AD NUMBER

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DASIAC-SR-208

GLOSSARY OF TERMS—NUCLEAR WEAPON PHENOMENA AND EFFECTS

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15 February 1985

Technical Report

CONTRACT No. DNA 001-82-C-0274

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Prepared for
Director
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SECURITY CLASSIFICATION OF THIS PAGE

AD-B098405L

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188
Exp. Date: Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Distribution authorized to U.S. Government agencies only; Administrative or Operational Use, 22 April
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A since UNCLASSIFIED	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) OASIAC SR 208	5. MONITORING ORGANIZATION REPORT NUMBER(S) OASIAC-SR-208
6a. NAME OF PERFORMING ORGANIZATION Kaman Tempo 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Director Defense Nuclear Agency
6c. ADDRESS (City, State, and ZIP Code) 816 State Street (P.O. Drawer QQ) Santa Barbara, CA 93101-3207	7b. ADDRESS (City, State, and ZIP Code) Washington, DC 20305-1000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER ONA 001-82-C-0274
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 62715H; PROJECT NO. P99QAX0; TASK NO. C; WORK UNIT ACCESSION NO. OH006373
11. TITLE (Include Security Classification) GLOSSARY OF TERMS—NUCLEAR WEAPON PHENOMENA AND EFFECTS	
12. PERSONAL AUTHOR(S) Kenneth E. Gould	
13a. TYPE OF REPORT Technical	13b. TIME COVERED FROM 831101 TO 841031
14. DATE OF REPORT (Year, Month, Day) 1985, February 15	15. PAGE COUNT 184
16. SUPPLEMENTARY NOTATION This work was sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B337082466 P99QAX0C00008 H25900.	

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP
05	02	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Nuclear
Nuclear Weapons
Nuclear Weapon Effects

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This glossary is a broad reference encompassing words and acronyms used in the variety of disciplines related to the study of nuclear weapon phenomena and effects. The terms and discussions are collected from various source documents, with weight given to the most authoritative.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☒ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Betty L. Fox	22b. TELEPHONE (Include Area Code) (202) 325-7042 22c. OFFICE SYMBOL ONA/STTI

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

3. DISTRIBUTION/AVAILABILITY OF REPORT (Continued)

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INTRODUCTION

This glossary is a broad reference encompassing words and acronyms used in the variety of disciplines related to the study of nuclear weapon phenomena and effects. It is primarily intended for generalists and specialists confronted with terms outside their specialty. It is an attempt to bring some standardization of language to the diverse nuclear weapon effects (NWE) community.

The major source for this glossary is a 1967 glossary, *Definitions of Nuclear Terms -- Including Formulas and Tables*, NWEF Report 1001, by Eva M. Thorn (Reference 35). Ms. Thorn's glossary is strongly oriented to nuclear physics with terms defined and described in considerably more detail than suitable for the broader audience intended for this glossary. Accordingly, much of the detail in Ms. Thorn's terms has been eliminated and terms from references other than those oriented to nuclear physics have been included. This initial glossary is not intended to be complete or rigorous; it is expected to evolve with use.

The first priority in preparing this glossary was to collect and consolidate definitions and discussions from the various sources, giving weight to the most authoritative, rather than attempting to write a new narrative based on all information available. The source of the definition and discussion of each term is indicated by the number of the reference given in brackets following the discussion. The references are listed in the back of this glossary. The first 34 references are those used by Ms. Thorn in her glossary; the remainder are additional references used by this author. Where a discussion includes parts from more than one reference, each is cited. In general, preference is given to the most authoritative references, even when other references seem to have a better discussion. DOD definitions from JCS Pub. 1 (Reference 36) are most authoritative and are included herein virtually verbatim. TP4–1 (Reference 37) is taken as the second most authoritative source. In cases where the discussions from the major references conflict, both discussions are given (e.g., see *underground burst* under *burst, types of nuclear*).

Terms and acronyms are given in alphabetical order. When they consist of more than one word, they are ordered by the primary word. The primary word is often the noun, e.g., "gamma, prompt" rather than "prompt gamma." Many times, however, a term is listed by the modifier when this is judged more meaningful, e.g., "Compton effect" rather than "effect, Compton." Every attempt has been made to list multiple–word terms by all variations and cross reference them to the definition and discussion. Where terms consist of more than one word, all terms where the key word is last are listed before those where it is other than last. For example, all terms ending with the key word ionization (e.g., *ionization*; *ionization, impact*; *ionization, minimum*; *ionization, primary*; etc.) are listed in alphabetical order before the other terms where ionization is the key word (e.g., *ionization chamber*; *ionization density*; etc.). Otherwise, alphabetical order is strictly applied.

Users of this glossary are encouraged to submit comments and suggestions to DASIAC in care of the author. Bibliographic information on the source should be given for suggested additional terms or revisions.

A-bomb. Abbreviation for atomic bomb [49] (*see* weapon, nuclear).

ablative material. A material designed to dissipate heat by vaporizing or melting. It absorbs heat by an increase in temperature and change in chemical or physical state. The heat is carried away from the surface by a loss of mass (liquid or vapor). The departing mass also blocks part of the convective heat transfer to the remaining material. More specifically, an ablating material is used to cover a nosecone in order to protect the basic skin of the nosecone from heat upon reentry into the earth's atmosphere [37].

ablation. The process of melting or vaporizing material off the outer surface of a structure, e.g., a reentry vehicle or an antenna [40].

ABM. Abbreviation for anti-ballistic missile.

abort. Failure to accomplish a mission for any reason other than enemy action. It may occur at any point from initiation of operation to destination [36].

ABRES. Acronym for advanced ballistic reentry systems.

ABRV. Acronym for advanced ballistic reentry vehicle.

absorbed dose (*see* dose, absorbed).

absorbed dose rate (*see* dose rate).

absorber. Any material that absorbs or diminishes the intensity of ionizing radiation [35].

absorption. The irreversible conversion of the energy of an electromagnetic wave into another form of energy as a result of its interaction with matter. As applied to gamma (or X-) rays it is the process (or processes) resulting in the transfer of energy by the radiation to an absorbing material through which it passes. In this sense, absorption involves the photoelectric effect and pair production, but only part of the Compton effect [49]. Absorption should not include scattering (*see* attenuation) or geometric spreading, but rather should only refer to the processes by which radiation is converted to another form of energy. Absorption is often modified by an adjective indicating the radiation process; e.g., Compton absorption refers to absorption of photons produced by the Compton effects. (*See also* absorption coefficient; capture; Compton effect; pair production; photoelectric effect.)

absorption coefficient. A number characterizing the extent to which specified gamma (or X-) rays transfer their energy to a material through which they pass. The linear energy absorption coefficient is a measure of the energy transfer (or absorption) per unit thickness of material and is stated in units of reciprocal length (or thickness). The mass-energy absorption coefficient is equal to the linear absorption coefficient divided by the density of the absorbing material; it is a measure of the energy absorption per unit mass [49]. The total absorption coefficient is the sum of individual energy absorption processes (Compton effect, photoelectric effect, and pair production) [39]. (*See also* attenuation coefficient; extinction coefficient; gamma ray(s), intensity of; Lambert's absorption law.)

absorption coefficient, atomic. The linear absorption coefficient of a material divided by the number of atoms per unit volume of the material. If the material consists of a

single type of nuclide, the atomic absorption coefficient is equivalent to the nuclide's total cross section for the given radiation [39].

absorption coefficient, Compton. That fractional decrease in the energy of a beam of X- or gamma radiation due to the deposition of the energy to electrons produced by Compton effect in an absorber [39] (*see* Compton effect).

absorption coefficient, mass (*see* attenuation coefficient, mass).

absorption coefficient, mass-energy. The linear energy absorption coefficient divided by the density of the absorber. The linear energy absorption coefficient is equal to the linear energy transfer coefficient less the energy of secondary charged particles that is lost to bremsstrahlung in the material [5].

absorption index. A measure of the role of decrease of the amplitude of light traversing an absorbing material. The absorption index is related to the absorption coefficient by the relationship: (absorption index) = (absorption coefficient)(wavelength)/4 [from 48].

absorption law, Lambert's (*see* Lambert's absorption law).

absorption mean free path (*see* mean free path).

absorption ratio, differential. Ratio of concentration of a nuclide in a given organ or tissue to the concentration that would be obtained if the same administered quantity of this nuclide were uniformly distributed throughout the body [39].

accelerator. A device for increasing the velocity and energy of charged elementary particles, e.g., electrons or protons, through application of electrical and/or magnetic forces [35].

accident, nuclear weapon(s). An unexpected event involving nuclear weapons or radiological nuclear weapon components that results in any of the following: (a) accidental or unauthorized launching, firing, or use by US forces or US supported allied forces, of a nuclear-capable weapon system that could create the risk of an outbreak of war; (b) nuclear detonation; (c) nonnuclear detonation or burning of a nuclear weapon or radiological nuclear weapon component; (d) radioactive contamination; (e) seizure, theft, loss or destruction of a nuclear weapon or radiological nuclear weapon component, including jettisoning; (f) public hazard, actual or implied [36].

activated water (*see* water, activated).

activation. The process of inducing radioactivity by irradiation [39].

activation analysis. A method of chemical analysis, especially for small traces of material, based on the detection of characteristic radiations following a nuclear bombardment [39].

activation detector (*see* detector, activation).

active device (electronics). A device capable of controlling voltages or currents to produce gain or switching action in a circuit. Examples include ferromagnetic cores, saturable reactions, diodes, and transistors. Also called active element [53].

active material. Material, such as plutonium and certain isotopes of uranium, that is capable of supporting a fission chain reaction [36].

activity. The rate of decay of radioactive material expressed as the number of nuclear disintegrations per second [38]. The unit is the becquerel, equal to 1 disintegration per second; it was formerly the curie, equal to 3.7×10^{10} disintegrations per second.

activity, specific. Total activity of a given nuclide per gram of a compound, element, or radioactive nuclide [39] (*see* radioactivity).

actual ground zero (*see* ground zero).

acute radiation dose (*see* dose, acute radiation)

adiabatic. Occurring without change in heat content, i.e., without gain or loss of heat by the system involved [38].

adsorption. The adhesion of one substance to the surface of another [39].

aerospace. Of, or pertaining to, earth's envelope of atmosphere and the space above it; two separate entities considered as a single realm for activity in launching, guidance, and control of vehicles that will travel in both entities [36].

aerothermodynamic border. The area above an altitude of about 100 miles, where the atmosphere becomes so rarefied that there is no longer any significant heat-generating air friction on the skin of vehicles [21].

aerothermodynamics. A branch of thermodynamics that treats of mechanical actions or relations of heat generated by friction between air particles and a moving body [21].

AF&F. Abbreviation for arming, fuzing, and firing.

afterwinds. Wind currents set up in the vicinity of a nuclear explosion directed toward the burst center, resulting from the updraft accompanying the rise of the fireball [36].

age, Fermi (*see* Fermi age).

airblast (or air blast). The shock wave transmitted through the air as the result of an explosion is referred to as a blast wave or airblast [38].

airblast-induced ground direct motion. The signal or stress wave that follows a direct or vertical path from the passing airblast wave to a point of observation on or beneath the ground surface. It is often referred to simply as the direct wave, which is not to be confused with direct ground shock whose point of origin is ground zero of the burst [37].

airblast-induced ground transmitted motion. The signal or stress wave that follows a refracted path, i.e., a path from ground zero of the airblast wave to a point of observation on the ground, as an airblast wave passes away from ground zero over the surface of the ground. It is often referred to simply as the ground wave whose point of origin is ground zero [37].

airburst, nuclear (*see* burst, types of nuclear).

air sampler. A device used to detect and determine the amount of contamination in the air due to radioactive material [37].

air zero. That point in space at which a detonation occurs. This differs from the term ground zero in that the height of burst above the surface is specified [37].

albedo. The fraction of the incident radiation reflected by a material in any manner [38].

allobar. A form of an element having a different atomic weight from the naturally occurring form; hence, a form of element differing in isotopic composition from the naturally occurring form [32] (*see also* isotope).

allocation (nuclear). The apportionment of specific numbers and types of nuclear weapons to a commander for a stated time period as a planning factor for use in the development of war plans. (Additional authority is required for the actual deployment of allocated weapons to locations desired by the commander to support his war plans. Expenditures of these weapons are not authorized until released by proper authority.) [36].

allotrope. Certain metallic elements can exist in more than one crystal-structure form in different temperature and pressure ranges. These different forms are called allotropes [38].

alpha, fixed. Alpha radioactivity that cannot be easily removed, as evidenced by no measured change in a swipe of a 100 cm^2 area [50].

alpha decay (*see* decay (radioactive)).

alpha disintegration energy (*see* disintegration energy, alpha).

alpha particle. A charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to the helium nucleus, which has an atomic weight of four and an electric charge of +2 atomic mass and charge units, respectively, i.e., two protons and two neutrons [38]. It is the least penetrating of the three common types of radiation (alpha, beta, gamma) emitted by radioactive material, being stopped by a sheet of paper. It is not dangerous to plants, animals, or man unless the alpha-emitting substance has entered the body [29].

alpha particle binding energy (*see* binding energy, alpha particle).

altitude. The vertical distance of a level, a point, or an object considered as a point, measured from mean sea level [36] (*see also* elevation).

altitude, minimum normal burst. The altitude above terrain below which air defense nuclear warheads are not normally detonated [36].

altitude, stopping. The altitude in the vicinity of which a specified radiation coming from above (e.g., from a high-altitude nuclear explosion) deposits most of its energy by absorption in the atmosphere. The stopping altitude varies with the nature of the ionizing radiation [49].

aluminum equivalent. The thickness of aluminum affording the same attenuation, under specified conditions, as the material in question [39].

amorphous. Lacking in ordered crystalline structure [38].

ampere. The unit of current that, when flowing through each of two long parallel wires separated by 1 meter in free space, results in a force between the two wires (due to their magnetic fields) of 2×10^{-7} newton for each meter of length [39].

amplitude. The maximum displacement of an oscillating particle of wave from its position of equilibrium [38].

amu. Abbreviation for atomic mass unit.

anemia. Deficiency of blood as a whole, or deficiency in the number of red corpuscles or of the hemoglobin [39].

angle of incidence (*see* incidence, angle of).

angle of scattering (*see* scattering angle).

angstrom (A). A unit of length used to express short wavelengths, in particular, electromagnetic radiations, or the dimensions of atoms and molecules. One angstrom unit equals 10^{-10} meter [35].

anion. Negatively charged ion [39].

anisotropic. A body in which the value of any given property is dependent on the direction of measurement; i.e., it exhibits different properties when tested along different axes in different directions. It is a body that is not isotropic [35].

anisotropy. All characteristics of a medium caused by the variation of its properties in different directions along different axes [35].

annihilation. An interaction between a positive and a negative electron, or between any two antiparticles, in which they both disappear, their energy, including rest energy, being converted into electromagnetic radiation (called annihilation radiation) [39].

annihilation radiation. Electromagnetic radiation produced by the union, and consequent annihilation of a positron and an electron, or between any two antiparticles. Each such annihilation usually produces two (rarely one or three) photons. These photons have properties identical with those of gamma rays, and accompany the decay of all positron-emitting radioactive substances [32].

antenna cross section, effective. The area of a sheet of perfectly absorbing material that, when oriented perpendicular to the direction of arrival, absorbs the same amount of energy as the antenna [46].

antimatter (antiparticles). Matter in which the ordinary nuclear particles (neutrons, protons, electrons, etc.) are conceived of as being replaced by their corresponding antiparticles (antineutrons, antiprotons, positrons, etc.). An antihydrogen atom, for example, would consist of a negatively charged antiproton with an orbital positron. Normal matter and antimatter would mutually annihilate each other upon contact, being converted totally into energy [39].

antineutron. A postulated fundamental particle of zero charge and mass equal to that of the neutron. It is capable of combining with a neutron. When this occurs, both particles annihilate each other, resulting in the production of mesons [35].

antiparticles (*see* antimatter).

antiproton. A fundamental atomic particle that is the negatively charged counterpart of the positive proton. It differs from a proton only in that its charge is negative. It has the same mass as the proton and a mean life of approximately 5×10^{-8} second. When an antiproton and proton combine, they annihilate each other, converting mass into energy [35].

apogee. The point at which a missile trajectory or a satellite orbit is farthest from the center of the gravitational field of the controlling body or bodies [36].

apparent crater (*see* crater, apparent).

arching. In the case of a buried structure, it is the tendency for the soil particles to lock together in the form of an arch, with the result that part of the stress is transmitted around the structure instead of through it [49].

armed. The configuration of a nuclear weapon in which a single signal will initiate the action required for obtaining a nuclear detonation [37].

artificial radioactivity (*see* radioactivity, artificial).

assignment (nuclear). A specified number of complete nuclear rounds authorized for expenditure by a commander. An assignment may be made for a specific period of time, for a phase of an operation, or to accomplish a particular mission [36 (1979 edition)].

associated corpuscular emission (*see* corpuscular emission, associated).

atmosphere. The air surrounding the earth [36] (*see also* ionosphere; stratosphere; tropopause; troposphere).

atmosphere, effective. That part of the atmosphere that effectively influences a particular process or motion. The outer limit varies according to the terms of the process or motion [47]. Also known as the sensible atmosphere.

atmospheric temperature inversion (*see* inversion).

atmospheric transmissivity (*see* transmissivity (or transmittance), atmospheric).

atom. Smallest particle of an element that is capable of entering into a chemical reaction [39]. Every atom consists of a positively charged central nucleus that carries nearly all the mass of the atom, surrounded by a number of negatively charged electrons, so that the whole system is electrically neutral [49]. (*See also* ion; shell structure of the atom; shell structure, nucleus.)

atom, radiating. An atom that is the source of electromagnetic radiations. These radiations are the product of electron transfer from one energy level to a lower energy level [4].

atom, recoil. An atom that is suddenly deflected in its path according to the principle of conservation of momentum owing to the recoil action from the omission of a particle or photon; or an atom whose path is suddenly deflected by collision [4] (*see also* knock-on atom; radiation, recoil).

atom model, Bohr (*see* Bohr atom model).

atom theory, Bohr (*see* Bohr atom theory).

atomic absorption coefficient (*see* absorption coefficient, atomic).

atomic bomb (*see* weapon, nuclear).

atomic cloud (*see* cloud, nuclear).

atomic demolition munition. A nuclear device designed to be detonated on or below the ground surface, or under water as a demolition munition against material-type targets to block, deny, and/or canalize the enemy [36].

atomic energy (*see* energy, nuclear).

atomic energy level (*see* energy level, atomic).

atomic form factor (*see* form factor, atomic).

atomic gram weight (*see* gram atomic weight)

atomic mass unit (amu). Used to express the relative masses of isotopes. It is one-twelfth the mass of a neutral atom of the most abundant isotope of carbon, carbon-12 (i.e., 1.6604×10^{-24} gm) [29].

atomic nucleus (*see* nucleus).

atomic number (Z). The number of protons in the nucleus of a neutral atom of a nuclide. The "effective atomic number" is calculated from the composition and atomic numbers of a compound or mixture. An element of this atomic number would interact with photons in the same way as the compound or mixture [39].

atomic number, effective (*see* atomic number).

atomic photoelectric effect (*see* photoelectric effect).

atomic scattering coefficient (*see* scattering coefficient, atomic).

atomic scattering factor (*see* form factor, atomic).

atomic spectrum (*see* spectrum, atomic).

atomic stopping power (*see* stopping power).

atomic volume (*see* volume, atomic).

atomic warfare (*see* warfare, nuclear).

atomic weapon (*see* weapon, nuclear).

atomic weight (*see* weight, atomic).

atomolysis. A process for the separation of gases from a gaseous mixture utilizing their different diffusion rates through a common material, which allows them to percolate through at different speeds [4].

attenuation. Decrease in intensity of a signal, beam, or wave as a result of absorption of energy and of scattering out of the path of a detector, but not including the reduction due to geometric spreading, e.g., the inverse square of distance effect [36]. As applied to gamma (and X–) rays, attenuation refers to the loss of photons (by the Compton, photoelectric, and pair–production effects) in the passage of the radiation through a material [49]. (*See also* absorption; attenuation, geometric; inverse square law.)

attenuation, geometric. When radiation, such as thermal or nuclear, from a point source is emitted uniformly in all directions, the amount received per unit area at any given distance from the source, assuming no absorption, is inversely proportional to the square of that distance (proportionality factor is $1/4\pi R^2$) [40].

attenuation coefficient. When preceded by a modifier (Compton, pair–production, or photoelectron effect), the attenuation coefficient indicates the fractional decrease in intensity of a beam of radiation passing through a medium due to the particular type of radiation interaction (*see also* extinction coefficient).

attenuation coefficient, linear. The fractional number of photons removed from a beam of radiation per unit thickness of a material through which it is passing due to all absorption and scattering processes [39].

attenuation coefficient, mass. A synonym for mass absorption coefficient. It is the linear absorption coefficient divided by the density of the absorber in grams per cubic centimeters. It is frequently expressed as α/ρ, where α is the linear absorption coefficient and ρ the density [32]. For X– or gamma radiations the mass attenuation coefficient is the sum of the photoelectric, Compton, coherent scattering, and pair–production mass attenuation coefficients [35].

attenuation factor. The ratio of the incident radiation dose or dose rate to the radiation dose or dose rate transmitted through a shielding material. This is the reciprocal of the transmission factor [36].

