS

18535

B. E. Freeman
RADIATION TRANSPORT IN SPHERICALLY SYMMETRIC CONFIGURATIONS
NUCLEAR PULSE PROPULSION CONCEPT
General Dynamics Corp., General Atomic Div., John Jay
Hopkins Laboratory for Pure and Applied Science, San Diego,
Calif., GAMD 3488, Sept. 4, 1962, AF 29(601)-2207,
11 pp

This note gives an interim report on work toward development of numerical methods for calculation of energy transport by radiation through spherically symmetric systems. Of principal concern here is the treatment of the geometric as contrasted with the frequency-dependent aspects of the problem, although the latter are important and as yet inadequately resolved.

18536

G. T. Western
ENERGY AND ANGULAR DISTRIBUTION EXPERIMENT VOLUME I:
ANGULAR DISTRIBUTION OF REACTOR RADIATION FROM SLABS
AND OF EMERGENT SECONDARY GAMMA RAYS
General Dynamics/Fort Worth, Nuclear Aerospace Research
Facility, Fort Worth, Tex., NARF-62-16T, FZK 9-183-1,
Dec. 31, 1962, AF 33(657)-7201, 70 pp

Radiation from the Aerospace Systems Test Reactor positioned within the Outside ASTR Tank was directed, with a narrow-beam slab geometry, onto test materials of 3 per cent borated polyethylene and of lead. Measurements for polyethylene and lead, except as noted, were made of (1) the radiation source term; (2) the flux distribution of thermal and fast neutrons within the test materials; (3) the angular distribution of thermal- and epithermal-neutron flux, fast-neutron dose rate, and secondary gamma rays from the test materials; (4) the reflection of neutrons from borated polyethylene and from steel; (5) the angular distribution of fast-neutron and gamma-ray number-energy flux; and

(6) the angular distribution of gamma-ray dose rate resulting from primary gamma rays scattering in and from the test materials. Data for items 1, 2, 3, and 4 are presented in Volume I of this report; data for items 5 and 6 will be published in Volume II.

18537

C. R. Haave, A. J. Zmuda, and B. W. Shaw
VLF PHASE PERTURBATIONS WITH HIGH ALTITUDE NUCLEAR
BURSTS
APL Technical Digest, 2, (2), Nov.-Dec., 1962, pp 14-19

VLF propagation paths remote from the July 9 nuclear burst were perturbed by the effect of charged particles geomagnetically deflected into the VLF path. Some of these particles attach to field lines directly accessible from the burst region, and others are geomagnetically trapped and drift longitudinally from the burst to the VLF path.

18538

NUCLEAR BLAST EFFECTS ON COMMUNICATIONS
Electronics, 36, (6), Feb. 8, 1963, pp 74, 77-78

Effects of nuclear explosions on radio communications, on satellite functioning, and on radiation fields surrounding the earth were reported in several papers at the New York meeting of the American Institute of Physics. Nuclear effects on the Van Allen radiation belts as detected by Telstar and Explorer XIV and XV satellites, were described by W. L. Brown of Bell Telephone Laboratories. John Hopkins Applied Physics Laboratory scientists A. J. Zmuda, B. W. Shaw, and C. R. Haave reported on the effects of nuclear explosions above 50 kilometers on vlf (3 to 30-Kc) radio communication channels.

18539

R. F. Goodrich, L. M. Hocking and D. B. van Hulsteyn
ATMOSPHERIC PROPAGATIONS FROM A NUCLEAR EXPLOSION
University of Michigan, Ann Arbor, Mich., AFCRL-62-621,
March, 1962, Final Rpt., AF 19(604)-5470, 57 pp
Avail: ASTIA, AD 277565, OTS

The pressure pulse at large distances from a nuclear explosion is investigated. A source representation is established which produces parameters characteristic of these explosions on a surface enclosing the source. An integral equation for the pressure is obtained in terms of a ring source Green's function, where the integration extends over the source. Pulse forms are obtained for explosions on the ground and in the atmosphere when various temperature models are considered. When the stratosphere is assumed to be either of the isothermal or thermospheric type, a general theory is established for determining the number of modes of propagation. In addition, a method for examining the dispersive effect of local winds is established.

18540
F. S. Mozer, D. D. Elliott, J. D. Mihalov, G. A. Paulikas,
A. L. Vampola, and S. C. Freden
PRELIMINARY ANALYSIS OF THE FLUX AND SPECTRA OF TRAPPED
PARTICLES FOLLOWING THE NUCLEAR TEST OF JULY 9, 1962
Aerospace Corporation, El Segundo, Calif., SSD-TDR-62-183,
TDR-169(3260-20)TN-1, Nov. 15, 1962, AF 04(695)-169,
25 pp

Particle detectors have been flown on a low-altitude, polar satellite to measure the fluxes and energy spectra of protons and electrons. In the region of the South Atlantic magnetic anomaly, electrons were observed with a fission-like spectrum above 2 Mev. Comparison on B, L plots of the electron fluxes with those obtained one week after the explosion indicates that the electron lifetime is ≥ 20 days. The lifetime and the observed deficiency of fission electrons below 2 Mev are consistent with the loss mechanism of atmospheric interaction. Near $L = 4.5$ and $B = 0.4$ gauss, only natural electrons were observed. The proton flux and spectral measurements yield no evidence that protons were either injected into or removed from the radiation belt by the high-altitude explosion.

18541
J.W.M. van Rossum
BIBLIOGRAPHY ON BLAST, SHOCK WAVES AND ALLIED TOPICS,
FEATURING NUCLEAR EXPLOSIONS
Technisch Documentatie, En Informatie, Centrum Voor De
Krijgsmacht, The Hague, Netherlands, TDCK-30050,
June, 1962, 450 pp

The compilation of the material in this report was undertaken to provide a convenient reference source for shock wave and blast problems, in view of the construction or hardening of strategic military facilities to resist either nuclear or conventional explosions. Entries include references to reports pertaining to characteristics of nuclear explosions - air burst, ground burst and underwater burst - together with the response of structures to blast loading. Attention is paid to measurements, experimental techniques and testing equipment.

CERAMIC MATERIALS

18542
Kazuhisa Shirayama
PROPERTIES OF RADIATION SHIELDING CONCRETE
Journal of the American Concrete Institute, 60, (2),
Feb., 1963, pp 261-279

Reports on a study of boron-containing aggregates from the United States and England and of seven heavy aggregates from Japan. Data are presented and discussed concerning mix proportions, workability, unit weight, strength, drying shrinkage, and absorption coefficients for γ - and X-rays. Based on data obtained for mix proportions, formulas for estimating the unit weight of concrete from the specific gravity of the aggregate are proposed. The hematite ore used was found to be unsuitable for concrete aggregate because of an excessive amount of fines coating its surface. The tests indicated that, of the boron-containing

material, the deleterious effects of colemanite on concrete strength and setting time is greater than that of borocalcite. This effect increases with increased fineness. The barite concretes provided better shielding against X rays than anticipated from density calculations. Barite or magnetite concretes were more suitable in shielding against gamma rays.

18543

W. N. Reynolds and P. A. Thrower
IRRADIATION DAMAGE IN GRAPHITE
Atomic Energy Research Establishment, Metallurgy Div.,
Harwell, Eng., AERE-R3979, March, 1962, 15 pp

A wide study of defect clusters formed in graphite by higher flux neutron irradiation at temperatures up to 650 C has been made, using the techniques of transmission electron microscopy. A linear relationship exists between cluster radius and irradiation temperature, and the subsequent annealing behavior of the defects is consistent with the hypothesis that the visible defects are all of one kind, probably interstitial.

18544

Donald G. Schweitzer
FUNDAMENTAL STUDIES OF RADIATION DAMAGE IN GRAPHITE
Brookhaven National Lab., Upton, N. Y., BNL 745(T 270),
April 17, 1962, Lecture Series No. 16, 15 pp
Avail: OTS

Graphite as a reactor material, radiation damage model, radiation growth mechanism, reirradiation reactions, and annealing reactions are covered.

18545

I. T. Myers
RADIATION DAMAGE IN GRAPHITE BY HIGH ENERGY ELECTRONS
General Electric Co., Hanford Atomic Products Operation,
Richland, Wash., HW-75428, Oct. 29, 1962, AT(45-1)-1350,
10 pp
Avail: OTS

Measurements of radiation damage were made in NPR and KC graphite, using a 1.5 beam of electrons at 150 C and dry-ice temperatures. These included measurements of length changes, lattice spacing changes, and resistivity changes upon electron irradiation. It was found that significant quantities of ozone were produced when irradiations were done using liquid nitrogen as a coolant.

18546

Sigmund Weissmann and Koichi Nakajima
DEFECT STRUCTURE AND DENSITY DECREASE IN NEUTRON
IRRADIATED QUARTZ
Rutgers, The State University, College of Engineering,
New Brunswick, N.J., NYO-10-445, Sept., 1962,
Second Tech. Rpt., AT(30-1)-2937, 16 pp

material, the deleterious effects of colemanite on concrete strength and setting time is greater than that of borocalcite. This effect increases with increased fineness. The barite concretes provided better shielding against X rays than anticipated from density calculations. Barite or magnetite concretes were more suitable in shielding against gamma rays.

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IRRADIATED QUARTZ
Rutgers, The State University, College of Engineering,
New Brunswick, N.J., NYO-10-445, Sept., 1962,
Second Tech. Rpt., AT(30-1)-2937, 16 pp

Lattice defects in quartz, induced by fast neutron irradiation ranging from 1×10^{19} to 1.5×10^{20} nvt, were studied by combined methods of X-ray diffraction and transmission electron microscopy. The developed defect structure is characterized by clusters of interstitials enriched in ruptured silicon atoms. The size and density of the defect clusters increase with increasing dose until mutual interaction occurs, resulting in the formation of a stable, hexagonal-like structure resistant to prolonged annealing at 500 C. In thin crystals the size and volume fraction of the defect clusters are dependent on crystal orientation, being related to the ease of diffusion of the interstitials in directions relative to the open screw channels of the quartz structure. A relationship was established between the total volume fraction of defect clusters and fractional decrease in density induced by neutron irradiation, accounting satisfactorily for the hydrostatic density measurements reported in the literature.

18547

Albert J. Rothman

-PROPERTIES OF BeO CERAMICS AND THEIR APPLICATION IN A
NUCLEAR PROPULSION SYSTEM (PLUTO)

University of California, Lawrence Radiation Lab.,
Livermore, Calif., UCRL-6743, Sept. 13, 1962,

7 pp

Avail: OTS

Project Pluto requires a moderator and fuel capable of withstanding high temperatures and stresses in an oxidizing environment. Its high melting point, thermal conductivity, and rupture modulus make BeO an excellent choice.

18548

HIGH TEMPERATURE MATERIALS PROGRAM

General Electric Co., Nuclear Materials and Propulsion
Operation, Flight Propulsion Lab. Dept., Cincinnati,
O., GEMP-18A, Dec. 14, 1962, Prog. Rpt. No. 18, Part
A, Sept. 15 - Nov. 15, 1962, AT(40-1) 2847, 37 pp

Avail: OTS

Post-irradiation measurements indicate that BeO specimens of 5-micron grain size retained about 25 per cent of their unirradiated strength in irradiations at 600 C to a dosage of 1.5×10^{21} nvt (≥ 1 Mev). Comparable reduction in strength occurred in larger grain size materials at as little as one-fifth this dosage. Gas bubbles were observed in a specimen irradiated at 1000 C to 3.4×10^{20} nvt (≥ 1 Mev).

18549

E. W. Hoyt, W. V. Cummings, D. L. Zimmerman, and
H. E. Perrine

RARE EARTH OXIDES AND RARE EARTH BORATES CORROSION,
COMPATIBILITY, AND RADIATION EFFECTS

General Electric Co., Vallecitos Atomic Lab., San Jose,
Calif., GEAP-3909, April 17, 1962, AT(04-3)-189,

35 pp

Avail: OTS

Samples of several different rare earth oxides and borates were irradiated in the General Electric Test Reactor (GETR) with thermal neutron fluxes of approximately 1.5×10^{14} nv, with peak fluxes as high as 2.9×10^{14} nv, and maximum fast (>0.18 Mev) fluxes of 3.9×10^{14} nv. In general, the oxide samples appeared to be in good condition, with only a few exhibiting cracking or fragmentation. Comparison of the pre- and post-irradiation microstructures revealed that no significant changes occurred during irradiation. The Sm_2O_3 and Eu_2O_3 specimens underwent significant softening while the Gd_2O_3 showed an apparent increase in hardness during irradiation. All but the SmBO_3 samples released very large fractions of the generated helium. These high values are apparently related to the relatively low starting densities and also to the extensive fragmentation which occurred during irradiation. The fractional burnup of B-10 atoms in several of the borate samples was also determined.

18550

Glen B. Engle

HIGH-ENERGY NEUTRON INDUCED CHANGES IN CARBON AND GRAPHITE

A REVIEW

General Dynamics Corp., General Atomic Div., John Jay

Hopkins Laboratory for Pure and Applied Science, San Diego,

Calif., GA-2802, September 20, 1962, AT(O4-3) 314, 100 pp

Avail: OTS

The pertinent data on the effects of high-energy neutron bombardment on carbon and graphite structure, dimensional stability, properties, and some gas reactions are presented. The irradiation data are reviewed with emphasis on correlation of irradiation effects with basic carbon structure.

18551

P. A. Thrower and W. N. Reynolds

MICROSTRUCTURAL CHANGES IN NEUTRON IRRADIATED GRAPHITE

Atomic Energy Research Establishment, Metallurgy Div.,

Harwell, Eng., AERE-R 4007, March, 1962, 10 pp

The growth in neutron irradiated graphite and the effect of annealing on high dose irradiations have been studied. Irradiations were conducted at 200 C at doses of 10^{20} n/cm². Etch Pits formed during the preparation of specimens have been observed on irradiated reactor graphite and also on a compact of naturally occurring graphite crystals. These are identified with a complex dislocation structure along grain boundaries.

ORGANIC, INORGANIC MATERIALS AND PROPELLANTS

18552

M. H. Kalos, H. Goldstein, and J. Ray

REVISED CROSS SECTIONS FOR NEUTRON INTERACTIONS WITH

OXYGEN AND DEUTERIUM

United Nuclear Corp., Development Div., White Plains,

N. Y., UNC-5038, Aug. 31, 1962, Topical Rpt.,

DA 18-108-CML-7156, 19 pp

Avail: ASTIA

A revision of the data for angular distributions for elastic neutron scattering in oxygen and deuterium is presented. The kinetics of the (n, 2n) reaction in deuterium is discussed and a Monte Carlo scheme for generating the energy and direction of secondary neutrons is given. Complete sets of the cross sections for both materials are tabulated.

18553

Kalman Held and Richard J. Goldman
SYNTHESIS OF SEMICONDUCTOR MATERIALS BY RADIATION INDUCED
REACTIONS
Technical Research Group, Inc., Syosset, N. Y., NYO-9863,
1962, Qdly. Status Rpt., No. 11, Nov. 1, 1961 - Jan. 31,
1962, AT(30-1)-2392, 10 pp

The work performed during the period of this report consisted of the following:
(1) Continuous flow decomposition experiments on silane at elevated temperatures.
(2) Construction and testing of the irradiation unit for continuous flow decomposition experiments on silane passing through a Cobalt-60 source. (3) Cobalt-60 irradiation of silane in a flow system at elevated temperatures.

18554

Robert Owen Bartlett
THE NUCLEAR EFFECT OF USING LITHIUM HYDRIDE AS THE
PROPELLANT IN A NUCLEAR ROCKET REACTOR
Presented to the Faculty of the School of Engineering of
the Institute of Technology (Air University), May,
1962, Thesis, 115 pp
Avail: ASTIA, AD 284016

This study is a presentation of the calculated results of using lithium hydride as the propellant in a nuclear rocket reactor. Reactor calculations were made for an unreflected reactor using lithium hydride of 10 per cent Li-6 - 90 per cent Li-7, and 0 per cent Li-6 - 100 per cent Li-7 as propellant. The results of these calculations are presented as plots of critical mass versus propellant mass, and although they show the poison effect of the Li-6, they leave undetermined the effect of using lithium hydride of varying Li-7 enrichments between 90 per cent and 100 per cent; and especially the effect of natural lithium which contains 7.4 per cent Li-6 and 92.6 per cent Li-7.

18555

Erminio Piantanida and Marcello Piazzi
BEHAVIOR OF EXPLOSIVES UNDER THE ACTION OF GAMMA RAYS
II
Picatinny Arsenal, Feltman Research Labs., Dover, N. J.,
Translated by U. S. Joint Publication Research Service
as Technical Memo. 1040, Sept., 1962, La Chimica El'
Industria, 43, (12), Dec., 1961, pp 1389-1393
Avail: ASTIA, AD 284470

This paper reports the experimental results relating to the behavior of some high explosives (demolition type) exposed to radiation. The effects induced by gamma rays are deduced from variations in the chemical stability and the fusion point. Explosives consisting of substances from three different categories of

chemical compounds: aromatic nitroderivatives, nitric esters, and nitroamines. Specifically: (1) 2,4,6-trinitrophenol (picric acid, pertite, melinite, lyddite) and 2,4,6-trinitrotoluol (tritol, tolite, TNT, trotyl); (2) pentaerythrol tetranitrate (penthrite, pentanitate) PETN; (3) cyclotrimethylenetrinitramine (T4, RDX, cyclonite, hexogen) were exposed to 10^7 ergs $g^{-1}(C)$. The effects of the gamma radiation on the explosives was checked by determining their chemical stability by Taliani's method that is, by maintaining the sample at a temperature or 120 degrees centigrade, by measuring the pressure exerted by any decomposition products of the explosive, and by expressing the value of the stability itself by the number of minutes required to reach a pressure of 300 millimeters of the mercury column. The time-pressure curves for each group of experiments and, whenever possible, the stability-roentgen dose curves, were drawn. The fusion points of the various samples were determined before and after irradiation.