Auger coefficient. The ratio of Auger yield to fluorescence yield or the ratio of the number of Auger electrons to the number of X–ray photons emitted from a large number of similarly excited atoms [32].

Auger effect. The nonradiative transition of an atom from an excited electronic energy state to a lower state with the emission of an electron. The term usually refers to the X–ray region of energy states. The final state corresponds to one higher degree of ionization than does the initial state. The effect is an alternative process to the transition to a lower state having the same degree of ionization with the emission of an X–ray photon, and thus is analogous to the internal conversion of a nuclear transition [32].

Auger electron. An electron emitted from an excited atom during its transition to a lower energy state [32].

Auger yield. The Auger yield for a given excited state of an atom of a particular element is the probability of deexcitation by the Auger effect rather than by X-ray emission. It is the difference between unity and the fluorescence yield for that state, and also equals the sum of the Auger yields for the various possible Auger transitions from that state [32].

avalanche (electronics). The exponential current increase caused by internal ionization and carrier multiplication in a semiconductor at a critical voltage threshold; also a mode of bipolar transistor operation and a mechanism for exciting microwave oscillation [41].

avalanche (radiation). The multiplicative process in which a single charged particle accelerated by a strong electric field produces additional charged particles through collision with neutral gas molecules. This cumulative increase of ions is also known as "Townsend ionization" or "Townsend avalanche" [39].

average life (mean life). The average of the individual lives of all the atoms of a particular radioactive substance. It is 1.443 times the radioactive half-life [39].

Avogadro constant (*see* Avogadro's number).

Avogadro's law. Avogadro's law states that under the same conditions of temperature and pressure, equal volumes of different gases contain equal numbers of molecules [35].

Avogadro's number. Number of atoms in a gram atomic weight of any element; also the number of molecules in a gram molecular weight of any substance. It is numerically equal to 6.023×10^{23} on the unified mass scale [39].

AWACS. Acronym for Airborne Early Warning and Control System [36].

background count (*see* count, background).

background radiation (*see* radiation, background).

backscattering (backward scattering) (*see discussion under* scattering, forward).

balanced hardness (*see* hardness, balanced).

ballistic coefficient. A coefficient expressing the relative efficiency of a projectile in overcoming air resistance [4]. It is the ratio of the weight of a vehicle to the product of the drag coefficient and reference cross-sectional area. This term characterizes the size, shape, and weight of the vehicle [30].

ballistic missile. Any missile that does not rely upon aerodynamic surfaces to produce lift and consequently follows a ballistic trajectory when thrust is terminated [36].

ballistic trajectory. The trajectory traced after the propulsive force is terminated and the body is acted upon only by gravity and aerodynamic drag [36].

ballistics. The science or art that deals with the motion, behavior, appearance, or modification of missiles or other vehicles acted upon by propellants, wind, gravity, temperature, or any other modifying substance, condition, or force [36].

bar. A unit of pressure equal to 10^6 dynes/cm^2, or 14.5 psi (i.e., approximately sea-level atmospheric pressure) [35] (*see also* barye).

Barlow rule. A relationship between the space occupied by constituent atoms of a molecule and their valences, which states that there exists an approximate proportionality between the volumes of the atoms and the valences of the atoms. For atoms having more than one valence, the proportionality applies to the lowest valence exhibited [4].

barn. Unit expressing the probability of a specific nuclear reaction in terms of cross-sectional area. Numerically, it is 10^{-24} cm^2 [39] (*see also* cross section; shed).

barye. The absolute unit of pressure in the centimeter-gram-second (cgs) system of units, equal to a pressure of one dyne per square centimeter. A larger unit is the bar, equal to 10^6 baryes [35].

baryon. One of a class of heavy elementary particles that includes protons, neutrons, and cascade particles (or cascade hyperons). All free baryons heavier than a proton decay into a proton plus other end products [24]. They are very short-lived and require great energy for formation [29].

base surge. A cloud that rolls out from the bottom of the column produced by a subsurface burst of a nuclear weapon. For underwater bursts the surge is, in effect, a cloud of liquid droplets that has the property of flowing almost as if it were a homogeneous fluid. For subsurface land bursts, the surge is made up of small solid particles but still behaves like a fluid [36]. A soft earth medium favors base surge formation in an underground burst [49].

bathochrome. A group of atoms that lowers the frequency of radiation absorbed by the organic compound containing these atoms [4].

beam. A unidirectional or approximately unidirectional flow of electromagnetic radiation or of particles [39].

beam hole (glory hole). Hole through the shield, and usually through the reflector, of a reactor to permit the escape of a beam of radiation, in particular a beam of fast neutrons, for experimental purposes [39].

becquerel (Bq). Unit of radioactivity equal to the amount of radioactive material in which one disintegration per second occurs. Becquerel is replacing curie (Ci); 3.7×10^{10} Bq = 1 Ci.

Becquerel ray(s). Nuclear physics had its origin in the discovery by H. Bequerel in 1896 that the crystals of a uranium salt emitted rays that were similar to X-rays in that they were highly penetrating, induced electrical conductivity in gases, and affected a photographic plate. These rays were subsequently called Becquerel rays. They were shown to be made up of alpha, beta, and gamma rays. Becquerel's discovery led to the identification of polonium and radium by the Curies in 1898 [35].

bent spear. A DOD term used to identify and report a nuclear incident involving a nuclear weapon/warhead or nuclear component. In the Army and Air Force, this includes a "significant incident" [37]. (*See also* incident nuclear.)

berm. Any mixture of earth, soil, gravel, rock, etc. used as a protective surface covering for buried structures [40].

Bernoulli equation. An equation expressing the probability P_n that exactly n counts will be obtained in a single period when there are N atoms present, each with the probability P of disintegrating and being counted in that period [32]. A synonym is Bernoulli binomial distribution (*see* binomial distribution).

Bessel functions. Solutions of Bessel's differential equation:

$$\frac{d^2R}{dr^2} + \frac{1}{r}\frac{dR}{dr} + \left(1 - \frac{p^2}{r^2}\right)R = 0$$

where R is the function to be determined, r is the radius vector of cylindrical coordinates, and p is a constant. This equation is important in the solution of electromagnetic problems involving cylindrical harmonics [35].

beta activity. A form of radioactivity in which beta particles are emitted from a radioactive body [35].

beta aurora. Fluorescence caused by deposition of beta particle energy in the atmosphere [38].

beta decay (*see* decay (radioactive)).

beta disintegration energy (*see* disintegration energy, beta).

beta particle. A charged particle emitted from the nucleus of an atom and having a mass and charge equal in magnitude to that of a negative electron or a positive electron (positron) [10]. Most, if not all, of the direct fission products emit negative beta

particles. Physically, the beta particle is identical with an electron moving at a high velocity [49]. Beta particles are more penetrating than alpha particles but less penetrating than gamma rays or X-rays [28].

beta patch. A region of air fluorescence formed by absorption of beta particles from the fission products in the debris from a nuclear explosion above about 40 miles altitude [49].

beta rays (*see* beta particle).

betatopic. A term applied to two atoms or elements with atomic numbers differing by one atomic number. More especially it applies to pairs of nuclides, one of which can be formed from the other by a decay process [4].

betatron. A doughnut-shaped accelerator in which electrons, traveling in an orbit of constant radius, are accelerated by a changing magnetic field [29]. A magnetic induction accelerator that makes use of a varying magnetic field to accelerate electrons. Electrons are injected into a toroidal vacuum chamber between the poles of an iron-core magnet. The rate of change of the magnet flux and magnetic field at the orbit radius are related to maintain a constant radius for the accelerating electrons [39].

beV. Abbreviation for billion electron volt.

bhangmeter. A device that measures bomb yield based on light generated by the explosion [50].

bias, forward (transistors). Voltage applied across a PN junction in such a direction as to cause conduction through the junction, i.e., the most positive potential is connected to the P side of the junction [38].

billion electron volt (beV). A unit of energy used in nuclear physics. In the United States and France 1 beV equals 10^9 electron volts (eV) [35]. (In European countries other than France, a billion equals 10^{12}.)

BIM. Acronym for ballistic intercept missile.

binding effect, chemical. The dependence of the neutron cross sections of a material on the chemical bonding of the atoms composing the material [32].

binding energy. The energy needed to release an elementary particle or other component from a system [35]. (*See specific entries, which follow*; *see also* mass defect; packing fraction; pairing energy.)

binding energy, alpha particle. The energy required to remove an alpha particle from a nucleus [32]. For spontaneous alpha emitters it is the negative of the alpha disintegration energy [48]. (*See also* disintegration energy, alpha.)

binding energy, electron. The energy required to remove an electron from an atom. It is identical with ionization potential [48].

binding energy, neutron. The energy required to remove a single neutron from a nucleus [32].

binding energy, nuclear. The energy that would be required to separate an atom of atomic number Z and mass number A into Z hydrogen atoms and N = A – 2 neutrons. It is the energy equivalent of the difference between the sum of the masses of the product particles (hydrogen atoms and neutrons) and the mass of the atom [48]. The term is also defined occasionally as the energy required to separate a nucleus of atomic number Z into Z protons and N neutrons. The only difference in the two definitions lies in the electron binding energy, which is about 3 keV per nucleon. The terms mass defect and nuclear binding energy are often used synonymously [4].

binding energy, proton. The energy required to remove a single proton from a nucleus [32].

binding energy, total electron. The energy required to remove all of the electrons of an atom to an infinite distance from the nucleus and from each other, leaving only the bare nucleus. It is equal to the sum of all of the ionization potentials of the atom [32].

binomial distribution. The fundamental probability frequency distribution covering random events. If p is the probability that an event will occur, and if q is equal to (1 – p) and is the probability that it will not occur (for instance, the radioactive decay of nuclei), then in a random group of z independent trials, the probability p_x that the event will occur x times is given by that term in the binomial expansion of $(p + q)^z$, which contains p^x. Note that $(p + q)^z = 1$. This type of statistical treatment is used only in cases where z, the number of trials, and x, the number of successes, are both integers. An expression for p_x is as follows:

$$p_x = \frac{z!}{x!(z-x)!} p^x (1 - p)^{z-x} .$$

From [35]. (*See* Bernoulli equation.)

binomial theorem. A rule for the expansion of $(a \pm b)^n$. It is given by

$$(a + b)^n = a^n \pm na^{n-1}b + \frac{n(n-1)}{2!} a^{n-2}b^2 \pm \frac{n(n-1)(n-2)}{3!} a^{n-3}b^3 + \ldots$$

If n is a positive integer, the series is finite and contains n + 1 terms; otherwise, it is infinite, converging for $b/a < 1$ and diverging for $b/a > 1$ [35].

biological dose (*see* dose, biological).

biological effectiveness of radiation (*see* RBE).

biological half-life or half-time (*see* half-life, biological).

bipolar transistor. A transistor that utilizes both minority and majority carriers [38].

birefrigence. Splitting of an electromagnetic wave into two components that travel at different velocities. A synonym is double refraction [4].

bit. An acronym for binary digit, a single character in a binary number produced by a single pulse or a group of pulses either + or –, i.e., 1 or 0. A spurious pulse or signal can cause the bit to change from + to –, or vice versa [45].

blackbody. A perfect radiator (emitter) of electromagnetic energy. The radiating characteristics of a blackbody are completely specified by its temperature [38]. An ideal body that would absorb all (and reflect none) of the radiation falling upon it. The spectral energy distribution of a blackbody is described by Planck's equation; the total rate of emission of radiant energy is proportional to the fourth power of the absolute temperature [49]. The spectral energy distribution of a nuclear explosion is often given in terms of one or more blackbodies of different temperatures [30]. (*See also* Planck's radiation law; Stefan–Boltzmann law.)

blackbody radiation (*see* Planckian radiation).

blackout. The disturbance or degradation of radar and radio signals produced by nuclear detonations, including the attenuation, refraction, clutter, and scattering of electromagnetic signals due to ionization produced by a nuclear detonation [40]. The complete disruption of radio (or radar) signals over large areas caused by the ionization accompanying a high–altitude nuclear explosion, especially above about 40 miles [49].

blast. *1.* The brief and rapid movement of air vapor or fluid away from a center of outward pressure, as in an explosion or in the combustion of rocket fuel; *2.* the pressure accompanying this movement. This term is commonly used for "explosion," but the two terms may be distinguished [36]. (*See also* blast wave; shock wave.)

blast effect. Destruction of or damage to structures and personnel by the force of an explosion on or above the surface of the ground. Blast effect may be contrasted with the cratering and ground–shock effects of a projectile or charge that goes off beneath the surface [36]. Primary, secondary, and tertiary blast effects are biologically those due, respectively, to (1) pressure variations *per se*, (2) the impact of penetrating or nonpenetrating missiles energized by the blast, and (3) the physical displacement of a target by blast winds (may be damaging during the accelerative or decelerative phase of the experience) [48].

blast lethal volume. The region in the atmosphere, relative to a target, within which the combined overpressure and dynamic pressure loading of a nuclear burst will destroy the target [37].

blast line. A horizontal radial line on the surface of the earth originating at ground zero on which measurements of blast from an explosion are taken [36].

blast loading. The loading or force on an object caused by the air shock wave striking and flowing around the object. It is a combination of overpressure (diffraction) and dynamic pressure (drag) loading [37]. (*See also* diffraction loading; diffraction, blast wave; drag loading.)

blast pressure. The overpressure of a shock wave in air at a given distance from the source of detonation [37] (*see also* dynamic pressure; overpressure).

blast scaling laws (*see* scaling law).

blast wave. A sharply defined wave of increased pressure rapidly propagated through a surrounding medium from a center of detonation or similar disturbance [36]. It usually refers to a shock wave transmitted through the air as a result of an explosion and is often referred to as airblast (*see also* yield, blast).

blast wave diffraction (*see* diffraction, blast wave).

blast yield (*see* yield, blast).

blowin. The movement of air into a column of an underwater explosion if the column walls rupture when the enclosed explosion bubble contents are below atmospheric pressure [38] (*see also* bubble; column).

blowoff. Fragments of material separating from the surface of a material [38].

blowout. The escape of underwater explosion bubble contents to the atmosphere at high pressure leading to the formation of a cauliflower cloud considerably wider than the column [38] (*see also* bubble; cloud, cauliflower).

BMD. Abbreviation for ballistic missile defense.

body waves (*see* waves (ground motion), types of).

Bohr atom model. Theoretically, a miniature solar system in which the sun at the center corresponds to the nucleus of the atom, while the planets, at relatively large distances from the sun, correspond to electrons [35].

Bohr atom theory. A theory based on the following three postulates. (1) An electron in an atom can revolve in certain specified orbits without the emission of radiant energy. (2) An electron can jump from one of its specified nonradiating orbits to another of lower energy. When it does so, a single photon is emitted whose energy equals the energy difference between the initial and final states, and whose frequency ν is given by the relation:

$$h_\nu = E_1 - E_2$$

where h is Planck's constant and E_1 and E_2 are the initial and final energies. (3) The electrons are permitted to rotate about the nucleus only in those orbits for which the angular momentum (mvr) is some integral multiple of $h/2\pi$ [from 4].

Bohr magneton. A unit of magnetic moment in specifying the magnetic moment of an atomic particle or system of particles [32].

Bohr radius. The radius r_1 of the orbit of lowest energy in the Bohr model of the hydrogen atom [32].

Bohr–Wheeler mass formula (*see* mass formula, empirical).

Bohr–Wheeler theory. A theory concerning nuclear fission. It is based on the nucleus liquid–drop model of Bohr and Wheeler [35]. (*See also* nucleus model, liquid–drop.)

Boltzmann constant. A physical constant (k) equal to the ideal gas constant per mole, divided by Avogadro's constant [35].

Boltzmann equation. A detailed particle conservation equation, based on the description of individual collisions. In reactor physics, neutron–neutron collisions are negligible [32]. (*See also* diffusion equation.)

Boltzmann factor. In spectroscopy, a factor used in the calculation of spectral line intensities to account for the effect of thermal excitation [4].

bomb, nuclear. An item designed to be dropped from an aircraft and to produce a nuclear explosion. It includes all the components of a nuclear warhead, arming and fuzing system, and the complete outer case. It is fitted for or includes nuclear components [37]. (*See also* weapon, nuclear.)

bonding (electrical). A system of connections between metal parts of a system forming a continuous electrical unit [53].

bone marrow. Soft material that fills the cavity in most bones; it manufactures most of the formed elements of the blood [39].

bone seeker. Any compound or ion that migrates in the body preferentially into bone [39].

bonus effects, nuclear. Desirable damage or casualties produced by the effects from friendly nuclear weapons that cannot be accurately calculated in targeting as the uncertainties involved preclude depending on them for a militarily significant result [36].

boosted fission weapon (*see* weapon, nuclear).

booster. *1.* A high-explosive element sufficiently sensitive so as to be actuated by small explosive elements in a fuze or primer and powerful enough to cause detonation of the main explosive filling. *2.* An auxiliary or initial propulsion system that travels with a missile or aircraft and that may or may not separate from the parent craft when its impulse has been delivered. A booster system may contain or consist of one or more units [36].

Bose-Einstein statistics (*see* quantum statistics).

boson (*see* fermion).

Bouguer formula. An expression of the relationship between gravity and altitude [4].

Bouguer law (*see* Lambert's absorption law).

Bragg Gray principle. The relationship between energy absorbed in a small gas-filled cavity in a medium and energy absorbed (in the medium) from ionizing radiation. The relationship is expressed as $E = W \times J \times S$; where E = energy/cm^3 absorbed in the medium; W = average energy needed to produce an ion pair in the gas; J = number of ion pairs/cm^3 formed in the gas; and S = ratio of the stopping power for secondary particles in the medium to that in the gas [39].

branching. The occurrence of two or more modes by which a radionuclide can undergo radioactive decay. For example, copper-64 can undergo β^-, β^+, or electron capture decay. An individual atom of a nuclide exhibiting branching disintegrates by one mode only. The fraction disintegrating by a particular mode is the "branching fraction" for that mode. The "branching ratio" is the ratio of two specified branching fractions (also called multiple disintegration) [39].

breakaway. The onset of a condition in which the shock front [in air] moves away from the exterior of the expanding fireball produced by the explosion of a nuclear weapon [36].

breakdown voltage. In general, the voltage at which an insulating material ceases to insulate and becomes electrically conductive [53]. In semiconductors that voltage that causes appreciable conduction in the reverse direction [38].

breaking wave. A wave of such steep slope that it is unable to maintain its shape and loses height by tumbling or falling over [38].

breakover voltage (semiconductors). The voltage in silicon PNPN devices at which the device switches. That is, the device switches from a high-voltage, low-current state to a low-voltage, high-current state [38].