18556

Kalman M. Held and Richard J. Goldman
SYNTHESIS OF SEMICONDUCTOR MATERIALS BY RADIATION
INDUCED REACTIONS

Technical Research Group Inc., Syosset, N. Y., TRG-132-FR,
NYO-9864, Final Rpt., AT(30-1)-2392, 42 pp

Several static experiments employing silane in the BNL reactor were conducted. The sample was analyzed by measurement of gas evolution at low temperatures. Experiments were carried out at 100, 175, 200, and 250 C. In all cases decomposition was evidenced by metallic deposits on the container walls. Decomposition without significant thermal contribution and at temperatures where thermal effects do not increase the rate of decomposition to a point where metallic deposition occurs has been achieved. Accurate calculations for the G value of the in pile decomposition of silane have not been possible due to the lack of reliable data on gamma dosimetry in the reactor locations.

18557

H. G. Carter
ENERGY STORAGE MECHANISMS IN LIQUID HYDROGEN
General Dynamics/Fort Worth, Nuclear Aerospace Research
Facility, Fort Worth, Tex., NARF-62-15T, FZK-9-180,
Oct. 31, 1962, AF 33(657)-7201, 131 pp

Energy-storing molecular products of radiation in liquid hydrogen are examined from the point of view that the explosion of potential energy in the form of such products may lead to lower design weights for nuclear rockets. It is found that a significant fraction of the energy deposited by radiation in liquid hydrogen is stored temporarily through the dissociation and excitation of H_2 molecules. Experimental and theoretical results are consistent with a rate of dissipation of such energy into thermal motion which is much slower than the rate at which the radiation products are expelled from the tank. It is shown that, if this is the case, relatively high levels of infrared radiation are to be expected but that such energy will not rapidly be translated into thermal motion. It is concluded that, insofar as radiation heating of the propellant is a significant design factor, further consideration should be given to radiation-induced reactions in liquid hydrogen and that any radiation-heating experiments should be interpreted in terms of possible energy-storage effects.

18558

George Odian, Terese Acker, and Thomas Pletzke
RADIATION-INDUCED SOLID PROPELLANT DECOMPOSITION
Radiation Applications Inc., Long Island City, N. Y.,
RAI-314, Jan. 15, 1963, Tech. Doc. Rpt., 1962,
AF 49(638)-1125, 19 pp

The strand burning rates of various composite ammonium perchlorate solid propellants were studied as a function of the amount of radiation received by them. The dose range 0-50 Mrads was studied. Radiation from an electron accelerator was employed for these studies. The results may be summarized in the following manner: (1) The burning rates of two Thiokol (TP L 3014 and TP-L 3014a) polysulfide propellants decrease upon irradiation. (2) The burning rates of Thiokol (TP H 3062) hydrocarbon and Hercules (HES 5805) cellulose acetate propellants remain unchanged upon irradiation. (3) The burning rates of Hercules (HES 6648) polyacrylonitrile, Hercules (HES 6420) polyethyl acrylate and Thiokol (TP-6-3129) polyurethane propellants increase upon irradiation.

18559

John M. Allen, Arthur Levy, John F. Kircher, Richard
Markel, John W. Droege, Harold E. Bigony, and Glenn
B. Shoop
EVALUATION OF SOLID PROPELLANTS AND SOLID-PROPELLANT
SYSTEMS FOR SPACE APPLICATION
Battelle Memorial Institute, Columbus, O., Dec. 31, 1962,
Sixth Qtly. Rpt., Oct. 1 - Dec. 31, 1962, NAS8-1683,
14 pp

PBAA tensile specimens were lost during exposure; there are no plans to repeat the exposure. The burning strands, however, survived without damage throughout the 5-month period. The burning rates are reported. Polyurethane propellant is similar to that carried out with the PBAA. Specimens were irradiated at a high dose rate for four time periods, to give specimens irradiated to total-dose levels of 5×10^7 , 5×10^8 , and 1×10^9 ergs/g(C). A preliminary study of the gases released during radiation has been made. First results indicate that hydrogen accounts for about 95 per cent of the noncondensable gases released, while water makes up 98 per cent or more of the condensable.

18560

N. Zessoules, J. Brinkerhoff, and A. Thomas
EFFECTS OF NUCLEAR RADIATION IN A LIQUID HYDROGEN MEDIA
Laboratory for Electronics, Inc., Tracerlab Div., Waltham,
Mass., Fourth Qtly. Rpt., Oct. 1, 1961 - March 27, 1962,
NASr-20, 31 pp
Avail: NASA

This report covers the final design and development of apparatus and procedures to obtain experimental data on ionization in liquid hydrogen media. Aside from establishing the fact that ionization induced by a radioactive source at a particular point in a flowing stream of liquid hydrogen can be detected downstream as an ionization current, the ionic mobility and the recombination coefficient were able to be measured independently. In addition, the fraction of the volumetric ionization rate was able to be estimated.

18561

J. W. Boag, Mount Vernon Hospital, Northwood, Middlesex,
Eng. and Edwin J. Hart, Argonne National Lab., Argonne,
Ill.

ABSORPTION SPECTRA IN IRRADIATED WATER AND SOME SOLUTIONS
Nature, 197, (4862), Jan. 5, 1963, pp 45-47

The absorption spectra of various aqueous solutions after exposure to a pulse of 1.8 Mev electrons have a broad transient absorption band extending from wavelengths below 5000 A to beyond the limit of the emulsion sensitivity at 8800 A, and having a peak near 7000 A. Since the transient spectrum is produced by the irradiation of pure de-aerated water, is affected in intensity but not in character by the presence of various alkali metal ions and various anions, is suppressed by oxygen, is of short life, and is a broad band resembling the spectrum of the solvated electron in liquid ammonia, methylamine and ethylamine. It is believed to be due to the electron trapped in a similar manner in water.

18562

Helmut H.A. Krueger, William R. Cook, Jr., Clevite Corp.,
Cleveland, O., C. C. Sartain, and Hubert P. Yockey,
Oak Ridge National Lab., Oak Ridge, Tenn.

RADIATION DAMAGE AND THE FERROELECTRIC EFFECT IN ROCHELLE
SALT

Journal of Applied Physics, 34, (1), Jan., 1963, pp 218-224

Rochelle salt plates were exposed to Cobalt-60 radiation of 8.6×10^3 to 2.6×10^7 R and reactor radiation up to 2.4×10^6 R gamma plus 3.5×10^{15} neutrons/cm² at -196 C. Measurements were made over a temperature range including both Curie points (-30 to +30 C) of dielectric constant and loss, elastic stiffness coefficients and mechanical Q. In addition, double-crystal X-ray rocking curves were made above the upper Curie point to check line broadening. All the data indicate an initial improvement in crystal perfection (Curie points are sharper, linewidths narrower) up to 8.6×10^4 R, with subsequent degradation (Curie point and linewidth broadening: finally coalescence of Curie points) including elimination of the ferroelectric phase after 2.6×10^6 R Cobalt-60 radiation or 2.4×10^6 R gamma plus 3.5×10^{15} neutrons/cm² reactor radiation. The Q rose with radiation dosage as the ferroelectric phase disappeared, dropping only at the highest dosage. Destruction of the ferroelectric phase by radiation is compared to similar effects due to substitution of NH₄ for K in the Rochelle salt lattice.

18563

James A. Knight, Jr.

RADIATION CHEMISTRY OF ORGANIC SYSTEMS

Georgia Institute of Technology, Engineering Experiment

Station, Atlanta, Ga., Jan. 28, 1963, Annual Rpt. No. 4,

Jan. 1 - Dec. 31, 1962, AT (40-1)-2490, 37 pp

The results of the X irradiations of 2,2,4-trimethylpentane and 2,2,4,6,6-pentamethylheptane for the identification of radiolysis products and determination of G values are reported.

18564

S. P. Ansley, Jr.

CRYOGENICS AS APPLIED TO THE DESIGN AND FABRICATION OF
A SPACE SIMULATION TEST CELL

ARO Inc., Aerospace Environmental Facility, AEDC-TDR-62-
201, Jan., 1963, Tech. Doc. Rpt., AF 40(600)-1000,

35 pp

Avail: ASTIA

The unusual features of the Ultrahigh Altitude Rocket Cell J-2A at Arnold Engineering Development Center are described with emphasis on the cryogenic systems for cooling the diffuser and chamber liner to liquid-nitrogen temperature and the helium-refrigerated cryopumping surfaces to 20 K.

18565

E. E. Kerlin and E. T. Smith

INVESTIGATION OF COMBINED EFFECTS OF RADIATION AND
VACUUM AND OF RADIATION AND CRYOGENIC TEMPERATURES
ON ENGINEERING MATERIALS

General Dynamics/Fort Worth, Nuclear Aerospace Research
Facility, Fort Worth, Tex., FZK-152, Aug. 15, 1962,

Third Qtly. Prog. Rpt., May 9 - July 31, 1962,

NAS8-2450, 82 pp

Avail: NASA

The lubricants selected for study in the combined radiation and vacuum environment are given and the effects of gamma irradiation on these lubricants are reviewed. The adhesives, seals, insulations, and thermal-control coatings have been selected for testing in radiation and cryogenic temperature environments. The testing facilities are described.

18566

Robert L. Adamczack, Robert J. Benzing, and Herbert Schwenker
LUBRICATION IN SPACE ENVIRONMENTS

Wright-Patterson Air Force Base, Aeronautical Systems Div.,
O., ASD-TDR-62-541, June, 1962, Tech. Doc. Rpt.,

12 pp

Avail: ASTIA, AD 284165

Solid, semi-solid, and liquid lubricants, hydraulic fluids, heat-transfer fluids, and novel lubrication techniques are discussed with respect to the current state of the art and the future capabilities of these various materials and/or their application. The severe environmental conditions of space are compared against both the current and future state of the art in the field of lubrication and energy-transfer media.

18567

M. Burton and D. B. Peterson

RADIATION CHEMISTRY OF BENZENE SOLUTIONS OF ORGANOMETALLIC
COMPOUNDS OF THE TYPE $M(C_6H_5)_n$

University of Notre Dame, Radiation Lab., Notre Dame, Ind.,

ASD TDR-62-875, Oct., 1962, Tech. Doc. Rpt., period ended
June 30, 1962, AF 33(616) 7075, 24 pp

Avail: ASTIA, CTS

Product yields are reported for Cobalt-60 gamma radiolysis of dilute benzene solutions of tetraphenyls of Si, Ge, Sn and Pb and triphenyls of As and Bi. The latter four compounds undergo a concentration-dependent, sensitized decomposition best explained in terms of energy transfer from excited benzene to organometallic. $G(H_2)$ and $G(C_2H_2)$ for benzene are unaffected by any of the solutes indicating that these two products are formed from a state or states of benzene other than the state(s) transferring energy to the organometallic. All irradiations were carried at ambient temperature in an underground Ghormley-Hochanadel type Cobalt-60 source. Samples were irradiated at a dose rate of 2.4×10^{22} ev liter⁻¹ hr⁻¹.

18568

W. G. Burns, C.R.V. Reed, R. W. Wilkinson, and J. A. Winter
THE RADIATION AND THERMAL STABILITY OF SOME POTENTIAL ORGANIC
MODERATOR-COOLANTS PART VI THE EFFECT OF TEMPERATURE
ON THE RADIOLYSIS OF BIPHENYL, ISOPROPYL BIPHENYL,
METATERPHENYL AND SANTOWAX R
Atomic Energy Research Establishment, Chemistry Div.,
UKAEA, Harwell, Eng., AERE R-3989, Aug., 1962, 28 pp

Biphenyl, irradiated with fast electrons, also with pile radiation, and isopropyl biphenyl, with pile radiation only, were radiolysed to low per centage conversions over a wide range of temperatures, 100 - 400 C. In addition the temperature region 400 - 420 C for the radiolysis of Santowax R and metaterphenyl was studied using BEPO. At higher temperatures the gas G values increased in general more rapidly than the values of $G(\rightarrow HBR)$, except at the highest temperatures with metaterphenyl and Santowax R. With metaterphenyl and Santowax R at ~400 C the value of $G(\rightarrow HBR)$ increased very steeply with temperature.

18569

T. D. Nevitt, R. E. Rondeau, L. A. Hagan, J. H. Barber,
Jr., and J. Maniotes
RADIATION CHEMISTRY OF TRIPLE BOND COMPOUNDS: PART I:
ACETONITRILE AND BUTYNE-2, LIQUID PHASE
The American Oil Co., Whiting, Ind., ASD-TDR-63-144,
Part I, Feb., 1963, Tech. Doc. Rpt., Dec. 1, 1961 -
Nov. 30, 1962, AF 33(616)-8247, 26 pp
Avail: ASTIA

Product yields were obtained at γ -radiation doses ranging from 2×10^{20} to 10^{21} ev/g, and a tentative scheme for the radiolytic decomposition of these acetonitrile and butyne-2 was formulated. Major radiolysis products of butyne-2 are: hydrogen, $G = 0.79$; methane, $G = 0.14$; propyne, $G = 0.09$; butadiene-1,2, $G = 0.23$; trans-butene-2, $G = 1.02$; cis-butene-2, $G = 0.71$; octadiyne-2,6, $G = 1.09$; other C_8 's, $G = 1.17$; trimer; and polymer. These products result from radical reactions. Acetylene, $G = 0.04$ and ethane $G < 0.1$ may result from nonradical reactions. Major radiolysis products of acetonitrile are: hydrogen, $G = 0.75$; methane, $G = 0.75$; succinonitrile, $G = 0.52$; four unidentified liquid products; and polymer. Hydrogen cyanide and cyanogen were not detected.

18570

ORGANIC REACTOR TECHNOLOGY

Phillips Petroleum Co., Atomic Energy Div., Idaho Falls,
Idaho, IDO-16807, Oct. 15, 1962, Qtly. Rpt., April 1 -
June 30, 1962, AT(10-1)-205, 97 pp
Avail: OTS

The deposition of film was studied in irradiated circulating loops, in which both grounded and insulated plates were in the irradiated coolant volume. Iron percarbide (Fe_{20}C_9) was made under conditions comparable to those in the OMRE. It was made from an iron chelate by carbon monoxide reduction and emphasizes the possible importance of oxygen containing chelate in the transport of iron and deposition of film. The hexaphenyls produced in irradiation of m- and p-terphenyls and in the reaction of polyphenyls with hydrogen atoms was studied. Coolants under study included non-benzenoid heterocyclics, fused ring compounds, and hydrogen donor compounds. Partially hydrogenated fused ring structures, such as dihydrophenanthrene, continue to look very promising. The stabilizer program was brought to a close.

18571

R. O. Bolt, M. L. Burrous, J. G. Carroll, K. L. Hall,
M. A. Sweeney, and W. W. West
RADIATION STABILITY OF ORGANIC FLUIDS
California Research Corp., Richmond, Calif., TID-16999,
Sept. 21, 1962, Prog. Rpt. No. 17, April 1 - June 30,
1962, AT(04-3) 248, 40 pp
Avail: OTS

Polyphenyl coolants were irradiated in the Suisie reactor. Results confirm that there is a fast neutron effect in polyphenyls. Radiation stability depends on temperature and on high boiler content. Qualitatively, G_M is higher for neutron-rich than for γ -rich irradiations. G_M is lower for higher conversion and increases with higher irradiation temperature.

18572

K. E. Demorest and E. C. McKannan, NASA-Marshall Space
Flight Center, Huntsville, Ala.
VIBRATION OF JOURNAL BEARINGS IN VACUUM
Lubrication Engineering, 19, (2), Feb., 1963, pp 59-67

Dry film lubricated bearing surfaces operating in a vacuum environment have been studied as a step in the analysis of the problem of lubrication in space. Journal bearings, which operated successfully at a pressure of one atmosphere, failed after a short time when exposed to a pressure on the order of 10^{-6} mm Hg. Failures were observed to be due to vibrations of the journal in the bushing rather than seizure or damaged surfaces. In this paper, the test system is described, and two suggested approaches toward an explanation of the failures are discussed.

18573

Earl G. Jackson, National Research Corp., Cambridge, Mass.
LUBRICATION IN SPACE VEHICLES
Wear, 5, (6), Nov. - Dec., 1962, pp 417-434

Operation of mechanical devices beyond the earth's atmosphere presents a number of peculiar problems to the lubrication engineer. The environment includes meteoroids, weightlessness, various forms of radiant energy, temperature extremes, and ultrahigh vacuum. From a practical viewpoint, the high vacuum provides the most interesting challenges in designing bearing systems. A variety of methods are available for application to space vehicle lubrication problems, from standard fluid lubricated systems to use of solids which have been developed for very high temperatures. But, improvements in length of life and reliability are badly needed, and there is increasing laboratory activity aimed at producing them.

18574

Paul H. Bowen, Westinghouse Electric Corp., Pittsburgh, Pa.
DRY LUBRICATED BEARINGS FOR OPERATION IN A VACUUM
ASLE Transactions, 5, (2), Nov., 1962, pp 315-326,
presented at the Annual Meeting of the American Society
of Lubrication Engineers held in St. Louis, Mo.,
May, 1962

Ball bearings incorporating two different types of dry self-lubricating retainer materials were successfully operated in a vacuum over the pressure range of 1×10^7 to 2×10^8 (mm of Hg) torr for prolonged periods of time. A 20 mm bore ball bearing of AISI M-10 tool steel with a filled plastic retainer was operated over a range of temperatures from 100 F to 160 F and similar bearings with filled metal retainers were operated over a temperature range of -300 F to 450 F, at radial loads up to 75 pounds. Other ball bearings using both types of self-lubricating retainer materials were operated in electric motors in the vacuum environment. This investigation was conducted with the financial support of the US Air Force under Contract AF 40(600)-915.

18575

Gilbert J. Mains, H. Niki, and M.H.J. Wijnen, Carnegie
Institute of Technology, Pittsburgh, Pa., and The
Radiation Research Laboratories, Mellon Institute,
Pittsburgh, Pa.
THE FORMATION OF BENZENE IN THE RADIOLYSIS OF ACETYLENE
Journal of Physical Chemistry, 67, (11), 1963, pp 11-16

The radiolysis of acetylene was studied over the pressure range 10 to 300 mm and over the temperature range 25 to 262 degrees. The effects of small amounts of free radical scavengers, the effects of excess krypton, and the effects of an excess of mercury vapor on the radiolysis yield of benzene were studied. $C_2H_2:C_2D_2$, $C_2H_2:D_2$, and $C_2D_2:H_2$ mixtures also were subjected to radiolysis. Two Cobalt-60 sources were used. Source I exhibited a dose rate in water of 8.50×10^{14} ev/cc/sec; Source II, 4.91×10^{15} ev/cc/sec. X-radiations were performed using a dose rate of 1.04×10^{14} ev/cc/sec in N_2O at 25 degrees and 93 cm, assuming a G-yield of 9.7 for N_2 formation. The products observed in the γ -radiolysis experiments at 25 degrees were benzene, diacetylene, 1,3-butadiene, and polymer. In the X-radiolysis experiments and the photolysis experiment, benzene, vinylacetylene, diacetylene, phenylacetylene, and cyclooctatetraene were observed as products of decreasing importance. 1,3-Butadiene was observed in trace yields in all 262 degrees experiments.

18576

D. E. Field, J. E. Cowling and F. M. Noonan
THE ULTRAVIOLET DEGRADATION OF ORGANIC COATINGS: PART
IV - RADIATION IN A VACUUM
U. S. Naval Research Lab., Washington, D. C., WADD-TR-
60-703, Part IV, July, 1962, Tech. Rpt., July, 1960 -
Jan., 1961, MIPR 33(616)-61-10, 31 pp
Avail: ASTIA, AD 287109

The optical properties of most organic coatings are changed on exposure to intense ultraviolet radiation in high vacuum. Current studies compared zinc sulfide (Cryptone 800) and titanium dioxide (R 610) on the basis of medium-to-high pigment volumes in a silicone resin matrix. Two formulations, one with zinc sulfide and the other with basic white lead carbonate, have also been prepared at 30 per cent pigment volume in Acryloid A-10. On exposure to the ultraviolet radiation in a vacuum, a considerable decrease in the reflectance of the white lead formulation was noted, but the zinc sulfide formulation was very resistant to a change in optical properties. White silicone coatings afford a very good combination of infrared emission and long serviceable life in a space environment in spite of the fact that considerable discoloration develops under ultraviolet irradiation. However, in at least one instance, the acrylic formation with zinc sulfide pigmentation has proven superior to all silicone formulations.

POLYMERIC MATERIALS

18577

C. D. Miller
DEGRADATION STUDY OF ELASTOMERS
Illinois Institute of Technology, Armour Research
Foundation, Chicago, Ill., ASD-TR-61-84, Part IV,
Dec., 1961, Tech. Rpt., May - Dec., 1961, AF 33(616)-
7310, 24 pp
Avail: ASTIA, AD 277057

The effects of high vacuum (to 10^{-6} mm Hg), ultraviolet radiation (to 2000 A), and moderate temperatures (to 300 F) were determined for a series of twelve elastomers: Neoprene, Neoprene W; Natural rubber; SBR, Philprene 1500; Carboxy-nitrile, Hycar 1072; Urethane, Adiprene C; Polyacrylic, Hycar 4021; Nitrile, Hycar 1042; Silicone, Silastic 916; Hypalon 40; Fluorosilicone, Silastic LS-63; Butyl 325; and Fluoroelastomers, Viton A and Viton B. The irradiated surfaces became hard and brittle. When the irradiated samples were released from tension, they developed a curvature, indicating permanent set of the top surface. Most samples show very little stress decay, indicating little or no bulk chain scission at low temperatures. At temperatures above 300 F bulk pyrolysis becomes important for many of these elastomers, resulting in marked stress decay. Quantitative methods for describing the extent of degradation are being developed.

18578

H. M. Price

MATERIALS - TANK SEALANTS - IRRADIATION OF TWO FLUXES
AND ONE TEMPERATURE - EFFECTS OF

General Dynamics/Forth Worth, Forth Worth, Tex.,
FTDM 1904, Nov. 2, 1962, AF 33(657) 7248, 35 pp
Avail: ASTIA, AD 288562

The effects of nuclear radiation at two fluxes, 3.6×10^{14} neutrons/cm², 2.5×10^{16} gammas/cm² and 1.1×10^{15} neutrons/cm², 8.6×10^{16} gammas/cm² and at 72-95 F on the hardness, tensile strength, per cent elongation, peel strength, and thermal rupture properties of four high temperature sealants and one pre-fabricated fillet material were determined. The general strength characteristics of sealants EC 1520, EC 1605, and EC-1610 were improved after exposure to both fluxes. On the other hand, a trend was noted in that the strengths of PR-1422 and IE 1240 (prefabricated fillet) were adversely affected by radiation. EC-1520, EC 1605, and EC-1610 without a top coating of EC-776 showed more improvement after irradiation than when coated, while uncoated PR 1422 and IE-1240 showed less degradation than when coated. Overall, these materials were not affected to such an extent as to preclude their use in a nuclear powered aircraft.

18579

H. M. Price

MATERIAL - EFFECTS OF NUCLEAR RADIATION ON CERTAIN FUEL
TANK SEALANTS AND PRESSURE SEALANTS

General Dynamics/Fort Worth, Fort Worth, Tex., FTDM-2505,
Nov. 2, 1962, AF 33(657)-7248, 28 pp
Avail: ASTIA, AD 288936

The effects of several integrated fluxes of 10^9 ergs/g(C), 10^{15} n/cm² and 10^{10} ergs/g(C), 10^{16} n/cm² at ambient reactor temperature (without fuel immersion and during fuel immersion) upon the tensile, peel, and cohesive strengths of sealants EC-1610, EC 1520, PR-1422, and 7 Thiokol-based compounds were determined. Among the fuel tank sealants, EC-1520 appeared to be least affected by nuclear radiation.

18580

J. W. Born

NUCLEAR RADIATION RESISTANT POLYMERS AND POLYMERIC COMPOUNDS

B. F. Goodrich Co., Research Center, Brecksville, O.
WADC-TR-55-58, Part VII, March, 1962, Tech. Doc. Rpt.,
April 1, 1960 - May 31, 1961, AF 33(616)-7491, 205 pp
Avail: ASTIA, AD 276227

Studies of basic mechanisms of radiation damage and its inhibition are in progress to guide the design of organic high polymers with superior radiation stability and of improved antirads. Analysis of radiation-induced structural changes in deuterated polybutadiene revealed that saturation, unsaturation, and double bond shifts occur. A basic approach to correlate polymer structure with radiation stability involves determining the absorbed energy per crosslink or chain scission, correcting for the molal volume of the protective structural group, and expressing the protection factor of the given group relative to the comparable group in the control polymer molecule. A considerable number of G values of crosslinking and chain scission are reported along with second order

transition temperatures. Poly (phenyl acrylate) and poly (4-phenylbutyl methacrylate) have G values of 0.047 and 0.081 for crosslinking and 0.019 and 0.019 for chain scission, respectively. In comparison polystyrene, probably the most radiation-stable conventional organic polymer, has a G (x) of 0.004 and a G (s) of 0.035. Compression set during irradiation has continued to be an effective index of the radiation resistance of vulcanized rubber compounds. In general, rubber compounds without antirads require radiation exposure from 1.0×10^8 to 2.7×10^9 ergs/gram (C) to effect 50 per cent net compression set. When antirads are present, the range becomes 3.0×10^8 to 4.4×10^9 . However, Estane VC rubber cured with dicumyl peroxide, the most radiation-resistant vulcanizate tested so far, requires 5.5×10^9 ergs/gram (C) to induce 50 per cent net compression set. The radiation testing of "O" rings and other vulcanized samples of NBR, NBR/SBR, Cr, and Viton A rubber compounds is completed. Stress - strain measurements before and after gamma radiation exposure doses of 0, 5, 10, 25, 50, and 100×10^8 ergs/gram (C) rated these control gasket stocks' radiation resistance as follows: NBR > NBR/SBR > CR > Viton A. Measurements of compression set during irradiation rated the four vulcanized control rubber compounds' radiation resistance in the decreasing order NBR/SBR > CR > NBR > Viton A. Antirad protection afforded to these stocks decreased in the order NBR > NBR/SBR > CR > Viton A. The NBR/SBR vulcanizate with 3 phr of Antioxidant 4010 is the most radiation-resistant practical rubber compound tested so far.

18581

R. M. Heitz, R. W. Hunter and P. J. D'Anna
RESEARCH ON ELASTOMERIC AND COMPLIANT MATERIALS FOR
AEROSPACE SEALANTS

Northrop Space Laboratories, Hawthorne, Calif., ASD-TDR-62-709,
NSL-62-35-1, Aug. & Oct., 1962, Tech. Doc. Rpt., Final
Rpt., May 1, 1961 - April 30, 1962, AF 33(616)-8258, 182 pp

Silicones, fluoroelastomers, chlorosulfonated polyethylenes, polychloroprenes, chlorobutyl and chlorobutyl-polychloroprene blends, polysulfides and polyurethane were exposed to seven different irradiation conditions, including gamma or combined gamma (10^8 and 10^9 ergs/g (C)) and ultraviolet radiations in vacuum or air for times of 16 and 100 hours. Tensile strength, 100 per cent modulus, ultimate elongation and hardness were determined before and after exposure, supplemented by analysis of the gases generated during the irradiation tests and visual examination of the specimens. The effects of the radiation conditions on materials are compared both within a class and for the different classes. For most of these elastomers, the primary reaction seemed to be cross linking with only minor amounts of chain scission. Self-sealing concepts are compared analytically to several other methods of prevention and control of meteoroid damage and the potential air leakage due to penetration.

18582

Arthur A. Armstrong, Jr. and Henry A. Rutherford
MODIFICATION OF TEXTILE FIBER PROPERTIES BY GAMMA
RADIATION

North Carolina State College of Agriculture and
Engineering, Raleigh, N.C., NCSC-2477-6, Jan. 1, 1962,
Annual Rpt., Nov. 1, 1960 - Oct. 31, 1961, AT (40-1)-
2477, 100 pp

A broad study was made covering (1) the modification of textile fibers by exposure to radiation, and (2) the modification of fibers by polymerization and/or graft polymerization of vinyl monomers. The effects of doses in the range of 1×10^3 to 5×10^7 rads on the breaking strength, elongation, and modulus of rayon, acetate, polyester, nylon 66, acrylic, polypropylene, wool, and silk were investigated. All of the materials that were investigated except acrylic, polyester and wool were adversely affected by the gamma radiation in relatively short periods of time. Data are presented for the vapor-phase addition of the most common vinyl monomers to the various textile fibers and for the vapor-phase addition of acrylonitrile to cotton. The graft polymerization of acrylonitrile to cotton cloth produces a material resistant to attack by micro-organisms and to heat degradation. Another procedure, that of post-irradiation grafting of acrylonitrile to cotton in nitrogen atmosphere, was also investigated.

18583

George Odian, Terese Acker, and Marjorie Sobel, Radiation Applications, Inc., Long Island City, N. Y.
ACCELERATIVE EFFECTS IN RADIATION-INDUCED GRAFT POLYMERIZATION
Journal of Applied Polymer Science, 7, (1), Jan., 1963,
pp 245-250

The use of solvent additives can substantially increase the rate of radiation-induced graft polymerization in the systems polyethylene-styrene, polypropylene-styrene, polyvinyl chloride-styrene, nylon-styrene, polyethylene-methyl acrylate, polypropylene-methyl acrylate, nylon-methyl acrylate, Teflon-methyl acrylate, and polyethylene-tert-butylaminoethyl methacrylate. Two different mechanisms have been shown to be responsible for the observed accelerative effects. One is the incursion of a Trommsdorff effect due to the insolubilization of the growing graft polymer chains in the solvent-monomer medium. The other mechanism is the enhancement in the degree of accessibility of monomer to grafting sites within the polymer brought about by the greater ability of the solvent additive to swell certain base polymers.

18584

Roy W. Roth and Robert F. Stamm, Central Research Div., American Cyanamid Co., Stamford, Conn.
THE EFFECT OF IONIZING RADIATION ON ACRYLAMIDE-METHYLENEBISACRYLAMIDE GELS
Journal of Applied Polymer Science, 7, (1), Jan., 1963,
pp 53-57

Acrylamide-methylenebisacrylamide gels (95/5 monomer ratio) of 10, 6, and 4 per cent total monomer concentration were subjected to 0 to 57.6 Mrad of 3 Mev electron at 40 C radiation. With increasing radiation dosage, the gels first shrink because of further crosslinking, then rupture and break into gel particles. At a dose rate of 0.5 to 1 Mrad/sec, the gels will absorb about 5 Mrad before degradation begins. Weaker gels (4 per cent) will absorb more irradiation before they degrade than will stronger gels (10 per cent).

18585

Joseph Marin and Paul B. Griesacker, Pennsylvania State University, University Park, Pa.

EFFECT OF RADIATION ON CREEP OF POLYETHYLENE

Journal of Applied Polymer Science, 7 (1), Jan., 1963,

pp 133-141

The influence of radiation on the creep of polyethylene in tension and compression was studied after a 1, 2.5, 5.0, and 7.5×10^{17} radiation dose of nvt. Even for small doses of radiation, it was found that the creep resistance of the material was increased. However, it should be noted that with decrease in creep deformations, the time to rupture for a given stress will very likely be decreased. In addition, the short-time properties may be adversely influenced by radiation.

18586

Joseph Marin and Paul B. Griesacker, Pennsylvania State University, University Park, Pa.

EFFECT OF RADIATION ON TENSION, COMPRESSION, BENDING, AND SHEAR PROPERTIES OF POLYETHYLENE

Journal of Applied Polymer Science, 7, (1), Jan., 1963,

pp 153-169

The influence of nuclear radiation on the stress-strain properties of polyethylene for tension, compression, bending, and shear stresses was determined. Four sets of tests were made with irradiation doses of 1.0×10^{17} nvt, 2.5×10^{17} nvt, 5.0×10^{17} nvt and 7.5×10^{17} nvt. In interpreting the test results, an attempt was made to determine the optimum radiation dose for each of the properties evaluated. In addition to the nominal tension and compression properties, the true stress-strain properties were determined. Nominal properties in bending and torsion were also found. For all four types of stress, the influence of radiation was found using four different doses of radiation. The theoretical prediction of bending-curvature and torque-twist relations from true stress-strain curves in tension and compression is also included.

18587

Francis Cracco, Louvain, Belgium, A. J. Arvia, Universidad Nacional de La Plata, La Plata, Argentina, and

Malcolm Dole, Northwestern University, Evanston, Ill.

ESR STUDIES OF FREE RADICAL DECAY IN IRRADIATED POLYETHYLENE

Journal of Chemical Physics, 37, (10), Nov. 15, 1962,

pp 2449-2457

A study has been made of the temperature and rates at which molecular hydrogen is evolved and free radical decay occurs when semicrystalline polyethylene, irradiated to a total dose of 6.4×10^8 ergs/g(C) at liquid-nitrogen temperature, is warmed to room temperature. Hydrogen evolution and free radical decay roughly parallel each other. The reaction rate constant for free radical decay calculated from D-H exchange experiments agrees with that deduced from the ESR measurements. It is also concluded that the persistent free radical in polyethylene irradiated to moderate doses is the allyl free radical.

18588

C. E. Jolley and J. C. Reed, E. I. du Pont de Nemours
& Co., Inc.

TEFLON RESINS IN THE SPACE ENVIRONMENT

Space/Aeronautics, 39, (2), Feb., 1963, pp 105-109

Teflon TFE and FEP resins will not evaporate in a vacuum of 10^{-7} mm Hg. Theoretical calculations show that they will not evaporate in any anticipated space vacuum to an extent that would limit their usefulness. Although some outgassing occurs initially, the volatiles are all absorbed atmospheric gases. The presence of oxygen greatly influences the physical and electric properties of TFE and FEP irradiated at more than about 4×10^4 rads. Properly applied, TFE remains useful after irradiation of 10^7 rads (or perhaps more) in the absence of oxygen. FEP irradiated at more than 2.6×10^6 rads in the absence of oxygen and at more than 80 C shows an improvement in certain desirable physical properties. The low-frequency loss properties of TFE polymers are drastically affected by X-ray irradiation, the high frequency loss properties considerably less so. The increases in dielectric constant and dissipation factor depend on the ambient oxygen concentration during exposure and recovery. The dielectric constant and dissipation factor of FEP remain unaffected by X ray irradiation in vacuum at frequencies from 60 CPS to 100 kc.

SPACE ENVIRONMENT AND EFFECTS ON MATERIALS

18589

Norris F. Dow, S. P. Shen, and J. F. Heyda

EVALUATIONS OF SPACE VEHICLE SHIELDING

General Electric Co., Missile and Space Vehicle Dept.,

Philadelphia, Pa., R62SD31, April, 1962, NASr-34,

130 pp

Avail: OTS

A general method of evaluating the efficiency of space vehicle shielding is developed and used to compare various active and passive systems for protection against ionizing radiation. Available permanent magnets are found useless for active shielding, and combined active-passive systems in general are determined to be inefficient. On the other hand, evaluations show that active electrostatic shielding may have possibilities for weight savings if electrical conditions (presently unknown) are favorable therefore in space. Further, a positive potential improvement is calculated for an active shielding system which utilizes superconducting Nb_3Sn to provide a confined magnetic flux to deflect incident charged particles; this potential points toward substantial reductions in shield weight for the protection of large vehicles from highly energetic particles. Recommendations are made for further research, particularly for flight experiments to measure directionality of solar flare protons.