Breit-Wigner theory. A theory proposed by Breit and Wigner concerned with certain features of neutron absorption. According to this theory, an equation is established relating the cross section σ of a particular nuclear reaction to the energy E of the incident particle, and energy E_o of a resonance level of the compound nucleus when E is close to E_o [32].

bremsstrahlen. The radiation produced by the bremsstrahlung process [35].

bremsstrahlung. Secondary photon radiation produced by deceleration of charged particles passing through matter [39]. Literally, "breaking radiation." The spectral distribution is continuous, continuous X-radiation being a prominent example. For very energetic electrons (above about 50 MeV), the energy loss by radiation far exceeds that by ionization as a stopping mechanism in matter; this process is sometimes called outer bremsstrahlung in order to distinguish it from inner bremsstrahlung. A very weak electromagnetic radiation with a continuous spectral distribution is sometimes observed from beta-active substances; this is due to one or both types of bremsstrahlung [32].

bremsstrahlung, inner. A process occurring infrequently in beta disintegration and resulting in the emission of a photon of energy between zero and the maximum energy available in the transition. The sudden change in the electric field in the region of the nucleus of the atom undergoing disintegration sometimes results in the production of a photon, in a manner analogous to the emission of a photon in the ordinary (outer) bremsstrahlung process. In negatron and positron emission, the energy of the neutrino pair, and the spectral distribution, decreases continuously with increasing energy to zero at the limiting energy of the beta particles. In electron capture, the photon energy comes at the expense of the neutrino, and the spectral distribution is maximum at about one-third of the normal neutrino energy and at the normal neutrino energy. The number of photons per disintegration ranges from 10^{-6} to 10^{-3}, depending on the energy, atomic number, and type of disintegration [32].

bremsstrahlung, outer (*see* bremsstrahlung).

brisance. The intensity of an explosion (or release of energy) is evidenced as a shattering power and is termed "brisance." The brisance characteristic of conventional chemical explosives has been found to be directly proportional to the speed with which its explosive decomposition occurs [17].

broadband (emission). Emission that has a spectral energy distribution sufficiently broad, uniform, and continuous so that the response of a broadband measuring receiver does not vary significantly when tuned over a large bandwidth [53].

broken arrow. A DOD term to identify and report on an accident involving a nuclear weapon/warhead or nuclear component. In the Navy this includes a "significant incident" [37]. (*See also* accident, nuclear weapon(s).)

bubble. The globe of gas, vapor, and explosion products that forms when an explosion occurs underwater [38].

bubble chamber. A device used for detection and study of elementary particles and nuclear reactions. Charged particles from an accelerator are introduced into a superheated liquid, each forming a trail of bubbles along its path [35].

buffer distance (nuclear). *1.* The horizontal distance that when added to the radius of safety, will give the desired assurance that the specified degree of risk will not be exceeded. The buffer distance is normally expressed quantitatively in multiples of the delivery error. *2.* The vertical distance that is added to the fallout safe height of burst in order to determine a desired height of burst, sufficient to provide the assurance that militarily significant fallout will not occur. It is normally expressed quantitatively in multiples of the vertical error [36].

buildup factor. The ratio of the intensity of X- or gamma radiation (both primary and scattered) at a point in an absorbing medium to the intensity of only the primary radiation. This factor has particular application for "broad beam" attenuation. "Intensity" may refer to energy flux, dose, or energy absorption [39].

bulk conductivity. A measure of the ability of a material to conduct electric current [38].

burn (skin). *First-degree burn:* Flash or flame burn producing only redness of the skin and roughly similar to a moderate sunburn. *Second-degree burn:* Burn that produces superficial or deep blisters of the skin. In case a significant area of the body is involved, these burns usually require expert medical care. *Third-degree burn:* Burn of such severity as to completely destroy the full thickness of the skin, healing taking place by the process of scar formation. Even relatively small areas, particularly involving the face, hands, or flexion surfaces of the body, require prolonged medical attention including skin grafting [40].

burnout (electronics). A type of failure that implies the destruction of a component due to a permanent change in one or more characteristics beyond an acceptable amount [53].

burst, nuclear. Common expression for the explosion from the detonation of a nuclear device. (*See specific items under* burst, types of nuclear.)

burst, types of nuclear.

- airburst, high. The fallout safe height of burst for a nuclear weapon that increases damage to or casualties on soft targets, or reduces induced radiation contamination at actual ground zero [36].
- airburst, low. The fallout safe height of burst for a nuclear weapon that maximizes damages to or casualties on surface targets [36].
- airburst, nuclear. The explosion of a nuclear weapon in the air at a height greater than the maximum radius of the fireball [36]. The explosion of a nuclear

weapon at such a height that the weapon phenomenon of interest is not significantly modified by the earth's surface. For example, these heights are such that for [38]:

Blast -- The reflected wave passing through the fireball does not overtake the incident wave above the fireball ($\approx 160\ W^{1/3} \pm 15$ percent).

Thermal Radiation -- The apparent thermal yield viewed from the ground is not affected by heat transfer to the earth's surface nor by distortion of the fireball by the reflected shock wave ($\approx 180\ W^{0.4} \pm 20$ percent for 10 to 100 KT and ± 30 percent for other yields).

Fallout -- Militarily significant local fallout of radioactive material will not occur. This height generally can be taken to be $100\ W^{0.35}$; however, a more conservative estimate of $180\ W^{0.4}$ feet may be desirable for use under some circumstances.

- exoatmospheric burst, nuclear. The explosion of a nuclear weapon above the sensible atmosphere (above 120 km) where atmospheric interaction is minimal (*in contrast to* airburst, nuclear, *below*) [36].
- high altitude burst. The explosion of a nuclear weapon that takes place at a height in excess of 100,000 feet (30 km) [36]. Above this level the distribution of the energy of the explosion between blast and thermal radiation changes appreciably with increasing altitude due to changes in the fireball phenomena [49]. Not to be confused with various effects regions for various nuclear weapon phenomena [40].
- subsurface burst. The explosion of a nuclear weapon in which the center of the detonation lies at any point beneath the earth's ground surface (underground burst) or water surface (underwater burst) [38].
- surface burst, contact (*see discussion of* surface burst, nuclear, *below*).
- surface burst, nuclear. An explosion of a nuclear weapon at the surface of land or water or above the surface at a height less than the maximum radius of the fireball [36]. An explosion in which the weapon is detonated actually on the surface (or within $5\ W^{0.3}$ feet above or below the surface, where W is the explosion yield in kilotons) is called a contact surface burst or true surface burst [49].
- surface-intersecting burst. Same as surface burst.
- underground burst, contained. An underground detonation at such a depth that none of the radioactive residues escape through the surface of the ground [49].
- underground burst, nuclear. The explosion of a nuclear weapon in which the center of the detonation lies at a point beneath the surface of the ground [36]. The explosion of a nuclear weapon with its center more than $5\ W^{0.3}$ feet (where W is the explosion yield in kilotons) beneath the surface of the ground [49].
- underwater burst, nuclear. The explosion of a nuclear weapon in which the center of the detonation lies at a point beneath the surface of the water [36].

burst geometry. The location of a nuclear detonation with respect to the ground surface or water surface or bottom [38].

c. Obsolete abbreviation for curie, used in the 1950s; now Ci.

C–neutrons. Neutrons of such energy that they are strongly absorbable in cadmium. C–neutrons have energies from 0.25 to about 0.3 eV [32]. (*See also* neutrons, slow.)

C^2. Abbreviation for command and control.

C^3. Abbreviation for command, control, and communications.

C^3I. Abbreviation for command, control, communications, and intelligence.

calibration. Determination of variation from standard, or accuracy, of a measuring instrument to ascertain necessary correction factors [39].

calorie. The amount of heat required to raise the temperature of 1 gram of water from 15°C to 16°C at 760 mm Hg pressure [38].

camouflet. The resulting cavity in a deep underground burst when there is no rupture of the surface [36] (*see also* crater).

cancer. Any malignant neoplasm (popular usage) [39].

capillary. A small, thin–walled blood vessel connecting an artery with a vein [39].

capture. Any process in which an atomic or nuclear system acquires an additional particle; for example, the capture of electrons by positive ions, or the capture of electrons or neutrons by nuclei [48]. In nuclear physics this term refers to any process in which a neutron, upon colliding with an atomic nucleus, is absorbed into it, or from which fission results [32]. (*See also* absorption; gamma ray(s), capture.)

capture, electron. A mode of radioactive decay involving the capture of an orbital electron by its nucleus. It is a radioactive transformation of a nuclide of atomic number Z and mass number A to the nuclide of atomic number (Z – 1) and mass number A, and in which a bound electron merges with the nucleus. A proton is converted to a neutron by the captured electron and a neutrino is emitted. The electron comes most commonly from the innermost K– or L–shell. (K–electron capture, L–electron capture, . . . refer to a capture of electrons initially in the designated atomic shell.) As a result of removal of an inner–shell electron, X–rays, gamma rays, and Auger electrons are emitted. For light elements, electron capture is much less probable than positron emission, whereas for heavy elements the situation is reversed [32].

capture, inverse electron. A term applied to a hypothetical nuclear reaction in which a neutrino is captured by a neutron in a nucleus, with emission of a negative electron, or in which an antineutrino is captured by a nuclear proton with emission of a positron [4].

capture, K–electron (*see* capture, electron).

capture, L–electron (*see* capture, electron).

capture, neutron. The process in which an atomic nucleus absorbs or captures a neutron. The probability that a given material will capture neutrons is measured by its neutron capture cross section, which depends on the energy of the neutrons and on the nature

of the material [29]. Neutron capture can result in the generation of gamma rays and/or charged particles [38]. (*See also* cross section, capture; capture, radiative.)

capture, neutron radiative. The capture of a neutron (usually a slow neutron) by an atomic nucleus, forming a compound nucleus. Capture is usually followed immediately by the emission of gamma radiation from the nucleus. The energy of this radiation is equal to the binding energy of the neutron in the nucleus [4].

capture, parasitic. In a reactor, any absorption of a neutron that does not result in either a fission or the production of a desired element, i.e., radiative capture [32].

capture, radiative. The process by which a nucleus captures an incident particle and loses its excitation energy immediately by the emission of electromagnetic radiation only [48].

capture, resonance. An inelastic nuclear collision occurring when the nucleus exhibits a strong tendency to capture incident particles or photons of particular energies [39].

capture cross section (*see* cross section, capture).

capture gamma ray(s) (*see* gamma ray(s), capture).

carcinogenic. Capable of producing cancer [39].

carcinoma. Malignant neoplasm composed of epithelial cells, regardless of their derivation [39].

carrier. A quantity of nonradioactive or nonlabeled material of the same chemical composition as its corresponding radioactive or labeled counterpart. When mixed with the corresponding radioactive labeled material, so as to form a chemically inseparable mixture, the carrier permits chemical (and some physical) manipulation of the mixture with less label or radioactivity loss than would be true for the undiluted label or radioactivity [39].

carrier, hold-back (*see* hold-back carrier).

cascade. A connected arrangement of units of equipment for separation of isotopes. A single device or process usually can produce only a small amount of isotopic separation, but if a number of these are connected together, the effect can be multiplied and a significant amount of separation achieved. An example is a cascade of barriers for the gaseous diffusion process [29].

cascade particle (*see* hyperon).

catalyst. A substance that alters the speed of a chemical reaction (positive catalysts increase speed) yet may be recovered practically unchanged after the reaction has occurred [39].

cataract. A clouding of the crystalline lens of the eye, obstructing the passage of light [39].

cation. Positively charged ion [39].

cavitation. The separation of the water particles and the forming of cavities. In water shock it occurs as a result of the inability of water to withstand the tensional wave reflected from the water surface [38].

cell (biological). The fundamental unit of structure and function in organisms [39].

cell, germ. A cell of an organism whose function is reproduction [39].

cell, somatic. Body cell, usually with two sets of chromosomes, as opposed to germ cells, which have only one set [39].

CEP. Abbreviation for circular error probable (*see* error probable, circular).

Cerenkov (or Cherenkov) radiation. Blue light emitted when a charged particle moves in a transparent medium with a speed greater than that of light in the same medium [39].

cermet. Acronym for ceramic metal.

chain fission yield (*see* fission yield).

chain reaction. A process in which some of the neutrons released in one fission event cause other fissions to occur [37]:

- multiplying chain reaction. An average of more than one fission is produced by the neutrons released by each previous fission.
- nonsustaining chain reaction. An average of less than one fission is produced by the neutrons released by each previous fission.
- sustaining chain reaction. An average of exactly one fission is produced by the neutrons released by each previous fission.

chamber, bubble (*see* bubble chamber).

chamber, cloud (*see* cloud chamber).

chamber, ionization (*see* ionization chamber).

chamber, spark (*see* spark chamber).

characteristic radiation (see radiation, characteristic).

characteristic X-rays (*see* X-rays, characteristic).

charge, space (*see* space charge).

charge carrier. Any particle possessing a net positive or negative electric charge [38] (*see also* ion).

charge transfer. The movement of electric charge from one material to another. Charge transfer often results in undesirable transient currents, electromagnetic fields, and steady-state voltages [38].

chemical binding effect (*see* binding effect, chemical)

chemical dosimeter (*see* dosimeter, chemical).

chemical energy (*see* energy, chemical).

Cherenkov radiation (*see* Cerenkov radiation).

chronic radiation dose (*see* dose, chronic radiation).

circuit (electrical). *1.* An electronic path between two or more points, capable of providing a number of channels. *2.* A number of conductors connected together for the purpose of carrying an electrical current [36].

circuit, equivalent. An electronic circuit having characteristics identical to those of a real circuit but composed of standard circuit elements more amenable to analysis. The generation of an equivalent circuit is the first, and most important, step in a circuit analysis [44].

circular error probable (CEP) (*see* error probable, circular).

circumvention (electronics). A general term applied to techniques that allow the circuits in a system to be temporarily perturbed by an ionizing radiation pulse, but that enable the system to recognize the cause of the perturbations and to ignore any spurious signals or misinformation generated by them [33]. A system protection technique in which detection of the onset of nuclear radiation or EMP puts a critical portion of the system in a protected condition [53].

civil defense. All those activities and measures designed or undertaken to: *1.* minimize the effects upon the civilian population caused or that would be caused by an enemy attack upon the United States; *2.* deal with the immediate emergency conditions which would be created by any such attack; *3.* effectuate emergency repairs to, or the emergency restoration of, vital utilities and facilities destroyed or damaged by any such attack [36].

civil nuclear power (*see* nuclear power).

cladding (clad). An external layer of material applied directly to nuclear fuel or other material to provide protection from a chemically reactive environment, to provide containment of radioactive products produced during the irradiation of the composite, or to provide structural support [39]. A spherical shell surrounding an initiator [37].

clamping (electronics). A technique by which the excursion of a voltage or current within a circuit is limited through the use of additional components (clampers); sometimes employed as a circuit-hardening technique [52].

classical electron radius (*see* electron radius).

classical shock wave (*see* shock wave).

clean weapon (*see* weapon, nuclear).

clipping (electronics). A desired or undesired amplitude-limiting action performed on a signal by a limiter [46].

cloud, cauliflower. The roughly spherical turbulent cloud that is formed above the column on a very shallow nuclear burst [38] (*see also* cloud, mushroom).

cloud, condensation. A mist or fog of minute water droplets that temporarily surrounds the fireball following a nuclear (or atomic) detonation in a comparatively humid atmosphere. The expansion of the air in the negative phase of the blast wave from the explosion results in a lowering of the temperature, so that condensation of water vapor present in the air occurs and a cloud forms. The cloud is soon dispelled when the pressure returns to normal and the air warms up again. The phenomenon is similar to that used by physicists in the Wilson cloud chamber and is sometimes called the cloud chamber effect [36].

cloud, mushroom. The cauliflower cloud and cloud stem or column.

cloud, nuclear. An all-inclusive term for the volume of hot gases, smoke, dust, and other particulate matter from the nuclear bomb itself and from its environment, which is carried aloft in conjunction with the rise of the fireball produced by the detonation of the nuclear weapon [36]. Clouds resulting from large-yield weapons may penetrate the tropopause and deposit debris in the stratosphere. The cloud contains radioactive fission products [38]. (*See also* fireball.)

cloud, radioactive (*see* cloud, nuclear).

cloud chamber. A device for observing the paths of ionizing particles. It is based on the principle that supersaturated vapor condenses more readily on ions than on neutral molecules [39].

cloud chamber, spark (*see* spark chamber).

cloud chamber effect (*see* cloud, condensation).

cloud column (*see* column, nuclear).

cloud top height. The maximum altitude to which a nuclear mushroom cloud rises [36].

code. Jargon for computer program.

coefficient, absorption (*see* absorption coefficient).

coefficient, atomic scattering (*see* scattering coefficient, atomic).

coefficient, ballistic (*see* ballistic coefficient).

coefficient, diffusion (*see* diffusion equation).

coefficient(s), Einstein (*see* Einstein coefficients).

coefficient, extinction (*see* extinction coefficient).

coefficient, linear absorption (*see* absorption coefficient).

coefficient, mass attenuation (*see* attenuation coefficient, mass).

coefficient, mass–energy absorption (*see* absorption coefficient, mass–energy).

coefficient, mass–energy transfer (*see* mass–energy transfer coefficient).

coefficient, nuclear danger (*see* danger coefficient, nuclear).

coefficient, pair–production mass attenuation (*see* attenuation coefficient, mass).

coefficient, reflection (*see* reflection coefficient).

coefficient, scattering (*see* scattering coefficient).

coherent scattering (*see* scattering, coherent).

coherent scattering mass attenuation coefficient (*see* attenuation coefficient, mass.)

coincidence counting (*see* counting, coincidence).

cold fusion (*see* fusion, cold).

cold X–rays (*see discussion under* X–rays).

collateral damage, nuclear. Undesired damage or casualties produced by the effects from friendly nuclear weapons [36].

collector junction. One of two junctions in a bipolar transistor. Typically the collector junction is the largest junction and generates the most photocurrent [38].

collimator. A device for confining the elements of a beam within an assigned solid angle [39].

collision. An encounter between two subatomic particles (including photons) that changes the existing momentum and energy conditions. The products of the collision need not be the same as the initial systems. In an elastic collision there is no change either in the internal energy of each participating system or in the sum of their kinetic energies of translation. In an inelastic collision there are changes both in the internal energy of one or more of the colliding systems and in the sums of the kinetic energies of translation before and after the collision [39].

collision frequency. The average number of collisions (involving momentum transfer) per second of a particle of a given species with particles of another or the same species [38].

column, nuclear. *1.* A hollow cylinder of water and spray thrown up from an underwater burst of a nuclear weapon through which the hot, high–pressure gases formed in the explosion are vented to the atmosphere. A somewhat similar column of dirt is formed in an underground explosion [36]. *2.* The visible column of particulate matter, which may extend to the tropopause (the boundary between the troposphere and the stratosphere) subsequent to the explosion of a nuclear weapon. Also, the hollow cylinder of material thrown up from a subsurface nuclear detonation [38].

column jets. Plumes that form on an expanding water column [38].

combat ineffective. An individual whose injuries are of such nature that he is no longer capable of carrying out his assigned task [38] (*see also* incapacitation).

communications (military). A method or means of conveying information of any kind from one person or place to another [36].

component (electronics). A device that performs a function and is not manufactured from other devices (e.g., transistor, integrated circuit, capacitor, resistor) [38]. A piece of equipment, a line, a section of line, or a group of items that is viewed as an entity for purposes of reporting, analyzing, and predicting outages [53]. (*See also* piece parts.)

component, nuclear. A part of a nuclear weapon that contains fissionable or fusionable material [37].

component damage. Permanent change in the characteristics of a device due to electromagnetic coupling [38] (*see* coupling).

compound (chemical). A distinct substance formed by a union of two or more ingredients in definite proportions by weight [39].

compression Mach wave (*see under* waves (ground motion), types of).

compression wave (*see* shock wave; *see under* waves (ground motion), types of).

Compton absorption coefficient (*see* absorption coefficient, Compton).

Compton attenuation coefficient (*see* attenuation coefficient).

Compton current. Electron current generated as a result of Compton processes [49] (*see* Compton effect).

Compton effect. The elastic scattering of photons (of gamma or X-rays) by the orbital electrons of atoms. In a collision between a (primary) photon and an electron, some of the energy of the photon is transferred to the electron, which is generally ejected from the atom (i.e., it becomes a secondary electron). Another (secondary) photon, with less energy, then moves off in a new direction at an angle to the direction of motion of the primary photon [49]. Consequently, Compton effect results in a change of direction (or scattering) of the gamma-ray photon and a degradation in its energy. The electron, after colliding with the primary photon, recoils in such a manner as to conserve energy and momentum, and is called a Compton or recoil electron [2]. Since the total energy and total momentum are conserved in the collisions, the wavelength of the scattered photon is changed (Compton shift) by an amount that depends on the Compton wavelength of the electron [32]. (*See also* gamma ray(s).)

Compton electron. Secondary electron created by the Compton effect (*which see*; *see also* electron, secondary).

Compton mass attenuation coefficient (*see* attenuation coefficient, mass).

Compton recoil particle. Any particle that has acquired its momentum in a scattering process similar in type to the Compton effect [32].

Compton scatterer. A fictitious medium consisting of a free–electron gas. In such a gas, the only important effect of radiation is incoherent or Compton scattering [35].

Compton scattering. Scattering photons through their interaction by means of the Compton effect [38].

Compton scattering coefficient (*see* scattering coefficient, Compton).

Compton shift (*see* Compton effect).

Compton wavelength. A wavelength characteristic of a particle of rest mass m_o and equal to h/m_oc. The Compton shift for Compton–type scattering through a given angle is proportional to the Compton wavelength of the particle but is independent of the wavelength of the photon. The Compton wavelengths should not be confused with the de Broglio wavelength [32].

concentration guide, radioactivity. The amount of any specified radioisotope that is acceptable in air and water used for continuous consumption [36].

condensation cloud (*see* cloud, condensation).

conduction current (radiation–controlled). An abnormally high leakage current that occurs in insulators or semiconductors because of a radiation–induced increase in their conductivity [41].

conductivity, prompt. Conductivity resulting from exposure to prompt gamma radiation [38].

confidence level. A number, given in percent, that reflects the degree of confidence placed in the accuracy of given data [44].

conflagration. A moving mass fire (*contrast with* firestorm).

conjugate points. Points at the north and south ends of a geomagnetic field line that are either at corresponding altitudes or at corresponding field strengths [38].

contact surface burst (*see* burst, types of nuclear).

contained underground burst (*see* burst, types of nuclear).

contamination (radioactive). The deposit and/or absorption of radioactive material on and by structures, areas, personnel, or objects [36]. The deposit of radioactive material on the surfaces of structures, areas, objects, or personnel following a nuclear explosion. This material generally consists of fallout in which fission products and other weapon debris have become incorporated with particles of dirt, etc. Contamination can also arise from the radioactivity induced in certain substances by the action of neutrons from a nuclear explosion [49]. (*See also* decontamination; fallout; radioactivity, induced; radiation, residual.)

contamination, residual. Contamination that remains after steps have been taken to remove it. These steps may consist of nothing more than allowing the contamination to decay normally [36].