18590

R. G. Alsmiller, Jr and J. E. Murphy

CALCULATIONS OF THE ATTENUATION OF A MODEL SOLAR FLARE
AND MONOENERGETIC PROTON BEAMS BY ALUMINUM SHIELDS

Union Carbide Corp., Oak Ridge National Lab., Neutron

Physics Div., Oak Ridge, Tenn., ORNL-3317, Jan. 23,

1963, W-7405-eng-26, 55 pp

Using the straight-ahead approximation, nucleon-meson cascade calculations have been carried out for a typical proton flare spectrum incident on a shield and also for approximately monoenergetic incident proton beams. The shield material considered has approximately the properties of aluminum. On the basis of the calculations a few tentative conclusions were drawn. In shielding against solar flares it seems that secondaries will not be a problem unless thick shields ($> 50 \text{ gm/cm}^2$ of aluminum) are used. The most characteristic feature of such a flare is the large number of very low-energy protons which will be stopped by even thin shields.

18591

W. F. Carroll

DEVELOPMENT OF STABLE TEMPERATURE CONTROL SURFACES FOR
SPACECRAFT

California Institute of Technology, Jet Propulsion Lab.,

Pasadena, Calif., JPL-TR-32-340, Nov. 20, 1962, Tech.

Rpt., Prog. Rpt. No. 1, NAS 7-100, 17 pp

Avail: NASA

Several white paints and non-paint "white" systems were tested for suitability as temperature control surfaces in space with high intensity ultraviolet radiation (approximately 10 x solar) in vacuum. Of the materials tested, only zinc sulfide pigmented silicone paint and aluminized FEP Teflon retained adequate solar reflectance to be useful for periods of several months of solar exposure in space.

18592

Jerome R. Redus

SPUTTERING OF A VEHICLE'S SURFACE IN A SPACE ENVIRONMENT

NASA-George C. Marshall Space Flight Center, Huntsville,

Ala., NASA-TN-D-1113, June, 1962, Tech. Note, 35 pp

Avail: NASA, N62-12347

The rates at which a vehicle's surface is sputtered by the earth's atmosphere, by radiation belts, and by solar corpuscular radiation are calculated. It is shown that the atmospheric sputtering constitutes a serious problem at low orbital altitudes and that the damage at 1 A.U. by solar corpuscular radiation is within an order of magnitude of that caused by micrometeorites.

18593

Syun-Ichi Akasofu, Sydney Chapman, Univ. of Alaska,

College, Alaska and Joseph C. Cain, NASA-Goddard

Space Flight Center, Greenbelt, Md.

THE MAGNETIC FIELD OF THE QUIET-TIME PROTON BELT

NASA-TN-D-1674, March, 1963, Tech. Note, 4 pp

Avail: OTS

The distortion of the earth's magnetic field produced by the proton belt is discussed. The magnetic field is calculated numerically, to a first approximation, for an analogous model belt, in a steady state. In the equatorial plane, at the earth's surface, it is estimated that the magnetic field produced by this belt is of order 38 gammas; it is directed southward. The maximum field reduction is of

the order of 72 gammas at 4.1 earth radii; this is 15.5 per cent of the dipole field intensity at this point. Beyond 6.7 earth radii, the belt increases the earth's field.

18594

F. J. Clauss
EVALUATION OF MATERIALS FOR SPACECRAFT APPLICATIONS
Lockheed Aircraft Corp., Missiles and Space Div.,
Sunnyvale, Calif., LMSD 5-10-61-11, June, 1961,
Tech. Rpt., 24 pp
Avail: ASTIA, AD 282601

Areas of research selected for discussion in this paper are: friction and wear of gears, bearings, electrical contacts, and other rubber surfaces under high vacuum; stability of temperature-control surfaces and thin films of organic polymers under ultraviolet radiation and high vacuum; and stability of organic adhesives under high-energy radiation and high-vacuum.

18595

Horace R. Moore, H. Bernstein, and R. S. Reynolds
A SOURCE AND DETECTOR OF RADIATION IN THE WAVELENGTH REGION
1500 - 50 ANGSTROMS SUITABLE FOR RADIATION EFFECTS STUDIES
ON MATERIALS IN VACUO PART II -- A STUDY OF VACUUM
ULTRAVIOLET RADIATION EFFECTS ON MATERIALS IN VACUO OF
ORDER 10^{-9} MM HG
Electro-Optical Systems, Inc., Pasadena, Calif., WADD
TR-60-371, Part II, Dec., 1962, Tech. Doc. Rpt.,
Dec. 20, 1960 - Sept. 30, 1961, AF 33(616)-6488, 79 pp
Avail: ASTIA, OTS

This report describes a space environmental research facility whereby the effects of ultrahigh vacuum and/or vacuum ultraviolet radiation on materials can be experimentally evaluated. The radiation source is a pulsed plasma discharge which emits a line and continuum spectrum extending from the visible, through the vacuum ultraviolet, into the soft X ray region. This report includes the results of studies of the effects of ultrahigh vacuum and/or vacuum ultraviolet radiation on the characteristics of a silicon solar cell, the electrical surface resistivity of aluminum oxide, and the optical reflectance of metallic mirror coatings.

18596

Donald L. Anderson and George J. Nothwang
EFFECTS OF SPUTTERING WITH HYDROGEN IONS ON TOTAL
HEMISPHERICAL EMITTANCE OF SEVERAL METALLIC SURFACES
NASA-Ames Research Center, Moffett Field, Calif.,
NASA-TN-D-1646, Jan., 1963, Tech. Note, 36 pp
Avail: NASA

The test specimens were cylindrical and were constructed from pure titanium, a titanium alloy containing 6-per cent aluminum and 4-per cent vanadium, pure aluminum, 2024 aluminum alloy, and pure copper. The energy level of the incident ions was 1000 electron volts. The test specimens were subjected to ion bombardment by immersion in a hydrogen plasma. The total hemispherical emittance of

each specimen was measured in a cold-wall, vacuum-type calorimeter. Five specimens were electropolished and one specimen was sandblasted before ion bombardment. Emittance was measured both before ion bombardment was initiated and after successive bombardment periods until a total of 10^{21} ions/cm² had bombarded each specimen. For the five initially polished specimens, the test results indicated that, for the total test period, the emittance of the pure aluminum increased the most (about 60 per cent from its initial value), whereas, the emittance of both the pure and alloyed titanium remained essentially unchanged. During the total test period, the emittance of the initially sandblasted copper specimen decreased to one-third of the unspattered value. Photomicrographs of all test specimens before and after bombardment with 10^{21} ions/cm² are presented and discussed. In addition, the changes in weight resulting from ion bombardment of all specimens are presented. The time required to achieve significant changes in emittance for surfaces in the spatial environment and in an ion engine is discussed briefly.

18597

Wilmot N. Hess

NEUTRONS IN SPACE

NASA-Goddard Space Flight Center, Greenbelt, Md.,

NASA-TN-D-1696, Feb., 1963, Tech. Note, 8 pp

Avail: NASA

The various neutron sources in the solar-system are discussed. Cosmic rays interacting with the atmosphere or surface of the planets are the major neutron source near the planets. Studies of the neutron energy spectrum can give some information about the chemical composition of the planets. The sun is a source of neutrons from several processes. Thermonuclear burn in the corona and leakage from the burning cone do not seem to be important sources, but a significant number of neutrons may result from high energy protons accelerated in flares on the sun.

18598

R. A. Hoffman, L. R. Davis, and J. M. Williamson
PROTONS FROM 0.1 to 5 MEV AND ELECTRONS OF 20 KEV AT
12 EARTH RADII DURING THE SUDDEN COMMENCEMENT ON
SEPTEMBER 30, 1961

NASA-Goddard Space Flight Center, Greenbelt, Md.,

NASA-TN-D-1700, March, 1963, Tech. Note, 7 pp

Avail: NASA

During the sudden commencement of the magnetic storm, the ion-electron detector aboard Explorer XII observed fluxes of low energy protons and electrons while the satellite was at 12 earth radii and outside the magnetosphere. The maximum flux of about 2×10^5 protons/cm²-sec-ster above 140 kev was attained 1/2 hour after the sudden commencement. The energy density of the proton spectrum (1×10^9 erg/cm³) was too small to account for the observed compression of the earth's field on the sunlit side during the magnetic storm. Time-coincident with the sudden jump in proton intensities, an electron flux first appeared and reached its peak value of 3×10^6 electrons/cm²-sec-ster in the 10 to 35 kev range about 1 minute before the observance of the sudden commencement on the earth's surface; it continued for about 10 minutes and then disappeared. The detection efficiency for electrons places an upper limit of 2×10^5 electrons/cm-sec-ster for the remainder of the storm.

18599

Wilmot N. Hess and John A. Poirier
ENERGY SPECTRUM OF ELECTRONS IN THE OUTER RADIATION
BELT

NASA-Goddard Space Flight Center, Greenbelt, Md.,
NASA-TN D-1717, March, 1963, Tech. Note, 15 pp
Avail: NASA

The equilibrium energy spectrum of electrons in the outer radiation belt is determined by the injection spectrum and the loss processes that operate to remove the electrons or change their energy. The loss processes considered here are ionization energy loss, multiple scattering, and electron-electron scattering; the injection spectra considered are neutron β -decay electrons and monoenergetic electrons of 780 and 20 kev. The problem is treated numerically. The results of the numerical calculation are compared with recent measurements of the outer-belt electron spectrum; it appears that neutron decays produce a reasonable fraction of the outer-belt electrons, but other processes such as acceleration may be important.

18600

V. E. Kistler
A DISCUSSION AND BIBLIOGRAPHY OF CURRENT LITERATURE
CONCERNING VAN ALLEN BELTS FOR USE IN SNAP SPACE
ENVIRONMENTAL STUDIES

North American Aviation, Inc., Atomics International,
Canoga Park, Calif., NAA-SR-7849, Feb. 15, 1963,
AT(11-1) GEN-8, 42 pp
Avail: OTS

The trapped radiation region will have characteristic effects upon the instrumentation, payload, and reactor core of SNAP flight systems. Possibilities are present to design reactor systems that make use of this radiation field as a reactor startup source. Whatever the benefits or liabilities of this radiation field, allowances must be made for its presence if top performance goals of long life, reliability, and steady-state operation are to be accomplished. The bibliography is divided into five sections: (1) inner radiation belt (experiment), (2) inner radiation belt (theory), (3) outer radiation belt (experiment), (4) outer radiation belt (theory), and (5) general papers on Van Allen Belts.

18601

OPTICAL PROPERTIES OF SATELLITE MATERIALS - THE THEORY
OF OPTICAL AND INFRARED PROPERTIES OF METALS
NASA-George C. Marshall Space Flight Center, Huntsville,
Ala., NASA-TN-D-1523, March, 1963, Tech. Note, 253 pp
Avail: NASA

The probable effects of solar radiation, primary cosmic rays, Van Allen radiation and meteoric dust on the emissive properties of materials are reviewed. Experimental data on the spectral emittance (.25 to 27 microns) of metals with polished and carefully abraded surfaces are presented. A theory is presented to account for the optical properties of metals in the entire free electron region at all temperatures of interest.

18602

S. I. Rasool, NASA Goddard Institute for Space Studies,
New York, N. Y.

STRUCTURE OF PLANETARY ATMOSPHERES

AIAA Journal, 1, (1), Jan., 1963, pp 6-19

This article reviews the properties of the atmospheres of Mars, Venus, and Jupiter in the light of the most recent observational results.

18603

Joseph N. Kotanchik and H. Kurt Strass, Manned Spacecraft
Center

FACILITIES FOR MANNED SPACECRAFT DEVELOPMENT - MSC TEST
FACILITIES

Astronautics and Aerospace Engineering, 1, (1), Feb., 1963,
pp 78-81

The Manned Spacecraft Center at Houston, Texas is constructing a group of facilities essential to its mission of developing and operating manned spacecraft. The facilities, reviewed here, will have capabilities which, in general, do not exist elsewhere in terms of size, performance, manrating of equipment, or work loads. The Space Environment Simulation Facility will contain two space chambers, the larger for space and lunar-surface environment simulation, and the smaller for astronaut training.

18604

EXPLORER XV ENERGETIC-PARTICLES SATELLITE STUDY OF

STARFISH ARTIFICIAL RADIATION BELT

IG Bulletin, (68), Feb., 1963, pp 12-16

The Explorer XV satellite was launched to study the artificial radiation belt created by the starfish high-altitude nuclear test. The use of a special satellite to study the location, composition, and decay rate of the artificial radiation also provides an unparalleled opportunity to improve understanding of the physical processes responsible for the Van Allen trapped radiation region. A solar-cell damage experiment provides a means of establishing integral radiation damage in the Explorer XV orbit. The experiment consists of four groups of solar cells shielded with different thicknesses of sapphire; shielding thicknesses are 0.10, 0.30, 0.50, and 0.80 g/cm².

18605

S. I. Akasofu, Geophysical Institute, Univ. of Alaska,
College, Alaska and W. C. Lin, State Univ. of Iowa,
Iowa City, Iowa

THE MAGNETIC MOMENT OF MODEL RING CURRENT BELTS AND THE
CUTOFF RIGIDITY OF SOLAR PROTONS

Journal of Geophysical Research, 68, (4), Feb. 15, 1963,
pp 973-977

The magnetic moment M_R of the ring current is calculated for model ring current belts, together with their magnetic fields along an equatorial radius. The entry of low-energy solar protons is discussed, and it is shown that the ring current alone cannot produce the drastic reductions of apparent cutoff rigidity of solar protons observed by detectors carried by balloons and satellites.

18606

SPACE TEMPERATURES YIELD TO TECHNOLOGY

Industrial and Engineering Chemistry, 55, (2), Feb., 1963,

p 9

Combinations of inorganic pigments and alkali silicates can give coatings with a ratio of solar absorptance to infrared emittance ranging from 0.1 to 1.1. Coatings with these ratios can control component temperatures over a wide range. The best combination of properties found so far comes from cobalt oxide and zirconium silicate in a sodium silicate vehicle. The ratio of cobalt oxide to zirconium silicate determines the ratio of absorptance to emittance.

18607

EARLY EXPERIMENTAL RESULTS FROM TELSTAR I

IG Bulletin, (62), Aug., 1962, pp 6-11

Telstar's radiation-sensing diodes have been reporting particle-flux data at all sensitivity levels of the experiment. After about two weeks in space, the least heavily shielded cell (20 mils of sapphire) showed a decrease in current output of 10 per cent \pm 2 per cent, and cells with 25 and 30 mils of sapphire shielding show changes of 5 per cent \pm 2 per cent. Radiation has steadily degraded the six sensitive silicon transistors at a rate correlating very closely with the relative thickness of shielding. The current gain of the least heavily shielded transistor has decreased by a factor of 8.

18608

S. J. Bame, J. P. Conner, H. H. Hill, Los Alamos Scientific
Lab., Los Alamos, N. M., and F. E. Holly, Air Force
Special Weapons Center, Kirtland AFB, N. M.

PROTONS IN THE OUTER ZONE OF THE RADIATION BELT

Journal of Geophysical Research, 68, (1), Jan. 1, 1963,
pp 55-63

The trapped protons in the outer zone of the Van Allen radiation belt were measured on October 4, 1960, by means of a Scout rocket payload containing a two-crystal scintillation spectrometer. Protons with energies above 1 Mev were detected, the intensity rising above background at an altitude of 1200 km. Representative intensities for $1 \leq E_p \leq 80$ Mev at 2, 3, 4, and 5×10^3 km, through a range of 42 N to 30 N geomagnetic latitudes, were 0.27, 0.90, 2.02, and 4.56×10^5 protons/cm² sec ster. These intensities are averages for protons having pitch angles between 90 and \sim 60 degrees. The proton energy spectrum at 5000 km is $J(E) = 2.0 \times 10^{6E-5.2}$ protons/cm² sec ster Mev for $1.02 \leq E_p \leq 2.24$ Mev, and $J(E) = 0.71 \times 10^{6E-3.9}$ for $2.24 \leq E_p \leq 7.3$ Mev. The pitch angle distributions for altitudes of 4600 km and 5150 km were also obtained for angles between 90 and 58 degrees. There was no evidence for a proton intensity maximum coincident with the E_2 maximum.

18609

W. L. Brown, Bell Telephone Labs., Murray Hill, N. J.,
W. N. Hess, Goddard Space Flight Center, Greenbelt, Md.,
and J. A. Van Allen, State Univ. of Iowa, Iowa City
Iowa

COLLECTED PAPERS ON THE ARTIFICIAL RADIATION BELT FROM
THE JULY 9, 1962, NUCLEAR DETONATION
Journal of Geophysical Research, 68, (3), Feb. 1,
1963, pp 605-758

On September 10 and 11, 1962, a symposium was held at Goddard Space Flight Center to bring together scientists from various fields to discuss the measurements concerning the artificial radiation belt. The material presented here is an outgrowth of the Goddard symposium. Information has been revised and brought up to date; but the main subject matter presented here corresponds roughly to a proceedings of the Goddard meeting and is concerned with observations before and after July 9 and until about September 1. One paper gives a brief report on pertinent observations by Explorer 14 during early October.

18610

Irwin Stambler
THE OGO

Space/Aeronautics, 39, (2), Feb., 1963, pp 70-77

The Ogo experiments are designed principally to provide data on the intensity and behavior of charged particles (including cosmic-ray particles) in the earth's atmosphere, on the earth's magnetic field, and on the atmosphere. In addition, the Ogos will study the radiation belt produced by nuclear explosions at high altitude. Both Ego and Pogo are being designed and built by Space Technology Labs. Ego will be placed in a highly elliptic orbit ranging in altitude from 60,000 nm--beyond the interface of the interplanetary and terrestrial magnetic fields--down to 150 nm above earth's surface. Details are given on the novel methods devised by STL to meet the special needs of short-run satellite production.

18611

U.S. STANDARD ATMOSPHERE, 1962
United States Committee on Extension to the Standard
Atmosphere, Dec., 1962, 278 pp
Avail: Superintendent of Documents, U.S. Government
Printing Office, Washington, D. C.

The U.S. Standard Atmosphere, 1962 is a product of COESA generated under the impetus of increased knowledge of the higher atmosphere and more accurate determinations of basic quantities, such as redefinition of the absolute thermodynamic temperature scale. For all practical purposes the U.S. Standard Atmosphere, 1962 is in agreement with the ICAO Standard over their common altitude range. Background information, including a brief historical statement, is given in the Foreword. The document is arranged in three parts. Part I gives the basis for the main tables of atmospheric properties and contains a full development of gravity and geopotential as well as the basic assumptions, formulas, and derived quantities. In Part II additional information relating to the atmosphere is given, including discussion of systematic variations, observed and inferred extremes, and representations of atmospheric variables as approximate analytic functions of altitude. Part III

contains the main tables of atmospheric properties to 700 kilometers calculated in both metric and English units. Throughout the document figures and short tables are introduced to aid in visualizing the variation with altitude of atmospheric parameters and to provide conversions between various units.

18612

C. E. McIlwain and G. Pizzella, Univ. of Rome, Italy
ON THE ENERGY SPECTRUM OF PROTONS TRAPPED IN THE EARTH'S
INNER VAN ALLEN ZONE
University of California, San Diego, La Jolla, Calif.,
NASR-116, Paper, 29 pp
Avail: NASA, N-62-16493

The proton energy spectrum in the inner Van Allen zone has been investigated in the range 30 to 40 Mev with the two Geiger counters aboard the satellite Explorer IV. It has been found that an exponential spectrum $dN = I_0 e^{-E/E_0} dE$ is suitable for describing the variation of the "hardness" of the spectrum with the magnetic coordinate L. It is believed that the relationship determined between E_0 and L supports the theory of a breakdown of the adiabatic conditions for the protons trapped in the earth's magnetic field.

18613

SPACE RADIATION EFFECTS ON MATERIALS
American Society for Testing and Materials, Philadelphia,
Pa., ASTM Special Tech. Publication, No. 330, 44 pp
Avail: ASTM

The atmosphere, meteorites, galactic, solar, and Van Allen radiations in space are discussed. The effects of irradiation on metal, ceramic, inorganic, organic, semiconductor, and electronic materials are reviewed.

18614

L. A. Frank, J. A. Van Allen, W. A. Whelpley, and
J. D. Craven, Dept. of Physics and Astronomy, State
Univ. of Iowa, Iowa City, Iowa
ABSOLUTE INTENSITIES OF GEOMAGNETICALLY TRAPPED
PARTICLES WITH EXPLORER 14
Journal of Geophysical Research, 68, (6), March 15, 1963,
pp 1573-1579

This is the initial report on a new series of observations on the absolute intensities of geomagnetically trapped protons and electrons in the earth's outer radiation zone and on the nature of the outer boundary of the magnetosphere. The equipment was carried on the NASA satellite Explorer 14, which was launched on October 2, 1962, into an eccentric orbit whose apogee was initially at 16.5 earth radii from the center of the earth on a line at 71 degrees to the line from the center of the earth to the sun.

18615

Richard Latter and Robert E. LeLevier, Rand Corp.,
Santa Monica, Calif.
DETECTION OF IONIZATION EFFECTS FROM NUCLEAR EXPLOSIONS
IN SPACE
Journal of Geophysical Research, 68, (6), March 15, 1963,
pp 1643-1666

The detection of nuclear explosions in space by observing the effects of explosion-induced ionization on the absorption of radio waves is considered. Ionizations due to explosion X-rays, γ -rays, and β -rays are considered separately, and the dependence of the absorption on explosion characteristics, distance from the earth's atmosphere, and frequency of the radio wave is determined.

METALLIC MATERIALS

18616

J. C. Robinson
IRRADIATION DAMAGE AND SUBSEQUENT RECOVERY IN METALS
THROUGH MEASUREMENTS OF ELASTIC MODULES AND DECREMENT
North American Aviation Inc., Atomics International,
Canogo Park, Calif., NAA-SR-Memo-7428, June 1, 1962,
20 pp

The primary objective in this study is to acquire an increased understanding of the effects of lattice defects on the physical properties of crystalline solids. The defects are induced in this case by high energy electrons, and the tools of investigation are changes in elastic modulus and decrement (internal friction) as a result of irradiation and subsequent thermal treatment. Modulus is measured as a function of resonant frequency of the sample and decrement as a rate of decay of the sample oscillation when the exciting source is removed.

18617

J. L. Christian
PHYSICAL AND MECHANICAL PROPERTIES OF PRESSURE VESSEL
MATERIALS FOR APPLICATION IN A CRYOGENIC ENVIRONMENT
General Dynamics/Astronautics, San Diego, Calif.,
ASD-TDR-62-258, March, 1962, Tech. Doc. Rpt., Dec.,
1960 - Jan., 1962, AF 33(616) 7719, 270 pp
Avail: ASTIA, OTS

The objectives of this investigation were to develop simple laboratory type tests to evaluate the toughness of high-strength sheet materials at cryogenic temperatures and to obtain useful engineering data on the properties of these materials from 78 to -423 F. Alloys investigated include Types 301, 304 ELC, 310, and AM-355 stainless steels, 2014-T6, 5052-H38, and 5456-H343 aluminum alloys and the 5Al-2.5Sn titanium alloy. The tests employed for evaluating the toughness of sheet alloys included notched ($K_t = 3.2, 6.3, \text{ and } 19$) tensile tests, fusion-weld tensile tests, and cross-tension and tensile-shear tests of individual resistance spot welds.

18618

P. G. Lucasson and R. M. Walker
RESEARCH DIRECTED TOWARD THE STUDY OF THE RADIATION
DAMAGE THRESHOLDS OF THE ELEMENTS
General Electric Co., Research Lab., Schenectady, N. Y.,
AFCRL-62-134, 62-GC-207, June, 1962, Scientific Rpt.
No. 5, AF-19(604)-5557, 45 pp
Avail: ASTIA, AD 276651

The changes in residual electrical resistance were measured for a number of metals as a function of electron energy in the range from 0.5 to 1.5 Mev. The irradiations were performed at ≤ 20 K, and recovery measurements were made up to 300 K. The production curves were analyzed using simple displacement theory and the following values were found for the average threshold energies: Al - 32 ev; Au - >40 ev; Ag - 28 ev; Cu - 22 ev; Fe - 24 ev; Mo - 37 ev; Ni - 24 ev; Ti - 29 ev; and W >35 ev. Approximate values for the resistivities of Frenkel pairs were also obtained as follows: Al - 3.4; Ag - 1.4; Cu - 1.3; Fe - 12.5; Mo - 4.5; Ni - 3.2, and Ti - 42.

18619

HIGH-TEMPERATURE MATERIALS PROGRAM
General Electric Co., Nuclear Materials and Propulsion
Operation, Cincinnati, O., GEMP-19A, Jan. 25, 1963,
Prog. Rpt. No. 19, Part A, Oct. 15 - Dec. 15, 1962,
AT(40-1) 2847, 49 pp
Avail: OTS

The effects of 5×10^{19} fast n/cm² neutron irradiation on the stress rupture properties of overaged and underaged specimens of Rene' 41 are presented. Preliminary studies on the creep-rupture properties of Hastelloy X are illustrated in the form of specimen elongations as a function of testing time for various temperatures and stresses.

18620

P. J. Peterson, J. A. Leary, and W. J. Maraman
REACTOR IRRADIATION OF URANIUM-IMPREGNATED GRAPHITE AT
1500 C TO 10 PER CENT BURNUP
University of California, Los Alamos Scientific Lab.,
Los Alamos, N. M., LAMS-2814, Jan. 28, 1963,
W-7405-ENG-36, 42 pp
Avail: OTS

Two type-AUC graphite fuel elements loaded by solution impregnation to an average concentration of 0.115 g/cc of 93.13 per cent enriched U converted to UC and UC₂ were irradiated at temperatures about 1500 C to a 10.2 per cent maximum burnup, corresponding to an irradiation level of 2.45×10^{19} fissions/cc of fuel element. Post-irradiation measurements of the elements showed dimensional changes of -4.3 and -4.8 per cent with the grain, and -0.8 to -2.5 per cent across the grain. Weight losses were 3.2 and 5.1 per cent for the individual elements with approximately 11 per cent of the total U²³⁵ being lost from the elements. With-the-grain thermal conductivity at nominal room temperature was reduced by a factor of ~ 7 and electrical conductivities by factors of 3.5 to 6.3, also at room temperature. Impact strength appeared to be somewhat improved by irradiation. Fission product release was high.

18621

L. J. Defferding
POSTIRRADIATION EVALUATION OF ZIRCALOY-2 PRTR PRESSURE
TUBES PART I

General Electric Co., Hanford Atomic Products Operation,
Richland, Wash., HW-73698-REV, Nov., 1962, AT(45-1)-1350,
37 pp
Avail: OTS

The room temperature burst properties, depth of fretting corrosion, changes in grain structure and the extent of crevice corrosion were determined. Irradiation to 10^{20} nvt ($E > 1$ Mev) produced a small increase in room temperature burst strength and a decrease in ductility.

18622

B. A. Loomis and D. W. Pracht
SWELLING OF URANIUM AND URANIUM ALLOYS ON POSTIRRADIATION
ANNEALING

University of Chicago, Argonne National Lab., Argonne,
Ill., ANL-6532, Sept., 1962, W-31-109-eng-38, 39 pp
Avail: OTS

The swelling of uranium and of a few selected uranium alloys on post-irradiation annealing was investigated by utilizing density measurements in conjunction with the observation of pores in the microstructures of annealed specimens. Specimens were irradiated to about 0.3 a/o burnup in a constrained condition at approximately 275 C and were subsequently pulse annealed. The amount of swelling was found to be less than 1 per cent for uranium specimens that were pulsed annealed up to 75 hr at temperatures below 550 C; the amount of swelling, however, increased considerably on annealing at temperatures between 550 C and 650 C. Uranium alloys containing between 1 w/o and 9 w/o of either titanium, zirconium, niobium, or molybdenum generally swelled more than pure uranium on pulse annealing up to 75 hr at 618 C and 740 C. An exception was the behavior of a U 4.0 w/o Nb alloy, which swelled less than uranium on annealing at 618 C. A carbon addition of 0.11 w/o to uranium substantially decreased the swelling on pulse annealing up to 75 hr at 618 C, whereas the effect of 0.02 w/o N was small; at 740 C, a nitrogen addition of 0.02 w/o to uranium caused an appreciable increase in the swelling, but the effect of 0.11 w/o C was slight.

18623

L. J. Defferding
EVALUATION OF PROPERTIES OF IRRADIATED ZIRCALOY-2
PRESSURE TUBE FROM KER LOOP 1

General Electric Co., Hanford Atomic Products Operation,
Richland, Wash., HW-67949-REV, Dec., 1962, AT(45-1)-
1350, 23 pp
Avail: OTS

The Zircaloy-2 pressure tube was removed from KER Loop 1 after 26 months irradiation. During this period, the tube operated at temperatures from 200 to 270 C for 380 days. The grain structure of the tube irradiation was heavily cold-worked with a ring of larger grains at the outer surface. During operation little recrystallization occurred throughout the tube. No evidence of hydrogen

pickup was found. The room temperature burst strength averaged 127,000 psi, hoop strength, for four normal samples as compared to an unirradiated hoop strength of 108,000 psi. The fractures were ductile at the point of maximum elongation and changed to semi-ductile after the crack had traveled 2 to 3 inches. Flattening tests were run at room temperature and 300 C on samples from the irradiated tube and from a companion tube that was unirradiated. The test indicated no measurable reduction in ductility.

18624

J. R. Hawthorne and L. E. Steele, U.S. Navy, Naval
Research Lab.

COMPARISON OF THE EFFECTS OF SIMULTANEOUS IRRADIATION
OF FIVE STEELS EXPOSED AT 240 F

Report of NRL Progress, Jan, 1963, pp 25-27

ASTM A212-B, ASTM A350-LF1, ASTM A350-LF3, ASTM A353, and ARMC0 17-4PH, were irradiated simultaneously at 240 F. The total neutron flux was 7.0×10^{18} n/cm² (>1 Mev). The transition temperature shifts observed for these steels are listed.

18625

J. R. Hawthorne and L. E. Steele, U.S. Navy, Naval
Research Lab.

NOTCH DUCTILITY OF Ni-Cr-Mo STEEL IRRADIATED AT 540 F,
640 F, AND 740 F

Report of NRL Progress, Nov., 1962, pp 31-33

Full size Charpy V-notch specimens of a quenched and tempered Ni-Cr-Mo steel have been irradiated at 540, 640, and 740 F to a neutron dosage (over 1.0 Mev) of 3.0×10^{19} n/cm². The transition temperature shifts noted for the 540 F and 640 F exposures were found to be in close agreement with those observed for an A302B steel irradiated under identical conditions. Postirradiation heat treatment was investigated as a method for achieving transition temperature recovery. The experimental results indicate that material exposed at 540 F undergoes partial recovery with 750 F and 800 F heat treatments. The data also indicates that, for 640 F irradiation, 800 F either is too low an annealing temperature or promotes a detrimental aging phenomenon in this steel.

18626

Walter Bauer, John W. DeFord and James S. Koehler,
University of Illinois, Urbana, Ill., and John W. Kauffman,
Northwestern University, Evanston, Ill.

LOW-TEMPERATURE ANNEALING SPECTRUM OF ELECTRON-IRRADIATED
GOLD AND CADMIUM

Physical Review, 128, (4), Nov. 15, 1962, pp 1497-1505

Cadmium and gold of 99.999 per cent purity were irradiated to an integrated flux of 7.5×10^{17} electrons/cm² using 3-Mev electrons. The resistivity increase was 8.5×10^{-9} Ω -cm in gold and 2.32×10^{-9} Ω -cm in cadmium. The resistivity versus integrated flux curve is linear. Isothermal annealing measurements were made in the region from 8 to 51 K. The resistivity annealing spectrum of gold was derived directly from the isothermal annealing curves. The spectrum consists of at least nine peaks, with 22 per cent of the damage annealing out up to 51 K.

18627

ALUMINUM ALLOYS PERFORM BETTER AT CRYOGENIC TEMPERATURES
Space/Aeronautics, 38, (7), Dec., 1962, p 121

Aluminum alloy 5083 in the O and H 113 tempers was studied at room temperature and at -320 and -452 F. Tensile evaluations were made from subsized specimens 0.250 in in diameter. The notched specimens had a 60 degree V notch with a nominal root radius of 0.001 in and a theoretical stress concentration factor of about 14.

18628

I. L. Mogford, Rutherford College of Technology and
D. Hull, University of Liverpool
EFFECT OF TEMPERATURE AND NEUTRON IRRADIATION ON YIELD
AND WORK HARDENING IN IRON
Journal of the Iron and Steel Institute, 201, Part 1,
Jan., 1963, pp 55-60

Two batches of pure iron with similar compositions have been irradiated to a maximum dose of 3×10^{17} neutron cm^{-2} > 1 Mev. Tensile tests have been carried out between 293 and 78 K to determine the effect of temperature and irradiation on the lower stress and the work hardening rate.

18629

Donald W. McLaughlin, Mechanical Technology Inc.,
Latham, N. Y.
NEUTRONS EMBRITTLE REACTOR VESSELS OF CARBON STEEL
Nucleonics, 21, (2), Feb., 1963, pp 36-41

Better methods for calculating and measuring reactor fast-neutron fluxes and the ductility losses they cause in steel are helping to define ways to design and operate vessels for longer lifetimes. Measurable increases in NDT start at $\sim 10^{18}$ n/cm², are roughly proportional to the log of dose up to $5-10 \times 10^{19}$ n/cm² and are sensitive to irradiation temperature above 450 F. Another data trend establishes that the NDT change is independent of alloying elements within the general class of ferritic steels used for reactor-vessel construction; thus early hopes for developing a radiation-resistant alloy have not been realized.

EXPERIMENTAL DEVICES AND TECHNIQUES

18630

Ivan Draganic, Boris Kidrich Institute of Nuclear Sciences,
Vincha, Yugoslavia
OXALIC ACID: THE ONLY AQUEOUS DOSIMETER FOR IN-PILE USE
Nucleonics, 21, (2), Feb., 1963, pp 33-35

Aqueous oxalic acid is unequaled among aqueous chemical dosimeters for measuring radiation dose within the reactor. Compared with existing chemical dosimeters it has many advantages: (1) the dose range and the upper limit that can be measured are considerably greater and permit measurements during longer irradiations or at very high dose rates, (2) the dosimeter is not made radioactive by neutrons, making it suitable for in-pile measurements, (3) the system is neither sensitive to impurities nor photosensitive.

18631

Helmut Faissner, Filippo Ferrero, Abdul Ghani, and
Max Reinharz, CERN, European Organization for Nuclear
Research, Geneva, Switzerland

NEW SCINTILLATION LIQUIDS

Nucleonics, 21, (2), Feb., 1963, pp 50-55

Several higher benzene derivatives and two cycloparaffines have been studied and compared with conventional scintillators. Because of their low cost and volatility, two liquids--Shellsol A and decalin--are suitable for large-scale applications. Shellsol A is a good choice if long-time chemical attack is either immaterial or can be avoided (for example by protective varnish) and the average light path is <1 meter. Decalin should be used whenever absolute chemical stability is essential and for all counters with average light paths exceeding 1 meter--in other words for counters with volumes of 100 liters or more.

18632

John A. Dooley

STUDY OF THERMAL NEUTRON DOSIMETRY

Aeronautical Systems Div., Nuclear Engineering Test Facility,

Wright-Patterson Air Force Base., O., ASD-TDR-62-313,

April, 1962, Tech. Doc. Rpt., Nov., 1961, 6 pp

Avail: ASTIA, AD 277284

A simple calculation of dose rate to flux conversion is presented. The results are consistent with Snyder's computations upon which the AEC has based its thermal neutron exposure limits. A chart of conversions used by various authors has been compiled indicating previous variance in usage. Calibration considerations for a neutron dosimeter for reactor monitor use are discussed.