Continental United States (CONUS). United States territory, including the adjacent territorial waters, located within the North American continent between Canada and Mexico. Also known as CONUS [36].

contingent effects. The effects, both desirable and undesirable, that are in addition to the primary effects associated with a nuclear detonation [36].

continuous X-rays (*see* X-rays, continuous).

contour method. The representation of the degree of radioactive contamination resulting from a nuclear burst by the use of contour lines to connect points of equal radiation dose or dose rate [38] (*see* isodose lines).

controlled area. A defined area in which the occupational exposure of personnel (to radiation) is under supervision [39].

controlled effects nuclear weapons (*see under* weapon, nuclear).

CONUS. Acronym for Continental United States (*which see*).

conversion (reactor technology). Nuclear transformation of a fertile substance into a fissile substance [39].

conversion, internal. One of the possible mechanisms of decay from the metastable state (isomeric transition) in which the transition energy is transferred to an orbital electron, causing its ejection from the atom [39]. Note that the process of internal conversion is not considered to be merely a gamma emission plus photoelectric effect within one atom, but a direct transfer of energy from the nucleus to a penetrating electron [32]. The ratio of the number of internal conversion electrons to the number of gamma quanta emitted in the deexcitation of the nucleus is called the "conversion ratio" [39]. Internal conversion is followed by emission of characteristic X-rays or Auger electrons as a consequence of the necessary rearrangement of the atomic electrons [32]. (*See also* K/L ratio; pair formation, internal.)

conversion coefficient (*see* conversion fraction).

conversion electron (*see* conversion, internal).

conversion fraction (nuclear engineering). The ratio of the number of internal conversion electrons emitted to the sum of the total number of quanta emitted and the number of conversion electrons emitted in a given mode of deexcitation of a nucleus. Partial conversion fractions refer to conversion fractions for various electron shells, e.g., K-conversion fraction, L-conversion fraction, etc. It is sometimes called conversion coefficient [32].

conversion ratio. The ratio of the number of fissile nuclei produced by conversion to the number of fissile nuclei destroyed. The term can refer to an instant of time or to a period of time [39].

convertible weapon (*see under* weapon, nuclear).

convolution. The convolution of two functions is the inverse Fourier or Laplace transform of the product of the Fourier or Laplace transforms of the two functions. The

convolution technique can be used in lieu of a series of transforms and inverse transforms in calculating certain time waveforms if the impulse or step-function response of a system is known [45].

coordinates. Linear or angular quantities that designate the position that a point occupies in a given reference frame or system. Also used as a general term to designate the particular kind of reference frame or system, such as plane rectangular coordinates or spherical coordinates [36].

corpuscle (biology). A blood cell.

corpuscular emission, associated. The full complement of secondary charged particles (usually limited to electrons) associated with an X-ray or gamma-ray beam in its passage through air. The full complement of electrons is obtained after the radiation has traversed sufficient air to bring about equilibrium between the primary photons and secondary electrons. Electronic equilibrium with the secondary photons is intentionally excluded [39].

cosmic rays. High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere [39].

Cottrell effect. The property of uranium under irradiation (e.g., in a nuclear reactor core) to lose its elasticity, and to flow like an extremely viscous liquid when stress is applied. A more common term for this behavior is creep [4].

coulomb. Unit of electrical charge in the MKSA system of units equal to 1 ampere second [39].

Coulomb's law (electrostatic attraction). Coulomb's law states that the force of attraction or repulsion between two charges of electricity concentrated at two points in an isotropic medium is proportional to the product of their magnitudes and is inversely proportional to the square of the distance between them. The force between unlike charges is an attraction, between like charges a repulsion. The proportionality factor is the reciprocal of the permittivity of the medium surrounding the charges [35].

count (radiation measurements). The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total number registered in a given period of time. The term often is erroneously used to designate a disintegration, ionizing event, or voltage pulse. A spurious count is a count caused by something other than radiation [39].

count, background. The evidence or effect on a detector of radiation, other than that which it is desired to detect, caused by any agency. In connection with health protection, the background count usually includes radiation produced by naturally occurring radioactivity and cosmic rays [36].

counterpoise. An electrically continuous conductive material usually installed around the perimeter of a building to reduce the apparent electrical ground resistance [38]. A mesh or grid of conductors that are electrically bonded together at one or more points, which is intended to provide a low impedance ground for system connection applications [53].

counting, coincidence. A method for detecting or identifying radioactive materials and for calibrating their disintegration rates by counting two or more characteristic radiation events (such as gamma-ray emissions) that occur together or in a specific time relationship to each other [29].

coupling. Interaction of electromagnetic fields with electrical systems whereby part of the energy of the field is transferred to the system. Electromagnetic coupling may be direct through a wire, resistive through a resistor, inductive (magnetic coupling) through a magnetic element, or capacitive (electrostatic coupling) through a capacitance [53]. Also the energy transfer of a shock wave traveling in one medium, which produces a shock wave in a second medium at their common interface [37]. Also the absorption of radiant energy by a material by conversion to internal energy, resulting in a shock wave being developed in the material [38]. In general, coupling is an interaction between different properties of a system, or an interaction between two or more systems [32]. See below for various types of electromagnetic coupling of EMP concern [53]:

- cross coupling. The capacitive and inductive coupling between conductors that permits a transient on one conductor to induce a transient on the other conductor.
- electromagnetic coupling. Coupling that takes place between the incident external electromagnetic fields and a system, resulting in currents or voltages appearing on or within the system.
- electrostatic coupling. Capacitive coupling between two lines.
- external coupling. Electromagnetic coupling of fields to portions of the system external to the main body or enclosure. It is called external because the electromagnetic energy interacts with wires or cables that run external to the overall system enclosure. (Not all electromagnetic coupling is external to the enclosure, however.)
- internal coupling. That part of the overall EMP energy-transfer process that usually occurs inside the system structural enclosure and consists primarily of current traveling along cables or conductors inside.
- magnetic coupling. Energy imported to (or voltage induced in) a loop of finite area due to a change in flux linkages within the loop.

coupling, j-j (*see* j-j coupling).

coupling, Russell-Saunders (*see* Russell-Saunders coupling).

cow. A device in which a daughter radionuclide is cluted (removed by dissolving) from an ion exchange column containing a parent radionuclide long-lived compared to the daughter [39].

CPM. Abbreviation for counts per minute, a measure of radioactive material disintegration [50].

crack (underwater shock). A rapidly expanding white disc on the water surface whose leading edge follows closely behind the intersection of the underwater shock wave with the surface (the slick). The whiteness is believed to be the cavitated region caused by the rarefaction wave, which forms and moves downward when the primary shock is reflected from the surface [38].

crater. The pit, depression, or cavity formed in the surface of the earth by an explosion. It may range from saucer-shaped to conical, depending largely on the depth of burst. In the case of a deep underground burst, no rupture of the surface may occur. The resultsulting cavity is termed a camouflet [36]. Crater formation can occur by vaporization of the surface material, by the scouring effect of airblast, by throwout of disturbed material, or by subsidence. In general, the major mechanism changes from one to the next with increasing depth of burst. The apparent crater is the depression that is seen after the burst; it is smaller than the true crater (i.e., the cavity actually formed by the explosion) because it is covered with a layer of loose earth, rock, etc. [49].

crater, apparent. The visible crater remaining after a nuclear detonation [38]. The depth and radius of the apparent crater are termed apparent crater depth and apparent crater radius.

crater, true. The crater excluding fallback material [38] (*see* crater). The depth and radius of the true crater are termed true crater depth and true crater radius.

crater depth. The maximum depth of the crater measured from the deepest point of the pit to the original ground level [36].

crater radius. The average radius of the crater measured at the level corresponding to the original surface of the ground [36].

crit. Abbreviation for critical mass.

critical. Capable of sustaining (at a constant level) a chain reaction. "Prompt critical" means sustaining a chain reaction without the aid of delayed neutrons [39] (*see* subcritical; supercritical).

criticality. The state of a given fission system when the specified conditions are such that the mass of active material present in the system is precisely a critical mass. Thus, the fission neutron production rate is a constant and is exactly balanced by the total of neutron loss and utilization rate, and the neutron population remains constant. The word "criticality" alone is often used improperly to describe the degree of criticality of a system, which is a relative term describing a variable physical property of the fissionable assembly. The degree of criticality is the ratio of the mass of active material actually present in the system to the critical mass under the identical conditions, and is usually expressed as a decimal [37].

critical mass (crit). The minimum amount of fissionable material capable of supporting a chain reaction under precisely specified conditions [36]. Such conditions include the nature of the material and its purity, the nature and thickness of the tamper (or neutron reflector), the density (or compression), and the physical shape (or geometry). For an explosion to occur, the system must be supercritical, i.e., the mass of the material must exceed the critical mass under the existing conditions [49].

critical radiant exposure (*see* radiant exposure, critical).

cross section. The probability that a certain reaction between a nucleus and and incident particle or photon will occur. It is expressed as the effective "area" the nucleus presents for the reaction. The unit of area is commonly the barn (10^{-24} cm^2). "Macroscopic cross section" refers to the cross section per unit volume (preferably) or

per unit mass. "Microscopic cross section" is the cross section of one atom or molecule [39]. For a given species there is a scattering cross section, capture cross section, etc.; the total cross section is the sum of the specific partial cross sections for the individual interactions. Both partial and total cross sections vary with the energy of the radiation, often in a very complex manner [2]. (*See also* barn).

cross section, capture. The probability that a nucleus will capture an incident particle [39].

cross section, differential. The cross section for a nuclear process leading to emission of particles or photons at a specified angle relative to the direction of incidence, per unit angle or per unit solid angle. Integration over all angles, or solid angles, gives the ordinary cross section for the process [32]. (*See also* cross section, differential scattering.)

cross section, differential scattering. The cross section for the scattering of a nuclear particle or photon from its initial velocity to a new given velocity. It is usually designated in terms of scattering cross section per unit solid angle or per unit plane angle, since the scattering angle defines the energy (and thus speed) of the scattered particle. Where a spread of velocities might be scattered into a given solid angle, it would be given in terms of scattering cross section per unit solid angle per unit speed at the solid angle and speed in question [32]. (*See also* cross section, differential.)

cross section, geometric. The product πr^2, where r is a nuclear radius. Thus, the geometric cross section is the area that a target nucleus presents to a bombarding particle. However, the cross sections for nuclear reactions bear little relationship to the geometric cross section [35].

cross section, kT. A term used to denote $2/\sqrt{\pi}$ multiplied by the thermal cross section measured with neutrons of "temperature" T. If the thermal neutrons have a Maxwellian distribution, and the cross section varies as 1/u, then σkT is the cross section for monoenergetic neutrons of energy kT [32]. u is the neutron velocity, k is Boltzmann's constant, and σkT is the symbol used for the kT cross section [35].

cross section, macroscopic (*see* cross section).

cross section, microscopic (*see* cross section).

cross section, neutron fission. A measure of the ability of the material to capture a neutron and undergo fission [11].

cross section, partial (*see* cross section, total).

cross section, thermal. Cross section for a process involving thermal neutrons [32].

cross section, total. That cross section effective for removal of an incident particle from a beam; it is the sum of the separate (partial) cross sections for all processes by which the particle can be removed from the beam [32].

cross section, transport. Reciprocal of the transport mean free path [32].

crown (cloud). The crown of a nuclear cloud may be the familiar mushroom-shaped top of the column for a shallow burst, or it may be contained within the column for an

intermediate depth of burst. The crown phenomenon occurs only in the shallow, very shallow, and intermediate depth ranges [37]. (*See also* base surge; column, nuclear; plume.)

cruise missile. Guided missile, the major portion of whose flight path to its target is conducted at approximately constant velocity; depends on the dynamic reaction of air for lift and upon propulsion forces to balance drag [36].

crystalline. Refers to a material (e.g., a semiconductor) possessing an ordered lattice structure [38]. Almost all elements and compounds solidify in orderly, repetitive, three–dimensional arrangements of atoms called crystals [28].

cube root law. A scaling law applicable to many blast phenomena. It relates the time and distance at which a given blast effect is observed to the cube root of the energy yield of the explosion [49]. (*See also* scaling law.)

curie (Ci; formerly c). A unit of radioactivity; it is the activity of a quantity of any radioactive species in which 3.7×10^{10} nuclear disintegrations occur per second (approximately the radioactivity of 1 gram of radium). The gamma curie is sometimes defined correspondingly as the activity of material in which this number of gamma–ray photons is emitted per second. The curie is being replaced by the becquerel (Bq), which is equal to one disintegration per second [50].

curie temperature. The temperature at which a substance becomes ferromagnetic [27].

current, conventional. Electric current assumed to flow from the most positive point of a circuit to the most negative point in the circuit, relative to ground [38].

current injection. A process by which simulated EMP transient pulses are introduced into a functioning component, circuit, or system to measure damage or upset thresholds [53].

Cutie Pie. Any of several designs of a gamma dose rate meter with a pistol grip and a large–diameter plastic "barrel" that contains the ionization chamber [4].

cyclotron. A particle accelerator that uses a magnetic field to confine a positive ion beam to a plane while an alternating electric field accelerates the ions in a spiral path. A radiofrequency voltage is applied between one or two hollow semicircular electrodes called "dees" at the frequency at which the ions rotate (which is constant in the conventional cyclotron). As the voltage between the dees alternates, particles are accelerated as they enter and leave the dees [39].

D–day. Term used to designate the unnamed day on which a nuclear test takes place. The equivalent rule applies to H–hour. Time in plans is indicated by a letter that shows the unit of time employed in figures, with a minus or plus sign to indicate the amount of time before or after the reference event, e.g., D+7 means 7 hours after D–day, H–2 means 2 hours before H–hour [50].

D–neutrons. Obsolete term for neutrons of such energy that they are strongly absorbable by rhodium covered with cadmium [32].

D–region (*see* ionosphere).

damage, nuclear (land warfare) [36].

- light damage. Damage that does not prevent the immediate use of equipment or installations for which it was intended. Some repair by the user may be required to make full use of the equipment or installations.
- moderate damage. Damage that prevents the use of equipment or installations until extensive repairs are made.
- severe damage. Damage that prevents use of equipment or installations permanently.

damage assessment, nuclear. The determination of the damage effect to the population, forces, and resources resulting from actual nuclear attack. It is performed during and after an attack. The operational significance of the damage is not evaluated in this assessment [36]. (*See also* damage, nuclear.)

damage criteria. The critical levels of various effects, such as blast pressure and thermal radiation, required to achieve specified levels of damage [36].

damage level. Degree of damage [37] (*see* damage, nuclear).

damage radius (*see* radius of damage).

danger coefficient, nuclear. The nuclear danger coefficient of a substance for a particular reactor is the change in reactivity caused by inserting that substance in the reactor. From this coefficient one can estimate the loss in reactivity that would be incurred by placing various materials in the reactor [32]. (*See also* danger coefficient method.)

danger coefficient method. The absorption cross section refers to reactions in which a neutron is not re–emitted. The absorption cross section of thermal neutrons can be measured very accurately by a method that is sensitive to the disappearance of a neutron, but not affected by scattering. The use of a chain–reacting pile is one method used to make such a measurement. If a pile is operating at a constant neutron flux, the material whose cross section is to be determined is inserted into the pile. The absorption of neutrons by this material will result in a gradual decrease in the neutron flux. This decrease can be measured accurately and it is not sensitive to the scattering properties of the absorber even when the absorption cross section is small [35].

dark current. A current that flows in photoemissive and photoconductive detectors when there is no radiant flux incident upon the electrodes. The dark current may vary considerably with temperature [52].

data link. A communications link suitable for transmitting data [36].

data mile. A standard unit of distance -- 6,000 feet [36].

daughter (element) (*see* series, radioactive).

dazzle. Temporary loss of vision or a temporary reduction in visual acuity [36] (*see also* flash blindness).

debris, weapon (nuclear). The residue of a nuclear weapon after it has exploded; that is, the materials used for the casing, and other components of the weapon, plus unexpended plutonium or uranium, together with fission products [36]. This debris is highly radioactive.

debris entrapment. Trapping a major part of the radioactive debris from an underground nuclear explosion, e.g., by ejecting it down a hole below the burst point or by HE closures and test gate valves [37].

debris radiation (*see* radiation, debris).

de Broglie relation. The expression $\lambda_d = h/p$ for the de Broglie wavelength λ_d ascribed by wave or quantum mechanics to any particle having momentum p, where h = Planck's constant [35].

decay (radioactive). The decrease in the radiation intensity of any radioactive material with respect to time [36]. Radioactive decay is due to the spontaneous transformation of an unstable nuclide into a different nuclide or into a different energy state of the same nuclide by the emission from the nucleus of alpha particles (alpha decay), beta particles (or electrons) (beta decay), or gamma rays (gamma decay); or the nuclear capture or ejection of orbital electrons (beta decay); or fission. Also called radioactive disintegration [29]. Every decay process has a specific half-life. (See also decay law, radioactive; series, radioactive; *topics under* disintegration; half-life.)

decay, alpha (*see* decay (radioactive)).

decay, beta (*see* decay (radioactive)).

decay chain (*see* series, radioactive).

decay coefficient (or constant) (*see* disintegration constant).

decay curves. Graph lines representing the decrease in radioactivity with the passage of time [36] (*see* decay law, radioactive).

decay law, radioactive. The exponential law represented by the equation

$$N = N_o e^{(-\lambda_c t)}$$

which governs the decrease with time of the number of atoms of a radioactive species, provided the number is large. In the above equation N is the number of atoms present at time t; N_o is the number of atoms present at time zero; and λ_c is the disintegration constant. The decay law is a statistical law, so that if N is the number of radioactive atoms present, the number that will disintegrate on the average in unit time is $\lambda_c N$ [32].

decay product (*see* series, radioactive).

decay rate, radioactive. The time rate of the disintegration of radioactive material generally accompanied by the emission of particles and/or gamma radiation [36].

decay scheme, radioactive. An energy level diagram presenting a representation of the manner in which a radioactive isotope decays to another element [4].

decontamination (radioactivity). The process of making any person, object, or area safe by removing radioactive material clinging to or around it [36]. The process of removing contaminating radioactive material from an object, a structure, or an area [38]. Decontamination may be accomplished by (1) treating the surface so as to remove or decrease the decontamination; (2) letting the material stand so that the radioactivity is decreased as a result of natural decay; and (3) covering the contamination so as to attenuate the radiation emitted [49]. (*See also* contamination.)

decontamination factor. The ratio of the amount of undesired radioactive material initially present to the amount remaining after a suitable processing step has been completed. Decontamination factors may refer to the reduction of some particular type of radiation, or to the gross measurable radioactivity [39].

decrement, performance (personnel). Reduction of efficiency in performance of a required task, such as increased reaction time, increased performance time, and/or increased error rate [38].

defense, nuclear. The methods, plans, and procedures involved in establishing and exercising defensive measures against the effects of an attack by nuclear weapons or radiological warfare agents. It encompasses both the training for, and the implementation of, these methods, plans, and procedures [36]. (*See also* defense, radiological; radsafe.)

defense, radiological. Defensive measures taken against the radiation hazards resulting from the employment of nuclear and radiological weapons [36]. It includes the detection and measurement of radioactivity, the protection of persons from radioactivity, and decontamination of areas, places, and equipment [50]. (*See also* defense, nuclear; radsafe.)

deficiency, nuclear weapon. A situation or condition that degrades or could degrade nuclear safety but is not serious enough to be a nuclear weapon accident or incident [37] (*see also* dull sword).

deflagration (explosives). Burning in which the velocity of the advance of the flame front is less than the velocity of sound in the material. In this case, heat is transferred from the reacted to the unreacted material by conduction, radiation, and convection, and the pressures developed are relatively low, i.e., not a high-explosive detonation [16].

degradation, nuclear weapon. The degeneration of a nuclear warhead to such an extent that the anticipated nuclear yield is lessened [36].

degree of risk (nuclear) (*see* risk, degree of (nuclear)).

delamination. Separation of bulk material [38].

delayed (or worldwide) fallout (*see* fallout).

delayed fission neutrons (*see* neutrons, fission).

delayed gamma rays (*see* gamma ray(s), delayed).

delayed neutrons (*see* neutrons, delayed).

delta ray. Any secondary ionizing particle ejected by recoil when a primary ionizing particle passes through matter [39].

denaturant. A nonfissionable isotope that can be added to fissionable material to make it unsuitable for use in nuclear weapons without extensive processing [32].

density, ionization (*see* ionization density).

density, relative air. The ratio of air density under a specified condition to the air density of the standard atmosphere at sea level [38].

depletion. Reduction of the concentration of one or more specified isotopes in a material or in one of its constituents [39] (*see also* uranium, depleted).