18633

J. W. Hallam and R. L. Williams

SOLID STATE CHARGED PARTICLE SILICON DETECTORS

RCA Victor Research Labs., Montreal, Quebec, Canada

ARL 62-406, Aug., 1962, Final Tech. Rpt., June 1, 1961 -

May 31, 1962, AF 33(616) 8373, 15 pp

Avail: ASTIA, AD 289009, OTS

The research carried out under this contract deals with the lithium ion drift method of making wide depletion layer solid state nuclear particle detectors. Lithium ions, drifting in the field of a reverse biased silicon diode at temperatures in the 100 to 140 C range, compensate to a high degree the original impurities of a pellet. With a suitably drifted unit, a voltage of 100 volts or less will extend the depletion layer completely across a compensated region a few millimeters deep. Lithium atoms were diffused through a surface which had been diffused previously with phosphorus. As a high surface concentration of lithium atoms is not required, only sufficient quantities need be diffused into the silicon pellet as are required for compensation of the original impurities. Aluminum alloy layers have been used for contacting to the back of the wafer. One of the features of lithium drift units is that the diode current is volume dependent, and with a well etched device has a value of about 2×10^{-8} amperes per cubic millimeter. Spectra taken using Cs-137 beta and gamma rays are presented along with a polonium spectrum.

18634

Darrel Leroy Mills
AN EVALUATION OF CADMIUM SULFIDE AS A NUCLEAR RADIATION
DETECTOR

Thesis, presented to the Faculty of the School of
Engineering of the Air Force Institute of Technology
Air University, Aug., 1962, 56 pp
Avail: ASTIA, AD 284020

Solid state radiation detectors were constructed using crystal platelets of CdS. Both intrinsic and p-n junction detectors were made and evaluated. Although alpha particles were detected by both types of detectors, the mobility-lifetime product of the charge carriers resulted in the pulse response not being proportional to the energy of the incident particle. The best experimental value for the mobility-lifetime product in CdS was 2.6×10^{-6} cm²/volt for the electrons and 2.1×10^{-6} cm²/volt for the holes. Also an experimental value of 5.2 electron volts dissipated per hole-electron pair formed was determined. A resolution of 6.8 per cent was obtained with one detector. Other phenomena such as the trapping of the charge carriers and the ionization of neutral impurity atoms also were evident in the crystal.

18635

E. L. Zimmerman, G. Baladjanian, A. Brainard,
L. Wang, and R. M. Olson
THE APPLICATION OF SEMICONDUCTOR RADIATION DETECTORS
TO THE OBSERVATION OF FAST NEUTRONS
Solid State Radiations, Inc., Los Angeles, Calif.
ASD-TDR-62-838, Dec., 1962, Tech. Doc. Rpt.,
April, 1961 - Aug., 1962, AF 33(616)-8340, 52 pp
Avail: ASTIA, OTS

Techniques for the application of neutron-sensitive materials to detector surfaces have been developed and the resulting coated detectors have been evaluated as both thermal and threshold detectors. A "good geometry" proton-recoil spectrometer utilizing a semiconductor detector has been built and used to observe fast neutrons. An analytical study of this device resulted in a method which can accurately predict its response as a function of incident neutron energy, hydrogenous radiator thickness, and system geometry. Good qualitative agreement was observed between the predicted and experimental response. The lithium ion drift detector, which is a good 4.5 Mev threshold neutron detector as well as a good device for observing minimum ionizing particles, has also been developed.

18636

CATALOG OF NEUTRON DETECTORS AND GAMMA IONIZATION
CHAMBERS
Reuter-Stokes Electronic Components, Inc., Warrensville
Heights, O., Trade Literature, 44 pp

The detectors listed in this catalogue are a cross section of those most frequently needed and used. Proportional counters, ionization chambers, and fission counter-chambers are covered.

18637

A. R. Jones

MEASUREMENTS OF γ -RADIATION DAMAGE TO pn JUNCTION
 γ -RAY DETECTORS

Atomic Energy of Canada Ltd., Chalk River, Ontario,
Canada, CRRD-1102, Sept., 1962, 7 pp

High resistivity pn junction detectors and lithium drift detectors have been exposed to gamma doses in the range 10^3 to 2×10^7 roentgens in decade steps. Between each exposure the noise counting rates and gamma sensitivities were measured. A group of controls, which were not exposed, were measured at the same time. The results so obtained are presented in graphical form. No deterioration was observed until a dose of 10^6 roentgens was reached. A transistor pre-amplifier was also irradiated at the same time and its noise performance measured as a function of dose.

18638

J. E. Doyle and W. C. Dickinson

THE CERENKOV RESPONSE OF LUCITE AND QUARTZ TO GAMMA
AND FAST NEUTRON RADIATION

University of California, Lawrence Radiation Lab.,
Livermore, Calif., UCRL-7032, July 5, 1962,
W-7405-eng-48, 26 pp

Avail: OTS

Experiments have been conducted to evaluate the effectiveness of Lucite and quartz as Cerenkov materials for fast gamma detectors. The relevant theory is presented as an aid in interpreting and extrapolating the experimental results. The current sensitivity for a Lucite Cerenkov detector (6-inch diameter by 6-inch long cylinder), per incident 1.25-Mev and 4.45-Mev gamma ray was measured to be a factor of 210 and 72 less, respectively, than for a fluor detector of similar geometry. The sensitivity of the Lucite Cerenkov detector to 4.45-Mev gamma rays relative to 14-Mev neutrons is almost a factor of 10 better than for the fluor detector. The predicted dependence of Cerenkov light emission on incident gamma energy has been confirmed by experiment.

18639

F. M. Russell, AERE, Harwell, England

PARTICLE DETECTORS

Instrument Practice, 17, (1), Jan., 1963,
pp 43-46

Surface-multiplication through the use of the photomultiplier tube, scintillation detectors, Cerenkov detectors, triggered mechanisms, cloud chambers, bubble chambers, and photographic emulsions are reviewed.

18640

Charles B. Childs, University of North Carolina,
Chapel Hill, N. C. and Goddard Space Flight Center,
Greenbelt, Md., and Lawrence M. Silfkin, University
of North Carolina

DELINEATION OF TRACKS OF HEAVY COSMIC RAYS AND NUCLEAR
PROCESSES WITHIN LARGE CRYSTALS OF SILVER CHLORIDE

The Review of Scientific Instruments, 34, (1), Jan.,
1963, pp 101-104

Tracks of energetic charged particles, such as heavy primary cosmic rays and the products of nuclear collisions, have been made visible within the interior of large, transparent crystals of silver chloride. The tracks are delineated by photoelectric formation of metallic silver along them. This technique may be useful as a convenient and distortion-free method for the study of heavy primaries and fission fragments.

18641

R. A. Coombe, Staffordshire College of Technology,
England
NEUTRON ENERGY SPECTRA--II. ITS MEASUREMENT IN THE
ENERGY RANGE 0.5 to 15 Mev
Nuclear Power, 8, (82), Feb., 1963, pp 46-48

A serialized survey of the various techniques available is given and the different types of detecting equipment used are described. Recoil telescopes, lithium iodide scintillation detectors, and helium gas counters are included.

18642

R. A. Hunt, University of Ghana, Accra, Ghana
A COMPACT ANTICOINCIDENCE COUNTER FOR TROPICAL CONDITIONS
Journal of Scientific Instruments, 39, (12), Dec., 1962,
pp 604-607

The beta counter is shielded by a hemispherical guard counter and when the whole assembly is mounted into a standard square castle (4.2 cm lead) a background count of 1.35 counts per minute is obtained. Transistors are used throughout the circuit which is operated directly from low voltage supplies.

18643

Stanley Kronenberg, U. S. Army Signal Research and
Development Lab., Fort Monmouth, N. J.
MEASURING FAST NEUTRON FLUXES IN MIXED NEUTRON-GAMMA
FIELDS
Nucleonics, 21, (3), March, 1963, pp 78-83

In pulsed nuclear-radiation research when very high-intensity gamma and neutron fluxes that vary rapidly with time are encountered, it is desirable to monitor the two fluxes separately. To accomplish this task two kinds of instruments that are used simultaneously have been developed. One records gamma flux as a function of time and is insensitive to neutrons; the other, a neutron dose-rate meter, ignores gamma radiation.

ELECTRONIC MATERIALS, COMPONENTS, AND DEVICES

18644

Fred J. Schmidt, et al
RESEARCH AND INVESTIGATION ON RADIATION RESISTANT
HIGH TEMPERATURE THERMIONIC CIRCUITRY
General Electric Co., Owensboro, Ky., ASD-TDR 62-1039,
Dec., 1962, Tech. Doc. Rpt., April 1, 1961 - Oct.,
1962, AF 33(616)-8096, 82 pp
Avail: ASTIA

This report discusses the progress made and problems encountered in designing and fabricating radiation tolerant, high temperature, thermionic integrated micro-module (TIMM) circuit elements and functional circuitry. A steady-state radiation test of TIMM components was conducted at the Battelle Memorial Institute Research Reactor. The purpose of the test was to determine gross radiation effects on TIMM components for a limited period of time. The test consisted of two capsules; one used as a control, the other as a test package to be irradiated adjacent to the core of the reactor. Each capsule contained the following components: triodes, diodes, resistors, and capacitors for a total of 52 components. Pulse and steady state radiation tests have shown that developmental TIMM components can tolerate 5×10^7 R/sec and 3×10^{18} NVT, respectively. Additional, extensive testing will be required to determine failure time, failure mechanisms or end points.

18645

C. W. Perkins
DETERMINATION OF TRANSISTOR FIGURE-OF-MERIT FOR RADIATION
EFFECTS
Hughes Aircraft Co., Nucleonics Div., Fullerton, Calif.,
Jan. 1, 1963, First Qtly. Prog. Rpt., June 1 - Aug. 31,
1962, DA 36-039-SC-90703, 27 pp
Avail: ASTIA

Preliminary transient effects experiments were made at the Sandia Pulsed Reactor Facility in Albuquerque, New Mexico with a tentative group of transistors similar to those selected later for the actual investigations. These tests revealed large change in open base saturation current I_{CEO} and a base current pulse of such polarity and magnitude as to suggest the introduction of an effective current generator in the base-emitter junction during irradiation. This would make it impossible to maintain base current constant during a measurement of Δh_{FE} . The final choice of transistors to be investigated in this program is as follows: germanium alloy, 2N331, 2N651; germanium mesa, 2N695, 2N1142; and silicon planar, 2N706, 2N709.

18646

V.A.J. vanLint, J. W. Harrity, H. Horiye, S. W. Kurnick,
D. K. Nichols, D. P. Snowden, E. G. Wikner, and
M. E. Wyatt, Jr.
RADIATION EFFECTS ON SILICON SOLAR CELLS
General Dynamics, General Atomic Div., John Jay Hopkins
Laboratory for Pure and Applied Science, San Diego,
Calif., GA-3872, Feb. 15, 1963, Final Rpt, Dec. 1,
1961 - Dec. 31, 1962, NAS7-91, 124 pp

Experiments have been performed to study the defects introduced into silicon by high energy (~ 30 Mev) electron irradiation. These defects are expected to be similar to those produced by high-energy protons. The diagnostic tools used include measurements of galvanomagnetic coefficients, excess carrier lifetime, electron-spin resonance, and infrared absorption. The results indicate that the A center in quartz-crucible-grown silicon is not the primary excess-carrier recombination center. Instead, recombination in quartz-crucible-grown and floating-zone refined silicon appears to be dominated by the same center. This center exhibits a strong dependence of the excess-carrier lifetime on excess-carrier density, with increasing lifetime at higher densities. The temperature dependence of the excess carrier lifetime appears to indicate an ionization energy of approximately 0.12 ev, and this same level is seen in the galvanomagnetic measurements. However, this activation energy may not be real, due to a strong temperature dependence of the recombination cross sections. A variety of other energy levels have been identified by the galvanomagnetic measurements and the rates of introduction of defects have been measured.

18647

J. F. Boland, R. D. DeForest, R. O. Ivins, F. S. Kirn,
H. Lawroski, and R. Liimatainen, Univ. of Chicago,
Argonne National Lab., Argonne, Ill.
SENSITIVITY OF PRESSURE TRANSDUCERS TO TRANSIENT NEUTRON
AND GAMMA RADIATION

Paper presented at the American Nuclear Society Meeting,
Boston, Mass., June, 1962, Feb., 1962, 3 pp

Experiments conducted in the Transient Reactor Test Facility have shown that unbonded strain-gauge and variable reluctance type pressure transducers are sensitive to neutron and/or gamma radiation. This sensitivity is manifested by extraneous signals which are a function of instantaneous flux, integrated flux, transducer type, and associated power supply or amplifier circuits. The strain-gauge type transducers produced signals which were functions of both instantaneous and integrated flux when connected to a conventional, ungrounded, direct-current power supply and differential amplifier. The magnitude of these signals was different for different transducers, but generally was between 5 per cent and 20 per cent of the transducer's range. The signal proportional to instantaneous power was greatly reduced when a 500-ohm resistor was connected from each lead of the power supply to ground or when a standard carrier-type instrument system was used. However, the signal proportional to integrated flux was essentially unchanged by these circuit changes. The peak neutron and gamma fluxes during these transient irradiations were in the order of 5×10^{15} nv and 5×10^{10} r/hr.

18648

H. P. Koehler and J. Pefhany
IRRADIATION TEST ON ELECTRICAL AND MECHANICAL COMPONENTS
FOR A GAUGING SYSTEM FOR REACTOR PRESSURE TUBES
A.V. Roe Canada Limited, Orenda Engines Div., Malton,
Ontario, Canada, AECL-1627, OEL-Nuclear-56, Feb. 9, 1962,
25 pp

The gauging system for reactor pressure tubes is designed to measure diameter, surface defects, wall thickness and straightness in a defuelled, drained channel during periods of reactor shut-down. The components tested were linear variable

differential transformers, electric resistance strain gauges, ultrasonic crystals, electrical lead wire, nylon, 'O' rings, and an electric light bulb. The design requirement for the equipment is to provide measurements with reasonable reliability in a gamma flux estimated at 10^7 roentgens per hour. Actual gauging operations on any one pressure tube will be of relatively short duration (hours) but to avoid the need for excessive service and maintenance, a life of 300 hours is considered desirable.

18649

C. W. Perkins

TRANSIENT RADIATION EFFECTS ON PASSIVE PARTS

Hughes Aircraft Co., Ground Systems Group, Fullerton,
Calif., FR 63-17-36, Rpt. No. 1, June 1 - Aug. 31,
1962, DA-36-039-SC-89112, 24 pp

Avail: ASTIA

Basic considerations lead to conclusions that external air leakage is the major effect in most passive parts, that internal effects can probably be related to internal capacitance, and that since internal capacitance is small in most passive parts, internal effects will be small and difficult to measure. Preliminary measurements at the Sandia Pulsed Reactor Facility, Albuquerque, New Mexico were made in tests in the following areas: (1) coaxial cable effects. Coaxial cable response is minimized by the application of a d.c. biasing voltage. For solid dielectric cables of types RG59/U and RG122/U (subminiature) the bias voltage required at the SPRF reactor for cables running up to within a few inches of the reactor is in the vicinity of +10 volts. (2) internal polarization effects. A method is described for the separating polarization effects (capacitance change) from internal leakage using sine wave voltages of various frequencies. The preliminary tests with Vitamin Q and paper capacitors indicate a slight increase in capacitance. (3) elimination of external leakage. The preliminary tests on carbon composition resistors indicate the method to be highly successful with the response being reduced to the order of that of the coaxial cables alone.

18650

C. W. Perkins

TRANSIENT RADIATION EFFECTS ON PASSIVE PARTS

Hughes Aircraft Co., Ground Systems Group, Fullerton,
Calif., FR 63-17-37, Second Qtly. Prog. Rpt.,
Sept. 1 - Nov. 30, 1962, DA 36-039-SC-89112,
25 pp

Avail: ASTIA

This report covers the results of tests during the week of November 5, 1962, at the Sandia Pulsed Reactor Facility. The a.c. tests indicate for paper and Vitamin Q capacitors a leakage resistance of the order of a megohm and a capacitance increase of the order of one per cent. Cable biasing near the crossover point is feasible if certain precautions are taken. These include adjustment of the biasing voltage from time to time to account for drift of the crossover point due to cumulative effects in the cable, and consideration of the effects on the crossover point by materials near the exposed end. Electrostatic shielding of parts is an effective means of eliminating external leakage, and in the case of resistors the shielding is improved through the use of a biased resistance paint coating. Rigid air dielectric coaxial lines are inferior to the solid dielectric cables RG

59/U and RG 122/U from the standpoint of leakage but may be a solution to the problem of cumulative effects observed in the solid dielectric types. It may be necessary, however, to go to an evacuated line to reduce the leakage.

18651

Louis J. Frisco

DIELECTRICS FOR SATELLITES AND SPACE VEHICLES

Johns Hopkins University, Dielectrics Lab., Baltimore,

Md., Rpt. No. 3, March 30, 1962, Final Rpt., March 1, 1959 -

Feb. 28, 1962, DA-36-039-SC 78321, 145 pp

Avail: ASTIA, AD 276867

Results of a study of the effects of simulated space environment on the electrical properties of solid insulating materials are reported. Equipment and techniques are described for the measurement of loss properties, flashover strength and electric strength during X-ray and ultraviolet irradiation at pressures in the 10^{-6} Torr range. Twenty-one organic and inorganic materials are included in the investigation. High-vacuum sparkover (uniform field) and flashover measurements at d-c and 60 cps show that electrode surface roughness is the controlling factor; that the dielectric properties of the material do not influence flashover voltage; and that X-ray and ultraviolet radiation have no effect on flashover voltage. The following materials were included in the program: polytetrafluoroethylene-TFE 6, TFE-7, copolymer of tetrafluoroethylene and hexafluoropropylene, melt processable resin, commercial designation FEP-100, polychlorotrifluoroethylene--commercial designation KF 6050, KF-6060, copolymer of chlorotrifluoroethylene and vinylidene fluoride, commercial designation KF-5120, polyethylene, ALATHON 4 BK 30, polystyrene-REXOLITE 1422, polyester-MYLAR 130-100C, MYLAR 130-100T, MYLAR 130-100A, multiple laminate radome material consisting of Rohm and Haas PARAPLEX P-43 polyester resin and Owens-Corning Fiberglas 181 glass cloth, copper clad epoxy laminate printed circuit board with two ounce copper, commercial designation FORMICA FF-95, FF-95 with coating of Hysol 6233 epoxy coating material, forsterite, $2\text{MgO}\cdot\text{SiO}_2$, commercial designation ALSIMAG 243, alumina, 99 per cent Al_2O_3 , steatite, $\text{MgO}\cdot\text{SiO}_2$, commercial designation ALSIMAG 665, beryllia, 99 per cent BeO, and polyurethane foam, commercial designation Eccofoam S. The specific electrical properties studied were: dielectric constant, volume resistivity, surface resistivity, electric strength, flashover strength, and microwave transmission properties.