deployed nuclear weapons. *1.* When used in connection with the transfer of weapons between the Department of Energy and the Department of Defense, this term describes those weapons transferred to and in the custody of the Department of Defense. *2.* Those nuclear weapons specifically authorized by the Joint Chiefs of Staff to be transferred to the custody of the storage facilities, carrying, or delivery units of the armed forces [36].

depolymerization. The breaking down of an organic compound into two or more molecules of less complex structure [39].

deposition region (EMP). The region of space where the radiation from a nuclear weapon deposits its energy, creating secondary ionization. Specifically, where a conducting plasma of 10^{-7} mho/m or greater is created [45].

depth of burst (or burial), optimum. That depth that produces, under prevailing conditions, the most favorable combination of crater dimensions for accomplishing the purpose of the intended crater [37].

design margin (electronics). The difference between the predicted failure level of an item and the specification level [53].

desired ground zero (*see* ground zero).

detector, activation. A material used to determine neutron flux or density by virtue of the radioactivity induced in it as a result of neutron capture [36].

detector, radiation. Any of a wide variety of materials or instruments that provide a signal when stimulated by the passage of ionizing radiation; the sensitive element in radiation detection instruments. The most widely used media for the detection of ionizing radiation are photographic film and ionization of gases in detectors (e.g., Geiger counters), followed by materials in which radiation induces scintillation [50].

detector, threshold. An element or isotope in which radioactivity is induced only by the capture of neutrons having energies in excess of a certain threshold value that is characteristic of the element or isotope. Threshold detectors are used to determine the neutron spectrum from a nuclear explosion, i.e., the number of neutrons in various energy ranges [2].

detonation, high-explosive. A chemical reaction in which the reaction front advances with a speed that exceeds the velocity of sound in the material. In this case, energy is transmitted from the reacted to the unreacted material by a shock wave, and the pressures developed are extremely high (usually greater than 100 kilobars); i.e., it is a high-explosive [16].

detonation, nuclear. A nuclear explosion resulting from fission or fusion reactions in nuclear materials [37].

detonation, one-point. An HE detonation that is initiated at a single point (*see also* one-point safe).

detonator. An electroexplosive device designed to produce a detonation in response to an applied electric current [37].

deuterium. An isotope of hydrogen (sometimes referred to as heavy hydrogen) of mass 2 units, with one proton and one neutron in the nucleus (symbol: ${}_{1}^{2}H$ or D) [39]. Deuterium can be used in thermonuclear fusion reactions for the release of energy [49].

deuteron. Nucleus of a deuterium atom.

deviation, standard. The square root of the average of the squared deviations from the mean; one standard deviation means that two-thirds of the values in a distribution deviate less than that amount from the mean value [35].

device, nuclear. Nuclear fission and fusion materials, together with their arming, fuzing, firing, and chemical-explosive components, that have not reached the development status of an operational weapon [50].

diagnostic experiment. An experiment that is intended only to furnish information regarding the efficiency and yield of a nuclear device [37]. Also used in this sense for high-explosive and other simulations. (*See* effects experiment *for contrast*.)

differential absorption ratio (*see* absorption ratio, differential).

differential cross section (*see* cross section, differential).

differential scattering cross section (*see* cross section, differential scattering).

diffraction. The bending of waves around the edges of objects [49].

diffraction, blast wave. The passage around and envelopment of a structure by the nuclear blast wave [36] (*see* drag *for distinction*).

diffraction loading. *1.* The force (or loading) on the structure during the envelopment process [36]. *2.* The forces exerted upon an object or structure by the blast wave

wave overpressures as the shock front strikes and engulfs it [38]. (*See* drag loading *for distinction.*)

diffraction target. A target that is primarily susceptible to the forces produced by the overpressure reflecting off the front face and diffracting around and over the target prior to complete engulfment of the target by the blast wave. Examples of diffraction targets are large closed structures such as houses [37]. (*See* drag target *for distinction.*)

diffusion. *1.* That process in which particles (e.g., charge carriers) move from a region of high concentration toward a region of lower concentration [38]. *2.* The scattering of light rays either when reflected from a rough surface or during the transmission of light through a translucent medium [36 (1979 edition)]. *3.* In nuclear reactor theory, the passage of particles, usually neutrons or gamma photons, through matter in such circumstances that the probability of scattering is large compared with that of leakage or absorption. It is often limited to phenomena described by a member of the class of differential equations known as diffusion equations [32]. (*See also* diffusion equation; diffusion length.)

diffusion, gaseous. A method of isotopic separation based on the fact that gas atoms or molecules with different masses will diffuse through a porous barrier (or membrane) at different rates. The method is used to separate uranium–235 from uranium–238; it requires large gaseous–diffusion plants and enormous amounts of electric power [29].

diffusion equation. In neutron theory, a balance relationship that states that the time rate of change of the number of neutrons per unit volume of a medium is equal to the resultant of three processes: (1) the diffusion of neutrons out of the volume, (2) the generation of neutrons in the volume per unit time, and (3) the number absorbed per unit time in the volume [4].

diffusion kernel (*see* kernel, diffusion).

diffusion length. The mean distance traveled by a diffusing particle (neutron or minority carrier) from the point of its formation to the point at which it is absorbed [48].

digital. Refers to quantized or discrete levels (e.g., voltage levels) [44].

DIHEST. Acronym for direct induced high–explosive simulation technique [40].

diode. A semiconductor junction device with two terminals and usually no more than three junctions. It has nonlinear voltage–current characteristics, which can be used for clamping. Examples are rectifier diodes, reverse–breakdown diodes (including Zener diodes), and diode thyristors [53].

di–proton. A term for a particle consisting of two bound protons. Such a combination would be a nucleus corresponding to one He^2. It has not been detected, and probably does not exist [4].

Dirac h. Dirac h or h–bar, written $\hbar$, represents the universal constant h/2 (where h is Planck's constant) equal to 1×10^{-34} joule–sec [35].

directly ionizing particle(s) (*see* ionizing particle(s), directly).

direct shock wave (*see* shock wave, direct).

dirty weapon (*see under* weapon, nuclear).

discomposition. The process in which an atom is "knocked out" of position in a crystal lattice by direct nuclear impact, e.g., by fast neutrons or by fast ions that have been previously knocked out of this lattice position. The atom so displaced eventually comes to rest at an interstitial position or at a lattice edge [34].

disintegration (nuclear). Any transformation or change involving nuclei. If the change is spontaneous, it is said to be radioactive; if it results from a collision, it is said to be induced. Despite its literal meaning, the term nuclear disintegration refers also to radiative capture, inelastic scattering, beta-disintegration energy, and isomeric transitions [45]. (*See also* radioactivity.)

disintegration, multiple (*see* branching).

disintegration chain. Synonym for radioactive series.

disintegration constant. The fraction of the number of atoms of a radioactive nuclide that decay in unit time; λ in the equation $N = N_0 e^{-\lambda t}$ (*see* decay law, radioactive), where N_0 is the initial number of atoms present, and N is the number of atoms present after some time t [39]. It is the reciprocal of the mean life of the given system before undergoing transformation. When branching occurs, there are partial disintegration constants λ_1, λ_2, . . . associated, respectively, with the various possible modes of disintegration; the total disintegration constant λ_c for the parent substance then is given by $\lambda_1 + \lambda_2 + \ldots$ [32].

disintegration energy. The energy evolved, or the negative of the energy absorbed, in a nuclear disintegration. It is equal to the energy equivalence of the sum of the masses of the products. (For each reactant or product that is a nucleus, the appropriate mass is that of the corresponding neutral atom.) If the disintegration energy is positive, the disintegration is exothermic; if it is negative, the disintegration energy is the ground-state disintegration energy, which is the disintegration energy when all reactant and product nuclei are in their ground states. The symbol then used is Q_0 [32].

disintegration energy, alpha. The disintegration energy of an alpha disintegration process [32].

disintegration energy, beta. The disintegration energy of a beta-decay process [32].

disintegration rate. The absolute rate of decay of a radioactive substance, usually expressed in terms of disintegrations per unit of time. It is the absolute rate of the transformation of a nuclide under bombardment [32].

disintegration series (*see* series, radioactive).

dispersion (EM propagation). Effects on an electromagnetic wave traversing a region in which the propagation characteristics are frequency dependent [38].

dispersion error. The distance from the point of impact or burst of a round to the mean point of impact or burst [37] (*see also* error probable, circular).

displacement (atoms). A type of transient and permanent damage in crystalline materials in which atoms are moved from their normal lattice positions [38].

displacement (ground shock).

displacement laws (radioactivity). Statements of the changes in atomic number Z and mass number A of a nuclide that accompany the various types of radioactive disintegration [32].

distribution, fissioning (*see* fissioning distribution).

dollar (reactor technology). A special unit of reactivity; equal to that amount of reactivity required to make a reactor critical on prompt neutrons only, and therefore equal to the effective delayed neutron fraction for that reactor [39]. One one-hundredth of a dollar is called a "cent" [32].

dome (*see* spray dome).

doppler effect. The change in the observed wavelength of a radiation, which results from the motion of its source relative to the observer [39].

dosage sensitivity (in relation to film). The equivalent dose recorded by a given film determined from a characteristic curve obtained with Co^{60} gamma rays, divided by the charged particle dose as determined by ionization chamber measurements [23].

dose, radiation. The total amount of ionizing radiation absorbed by material or tissues, commonly expressed in rads. The term radiation dose is often used in the sense of the exposure dose expressed in roentgens, which is a measure of the total amount of ionization that the quantity of radiation could produce in air. This could be distinguished from the absorbed dose, also given in rads, which represents the energy absorbed from the radiation per gram of specified body tissue. Further, the biological dose, in rems, is a measure of the biological effectiveness of the radiation exposure [36]. In the case of materials, the radiation dose may be expressed in cal/gm (material) or ergs/gm (material) [38]. For special purposes the term dose must be appropriately qualified. If unqualified, it refers to absorbed dose [39]. Dosage is used in older literature as well as exposure dose and simply exposure, and care should be exercised in their use [50]. The rad or gray unit is applicable to any type of ionizing radiation, but in reporting dose, the type of radiation, as well as the irradiated material (for instance, tissue), and the place of interest must be specified. Without the above three factors, a statement of absorbed dose received is incomplete and probably useless because the same dose of different kinds of radiation, even delivered to the same place, can produce entirely different effects [35]. (*See also* dose equivalent.)

dose, absorbed. The amount of energy imparted by nuclear (or ionizing) radiation to unit mass of absorbing material. The unit is the rad [36]. In civilian usage the rad unit is being replaced by the gray.

dose, acute radiation. Total ionizing radiation dose received at one time and over a period so short that biological recovery cannot occur [36].

dose, biological. A term that expresses the biological effectiveness of ionizing radiation. It is the product of the absorbed dose in rads (or grays) and the RBE. The unit is the rem (or sievert). (*See* dose equivalent *for distinction.*)

dose, chronic radiation. A dose of ionizing radiation received either continuously or intermittently over a prolonged period of time. A chronic radiation dose may be high enough to cause radiation sickness and death, but if received at a low dose rate, a significant portion of the acute cellular damage will be repaired [36]. Unrepaired cellular damage will produce long-term effects, such as cancer, that are manifested many years after the exposure.

dose, cumulative. The total dose resulting from repeated exposures to radiation [39].

dose, depth. The radiation dose delivered at a particular depth beneath the surface of the body. It is usually expressed as a percentage of surface dose [39].

dose, exit. Dose of radiation at surface of body opposite to that on which the beam is incident [39].

dose, exposure. The exposure dose at a given point is a measurement of radiation in relation to its ability to produce ionization. The unit of measurement of the exposure dose is the roentgen [36].

dose, infinite integrated. The radiation dose that would be received if a subject remained at a given position in a radiation field for an infinitely long time [37].

dose, integral (volume dose). A measure of the total energy absorbed by an organism or object during exposure to radiation [39].

dose, lethal (LD). A dose of ionizing radiation sufficient to cause death [37] (*see also* dose, median lethal).

dose, maximum permissible. That radiation dose that a military commander or other appropriate authority may prescribe as the limiting cumulative radiation dose to be received over a specific period of time by members of his command, consistent with current operational military considerations [36].

dose, median lethal (nuclear) (MLD). The amount of radiation over the whole body that would be fatal to 50 percent of the exposed personnel in a given period of time [36]. Sometimes abbreviated as MLD or LD_{50}. The median lethal dose for humans is not well established, but it is assumed to be approximately 450 rads if the total dose is delivered within a period of 24 hours or less [38].

dose, permissible. The dose of radiation that may be received by an individual within a specified period with expectation of no significantly harmful result [39]. That dose of ionizing radiation that is not expected to cause appreciable bodily injury to a person at any time during his lifetime [50].

dose, skin (radiology). Absorbed dose at center of irradiation field on skin. It is the sum of the dose in air and scatter from body parts [39].

dose, threshold. The minimum absorbed dose that will produce a detectable degree of any given effect [39].

dose, tissue. Absorbed dose received by tissue in the region of interest, expressed in rads or grays [39]. (*See also* dose; gray; rad.)

dose, tolerance. The amount of radiation which may be received by an individual within a specified period with negligible results [36].

dose, transit. Gamma dose received after nuclear detonation due to: (1) direct irradiation by the passing fallout cloud; (2) radiation from the base surge as it passes or envelops the dosed object; (3) radiation from contaminated water as a ship passes through it [4].

dose equivalent. In radiation protection associated with peacetime nuclear activities, dose equivalent is a measure of the biological effectiveness of absorbed ionizing radiation [49]. It expresses all radiations on a common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose in rads or grays, the quality factor, and certain modifying factors [39]. It is similar to the biological dose, which is used in connection with the large radiation exposures that might accompany a nuclear explosion [49]. The unit of dose equivalent is the rem or (more recently) the sievert (Sv). (*See* dose, biological *for distinction.*)

dose equivalent, maximum permissible (MPD). The greatest dose equivalent that a person or specified part thereof shall be allowed to receive in a given period of time [39].

dose rate, exposure (*see* exposure rate).

dose rate, radiation. The radiation dose (dosage) absorbed per unit of time. A radiation dose rate can be set at some particular unit of time (e.g., H+1 hour) and would be called H+1 hour radiation dose rate [36]. As a general rule, the amount of ionizing (or nuclear) radiation that an individual or material would receive per unit of time. It is usually expressed as rads or grays (or rems) per hour or in multiples or submultiples of these units, such as millirads per hour. The dose rate is commonly used to indicate the level of radioactivity in a contaminated area [49].

dose rate contour line. A line on a map, diagram, or overlay joining all points at which the radiation dose rate at a given time is the same [36].

dose rate–meter. Any instrument that measures radiation dose rate [39].

dosimeter. An instrument for measuring and registering the total accumulated dose of (or exposure to) ionizing radiations. Instruments worn or carried by individuals are called personnel dosimeters [49].

dosimeter, chemical. A self–indicating device for determining total or accumulated radiation exposure based on color changes accompanying chemical reactions induced by radiation [37] (*see* film badge).

dosimeter, personnel (*see* dosimeter).

dosimetry. The measurement of radiation doses. It applies to both the devices used (dosimeters) and to the techniques [36]. The process of measuring and providing a quantitative description of a radiation environment, preferably in terms relevant to the radiation effect being studied (e.g., neutron fluence, dose, etc.) [38].

DPM. Abbreviation for disintegrations per minute, a measure of radioactivity (*see* becquerel).

drag. Force of aerodynamic resistance caused by the violent currents behind the shock front [36] (*see* diffraction *for distinction*).

drag loading. The force on an object or structure due to transient winds accompanying the passage of a blast wave. The drag pressure is the product of the dynamic pressure and the drag coefficient which is dependent upon the shape (or geometry) of the structure or object [36]. (*See* diffraction loading *for distinction.*)

drag target. A target that is primarily susceptible to the drag forces produced by the dynamic pressures (mass air flow) of the blast wave. The target configuration is such that diffraction forces are of such short duration as to be of minor damage potential compared to the drag forces. Examples of drag targets are small targets, such as artillery pieces or telephone poles, or open structures, such as truss bridges [37]. (*See* diffraction target *for distinction.*)

drift. That process in which charge carriers move along the line of action of an electric field [38].

Duane and Hunt's law. The statement that the maximum photon energy in an X-ray spectrum is equal to the kinetic energy of the electrons producing the X-rays [35].

DUB. Acronym for deep underground (missile) basing.

ductility. The ability of a material or object to undergo large permanent deformations without rupture [38].

dull sword. A DOD term used to identify and report a nuclear weapon safety deficiency [37] (*see* deficiency, nuclear weapon).

duty cycle minimization. An operational procedure whereby a system is maintained in a less susceptible condition during nonoperative or standby periods [53].

dynamic pressure. Pressure resulting from some medium in motion, such as the air following the shock front of a blast wave [36]. It is equal to the product of half the density of the air through which the blast wave passes and the square of the particle (or wind) velocity behind the shock front as it impinges on the object or structure [49].

dyne. The unit of force that, when acting upon a mass of 1 gram, will produce an acceleration of 1 centimeter per second per second [39].

dyscrasia, blood. Any persistent change from normal of one or more of the blood components [39].

E–field (*see* electric field).

e–folding time. Time required for a function changing in amplitude exponentially to reach 1/e of its peak value [53].

E–layer (*see* ionosphere).

E–region (*see* ionosphere).

early (or local) fallout (*see* fallout).

early transient incapacitation (*see* incapacitation, early transient).

ECCM. Abbreviation for electronic counter–countermeasure.

ECM. Abbreviation for electronic countermeasure.

eddy currents. Currents set up in a substance (e.g., a shield) by variation of an applied magnetic field [48].

effective atmosphere (*see* atmosphere, effective).

effective atomic number (*see* atomic number).

effective energy (*see* energy, effective).

effective half–life (*see* half–life, effective).

effective multiplication factor (or constant) (*see* multiplication constant).

effective wavelength (*see* wavelength, effective).

effects experiment. An experiment whose purpose is to study what a nuclear explosion (or a high–explosive simulation) does to materials, equipment, and systems. Includes also measurement of the changes in the environment caused by the detonation, such as increased air pressures, thermal and nuclear radiation, cratering, water waves, etc. [50]. (*See* diagnostic experiment *for contrast*.)

efficiency, nuclear. The ratio (expressed as a percentage) of the number of atoms that fission or fusion to the total number of atoms originally present in the nuclear material in a nuclear weapon [37].

eigenfunctions. Functions that satisfy the Schrödinger equation for certain values of a parameter known as the eigenvalue. In general, each eigenvalue has one or more eigenfunctions associated with it and with no other eigenvalue. An example of eigenfunctions as solutions are the solutions to the problem of what the electron charge density distribution is for an atom bounded in a given manner and under given constraints [35].

eigenvalue (*see* eigenfunctions).

Einstein coefficients. The probabilities, expressed as coefficients, that radiation will be admitted or absorbed by an atom within a given stated time. There are two types of these coefficients: (1) the A_E coefficients, which are concerned with the probabilities

of spontaneous radiative transition, and (b) the B_E coefficients, which are concerned with the probabilities of an induced radiative transition [4].

Einstein equation (*see* mass–energy equivalence).

Einstein frequency condition. The statement that the energy of a photon emitted when an atom drops from one energy state to a lower state is the difference between the two energy states [35] (*see also* Bohr atom theory; photoelectric effect).

Einstein photoelectric equation (*see* photoelectric equation).

ejecta (crater). Original material dissociated and ejected to the area surrounding a crater. The ejecta create missile hazards [38].

elastic collision (*see* collision; scattering).

elastic range. The stress range in which a material will recover its original form when the force (or loading) is removed. Elastic deformation refers to dimensional changes occurring within the elastic range [49]. (*See also* plastic range.)

elastic scattering (*see* collision; scattering).

electric charge, unit of. Magnitude of the charge on the hydrogen proton and electron ($e = 1.6021 \times 10^{-19}$ coulomb) of which all other charges are integer multiples.

electric field (E–field). The electric field component associated with an electromagnetic wave or a field created by an electric charge distribution [53].

electric field, transverse. Those electric fields perpendicular to the direction of the propagation, usually referring to the phi and theta components in a spherical coordinate system [45].

electric surge arrestor. Hybrid device that produces EMP protection across the frequency spectrum and voltage spectrum [38].

electromagnetic compatibility (EMC). The ability of telecommunications equipment, subsystems, and systems to operate in their intended operational environments without suffering or causing unacceptable degradation because of electromagnetic radiation or response. (a) Design compatibility is achieved by incorporation of engineering characteristics or features in all electromagnetic radiating and receiving equipment in order to eliminate or reject undesired signals and enhance operating capabilities. (b) Operational compatibility is achieved by the equipment flexibility to insure interference-free operation. It involves the application of sound frequency management and clear concepts and doctrines to maximize operational effectiveness. Also called EMC [36]. The ability of a system of electrical components to operate properly with a defined margin of safety in the intended environment without degradation despite the coupling of spurious electrical stimuli between them [53].

electromagnetic pulse (*see* EMP).

electromagnetic radiation (EMR) (*see* radiation, electromagnetic).

electromagnetic spectrum (*see* spectrum, electromagnetic).

electron. Classically, a unit negatively charged particle usually bound to an atom and orbiting about its nucleus [38]. A particle of very small mass, carrying a unit negative or positive charge. Negative electrons, surrounding the nucleus (i.e., orbital electrons), are present in all atoms; their number is equal to the number of positive charges (or protons) in the particular nucleus. The term electron, where used alone, commonly refers to a negative electron. A positive electron is usually called a positron, and a negative electron is sometimes called a negatron [49]. Beta particles emitted by certain radioactive materials are high-speed electrons [35].

electron, Compton (*see* Compton electron).

electron(s), equivalent. Electrons that occupy the same subgroup in an atom. They have the same principal and orbital quantum numbers, but their magnetic orbital and magnetic spin quantum numbers are not the same [35]. (*See* shell structure of the atom.)

electron, extranuclear. An orbital electron [35] (*see* shell structure of the atom).

electron, metastatic. An electron characterized by its transitions from atom to atom or from one energy level to another within an atom, including those orbital electrons captured by the nucleus [4].

electron, recoil (*see* Compton effect).

electron, secondary. An electron ejected from an atom, molecule, or surface as a result of an interaction with a charged particle or photon [39].

electron binding energy, total (*see* binding energy, total electron).

electron capture (*see* capture, electron).

electron capture, inverse (*see* capture, inverse electron).

electron emission. The departure of electrons from a material [41].

electron injection. The transport of electrons from one medium into another, e.g., across junctions, barriers, and transition regions in semiconductors or across metal-dielectric interfaces [41].

electron-positron pair. The electron and positron simultaneously created in the process called pair production [32].

electron radius (classical). The classical electron radius is the radius r, usually given by the expression $r = e^2/m_e c^2 = 2.818 \times 10^{-13}$ cm, where m_e is the rest mass of the electron, e is the charge of an electron, and c is the velocity of light. This expression is obtained by equating the rest-mass energy $m_e c^2$ of the electron to its electrostatic self-energy e^2/r [32].

electron spin (*see* spin).

electron volt (eV). The amount of kinetic energy gained by an electron when accelerated through a potential of 1 volt (1.6×10^{-12} erg) [38]. In this definition, any bremsstrahlung that may be emitted from the system owing to acceleration of the electron is

neglected [35]. Larger multiple units of the electron volt are frequently used: keV for thousand, or kilo, electron volts; MeV for million, or mega, electron volts [39].

electron wavelength. The wavelength λ_c of an electron (suggested by de Broglie) for nonrelativistic velocities u that are slow compared to light is given by the relation

$$\lambda_c = \frac{h}{p} = \frac{h}{m_e u} = \frac{7.3}{u} \quad \text{cm}$$

where m_e is the rest mass, h is Planck's constant, and p is the momentum of the electron (in cgs units). The relation holds for electrons moving at relativistic velocities if the proper expression for momentum is used [35].

electronic line of sight (*see* line of sight, electronic).

electroscope. Instrument for detecting the presence of electric charges by the deflection of charged bodies [39].

electrostatic coupling. Capacitive coupling between two parallel lines [38] (*see* coupling).

electrostatic unit of charge (esu) (*see* statcoulomb).

element. A form of matter in which all the atoms have the same nuclear charge. It cannot be decomposed into (or be produced from) simpler forms of matter by means of chemical reactions (low-energy reactions) [35]. A category of atoms all of the same atomic number [39].

elementary particle (*see* particle, elementary).

element, daughter (*see* series, radioactive).

elevation. The vertical distance of a point or a level on, or affixed to, the surface of the earth, measured from sea level [36] (*see also* altitude).

EM. Abbreviation for electromagnetic.

EMC. Abbreviation for electromagnetic compatibility.

emergency risk (nuclear) (*see* risk, emergency (nuclear)).

emission. The ejection of electrons or electromagnetic waves from the surface of a material due to radiation, heat, nuclear reaction, or other causes [35].

emission, corpuscular (*see* corpuscular emission, associated).

emitter junction. One of two junctions in a bipolar transistor. Typically the emitter junction is the smaller junction and the photocurrent generated in it is often neglected [38].

EMP (electromagnetic pulse). The electromagnetic radiation from a nuclear explosion caused by Compton-recoil electrons and photoelectrons from photons scattered in the materials of a nuclear device or in a surrounding medium. The resulting electric and magnetic fields may couple with electrical/electronic systems to produce damaging

current and voltage surges. May also be caused by nonnuclear means. Also called EMP [36]. The burst of electromagnetic energy, in the frequency range of dc to UHF that propagates from, or is generated by, a nuclear explosion. EMP is often compared with a pulse–like radio wave of possibly very high field strength and as such does not include all electromagnetic radiation [53]. A simple relation exists between the electric field E and the magnetic field H under the condition of no free charge in the region of interest and at a long enough distance from the EMP source for the plane wave approximation to be valid. For these conditions $E/H = n_i$, where n_i is the intrinsic impedance of the medium and has the dimensions of ohms. For free space, n_i has a value of 377 ohms [30].

EMP, high–altitude (HEMP). The electromagnetic pulse produced when a nuclear explosion occurs essentially outside the earth's atmosphere, typically at an altitude of 100 to 1,000 km [53].

EMP, internal (IEMP). The production of transient electric and magnetic fields, currents, and voltages in enclosures and on cables and antennas, resulting from the direct interaction of gamma–ray and X–ray photons from a nuclear detonation with the enclosure walls and internal components [53].

EMP, secondary. Same as internal EMP.

EMP, system–generated (SGEMP). A term commonly applied to the replacement currents and the electric and magnetic fields generated within a system by the interaction of high–energy nuclear radiation (gamma rays, X–rays, neutrons) with the system [53].

empirical mass formula (*see* mass formula, empirical).

employment, tactical nuclear weapon. The use of nuclear weapons by land, sea, or air forces against opposing forces, supporting installations or facilities, in support of operations that contribute to the accomplishment of a military mission of limited scope, or in support of the military commander's scheme of maneuver, usually limited to the area of military operations [36].

EMR. Abbreviation for electromagnetic radiation.

emu. An abbreviation for electromagnetic unit. emu refers to the entire cgs electromagnetic system of units, or occasionally to the abcoulomb [35].

endoergic. A synonym for endothermic [35].

endothermic. A chemical reaction in which the products of the reaction absorb heat from an external source; hence the products of the reaction contain more energy than the original constituents [3].

end product (*see* series, radioactive).

energy. The capacity for doing work. It appears in many forms, such as kinetic energy, potential energy, gravitational energy, heat energy, nuclear or atomic energy, chemical energy, etc. It is always a measure of work done. Mass and energy are related through the Einstein relationship, $E = mc^2$, where E is the total energy of the particle, m is its mass, and c is the velocity of light. In this latter sense, mass and energy are said to be equivalent. MKSA units: $kg–m^2/sec^2$ or joules [35].

energy, chemical. Energy produced by reactions between atoms; carbon and oxygen atoms, for example, combine to form CO_2 and produce chemical energy in the form of heat [28] (*compare to* energy, nuclear).

energy, effective (X-rays). A term used to specify the quality (hardness or penetrating power) of an X-ray beam. It may be defined as that particular photon energy possessed by monochromatic gamma rays with the same half-value layer (HVL), or half-thickness, as the X-ray beam in question. The term is ambiguous for three reasons: (1) X-ray beams with the same HVL as a certain monochromatic gamma ray in one material will have a different HVL in another material; (2) the term has often been used in another sense, that is, instead of considering the HVL of a material, the slope of the absorption curve for the materials is considered, which is misleading because X-ray beams are composed of a spectrum of energies whose absorption curve slopes are not constant; (3) even when carefully defined, two X-ray beams of widely different characteristics may have the same effective energy. The only accurate method of specifying the quality of an X-ray beam is to provide the energy spectrum. If this is not possible, the tube voltage, filtration used, and half-value layers are superior to a statement of effective energy in specifying X-ray quality. The term effective energy is not the same as mean energy of the X-ray beam. The latter is the center of the energy distribution [4]. (*See also* half-value thickness; wavelength, effective.)

energy, ionizing (*see* ionizing energy).

energy, kinetic (*see* kinetic energy).

energy, nuclear. All forms of energy released in the course of a nuclear fission or nuclear transformation [36].

energy, pairing (*see* pairing energy).

energy flux density (*see* flux density, energy).

energy level, atomic. The series of energy levels corresponding to the several energy states of a stationary atom. These include the normal or ground state [4]. (*See also* energy-level diagram.)

energy level, nuclear. One of the quantum series of energy levels that can be assumed by a given nucleus. If the level is the lowest of the series, the nucleus is said to be in its ground state. If it is not the lowest, the nucleus is excited. If it remains in an excited state for an appreciable length of time, it is in a metastable state. Nuclei go from excited states to the ground state through gamma emission, internal conversion, or internal pair formation [4]. (*See also* isomer(s).)

energy-level diagram. A diagram that represents, by a series of horizontal lines, the discrete energy levels of a number of different excited states or different orbital electron states of an element. Lines are drawn vertically from level to level to indicate transitions. The difference in the two levels represents the energy emitted as a photon as a result of the transition [35].

energy partition. The distribution of the total energy released by a nuclear explosion among the various phenomena, e.g., nuclear radiation, thermal radiation, and blast. The exact distribution is a function of time, weapon yield, and the medium in which the explosion occurs [49].

energy ratio (ER). A proportional measure that provides a useful criterion for underground damage due to seismic waves. Assuming sinusoidal wave action in an underground explosion, it is the ratio of the square of the particle acceleration to the square of the resulting vibration frequency produced [37].

energy spectrum (*see* spectrum, energy).

energy transfer, linear (*see* linear energy transfer).

energy yield (*see* yield).

Eniwetok Proving Ground (EPG). An area in the Marshall Islands, including Eniwetok and Bikini atolls, once used for nuclear tests and formerly referred to as Pacific Proving Ground [2].

enriched material. *1.* Material in which the relative amount of one or more isotopes of a constituent as been increased. *2.* Uranium in which the abundance of the uranium-235 isotope is increased above normal [39].

enthalpy. Often called the total heat of a system. It is the sum of the internal and pressure energies of a substance or system. The change in enthalpy is equal to the amount of heat added to or subtracted from a system at constant pressure when the system changes from one state to another [35].

entropy. The measure of unavailable energy in a thermodynamic system. The entropy of a store of energy is an index of its unavailability; the greater its entropy, the less this energy is available for performing work. All spontaneous processes (e.g., explosions) represent some loss in availability, and hence are accompanied by entropy growth [35].

environment, nuclear. The environment resulting from a nuclear weapon detonation [37].

environment, nuclear radiation. The portion of the nuclear environment that includes photons (gamma rays and X-rays), neutrons, and alpha and beta particles [37].

environment, thermal. The environment produced by a nuclear detonation, which consists of radiation in the near ultraviolet, visible, and infrared regions of the electromagnetic energy spectrum [12].

enzyme. A biological catalyst of great specificity for a particular substance (substrate) or a particular group of closely related substances that generally activates or accelerates a biochemical reaction [39].

epicadmium neutrons (*see* neutrons, epicadmium).

epidermis. The outermost layer of cells of the skin [39].

epilation (depilation). The temporary or permanent removal or loss of hair [39].

epitaxial. The formation of single crystalline material upon a single cystalline substrate by chemical reduction from the vapor or liquid phase. The grown material assumes the same crystal orientation as the substrate [38].

epithelium. A term applied to cells that line all canals and surfaces having communication with external air; also cells specialized for secretion in certain glands as the liver, kidneys, etc. [39].

epithermal neutrons (*see* neutrons, epithermal).

equilibrium, radioactive. The state that prevails when the ratios between the amounts of successive members of a radioactive series remain constant [39].

equivalent circuit (*see* circuit, equivalent).

equivalent electron (*see* electron(s), equivalent).

equivalent fission yield (*see* yield, equivalent fission).

equivalent ton (*see* TNT equivalent).

erg. Unit of work done by a force of 1 dyne acting through a distance of 1 cm. Unit of energy that can exert a force of 1 dyne through a distance of 1 cm; cgs units: dyne–cm or gm–cm^2/sec^2 [39].

error, horizontal. The error in range, deflection, or radius that a weapon may be expected to exceed as often as not. Horizontal error of weapons making a nearly vertical approach to the target is described in terms of circular error probable. Horizontal error of weapons producing elliptical dispersion pattern is expressed in terms of probable error [36].

error probable, circular (CEP). An indicator of the delivery accuracy of a weapon system, used as a factor in determining probable damage to a target. It is the radius of a circle within which half of a missile's projectiles are expected to fall. Also called CEP [36].

error probability, spherical (SEP). A term used to designate the accuracy of a missile with respect to a target in the atmosphere or in space. It is a spherical volume analogous to the circular error probable (CEP) (also called circular error probability) commonly used to designate the accuracy of a missile or projectile with respect to a surface target [37]. (*See also* error probable, circular.)

erythema. An abnormal redness of the skin due to distension of the capillaries with blood. It can be caused by many different agents -- heat, drugs, ultraviolet rays, ionizing radiation [39].

erythrocyte. A red blood corpuscle [39].

esu. Abbreviation for electrostatic units (*see* statcoulomb).

eugenics. The science that deals with the influences that improve the hereditary qualities of a race or breed [39].

eV. Abbreviation for electron volt.

even–even nuclei. Nuclei that contain an even number of protons and an even number of neutrons [32].

even–odd nuclei. Nuclei that contain an even number of protons and an odd number of neutrons [32].

event (*see* shot (nuclear)).

excitation. The addition of energy to a system, thereby transferring it from its ground state to an excited state. Excitation of a nucleus, an atom, or a molecule can result from absorption of photons or from inelastic collisions with other particles [39].

excitation, nuclear. The addition of energy to a nucleus, thereby transferring it from its ground state to an excited state. Excitation of a nucleus can result from absorption of photons or from inelastic collisions with other particles [32]. (*See also* excitation energy.)

excitation curve. In nucleonics, a curve showing the relative yield of a specified nuclear reaction as a function of the energy of incident particles or photons [32].

excitation energy (nuclear). The energy required to change a system from its ground state to an excited state. Each different excited state has a different excitation energy [39]. (*See also* energy–level diagram.)

excitation function (nuclear). The cross section for a specified nuclear reaction expressed as a function of the energy of the incident particle or photon. It is a synonym for excitation curve [32].

excited atom. An atom in which the orbital electrons have been raised to energy levels higher than their normal level [35] (*see also* energy–level diagram).

excited state. A state of a nucleus, atom, or molecule having a higher energy than the ground state energy. A nucleus returns to the ground state through the emission of this excess energy in the form of a photon [4]. (*See also* energy–level diagram.)

exclusion principle, Pauli (*see* Pauli exclusion principle).

exoatmospheric burst, nuclear (*see* burst, types of nuclear).

exoergic. Synonym for exothermic [35].

exothermic. A chemical change in which the reaction liberates heat, and energy is lost; hence, the products of the reaction contain less energy than the original reactants [3].

exploding bridgewire initiator. An electro–explosive initiator that makes use of the intense shock wave generated by an exploding wire to initiate a secondary explosive charge placed in close contact with it [12].

explosion, nuclear. Explosive release of energy due to the splitting, or joining, or atoms. The explosion is observable by a violent emission of ultraviolet, visible, and infrared (heat) radiation, gamma rays, neutrons, and other particles. This is accompanied by the formation of a fireball. A large part of the energy from the explosion is emitted as blast and shock waves when detonated at the earth's surface or in the atmosphere. The fireball produces a mushroom–shaped mass of hot gases and debris, the top of which rises rapidly [50]. The explosion of a nuclear weapon or nuclear device is commonly called a burst, shot, detonation, or event.

exponential decay (*see* decay law, radioactive).

exposure (ionizing radiation). A measure of the ionization produced in air by X- or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The special unit of exposure is the roentgen. Acute exposure is irradiation exposure of short duration. Chronic exposure is irradiation exposure of long duration by fractionation or protraction [39]. (*See also* dose, exposure.)

exposure, radiant (*see* radiant exposure).

exposure, thermal (*see* thermal exposure).

exposure dose (*see* dose, exposure).

exposure rate (ionizing radiation). A measure of the radiation energy available per unit time (the dose rate in air). Exposure rate generally is specified in roentgens per second or roentgens per hour [38].

extinction coefficient. The sum of an absorption coefficient and a scattering coefficient for a particular material and radiation; i.e., the total attenuation coefficient [48].

extranuclear electron (*see* electron, extranuclear).

F–region (*see* ionosphere).

factor. A multiplier, frequently used to indicate range of coverage. For example, "correct within a factor of two" means correct within a possible range of values between twice and one–half the stated value [38]. (*See also* order of magnitude.)

failure threshold. That exposure that changes one or more material (device) properties to such an extent that the material (device) becomes unsuitable for a specified application [38].

fallback. Original material dissociated but not completely removed from the true crater. Upon impact, the fallback and ejecta assist in the development of the hazardous base surge dust cloud [38].

fallout. The precipitation to earth of radioactive particulate matter from a nuclear cloud; also applied to the particulate matter itself [36]. The process or phenomenon of the descent to the earth's surface of particles contaminated with radioactive material from the radioactive cloud. The term is also applied in a collective sense to the contaminated particulate matter itself. The early (or local) fallout is arbitrarily defined as those particles that reach the earth within 24 hours after a nuclear explosion. The delayed (or worldwide) fallout consists of the smaller particles that ascend into the upper troposphere and stratosphere and are carried by winds to all parts of the earth. The delayed fallout is brought to earth, mainly by rain and snow, over extended periods of time ranging from months to years [49]. Special forms of fallout are "dry fallout," "rainout," and "snowout" [39].

fallout, delayed (*see* fallout).

fallout, early (*see* fallout).

fallout, local (*see* fallout).

fallout, militarily significant. Radioactive contamination capable of inflicting radiation doses on personnel that may result in a reduction of their combat effectiveness [36].

fallout contours. Lines joining points which have the same radiation intensity to define a fallout pattern, represented in terms of roentgens per hour [36].

fallout pattern. The distribution of fallout as portrayed by fallout contours [36].

fallout prediction. An estimate, made before and immediately after a nuclear detonation, of the location and intensity of militarily significant quantities of radioactive fallout [36].

fallout safe height of burst. The height of burst at or above which no militarily significant fallout will be reproduced as a result of a nuclear weapon detonation [36] (*see* burst, types of nuclear).

fallout wind vector plot. A wind vector diagram based on the wind structure from the surface of the earth to the highest altitude of interest [36].

false curvature. Curvature of electron tracks in an ionization chamber when no magnetic field is applied. This effect is caused by a large number of scattering collisions between the electrons and gas atoms [4].

family, radioactive (*see* series, radioactive).

fast fission (*see* fission, fast).

fast neutrons (*see* neutrons, fast).

fast neutrons, integral (*see* neutrons, integral fast).

FBM. Abbreviation for fleet ballistic missile.

feather analysis. A technique for the determination of the range in aluminum of the beta particles of a radionuclide by comparison of the absorption curve with the absorption curve of a reference source, usually bismuth–210 (range––501 mg/cm^2) [39].

Fermat's least time principle. The principle that an electromagnetic wave will propagate between two points along the path that requires the least travel time [35].

Fermi age. In reactor theory, the value calculated for the slowing–down area used by the Fermi theory. The term is often synonymous with slowing–down area [32].

Fermi–age model. In nucleonics, a model for the study of the slowing down of neutrons by elastic collisions. It is assumed that the slowing down takes place by a very large number of very small energy changes. Phenomena due to the finite size of the individual energy losses are ignored [32].

Fermi constant. In nucleonics, a universal constant introduced in beta disintegration theory that expresses the strength of the interaction between the transforming nucleon and the electron–neutrino field. Its value lies between 10^{-48} and 10^{-49} $gm/cm^5–sec^{-2}$ [35].

Fermi intercept (*see* scattering length).

Fermi theory. A theory of beta decay that is based upon the implicit concept that electrons are emitted from nuclei as a result of a subnuclear transformation whereby a neutron transforms to a proton or a proton changes to a neutron. Fermi's theory gives the energy distribution of beta particles [4].

fermion. All elementary particles are classed into two groups, fermions and bosons. Two bosons can exist in the same energy state at the same time, but two fermions cannot; this fact is what differentiates between these large groups of particles. Strongly interacting fermions include baryons, which are omega hyperons, cascade hyperons, sigma hyperons, lambda hyperons, and nucleons (protons and neutrons); weakly interacting fermions include the leptons, which are muons, electrons, neutrino–muons, and neutrino–electrons; strongly interacting bosons include the mesons, which are eta–mesons, k–mesons, and pi–mesons; massless bosons are the photons and gravitons [24]. (*See* quantum statistics.)

fertile material. Material, not itself fissionable by thermal neutrons, that can be converted into a fissionable material by irradiation in a reactor. There are two basic

fertile materials, uranium–238 and thorium–232. When these fertile materials capture neutrons, they are partially converted into fissionable plutonium–239 and uranium–233, respectively [29].