18652

E. P. Plankis and R. A. Magnuson

RADIATION EFFECTS ON MICROWAVE DEVICES

General Electric Co., Power Tube Dept., Schenectady,

N. Y., SCL-5810A, Nov. 14, 1961, Prog. Rpt. No. 5,

July 1 - Sept. 30, 1962, DA-36-039-SC 87253, 19 pp

Avail: ASTIA

The experimental procedure for monitoring the noise spectrum of a voltage-tunable magnetron during a radiation pulse is described. A listing of the equipment for performing this test is also given. The results of a brief literature survey on materials used in the construction of traveling-wave tubes are given. A test procedure for monitoring traveling-wave tube DC and RF parameters during pulsed nuclear radiation is described.

18653

J. W. Winslow and R. R. Hart

RADIATION EFFECTS IN THERMOELECTRICS: 1. TECHNIQUES FOR
DETECTION OF TRANSIENT EFFECTS AND THEIR APPLICATION
TO COMMERCIAL GRADE BISMUTH TELLURIDE

U.S. Naval Radiological Defense Lab., San Francisco,
Calif., USNRDL TR-581, Sept. 13, 1962, Tech. Rpt.,
77 pp

Two satisfactory laboratory methods for detecting and studying transient radiation effects on Seebeck coefficient, S , and electrical resistivity, p , of materials having large thermoelectric figures of merit, z , have been developed. The transient effects of intense beams of 2 Mev electrons on z in commercially available, thermoelectric grade bismuth telluride, have been deduced from separate observations of S and p made using these methods, together with previously reported observations of thermal conductivity. These observations indicate that ionizing radiation has no transient effects on the point value of z , within experimental limits of accuracy amounting to ± 50 per cent. However, secondary effects very probably arising from inhomogeneity of the test material were observed. A simple model for, and some of the implications of, these observations are discussed. The radiation field was supplied by the NRDL Van de Graaff generator.

18654

E. F. Laine

RADIATION EFFECTS ON ELECTRONIC COMPONENTS

University of California, Lawrence Radiation Lab.,
Electronics Engineering Dept., Livermore, Calif.,
UCID-4544, Sept. 1, 1962, 70 pp

The information presented in this manual is a condensation of many reports from many investigators and this should give the electronic designer quick access to his problem and a "ball park" estimate of damage involved. This is a condensation of REIC state-of-the-art reports.

18655

G. R. Hopkins, A.L.A. Weiman, and D. E. Willis

TRANSIENT RADIATION EFFECTS ON COAXIAL CABLES

General Dynamics Corp., General Atomic Div., San Diego,
Calif., GA-3616, Dec. 18, 1962, Special Tech. Rpt.,
DA-36-039-SC-89196, 50 pp

An investigation into the radiation effects of gamma and neutron radiation on polyethylene coaxial cable has been started. By a series of tests made in the General Atomic TRIGA Mark F reactor, individual effects due to gamma, fast, and thermal neutron flux have been separated and analyzed. Gamma radiation produces a current nearly proportional to incident flux with the central wire at a negative potential. Thermal neutron flux also produces a nearly proportional signal but with the central wire going positive. Fast neutron flux produces a positive-going signal having two components. One component is proportional to flux; the other produces a very large initial signal but saturates quickly. Saturation occurs as integrated fast neutron flux increases and is not time dependent. Varying amounts and types of shielding provided large changes in relative components of flux, both with pulsing and steady-state modes of operation.

The data were analyzed for each type of radiation. Although the effects have been analyzed in some detail, more investigation is required to supply more accurate numbers. Special experiments should provide clues as to which of several possible mechanisms are involved.

18656

SOLID STATE DIVISION ANNUAL PROGRESS REPORT

Union Carbide Corp., Oak Ridge National Lab., Oak Ridge,
Tenn., ORNL-3364, Nov. 15, 1962, Annual Prog. Rpt.,
Period ending Aug. 31, 1962, W-7405-eng-26, 200 pp
Avail: OTS

This report is divided into six parts: theory, crystal physics, metals, nonmetals, radiation metallurgy, and reactor materials. The following are the sections which are pertinent to the REIC scope: (1) An experiment is proposed whereby the Mossbauer effect might be observable following thermal-neutron capture in certain materials. It is pointed out that the atom emitting the Mossbauer (recoilless) radiation may very well be in an interstitial position. In case it is so located, ways are discussed in which the interstitial position may affect the spectra of the Mossbauer radiation. (2) Radiation effects in uranium-doped zirconia are investigated in a study concerning the radiation-induced monoclinic-to-fcc phase transition in ZrO_2 with special emphasis placed on specific particle events. (3) The effect of neutron irradiation at 3.5 K on the superconducting transition of tin has been investigated. (4) The effect of neutron irradiation at several different temperatures on the magnetic properties of some commercial, magnetically soft nickel-iron alloys is reported. (5) Thermal- and fast-neutron damage effects have been studied separately in high-purity metals irradiated near 4 K. Unmoderated fission neutron damage has been studied in copper. (6) Preliminary flux measurements of a new high-purity thermal-flux facility and the construction progress of an associated 4 K irradiation facility are reported for the Bulk Shielding Reactor. (7) Extensive measurements on irradiated germanium indicate that previous analyses of the recombination process are incorrect. Observations of the annealing behavior of radiation-induced recombination centers have been made. A model which explains the recombination and annealing data is presented. (8) The annealing properties of irradiation-induced carrier change in antimony-doped germanium have been studied by using both isochronal and isothermal annealing. The irradiations were conducted at liquid-nitrogen temperature by using Cobalt-60 gamma irradiation. A model which explains the observed annealing behavior is proposed. (9) Although 40 per cent of the carriers were removed from a 2-ohm-cm n-type germanium sample by Cobalt-60 photon irradiation, the Seebeck coefficient remained relatively unchanged. A definitive experiment, using 0.2-ohm-cm n-type germanium, is in progress which will establish the validity of the premise that the Seebeck coefficient is less sensitive in antimony-doped germanium to Cobalt-60 photons than the theory predicts. (10) Preliminary optical studies of Cobalt-60 gamma-ray and reactor-neutron-irradiated single crystals of zinc sulfide indicate no observable change in the absorption spectrum. Measurements of electronic properties are expected to be a more sensitive indicator of radiation damage than are optical absorption data. (11) A study of the effects of Cobalt-60 gamma radiation upon extrinsic Bi_2Te_3 indicate that the damage to electrical properties of Bi_2Te_3 vary in a consistent manner with the atomic per cent of tellurium in the specimen. (12) A number of preliminary experiments have been considered or conducted in relation to their potential application toward ascertaining the experimental threshold energy required for the production of defect clusters (disordered regions) in materials. (13) The effect of gamma irradiation on KCl samples doped with Ca, Sr, Cd, and Mg was studied. The data

apparently indicate that crystals containing Mg and Cd have relatively fewer free positive-ion vacancies than those doped with Ca or Sr. (14) The effect of radiation on atomic rearrangements in Cu-Al, impact tests on irradiated pressure-vessel steels, and irradiation effects on metal-clad fuels are reported. (15) The acid concentration produced by irradiation of solutions of $C_2H_2Cl_4$ in C_8F_{16} and in $C_{10}H_{22}$ has been measured to determine the suitability of these systems as dosimeters. The C_8F_{16} solutions, to which 0.3 wt per cent $C_{10}H_{22}$ had been added to provide an adequate source of hydrogen, showed inconsistent acid yields unless water in excess of saturation (0.2 wt per cent) was present. The $C_{10}H_{22}$ solution showed a dependence on both the temperature and dose rate during irradiation.

18657

Ralph H. Jacobson

THE EFFECT OF TWO MEV DEUTERON AND PROTON RADIATION ON
THE CONDUCTIVITY IN N-TYPE GERMANIUM DENDRITE CRYSTALS

Thesis, presented to the Faculty of the School of
Engineering of the Air Force Institute of Technology
Air University, Wright-Patterson AFB, O., Aug., 1962,
51 pp

Avail: ASTIA, AD 287146

N-type germanium crystals, both dendrites and ordinary crystals, were irradiated with two Mev deuterons and protons in order to find if any differences in the effects on conductivity of radiation exist between the two types of crystals. The electron reduction rate and the hole production rate was found to be greater by a factor of approximately two in the dendrite crystals. The results indicate the formation of acceptor levels associated with the surface. These levels are relatively more important in the more perfect surfaces of the dendrites. A demonstration, showing the possibility of making electronic devices by a simple radiation process, was also conducted.

18658

James W. Diebold

RADIATION EFFECTS ON SOLAR CELLS

Thesis, presented to the Faculty of the School of
Engineering of the Air Force Institute of Technology
Air University, Wright-Patterson AFB, O., May, 1962,
55 pp

Avail: ASTIA, AD 283955

The results of this experiment are based on the irradiation of silicon solar cells, and to a limited extent, gallium arsenide solar cells. It appears that deuterons are more damaging than protons by a factor of 3 to 5, depending upon the energy. Also it is significant that gallium arsenide cells are more resistant to either type of radiation than silicon cells. The net result of the radiation is a reduction in minority carrier lifetime, and thus a reduction in the diffusion length. There appears to be a shift in the spectral response of the cells, although no explanation is at present offered for this phenomenon.

18659

APPLIED RESEARCH PROGRAM ON HIGH-TEMPERATURE RADIATION
RESISTANT SOLAR-CELL ARRAY

Radio Corporation of America, ASTRO-Electronics Div.,
Defense Electronic Products, Princeton, N. J.,
AED-1668, Oct. 31, 1962, Qtly. Tech. Prog. Rpt. No. 2,
Aug. - Oct., 1962, AF 33(657)-8490, 32 pp
Avail: ASTIA, AD 287570

Eight GaAs and twelve Si solar cells were irradiated with 17.6 Mev protons at the Princeton University cyclotron. The purpose of this experiment was to compare the radiation properties of GaAs and Si cells in filtered incandescent light and sunlight, as well as when extrapolated to outer space. Furthermore, one GaAs cell was irradiated at 150 C to discover if such operation substantially affects the radiation properties of GaAs. The cell measurements consisted of the spectral response and sunlight conversion efficiency, before and after bombardment. The major change in cell performance as a result of irradiation is the drop in short-circuit current due to a decrease in minority-carrier lifetimes. In Si cells, this decrease in lifetime occurs primarily in the base region and it is manifested by a loss in infra-red response. A consequence is the gradual decrease in output power as a function of bombardment. The response of GaAs cells, on the other hand, is due primarily to photons absorbed near the surface. When the highest efficiency GaAs cells are compared to Si cells of equivalent efficiency, the GaAs cells out perform the Si cells up to a flux level of 10^{13} protons/cm², after which the Si cells are superior. This reversal is a consequence of the rapid drop in output of the GaAs cells after a certain flux while that of Si drops gradually. The performance of GaAs cell, which was irradiated at 150 C, was not significantly different from that of cells irradiated at room temperature.

18660

G. R. Hopkins, A.L.A. Weiman, and D. E. Willis
TRANSIENT RADIATION EFFECTS ON ELECTRONIC PARTS
General Dynamics Corp., General Atomic Div., San Diego,
Calif., GA-3858, March 18, 1963, Qtly. Prog. Rpt.
No. 3, Oct. 1 - Dec. 31, 1962, DA-36-039-SC-89196,
39 pp
Avail: ASTIA

The TRIGA Mark F reactor has been used as a radiation source for a study of the electrical signals produced in coaxial cable by radiation. Data have been obtained with both pulsed and steady-state operation of the reactor. The results with zero voltage on the cable are: (1) gamma radiation produces a current nearly proportional to incident flux with the central wire at a negative potential; (2) thermal neutron irradiation also produces a nearly proportional signal but with the central wire at a positive potential; (3) fast neutron irradiation produces a positive potential signal with two components. Preliminary measurements of dose rate dependence have been made over a reactor power range of 2×10^0 ; i.e., 1 kw steady state to 2000 Mw pulsing. These results indicate that the linear saturated responses for neutrons are relatively dose rate independent. The gamma response, however, is somewhat dose rate dependent. The dose rate dependence of the initial saturable response has not as yet been analyzed. The physical mechanisms for explaining the different features of the signals are being investigated; however, conclusive results are not available. The primary mechanisms are secondary particle emission and conductivity effects.

18659

APPLIED RESEARCH PROGRAM ON HIGH-TEMPERATURE RADIATION
RESISTANT SOLAR-CELL ARRAY

Radio Corporation of America, ASTRO-Electronics Div.,
Defense Electronic Products, Princeton, N. J.,
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39 pp
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18661

E. P. Plankis and R. A. Magnuson
RADIATION EFFECTS ON MICROWAVE DEVICES
General Electric Co., Power Tube Dept., Schenectady,
N. Y., Qtly. Prog. Rpt. No. 6, Oct. 1 - Dec. 31, 1962,
DA-36-039-SC-87253, 31 pp
Avail: ASTIA

The procedure for remotely monitoring the noise characteristics of a voltage-tunable magnetron operating in a pulsed radiation environment is evolved. The method of monitoring the power-output spectrum of a voltage-tunable magnetron operating in nuclear environments over frequency bands of 70 to 200 megacycles wide is presented. The results of the literature survey on materials used in the construction of traveling-wave tubes are given. A test procedure for monitoring traveling-wave tube DC and RF parameters during pulsed nuclear radiation is described.

18662

GYRO PREAMPLIFIER IRRADIATION
Litton Systems, Inc., Nuclear Radiation Effects Section,
Woodland Hills, Calif., Feb., 1963, Prog. Rpt., period
ending Feb. 28, 1963, AF 33(657)-10584, 10 pp
Avail: ASTIA

The circuitry and materials required to design and construct a gyro preamplifier and test equipment have been investigated. Dosimetry requirements were studied and a preliminary analysis of the effect of neutron and gamma spectra on damage has commenced. No irradiation data given to date.

18663

C. W. Perkins
DETERMINATION OF TRANSISTOR FIGURE-OF-MERIT FOR
RADIATION EFFECTS
Hughes Aircraft Co., Nucleonics Div., Fullerton, Calif.,
FR-63-17-53, Qtly. Prog. Rpt. No. 2, Sept. 1 - Nov. 30,
1962, DA-36-039-SC 90703, 30 pp
Avail: ASTIA

This report covers the results of the preliminary tests with the Hughes Research Linear Accelerator (Linac) and the Sandia Pulsed Reactor Facility (SPRF). The Linac tests were meant to provide preparatory design information for the SPRF tests and so were brief and qualitative in nature. The results establish the occurrence of large positive collector current pulses in germanium alloy units and possibly in the germanium mesa units as well. The pulses are essentially independent of base conditions including the conditions for I_{CEO} . The base current pulses are of such polarity as to indicate the presence of an effective current generator in the base-emitter junction during the radiation pulse. The magnitudes were also larger than those which could be derived from the base current supply alone. Permanent damage measurements were made at SPRF on V_{SAT} and h_{FE} . I_{CEO} and I_{CBO} were too small to be measured with the instrumentation used. Using a digital recording voltmeter, the following changes were observed in these tests with a total integrated neutron flux of 3×10^{12} nvt (fast neutrons above 2.5 Mev). (1) in the germanium alloy units, V_{SAT} increased by an order of magnitude and h_{FE} decreased by 75 per cent. (2) in the germanium mesa units, V_{SAT} increased

considerably in the 2N695 type but only slightly in the higher frequency 2N1142 type, and h_{FE} did not change perceptibly in either. (3) in the silicon planar units, V_{SAT} increased considerably in the 2N706 but not in the 2N709. Both types showed a decrease in h_{FE} of 30 to 40 per cent overall.

18664

Joseph M. Stanley

THE EFFECTS OF PULSE NUCLEAR RADIATION ON QUARTZ CRYSTAL
UNITS

USA Electronics Research and Development Lab., Fort
Monmouth, N. J., USAELRDL-TR-2320, Nov., 1962, Tech.

Rpt., 30 pp

Avail: ASTIA, OTS

The experimental investigations described in this report have demonstrated that precision and nonprecision quartz crystal units are not permanently affected by irradiation in simulated nuclear weapons' environments. At a certain distance from an environment created by a real nuclear weapon, however, the precision type units undergo permanent changes in frequency on the order of ppm and changes in their aging characteristics which exceed the requirement of 10^{-7} /week. This requirement is based on a single sideband application for quartz crystals. These changes occurred at a fast neutron dose which approximated that received by units irradiated at the Sandia and Godiva Pulse Reactors. The gamma dose, however, was appreciably larger. From the standpoint of quartz crystal units, therefore, the damage incurred seems to be more a function of the gamma rate and dose than of the fast neutron dose or rate. The use, therefore, of the Godiva II, Sandia Pulse Reactor Facility, and similar pulse reactors for study of permanent effects in quartz crystals is open to question. Measurements made on nonprecision crystal units during gamma and fast neutron pulse radiation demonstrated that transient phase changes of varying magnitudes occur in the frequency of such crystals. The magnitude of the changes is dependent on the type of radiation, dose, type of electrode material, and possibly variations in manufacturing techniques. These tests also indicated that aluminum-plated resonators are, in general, more affected by pulse reactor radiation than either silver- or gold-plated resonators. Comparison of the changes resulting from the irradiation of moderate precision crystal units during a nuclear weapon test showed that resonators plated with a single layer of gold experienced larger permanent frequency changes than the same units plated with gold-nickel-gold. Pulse irradiation of quartz crystal units made from natural quartz and Y-bar synthetic quartz resulted in frequency changes of approximately the same magnitude.