FET. Abbreviation for field–effect transistor [44].

Fick's law. In nucleonics, the statement that the neutron diffusion current density is proportional to the negative of the gradient of the neutron density or of the neutron flux density. Fick's law is the basic assumption of the elementary diffusion approximation [32].

field–effect transistor (FET). A transistor that utilizes majority carriers (e.g., MOS) [44].

film badge. A photographic film packet in the form of a badge, to be carried by personnel, for measuring and permanently recording gamma ray dosage [36]. A type of dosimeter.

film ring. A film badge in the form of a finger ring [39]. A type of dosimeter.

filter (radiology). *Primary:* A sheet of material, usually metal, placed in a beam of radiation to absorb preferentially the less penetrating components. *Secondary:* A sheet of material of low atomic number (relative to the primary filter) placed in the filtered beam of radiation to remove characteristic radiation produced by the primary filter [39].

finite differencing. The process of approximately solving a differential equation or set of equations by representing a continuous set of numerical values at discrete points. The exact process of differentiation is approximated by dividing the difference between two values of the dependent variable by the difference between the two corresponding values of the independent variable [45].

fireball. The luminous sphere of hot gases that forms a few millionths of a second after detonation of a nuclear weapon and immediately starts expanding and cooling [36]. The fireball is due to the absorption by the surrounding medium of the thermal X–rays emitted by the extremely hot (several tens of millions degrees) weapon residues. The exterior of the fireball in air is initially sharply defined by the luminous shock front and, after breakaway, by the limits of the hot gases themselves (radiation front) [49].

fire storm. Stationary mass fire, generally in built–up urban areas, generating strong, inrushing winds from all sides; the winds keep the fires from spreading while adding fresh oxygen to increase their intensity [36] (*contrast with* conflagration).

fissile (*see* fissile material).

fissile material. Although the term "fissile material" is sometimes used as a synonym for fissionable material, it has also acquired a more restricted meaning, namely, any material fissionable by neutrons of all energies, from thermal neutrons (slow) to fast neutrons. Examples are uranium–235 and plutonium–239 [29].

fission (nuclear). The process whereby the nucleus of a heavy element splits into (generally) two nuclei of lighter elements, with the release of substantial amounts of energy [36]. Fission is accompanied by the emission of neutrons. Fission can be spontaneous or

it can be caused by the impact of a neutron, a fast charged particle, or a photon. The most important fissionable materials for weapons are uranium–235 and plutonium–239 [38]. (*See also* fission fragments; fission product(s).)

fission, fast. Fission caused by fast neutrons [37].

fission chain. A chain of beta decay processes that originates with a product of fission and results in a stable nucleus. The same mass number is maintained. Nuclei of fission fragments have too high a neutron–to–proton ratio to remain stable. One mode of disintegration that would reduce the ratio to normal is the emission of a neutron. This occasionally occurs, giving rise to the delayed neutrons. The normal process is negative beta emission, which does not change the mass number but increases by one unit the atomic number with each beta particle emitted [4].

fission fraction (*see* fission to yield ratio).

fission fragments. The primary or initial elements formed as the result of a fission reaction. They are of medium atomic weight and are radioactive [37]. (*See also* fission products.)

fission neutrons (*see* neutrons, fission).

fission neutrons, delayed (*see* neutrons, delayed).

fission neutrons, prompt (*see* neutrons, prompt).

fission poisons (*see* poisons, fission).

fission product(s). A general term for the complex mixture of substances produced as a result of nuclear fission [36]. A distinction should be made between these and the direct fission products or fission fragments that are formed by the actual splitting of the heavy element nuclei. The fission fragments, being radioactive, immediately begin to decay, forming additional (daughter) products, which are included in the complex mixture of isotopes that is observed at some time after the fission event [38]. There are approximately 80 different fission fragments and over 300 different fission products [49].

fission product gamma dose (*see* gamma dose, fission product).

fission product radiation (*see* radiation, fission product).

fission spectrum (*see* spectrum, fission).

fission to yield ratio (or fission fraction). Ratio of the yield derived from nuclear fission to the total yield; it is frequently expressed in percent [36]. For thermonuclear weapons the fission fraction averages about 50 percent [49]. (*See also* fission yield.)

fission yield. That portion of the yield that derives its energy entirely from nuclear fission [37]. The percentage of fissions leading to a particular nuclide [39]. (*See also* fission to yield ratio.)

fission yield, independent. The percentage of fissions giving rise to a particular fission product nuclide only by direct formation from fission, not by decay from earlier members of its fission chain. It is also called primary fission yield [32].

fission yield, primary (*see* fission yield, independent).

fission yield curve. A curve that shows the variation of fission yield percentage plotted against the mass number [35]. Typically it has two peaks separated by a trough indicating the lower probability of symmetric fission.

fissionable. Of a nuclide, capable of undergoing fission by any process [39].

fissionable material (*see* source and special (SS) nuclear material).

fissioning distribution. The modified neutron energy spectrum obtained by assigning to each neutron a weight equal to the probability that its next collision will result in fission [32]. This distribution is not to be confused with the fission spectrum [37].

fissions per kilogram. A unit used for fission density. The kinetic energy per fission in uranium–235 is approximately 165 MeV. When multiplied by kinetic energy per fission, one fission per kilogram is equivalent to 6.3 cal/gm in uranium–235 [32].

fixed alpha (*see* alpha, fixed).

flash blindness. Temporary impairment of vision resulting from an intense flash of light. It includes loss of night adaptation and dazzle and may be associated with retinal burns [36]. (*See also* dazzle.)

flash burn. A burn caused by excessive exposures of bare skin to thermal radiation [36]. (*See also* burn, skin.)

flash X–ray (FXR) machine. A laboratory environmental test facility that generates electromagnetic radiation by the bombardment of a target with high–energy electrons [44].

fleet ballistic missile (FBM). Strategic ballistic missile capable of being fired from surfaced or submerged nuclear submarines [37].

fluence. The number of particles or photons or the amount of energy that enters an imaginary sphere of unit cross–sectional area. It is the time–integrated flux [38].

fluence, energy. The sum of the energies, exclusive of rest energies, of all particles passing through a unit cross–sectional area [39]. The concept of energy fluence is "time integral of intensity" [35].

fluence, neutron. The number of neutrons entering an imaginary sphere of unit cross–sectional area. It is equal to the time–integrated neutron flux. It is generally expressed as n/cm^2. If expressed as Nvt, N is the neutron density (n/cm^3) in the beam, v is the average speed (cm/sec), and t is the time duration. The spectrum should be specified with the fluence, e.g., n/cm^2 (fission spectrum) [38].

fluorescence. The emission of light by a material as a result of the absorption of energy from radiation. The term may refer to the radiation emitted, as well as to the emission process [50].

fluorescent screen. A sheet of material coated with a substance (such as calcium tungstate or zinc sulfide) that will emit visible light when irradiated with ionizing radiation [39].

fluorography (photofluorography). Photography of image produced on fluorescent screen by X- or gamma radiation [39].

fluoroscope. A fluorescent screen, suitably mounted with respect to an X-ray tube for ease of observation and protection, used for indirect visualization (by X-rays) of internal organs in the body or internal structures in apparatus or in masses of material [39].

flux. The flow of photons, particles, or energy per unit time through an imaginary sphere of unit cross-sectional area [38] (*see* intensity; *see discussion under* flux density *for clarification*).

flux, integrated neutron. Same as neutron fluence (*see* fluence, neutron).

flux, neutron. The flow of neutrons into an imaginary sphere of unit cross-sectional area. It is generally expressed as $n/cm^2/sec$. If expressed as Nv, N is the neutron density in the beam (n/cm^3), and v is the average speed (cm/sec). The spectrum should be specified with the flux, e.g., $n/cm^2/sec$ (fission spectrum) [38]. Neutron flux is a term used to express the intensity of neutron radiation. In the physical sense, the term neutron flux (or simply flux) is the neutron flux density [32].

flux density. In normal usage flux density is the amount of radiation per unit time passing through a unit area. Under this definition, flux would be the integral of flux density over the cross-sectional area of interest and fluence would be the integral of flux density over time. However, most military references do not define flux density, but rather define flux as the radiation per unit time per unit area, i.e., equivalent to the normal meaning of flux density. In this context, fluence is the time integral of flux and flux is equivalent to intensity.

flux density, energy. The energy of any radiation incident upon or flowing through a unit area, perpendicular to a radiation beam, in unit time [38]. The sum of the energies, exclusive of rest energies, of all particles passing through a unit cross-sectional area per unit time (energy fluence per unit of time) [39]. (*See* intensity; *see discussion under* flux density *for clarification.*)

flux measurement, neutron (*see* neutron flux measurement).

forbidden energy gap. Energy interval between allowed energy bands in a solid, especially between the valence and conduction bands in a semiconductor [52]. The transition between two quantum mechanical states is described by certain selection rules that, in their purest form, state which transitions are "allowed" and which are "forbidden." In reality, forbidden transitions are merely improbable, the finite probability being due to effects present in real systems but not considered in the idealized models used to derive the selection rules [45].

forces, nuclear (physics). Nonelectromagnetic forces between and peculiar to nucleons. They are sometimes called specifically nuclear forces to emphasize that they do not include electrostatic and magnetic forces, even though the latter are operative in nuclei. Nuclear forces are of short range, are predominantly attractive, and are nearly

if not completely, charge independent; that is the neutron–neutron, neutron–proton, and proton–proton specifically nuclear interactions are almost identical in character [35].

form factor, atomic. In the determination of the scattering efficiency of X–radiation by a given crystal atom, the atomic form factor is a factor dependent on the charge density, the wavelength, and the direction and angle of incidence of the X–ray beam. This factor is proportional to the atomic number. It is synonymous with atomic scattering factor [4].

forward bias (*see* bias, forward).

forward resistance (*see* resistance, forward).

forward scattering (*see* scattering, forward).

forward voltage (*see* voltage, forward).

Fourier transform. An integral transform based on the Fourier theory and used where functions of one or more variables are of interest in the study of partial differential equations with constant coefficients [45].

four–shell. A plot of nuclear binding energy per nucleon versus mass number shows a series of peaks (i.e., a greater stability) for nuclides with mass numbers that are multiples of four, at least for light nuclei. This fact is evidence for the alpha particle nucleus model. These most stable nuclei are said to possess a series of closed or completed four–shells; i.e., the addition of two neutrons (with antiparallel spins) and two protons (with antiparallel spins) results in a closed shell structure, in accordance with the Pauli exclusion principle [4].

14–MeV neutrons. High–energy neutrons generated, in large numbers, by the detonation of a thermonuclear (fusion) weapon [44].

fourth power law (*see* Stefan–Boltzmann law).

fractionation. Any phenomenon (other than radioactive decay) that results in a fallout sample being nonrepresentative of the total amount of radioactivity produced by a nuclear explosion. For example, a bomb may produce x atoms of one fission product and y atoms of another. Any fallout sample (airborne or on the ground) for which the ratio of the number of these two products is different from x/y is said to be fractionated [38]. As a result of fractionation, the delayed fallout generally contains relatively more of strontium–90 and cesium–137, which have gaseous precursors, than does the early fallout from a surface burst [49].

fratricide (nuclear weapon). Disablement of a friendly weapon system resulting from a nuclear environment generated by friendly weapons [35].

free air. A region of homogeneous air sufficiently remote from reflecting surfaces or other objects that the characteristics of the direct shock are not modified in any way by reflected shocks or other disturbances arising from scattering objects [37].

free air overpressure (*see* overpressure, free air).

free charge (electronics). The charge carriers that are capable of moving (i.e., those that are not bound to atoms) [38].

free earth measurements. Quantitative determinations of acceleration, velocity, displacement, impulse, and pressure produced in the earth by an explosion, with the measurements made in such a manner that they are not influenced by discontinuities in the ground structure [37].

free field environment. The nuclear environment resulting from a nuclear detonation in the atmosphere or in a vacuum unperturbed by a system or the earth [37].

free field overpressure (*see* overpressure, free air).

Frenkel defect. When a high-energy charged particle or fast neutron penetrates a crystal lattice, atoms are displaced from their lattice positions and come to rest in positions intermediate between two lattice sites. The combination of a lattice vacancy thus produced and the interstitial atom is called a Frenkel defect [4].

frequency. Number of cycles, revolutions, or vibrations completed in a unit of time [39] (*see also* hertz).

frequency, natural. The frequencies of free oscillations in an undamped body [42].

frequency response. The portion of the frequency spectrum of the forcing function that is sensed by a system within specified limits of amplitude error [42].

functional analysis. A detailed study of how system parts work together to perform an overall function, and, in EMP/TREE upset analysis, performed to identify the anomalous response of those parts that may cause upset in their overall system function [53].

functional damage (EMP/TREE). Usually implies permanent damage to equipment and is typified by burnout of a component, destruction of some portion of the system through chain reaction effects, or permanent shutdown of operation [53].

fundamental particle (*see* particle, elementary).

fundamental-particle physics. Fundamental-particle physics is the study of the fundamental particles themselves, as opposed to nuclear physics, in which the primary problem involves forces binding together the nucleus. The major research tool of fundamental-particle physics is the very-high-energy particle accelerator [35].

fusion. The process whereby the nuclei of light elements combine to form the nucleus of a heavier element, with the release of tremendous amounts of energy [36]. The process by which nuclei of light elements, especially the hydrogen isotopes deuterium and tritium, combine to form the nucleus of a heavier element with a substantial exothermic release of energy [38].

fusion, cold. A nuclear fusion reaction catalyzed by mu mesons at liquid hydrogen temperatures [35].

gain (electrical systems). The ratio of output response to input signal. Gain is a measure of amplification [38].

gamete. Either of the two germ cells (sperm or ovum) [39].

gamma curie (*see* curie).

gamma ray(s). High energy electromagnetic radiation emitted from atomic nuclei during a nuclear reaction. Gamma rays and very high energy X-rays differ only in origin. X-rays do not originate from atomic nuclei but are produced in other ways [36]. A gamma ray is a quantum (photon) of electromagnetic radiation emitted by a nucleus, each such photon being emitted as the result of a quantum transition between two energy elevels of the nucleus. Gamma rays have energies usually between 10 keV and 10 MeV, with correspondingly short wavelengths and high frequencies. Gamma rays cause ionization in the body and in all other materials through several processes, the most notable of which are: the photoelectric effect, the Compton effect, and pair production. These three processes lead to the creation of secondary electrons that carry off part or all of an incident gamma's kinetic energy. Gamma rays are very penetrating and are best stopped or shielded against by dense materials such as lead or depleted uranium [32]. The term gamma rays is often modified by an adjective to indicate the source of the rays and when they are created. (*See items below.*)

gamma ray(s), absorption coefficient (*see* gamma ray(s), intensity of).

gamma ray(s), air inelastic. Delayed gamma rays resulting from inelastic scattering of neutrons by atoms of the air.

gamma ray(s), capture. Gamma rays emitted as a result of the capture of a particle by a nucleus [48].

gamma ray(s), delayed. Gamma rays following the prompt gamma pulse. They are arbitrarily terminated at 1 minute after the burst. These gamma rays include air inelastic gamma rays, isomeric gamma rays, nitrogen capture gamma rays, capture gamma rays, and portions of the fission-product gamma rays. (*See also* gamma ray(s), initial.)

gamma ray(s), fission (*see* gamma ray(s), peak prompt).

gamma ray(s), fission product. Gamma rays caused by the radioactive decay of fission products [14]. They comprise part of the initial gamma rays and the residual gamma rays.

gamma ray(s), initial. Artibrarily considered to be those emitted during the first minute after detonation [35]. They include prompt and delayed gamma rays. (*Contrast with* gamma ray(s), residual.)

gamma ray(s), instantaneous (*see* gamma ray(s), prompt).

gamma ray(s), intensity of. The rate at which energy from monoenergetic radiation flows past a unit area at a given location. It is essentially proportional to the exposure dose rate. If a narrow (or collimated) beam of gamma rays of a specific energy, having an intensity of I_0, falls upon a thickness x of a given material, the intensity I_α of the rays that emerge can be represented by the equation

$$I_\alpha = I_o e^{-\alpha x}$$

where is called the linear absorption coefficient. The distance x is usually expressed in centimeters, so that the corresponding units for α are reciprocal centimeters (cm^{-1}). The value of α, for any material and for gamma rays of a specific energy, is proportional to the sum of the Compton, photoelectric, and pair-production effects. It can be seen from the above equation that for a given thickness x of material the intensity or dose I_α of the emerging gamma rays will be less, the larger the value of α. In other words, the linear absorption coefficient is a measure of the shielding ability of a definite thickness (e.g., 1 cm, 1 foot, or other thickness) of any material [2]. Hard gamma refers to relatively high-energy gamma rays, whereas soft gamma refers to less energetic radiations.

gamma ray(s), isomeric. Initial gamma rays created by isomeric decay weapon materials that have been raised to high-energy states during the fission process and which decay to their normal energy state by emitting one or more gamma rays.

gamma ray(s), nitrogen capture. Initial gamma rays created from neutron capture by nitrogen atoms in the atmosphere.

gamma ray(s), peak prompt. Gamma radiation generated during the fission and fusion processes. The total number of gamma photons released during this phase (approximately 1 sec) is small compared with the quantities generated by scattering and capture of neutrons and by decay of fission products. However, the very short delivery time gives rise to extremely high dose rates [14]. (*See also* gamma ray(s), prompt.)

gamma ray(s), prompt. Gamma rays produced in fission and fusion reactions (peak prompt gamma) and as a result of nuclear excitation of the weapon materials [38] (*see also* radiation, prompt).

gamma ray(s), residual. Gamma rays emitted after 1 minute following a nuclear detonation [35] (*contrast with* gamma ray(s), initial).

gamma-ray constant, specific. For a nuclide emitting gamma radiation, the product of exposure rate at a given distance from a point source of that nuclide and the square of that distance divided by the activity of the source, neglecting attenuation [39]. Specific gamma-ray constant should be used instead of specific gamma-ray emission, which was used formerly. This focuses attention on the constancy of the quotient of the exposure rate at a given distance divided by the activity of a given nuclide, rather than on the emission of the source [5].

gamma-ray dose rate. The energy deposited by gamma rays while passing through a medium. It is usually given as the dose per gram of a reference material, either carbon or air. It is measured in rads/sec [13].

gamma-ray emission unit. As recommended by the International Commission on Radiological Units (1953), the unit for gamma-ray emission of a radioactive material is expressed in roentgens per hour per millicure at 1 cm from the source. Owing to the impossibility of making accurate measurements at a distance of 1 cm, the RHM value, i.e., roentgens per hour per curie at 1 meter, is more common [5].

gas constant. The constant in the ideal gas equation relating the pressure P, volume V, the number of moles of gas present n, and temperature T. It is equal to 8.3×10^7 ergs/(gm-mole-^oK). A synonym is universal gas constant [35].

Gaussian (or Normal) distribution. Distribution that describes the deviations of repeated movements from the mean value and applies in many experimental situations. It has the characteristics that positive and negative deviations are equally likely and small deviations are much more likely than large ones. Often called Normal distribution [48].

Geiger counter. Common name of the Geiger–Müller counter, a radiation detection and measuring instrument [29].

Geiger formula. The formula that relates the range of alpha particles and their initial velocity in air, given by $u^2 = ar$, where r is the range of the alpha particles from their starting point to a point where the probability of producing ionization is zero, u is the initial velocity of the particles, and a is a constant depending on the temperature and atmospheric pressure of the air. The formula is applicable to alpha particles from any source provided their range is between 3 and 7 cm [4].

gene. Fundamental unit of inheritance, which determines and controls hereditarily transmissible characteristics. Genes are arranged linearly at definite loci on chromosomes [39].

generation time (nuclear). Mean time for neutrons produced by one fission to produce subsequent fissions in a chain reaction (*which see*) [29].

genetic effect. The effect of various agents (including nuclear radiation) in producing changes (mutations) in the hereditary components (genes) of the germ cells present in the reproductive organs (gonads). A mutant gene causes changes, which may or may not be apparent, in the next generation [49]. On the basis of present knowledge these effects are purely additive; there is no recovery [39].

genetics. The branch of biology dealing with the phenomena of heredity and variation [39].

genotype. The fundamental hereditary (genetic) constitution of an organism [39].

geomagnetic field. The earth's magnetic field [40].

geometric attenuation (*see* attenuation, geometric).

geometric cross section (*see* cross section, geometric).

geometry, good. In nuclear physics measurements, an arrangement of source and detecting equipment such that the use of finite source size and finite detector aperture introduces little error [39].

geometry, nuclear The configuration of the nuclear material in a nuclear weapon [37].

geometry factor. The fraction of the total solid angle about the source of radiation that is subtended by the face of the sensitive volume of a detector [39].

geometry, poor. In a nuclear experiment, an arrangement in which the angular aperture between the source and detector is large, introducing into the measurement a comparative large uncertainty for which a correction may be necessary [39].

germ cell (*see* cell).