18665

M. S. George, L. Malcolm, and G. P. Champion
EQUIPMENT DESIGN PRACTICES AND TECHNIQUES FOR THE
NUCLEAR RADIATION ENVIRONMENT

Northrop Corp., Ventura Div., Newbury Park, Calif.,

Qtly. Prog. Rpt. No. 2, Sept. 1 - Nov. 30, 1962,

DA-36-039-SC-90738, 75 pp

Avail: ASTIA

This contract covers the first two phases of a research investigation leading to the issue of a document to be entitled, "Equipment Design for the Nuclear Environment." The probable nuclear environment and techniques for analyzing and predicting

performance of U.S. Army Communications and Surveillance equipment in this environment are to be established. Using computer techniques, Pentomic Division and Corps dispositions were war-gamed. Tabular data and graphs were produced which indicate the distribution of nuclear environments can be established. These data, when fully developed, will indicate the problem areas for communications equipment. A simple arbitrary problem representative of specific circuit analysis problems was run on three computers (special purpose digital general purpose digital and analog) to provide data for selection of computer and general format for circuit analysis. Essential requirements for a transistor analog model were determined. Parameters of the model and methods of measurement in the laboratory are being defined.

18666

G. L. Keister

ANALYTICAL METHODS FOR PREDICTING THE EFFECTS OF TRANSIENT
NUCLEAR RADIATION ON ELECTRONIC CIRCUITS AND DEVICES

The Boeing Co., Aero-Space Div., Seattle, Wash.,
Qtly. Prog. Letter No. 3, Oct. 1 - Dec. 31, 1962,
AF 29(601)-5238, 10 pp

Tests at the General Atomic linear accelerator and TRIGA reactor were made to determine the effects of permanent neutron damage on the primary and secondary photocurrents in transistors. Pre-, post-, and during-irradiation capacitor characterization has been performed in order to obtain radiation equivalent circuit constants for mica, ceramic, tantalum, mylar, Vitamin Q, and fixed paper capacitors. Flash X-ray, LINAC and TRIGA tests were performed at dose rates up to 10^9 r/sec and pulse doses up to 10^6 r. Data was obtained on prompt and delayed photoconductivity, dose dependence, part-to-part and vendor-to-vendor variation, and variation with applied potential and capacitance value. Several 1/2 watt and 1 watt carbon composition resistors (potted) were subjected to gamma radiation at the Boeing Cobalt-60 source. The purpose of the test was either to determine the electron scattering constant or to lower the upper limit of this constant as reported in Boeing Document D2-9878.

18667

G. L. Keister

ANALYTICAL METHODS FOR PREDICTING THE EFFECTS OF TRANSIENT
NUCLEAR RADIATION ON ELECTRONIC CIRCUITS AND DEVICES

The Boeing Co., Aero-Space Div., Seattle, Wash., Qtly.
Prog. Letter No. 1, March - June, 1962, AF 29(601)-5238,
14 pp

The objective of this program is to perform research, analysis, and experimentation extending the method for predicting the effects of transient nuclear radiation (gamma and neutron emission from a nuclear detonation) on electronic equipment, as developed under prior contracts AF 33(616)-7804 and AF 33(616)-7531. Studies of physical phenomena affecting materials, components, and basic circuits of existing electronic systems will provide additional basic parameters required for system radiation response analysis.

18668

G. L. Keister

ANALYTICAL METHODS FOR PREDICTING THE EFFECTS OF TRANSIENT
NUCLEAR RADIATION ON ELECTRONIC CIRCUITS AND DEVICES

The Boeing Co., Aero-Space Div., Seattle, Wash., Qtly.

Prog. Letter No. 2, July 1 - Sept. 30, 1962,

AF 29(601)-5238, 11 pp

Avail: ASTIA

The work accomplished is divided into the following four categories: (1) parts and materials studies - transistors, diodes, capacitors, and resistors (2) computer studies and predictions (3) experimental circuit tests (4) dosimetry.

18669

A. J. Saur, A. I. Anderman, and J. F. Zack, Jr.

TRANSIENT RADIATION EFFECTS IN ELECTRONIC MATERIALS

North American Aviation, Inc., Atomics International

Div., Canoga Park, Calif., AI-7640, Sept. 26, 1962,

Qtly. Rpt. No. 2, May 1 - July 31, 1962, MIPR-R-62-

16-SC-00-93, 23 pp

Avail: ASTIA

During the current report period, the design, fabrication, and testing of the apparatus and instrumentation required for the experimental program in the KEWB was completed. A detailed description of each aspect of the test configuration is provided. Also included is an extended discussion of the first series of KEWB experiments, designed to evaluate extraneous signals generated in the test circuit by KEWB radiation.

18670

Alton L. Long

COMBINED ENVIRONMENTAL TESTING OF SEMICONDUCTOR DEVICES

Burroughs Corp., Burroughs Labs., Paoli, Pa., Qtly.

Prog. Rpt. No. 1, June 15 - Sept. 15, 1962, DA-36-

039-sc-90766, 47 pp

Avail: ASTIA

The experiments to be conducted under this program call for recording data of the transient responses of the I_{CBO} , h_{FE} , and V_{SAT} parameters of several transistor types to a pulse of mixed neutron and gamma radiation and under a wide range of temperature conditions. The plan delineates the choice of devices, their operating points, test circuits, test instrumentation, exposure techniques, nuclear dosimetry, and development of an overall test procedure. Four transistor types: 2N559 (pnp diffused base germanium mesa); 2N599 (pnp germanium alloy junction); 2N703 (npn silicon planar); and 2N914 (npn epitaxial silicon planar) are to be studied. The operating points and test circuits have been selected and are being presented at this time. The devices will be irradiated at the Sandia Pulsed Reactor Facility at Sandia Base, Albuquerque, New Mexico. The exposure technique includes special high temperature termination of the telemetry cables and the use of an aluminum chamber to permit exposure of the devices under identical conditions over the range of temperatures (-65 C to 200 C).

18671

J. E. Bell, R. L. Helms, R. H. Pizarek, and K. R. Walker
THEORETICAL STUDY OF BURST-INDUCED TRANSIENT RADIATION

EFFECTS IN BASIC ELECTRONIC CIRCUITS

Hughes Aircraft Co., Fullerton, Calif., Dec. 31, 1961,
Semi-Annual Tech. Summary Rpt., Aug. 1 - Dec. 31, 1961,
AF 29(601)-4743, 41 pp

In this report, schematics, equivalent circuits, operational descriptions, and circuit equations for the circuits under investigation are described. All four circuits, closed loop transistor amplifier, wein-bridge oscillator, free-running multivibrator, and 90 degrees phase-shifter, are ready for computer programming and radiation simulation. The analog programs will include simulations of one linear and three non-linear circuits. These programs will also include step function and gaussian function variations in radiation parameters. The results of these simulations will present, in recorder form, the effects of nuclear radiation upon the circuits under investigation.

18672

H. A. Zagorites, E. A. Carr, and D. Y. Lee
EFFECTS OF NUCLEAR RADIATION ON SHIPBOARD ELECTRONIC
EQUIPMENT I. SOME EFFECTS OF SIMULATED TRANSIT
RADIATION ON PARTS A. TRANSISTORS

U.S. Naval Radiological Defense Lab., San Francisco,
Calif., USNRDL TR-577, Aug. 3, 1962, 238 pp
Avail: ASTIA

Twenty-six transistor types have been irradiated in simulated transit radiation fields in the first phase of a study of nuclear radiation effects on shipboard electronic equipment. The results showed that satisfactory transistor circuit performance is probable where conservative circuit designs can be used. However, it was predicted that some circuits will be susceptible to malfunctions in operationally significant transit fields. Possible effects on equipment reliability of such that they cannot be ignored by the designer. The tests were preceded by an evaluation of the nuclear warfare environment to estimate maximum radiation fields expected on combat effective ships. Fields based on these estimates were simulated with Cobalt-60 and provided a peak dose rate of about 250,000 r/hr and a dose of 13,100 r. A wide range was observed in the amount of radiation induced effects on β and I_{CO} , even within a group of one type of transistor. In general, only temporary changes were observed, with silicon types exhibiting smaller effects. For germanium types, I_{CO} was observed to change by a factor of 10-20 for some types while β changed by a factor of 2 or less, with the change persisting in some types. Analyses failed to show any strong correlations, in general, between radiation induced effects and between these effects and pre-irradiation characteristics of the transistors. In addition, the results indicated that behavior of an individual transistor cannot be predicted satisfactorily from preirradiation measurements. Conservative circuit design and improvement of transistor performance during irradiation appear to be the best approach to the problem of equipment reliability.

18673

W. C. Hallmark and W. J. Hesse
RADIATION EFFECTS STUDY FOR TERCOM
Chance Vought Corp., Aeronautics and Missiles Div.,
ASD-TR 62-550, May, 1962, Tech. Rpt., July 1, 1961 -
Feb. 28, 1962, AF 33(616) 7250, 272 pp
Avail: ASTIA, AD 284191

The objective of this program was the identification and evaluation of the problems associated with the operation of a TERCOM system in the environment of a nuclear powered missile. Certain critical equipment components were analyzed to determine the design criteria for radiation hardening. Where time permitted, these criteria were applied to prepare equipment items for test. Other items, having inherent radiation effects tolerance, were tested in off-the-shelf condition. These tests were designed to verify predicted analytical results and demonstrate the feasibility of performing the TERCOM function using equipment subjected to a minimum of radiation hardening. Additional radiation hardening design and modification are indicated in most areas, and the extension of experimental verification to include larger test samples is justified so as to establish higher levels of confidence in test results. In general, however, data were gained from analysis and tests and will provide a great deal of essential design information for TERCOM.

18674

H. Roth, W. Bernard, P. Zeldes, and A. P. Schmid,
Raytheon Research Div., Waltham, Mass.
VOLTAGE ANNEALING OF RADIATION DAMAGE IN TUNNEL DIODES
Journal of Applied Physics, 34, (3), March, 1963,
pp 669-671

The units were irradiated with 2 Mev electrons to a total integrated flux of 3×10^{16} electrons/cm². Approximately one half of the radiation-induced excess current in germanium tunnel diodes can be permanently removed by application of forward bias voltages. This "voltage-annealing" effect arises from the enhanced migration of charged lattice defects under the influence of the high electric fields present in degenerate semiconductor junctions. A tentative model, based on known deep-lying radiation damage levels, is proposed. Under suitable conditions of forward bias, a charged interstitial can be dissociated from its adjacent paired vacancy, allowing the now isolated interstitial to be swept from the junction region with an estimated activation energy of 0.25 ev.

18675

L. G. Sharendo and L. S. Smirnov, P.N. Lebedev Physics
Institute, Academy of Sciences, USSR, Moscow
RECOMBINATION LEVEL IN N TYPE GERMANIUM IRRADIATED
WITH ELECTRONS
Soviet Physics-Solid State, 4, (8), Feb., 1963,
pp 1565-1567, Translation of Fizika Tverdogo Tela,
4, (8), Aug., 1962, pp 2137-2140

The temperature dependence of the lifetime of excess carrier in n-type germanium, irradiated with fast electrons from a Sr⁹⁰-Y⁹⁰ source, was used to find the position of the recombination level of radiation defects. The level lies 0.26 ev above the valence band. The cross section for capture by a

recombination center are $2 \times 10^{-16} \text{ cm}^2$ for electrons and $65 \times 10^{-16} \text{ cm}^2$ for holes. Irradiation was carried out at room temperature. The position of the recombination level was not altered by annealing.

18676

V. S. Vavilov, G. N. Galkin, V. M. Malovetskaya, and
A. F. Plotnikov, P.N. Lebedev Physics Institute,
Academy of Sciences, USSR, Moscow
ENERGIES OF PHOTOIONIZATION AND THERMAL IONIZATION
OF THE DEEP LEVELS OF RADIATION DEFECTS IN SILICON
Soviet Physics-Solid State, 4, (7), Jan., 1963,
pp 1442-1443

Samples of p-type silicon with the main impurity concentration from 1×10^{-16} to $8 \times 10^{14} \text{ cm}^{-3}$ were subjected to an integrated 1 Mev electron flux ranging from 1×10^{15} to $6 \times 10^{16} \text{ cm}^{-2}$; the electrons were produced by an electrostatic generator. The defects with the $E_v + 0.21 \text{ eV}$ levels were almost completely destroyed by annealing at 130 C. The results of a determination of the carrier density from the Hall effect for the sample in the initial state after irradiation with electrons at 290 K and after annealing are given.

18677

F. C. Treble, Royal Aircraft Establishment, Farnborough,
Hants
THE EFFECTS OF RADIATION DAMAGE IN SOLAR CELLS
Electronics Reliability and Microminiaturization, 1,
Oct. - Dec., 1962, pp 299-309

An account is given of proton bombardment tests on samples of silicon and gallium arsenide solar cells at energies ranging from 25 to 140 Mev. The effects of radiation damage on the performance parameters of such cells are discussed, with particular reference to the influence of factors such as absorption characteristic, junction depth, minority carrier lifetime, type of cell (p-on-n or n-on-p) and proton energy. The results indicate that at the most damaging energy levels silicon cells lose about 75 per cent of their initial output after 10^{13} protons/cm². Gallium arsenide cells are much more resistant to radiation.

18678

Eberhard Both, H. P. Bruemmer, C. P. Lascaro, J. Newberg,
and W. Schlosser
NOISE SIGNALS AND CARRIER MODULATION ARISING IN ELECTRICAL
CABLES DURING NUCLEAR PULSE IRRADIATION
U.S. Army Electronics Research and Development Lab., Fort
Monmouth, N. J., paper, 2 pp

Several types of communication cable, including electrical telephone cable WD-1/TT, radio frequency cables RG59 B/U and RG62 A/U, and very high frequency (TV) cable were observed during exposure to repeated 100 usec pulses of mixed neutron and gamma radiation at the Sandia Pulse Reactor, Albuquerque, New Mexico. Noise signals generated in the cables were measured individually for each conductor as a function of the magnitude and polarity of the applied DC voltage. The amplitude and phase of the modulation of a 1 mc carrier signal during the

radiation pulse was measured at several signal levels. Additional measurements were made to determine the response of resistors and capacitors attached to the exposed cable end.

18679

J. A. Baicker, B. W. Faughnan, and J. J. Wysocki
RADIATION DAMAGE TO SILICON
Radio Corporation of America, Princeton, N. J., NP 12180,
July 31, 1962, Semi-Annual Rpt. No. 2, Jan. 1 - July 15,
1962, NAS5-457, 42 pp

This report is divided into two principle sections. The first describes the results of an investigation of recombination and trapping, and the second deals with electron spin resonance in normal and irradiated silicon. Four specimens of n-type silicon were studied for their radiation-induced recombination behavior. Three of the four yielded results similar to those reported by a group in the USSR who studied one sample using modulated photo-excitation of excess carriers. The recombination level was located 0.17 ev below the bottom of the conduction band. The fourth n-type sample in the present work exhibited behavior similar to that reported by Wertheim, who studied transient recombination in one sample using injection by short bursts of high energy electrons from an accelerator. The principal level was located 0.27 ev above the top of the valence band. Three samples of p-type silicon were also studied. The principal recombination center was a previously unreported level 0.18 ev above the top of the valence band. There is no previous experimental work with which to compare the p-type results. A theoretical treatment of trapping in the presence of direct or indirect recombination was developed and is presented. The results are in good agreement with experiments, which are also described. Three distinct trapping levels have been seen, of which two were present before and after electron irradiation, and one located 0.26 ev above the valence band was introduced by the bombardment. ESR spectra were studied in electron and proton irradiated n- and p-type silicon. The spectrum obtained from electron irradiated phosphorus doped silicon is shown to arise from the Si-A center previously identified by Watkins and Carbett and found by them in n-type silicon. The proton irradiated n- and p-type silicon give rise to spectra which are different from the A center and from each other. The spectra are discussed and damage introduction rates estimated for proton and electron irradiation.

18680

S. C. Rogers
RADIATION DAMAGE TO SATELLITE ELECTRONIC SYSTEMS
Sandia Corp., Albuquerque, N. M., TID-17210, SCDC-2843,
Oct., 1962, AT (29-1)-789, 30 pp
Avail: OTS

The sensitivity of satellite electronic components is considered. Methods are presented for determining the minimum radiation levels at which circuit failure will occur. The ARIEL I power inverter is evaluated for orbital life. The failure of the inverter at 3×10^{12} nvt is translated into days-in-orbit. With the geometry of the vehicle, orbital path, and other factors provide an estimated life in orbit as forty years.

18681

Gerald C. Huth

CONDUCTIVITY INDUCED IN SOLID INSULATING MATERIALS
DURING GAMMA IRRADIATION

General Electric Co., Aircraft Nuclear Propulsion Dept.,
Cincinnati, O., TID-15981, 20 pp

The electrical conductivity of solid insulating materials can be increased by the absorption of ionizing radiation with the return to normal value taking, in some cases, many hours when irradiation ceases. The magnitude of the conductivity change, being a function of the unirradiated conductivity of the material, is greater in the better insulating materials. This phenomenon until recently, has not been investigated in detail. In the first half of this paper, some of the work that has been reported will be briefly surveyed. Following this survey, an experiment will be discussed which was performed to measure radiation-induced currents in a number of ceramic insulating materials at elevated temperatures and at somewhat greater radiation-rates than had previously been investigated.