GeV. Abbreviation for giga–electron volt. It is equal to 10^9 electron volts, or one beV. This expression is used widely in Europe to describe particle accelerator energies [35]. (*See* giga.)

giga. A prefix such that the unit formed from use of this prefix with a basic unit is 10^9 times the basic unit. Thus, one gigahertz is one billion (U.S.) hertz. The term is internationally accepted and used widely in Europe, but has gained slow acceptance in the United States [35].

glory hole (*see* beam hole).

gonad. A gamete–producing organ in animals; testis or ovary [39].

gram atomic weight. A mass in grams numerically equal to the atomic weight of an element [39].

gram equivalent. Ratio of gram atomic weight of an element to its valence. Multivalent elements have a different gram equivalent for each valence [35].

gram–mole (*see* gram molecular weight).

gram molecular weight (gram–mole, or mole). Mass in grams numerically equal to the molecular weight of a substance [39].

gram–rad. Unit of measure of total energy absorbed. It is the product of the mass of an object irradiated and the energy absorbed per unit mass. 1 gram–rad = 100 ergs [18].

gray (Gy). A recently introduced ICRP term for absorbed radiation dose; 1 gray equals 100 rads [50].

ground loop. An interconnection of ground paths that results in the formation of a closed loop. This loop may act as an antenna to couple electromagnetic signals into equipment through the ground connection. This occurs especially at the higher frequencies when the inductance of the ground system results in a high impedance between the ground loop antenna and true ground [53].

ground motion. A general term that includes all aspects of motions of the ground, e.g., accelerations, particle velocity, displacement, stress and strain [37]. (*See also* airblast–induced ground direct motion; airblast–induced ground transmitted motion; waves (ground motion), types of.)

ground range. Distance along the surface of the ground from ground zero to the point of interest [51] (*see also* slant range *for distinction*).

ground state. The state of a nucleus, atom, or molecule at its lowest energy. All other states are "excited" [39]. To go from the ground state to an excited state requires the absorption of energy. A nucleus can go from an excited state to the ground state through emission of a photon or gamma ray. At atom or molecule can go from an excited state to the ground state through the emission of longer–wavelength electromagnetic radiation [35].

ground visibility (*see* visibility, ground).

ground waves. Waves formed in the ground by the blast from an explosion. These waves are of three types: longitudinal waves (compression), transverse waves (shear), and surface waves (similar to water rippling). (*See under* waves (ground motion), types of.) Sometimes referred to as seismic waves or stress waves. Stress waves in soil are not classical shock waves since dissipative and dispersive effects tend to increase markedly the rise time to the order of milliseconds [37]. (*See also* airblast–induced ground transmitted motion.)

ground zero (GZ). The point on the surface of the earth at, or vertically below or above, the center of a planned (desired ground zero, DGZ) or actual (actual ground zero, AGZ) nuclear detonation [36]. The point on the surface of land or water vertically below or above the center of a burst of a nuclear weapon; also called surface zero [38]. (*See also* zero point.)

ground zero, actual (AGZ) (*see* ground zero).

ground zero, desired (DGZ) (*see* ground zero).

growth curve, nuclear. An activity curve in which the radioactivity of a given type increases with time, or that portion of an activity curve showing such an increase. Also, a theoretical or experimental curve showing, as a function of time, the number of atoms (or the mass, or the activity) of a nuclide being produced in a radioactive transformation, or in an induced nuclear reaction [32]. (*See also* decay law, radioactive.)

gun–type weapon. A device in which two or more pieces of fissionable material, each less than a critical mass, are brought together very rapidly so as to form a supercritical mass that can explode as the result of a rapidly expanding fission chain [36].

gust loading. The loading on an aircraft in flight associated with the dynamic pressure in an air shock wave [37].

GZ. Abbreviation for ground zero.

H–bomb. Abbreviation for hydrogen bomb (*see* weapon, nuclear).

H–field (*see* magnetic field).

h–hour. Time zero, or time of detonation. When used in connection with planning operations it is the specific hour at which the operation event commences [50]. (*See* D–day.)

h, Dirac (*see* Dirac h).

half–life. The time required for the activity of a given radioactive species to decrease to half of its initial value due to radioactive decay. The half–life is a characteristic property of each radioactive species and is independent of its amount or condition [36]. (*See also* decay law, radioactive; half–life, effective.)

half–life, biological. The time required for the body to eliminate one–half of an administered dosage of any substance by regular processes of elimination. Approximately the same for both stable and radioactive isotopes of a particular element [39]. This does not include radioactive decay effects. (*See also* half–life, effective.)

half–life, effective. The time in which a given quantity of an isotope in the body will decrease to half as a result of both radioactive decay and biological elimination [36].

$$\text{Effective half–life} = \frac{\text{Biological half–life} \times \text{radioactive half–life}}{\text{Biological half–life} + \text{radioactive half–life}}$$

half–residence time. As applied to delayed fallout, the time required for the amount of weapon debris deposited in a particular part of the atmosphere [e.g., stratosphere or troposphere] to decrease to half of its initial value [49].

half thickness. Thickness of absorbing material necessary to reduce by one–half the intensity of radiation that passes through it [36]. Apparently a synonym for half–value thickness.

half–value layer. Synonym for half–value thickness.

half–value thickness. The thickness of a given material that will absorb half the gamma radiation incident upon it. This thickness depends on the nature of the material––it is roughly inversely proportional to its density––and also on the energy of the gamma rays [49]. Apparently a synonym for half thickness.

Hall effect. The development of a voltage in a liquid or solid conductor in a magnetic field [46].

hard. When referring to radiations the term indicates the more energetic or penetrating radiations of a given type, e.g., hard X–rays. (In general, the shorter the wavelength the harder the radiation.) When referring to a facility or system, the term indicates the facility or system is resistant to nuclear weapon effects.

hardening. The process of decreasing vulnerability to a nuclear explosion by design [38] (*see also* hardness, balanced).

hardened site. A site constructed to provide protection against the effects of conventional and nuclear explosions. It may also be equipped to provide protection against a chemical or biological attack [36].

hard missile base. A launching base that is protected against a nuclear explosion [36].

hardness. A measure of the ability of a system to perform its defined function after exposure to one or more of the effects of either nuclear or nonnuclear weapons [53].

hardness, balanced. That condition in which a system is hardened to *(a)* the various environmental constituents at levels corresponding to a single distance from a nuclear weapon burst [44]; or *(b)* a set of criteria so that no one effect is dominant over a range of threat yields [53].

hardness assessment (EMP). The determination of whether and to what degree an existing system, subsystem, or circuit can survive a specified threat without permanent damage or operational upset. This determination may be on an absolute basis, in which the minimum level of field strength, or voltage, etc. is determined, above which the system, subsystem, or circuit is expected to experience unacceptable damage or upset. Alternatively, it may be on a relative basis, in which it is determined whether a specified source level will cause unacceptable damage or upset [53].

hardness assurance (EMP). The procedures, controls, and tests applied during procurement, design, and production to insure that a system has a response to nuclear radiation that is within specified limits [53].

- System hardness assurance. The procedures applied during the production phase to insure the production line end product is in accordance with the hardened design and in compliance with the nuclear specifications.
- Piece part hardness assurance. The procedures, controls, and tests used to insure that a purchased part has a response to nuclear-induced stresses that is within specified limits.

hardness criteria (EMP). The characterization of the EMP field, power, energy, voltage, or current that could be imposed on a system, subsystem, element, or piece part by the specified threat definition(s) [53].

hardness maintenance. The combination of inspection, test, repair, and logistic activities accomplished during the operational phase of a hardened system to insure the hardness built into the system is retained throughout the system lifetime [53].

hardness surveillance. Those long-term inspection and test procedures beyond hardness maintenance that are conducted to assure that systems are in fact being properly maintained with the desired hardness [53].

hardness verification. The determination through a careful sequence of test and analysis that a system design is in fact hardened in compliance with the nuclear specifications [53].

HE. Abbreviation for high-explosive.

health, radiological. The art and science of protecting human beings from injury by radiation, and promoting better health through beneficial applications of radiation [39].

health physics. A science and profession devoted to the protection of man and his environment from unnecessary radiation exposure [39].

heat, atomic. The thermal capacity of one gram-atom. It is equivalent to the product of the atomic mass and the specific heat [35].

heavy hydrogen. Usually a synonym for deuterium (*see also* tritium).

heavy meson (*see* meson).

heavy water (*see* water, heavy).

height, safe burst. The height of burst at or above which the level of fallout, or damage to ground installations, is at a predetermined level acceptable to the military commander [36].

height of burst (HOB). The vertical distance from the earth's surface or target to the point of burst [36]. The height above the surface of the earth at which a weapon is burst. Altitude, by contrast, is the height above mean sea level [38].

height of burst, optimum. For nuclear weapons, the optimum height of burst for a particular target (or area) is that at which it is estimated a weapon of a specified energy yield will produce a certain desired effect over the maximum possible area [36]. (*See also* burst, types of nuclear.)

height of burst, scaled (SHOB). For a particular detonation the comparable height of burst for a 1-kiloton weapon. It is usually expressed as some function of the yield, and is determined by dividing the actual height of burst by the appropriate function of the yield [18].

Heisenberg uncertainty principle. A postulate of quantum mechanics that asserts that in the simultaneous determination of the values of any two canonically conjugate variables, the product of the smallest possible uncertainties in their values is of the order of magnitude of the Dirac h [32].

HEMP. Acronym for high-altitude EMP (*see* EMP, high-altitude).

HERO. Acronym for hazards of electromagnetic radiation to ordnance.

hertz (Hz). Standard unit of frequency equal to 1 cycle per second.

HEST. Acronym for high-explosive simulation technique.

high airburst (*see* burst, types of nuclear).

high altitude. Conventionally, an altitude above 10,000 meters (33,000 feet) [36] (*see* high-altitude burst *under* burst, types of nuclear, *for distinction*).

high altitude burst (*see* burst, types of nuclear).

high-energy physics (*see* particle physics).

high explosive (HE). An explosive that, when used in its normal manner, detonates rather than deflagrates or burns; that is, the rate of advance of the reaction zone into the

unreacted material exceeds the velocity of sound in the unreacted material [37] (*see also* low explosive).

high–Z. Expression to indicate a material of high atomic number, i.e., relatively heavy and therefore a good X–ray shield.

histogram. The common bar graph. It represents graphically the distribution of a set of objects with respect to some variable [35].

HOB. Abbreviation for height of burst [44].

hodograph. A common hodograph in meteorology represents the speed and direction of winds at different altitude increments [50]. It can be used to illustrate the paths of fallout in terms of a radioactive particle of specified size as these paths vary with the winds aloft and weapon yield.

hohlraum. A cavity whose walls are in radiative equilibrium with radiant energy within the cavity, i.e., a blackbody [47].

hold–back carrier. The inactive isotope or isotopes of a radioactive element, or an element of similar properties, or some reagent that may be used to diminish the amount of the radionuclide coprecipitated or absorbed in a chemical reaction [39].

hole. With reference to electronic valence, structure of a semiconductor that acts as a positive electronic charge with a positive mass [38].

horizontal error (*see* error, horizontal).

hot. A colloquial term meaning highly radioactive [37].

hot cell. A heavily shielded enclosure for handling and processing (by remote means or automatically) or storing highly radioactive materials [39].

hot spot. Region in a contaminated area in which the level of radioactive contamination is considerably greater than in neighboring regions in the area [36].

hot X–rays (*see* X–rays).

human nuclear tolerance (*see* dose, tolerance).

hydrogen bomb (*see under* weapon, nuclear).

hypergolic material. A material that is self–igniting upon contact of its components and requires no external initiating device. Hypergolic materials are sometimes referred to as rocket fuels [12].

hyperon. One of a class of baryons, heavier than nucleons (the constituents of atomic nuclei). There are several kinds of hyperons: omega hyperons, cascade hyperons (or xi hyperons), sigma hyperons, and lambda hyperons. In other words, the different hyperons are four of the subclasses of baryons [24]. All hyperons are unstable and yield a nucleon as a decay product [29]. The modes of decay of hyperons indicate that they are excited nucleons that transform into the normal nucleons by pion (π meson) emission.

Hyperons can take the place of nucleons in excited nuclear fragments called hyper-fragments [4].

hypersonic. Of, or pertaining to, speeds equal to or in excess of five times the speed of sound [36] (*see* sound, speed of).

hypocenter. A term sometimes used for ground zero [49].

Hz. Abbreviation for hertz.

ICBM. Abbreviation for intercontinental ballistic missile.

ICRP. Abbreviation for International Commission on Radiological Protection.

ideal gas. An ideal gas is a gas (not existing in nature) that obeys Boyle's law, $PV = nR_0T_0$, where P is the pressure, V the volume, T_0 the absolute temperature, n the number of moles of gas present, and R_0 the ideal gas constant equal to 8.3×10^7 ergs/gm-mole-^oK). Boyle's law is also called the ideal gas law. A synonym for ideal gas is perfect gas [35]. (*See also* Boltzmann constant.)

ideal shock wave (*see* shock wave).

IEMP. Abbreviation for internal EMP (*see* EMP, internal).

imagery. Collectively, the representations of objects reproduced electronically or by optical means on film, electronic display devices, or other media [36].

immediate radiation (*see* radiation, initial (nuclear)).

impact ionization (*see* ionization, impact).

impact parameter. In elastic scattering, the perpendicular distance from the initial position of the scattering center to the initial line of motion of the scattered particle. In general, in any nuclear reaction it is the perpendicular distance from the target nucleus to the initial line of motion of the incident particle [32].

impact polarization (*see* polarization, impact).

impedance (electrical). The total opposing force to current flow, a factor of energy dissipation [38].

implosion weapon. A device in which a quantity of fissionable material, less than a critical mass, has its volume suddenly decreased by compression so that it becomes supercritical and an explosion can take place. The compression is achieved by means of a spherical arrangement of specially fabricated shapes of ordinary high explosive that produce an inwardly directed implosion wave, the fissionable material being at the center of the sphere [36].

importance function. A measure of the importance to the chain reaction in a nuclear reactor of a neutron at a given position and with a given velocity. The relative importance of two types of neutrons, A and B, is given by the number of neutrons of type A that must be supplied to make up for the removal of one neutron of type B, the process being so carried out that the level of the chain reaction is not affected. The iterated fission expectation is a particular normalization of the importance function [32].

impulse. The product of the average force and the time during which it acts at a given point, or the integral of the curve representing variation of force with time, with integration over the time of interest. In considering the effectiveness of a shock wave in producing damage, it is generally more convenient to employ the concepts of overpressure impulse and dynamic pressure impulse. The overpressure impulse of the positive phase of a blast wave is the integral of the curve representing the variation of overpressure with time, the integration being performed from the time of arrival of

the shock front at a given location to the end of the positive phase at that location. The dynamic pressure impulse is a similar integral of the dynamic pressure–time curve [38].

incapacitation (personnel). The inability to perform a required task as the result of a physical or mental disability [37] (*see also* incapacitation, early transient; incapacitation, permanent complete).

incapacitation, early transient (personnel). A temporary inability of a person to perform a required task properly. Onset is shortly after exposure to insult or stress. The incapacitation will be followed by partial or complete recovery of performance ability (the recovery may also be temporary) [37].

incapacitation, permanent complete (personnel). The inability to perform any task as the result of a physical or mental disability that will not improve subsequently [37].

incidence, angle of. The angle between the perpendicular to a surface and the direction of propagation of a wave [38].

incident, nuclear. An unexpected event involving a nuclear weapon, facility, or component, resulting in any of the following, but not constituting a nuclear weapon(s) accident: *(a)* an increase in the possibility of explosion or radioactive contamination; *(b)* errors committed in the assembly, testing, loading, or transportation of equipment, and/or the malfunctioning of equipment and materiel that could lead to an unintentional operation of all or part of the weapon arming and/or firing sequence, or that could lead to a substantial change in yield, or increased dud probability; and *(c)* any act of God, unfavorable environment or condition resulting in damage to the weapon, facility, or component [36]. (*See also* accident, nuclear weapon(s); bent spear.)

independent fission yield (*see* fission yield, independent).

independent particle nucleus model (*see* nucleus model, independent particle).

indirectly ionizing particle(s) (*see* ionizing particle(s), indirectly).

induced radiation (*see* radiation, induced).

induced radioactivity (*see* radioactivity, induced).

induced shock wave (*see* shock wave, induced).

ineffective (*see* combat ineffective).

inelastic collision (*see* collision).

inelastic collisions, mean free path of (*see* mean free path).

inelastic scattering (*see* scattering, inelastic).

inertial guidance. A guidance system designed to project a missile over a predetermined path, wherein the path of the missile is adjusted after launching by devices wholly within the missile and independent of outside information. The system measures and converts accelerations experienced to distance traveled in a certain direction [36].

infinite dose (*see* dose, infinite integrated).

infrared. The band of electromagnetic wavelengths lying between the extreme of the visible and the shortest microwaves (approximately 0.75 to 1,000 microns). The infrared region is sometimes subdivided as follows: near infrared--0.75 to 3 microns, middle infrared--3 to 30 microns, and far infrared--30 to about 1,000 microns [48].

initial gamma rays (*see* gamma ray(s), initial).

initial radiation (nuclear) (*see* radiation, initial (nuclear)).

initiator (nuclear). An item used in a nuclear system to produce a burst of neutrons [37].

initiation (nuclear). The action that sets off a chain reaction in a fissile mass that has reached the critical state (generally by the emission of a "spurt" of neutrons) [36].

inner bremsstrahlung (*see* bremsstrahlung, inner).

insertable nuclear component weapon (*see under* weapon, nuclear).

inner quantum number (*see* quantum number, inner).

in situ. In its natural or original position, e.g., in situ soil samples.

integral fast neutrons (*see* neutrons, integral fast).

integrated neutron flux (*see* fluence, neutron).

intensity. The amount of energy of any radiation incident upon (or flowing through) unit area, perpendicular to the radiation beam, in unit time. The intensity of thermal radiation is generally expressed in calories per square centimeter per second falling on a given surface at any specified instant. As applied to nuclear radiation, the term intensity is sometimes used, rather loosely, to express the exposure (or dose) rate at a given location [49].

intensity, radiation. The radiation dose rate at a given time and place. It may be used, coupled with a figure, to denote the radiation intensity for a given number of hours after a nuclear burst, e.g., RI3 is the radiation intensity 3 hours after the time of burst [36].

interaction and coupling (EMP). The overall energy transfer process by which EMP fields penetrate and produce effects within a system [53].

intermediate neutrons (*see* neutrons, intermediate).

internal conversion (*see* conversion, internal).

internal EMP (*see* EMP, internal).

internal pair formation (*see* pair formation, internal).

internal radiation (*see* radiation, internal).

interstitial. An atom of a crystalline material located at some point other than a normal lattice position. Interstitials are created during the displacement process [38]. (*See also* displacement.)

inverse electron capture (*see* capture, inverse electron).

inverse nuclear reactions. Two nuclear reactions in which the products of one are the interaction members of the other. Examples are the reactions $Al^{27}(p,\alpha)Mg^{24}$ and $Mg^{24}(\alpha,p)Al^{27}$. The cross sections for the two reactions are inversely related; and if one is exothermic, the other is endothermic [4].

inverse square law. The law that states that when radiation, such as thermal or nuclear, from a point source is emitted uniformly in all directions, the amount received per unit area at any given distance from the source, assuming no absorption, is inversely proportional to the square of that distance, and only because of geometric spreading of the radiation [49].

inversion (atmospheric). A region in the lower atmosphere in which the temperature rises with increasing altitude instead of dropping, as it usually does [38].

ion. Atomic particle, atom, or chemical radical bearing an electrical charge, either negative or positive [39].

ion density (*see* ionization density).

ion exchange. A chemical process involving the reversible interchange of ions between a solution and a particular solid material such as an ion exchange resin consisting of a matrix of insoluble material interspersed with fixed ions of opposite charge [39].

ionization. The process of producing ions by the removal of electrons from, or the addition of electrons to, atoms or molecules [36]. The separation of a normally electrically neutral atom or molecule into electrically charged components. The term is also employed to describe the degree of extent to which this separation occurs. In the sense used generally, ionization refers especially to the removal of an electron (negative charge) from the atom or molecule, either directly or indirectly, leaving a positively charged ion. The separated electron and ion are referred to as an ion pair [49]. (*See other topics under* ionization; ionizing.)

ionization, impact. The loss of orbital electrons by an atom of a crystal lattice that has undergone a knock-on collision [4].

ionization, minimum. The smallest possible value of the specific ionization that a charged partical can produce in passing through a particular substance. It occurs for particles of velocity 0.95c (where c is the velocity of light), which corresponds to kinetic energies of about 1 MeV for an electron, 300 MeV for a pi meson, 2 GeV for a proton, and 8 GeV for an alpha particle. If the specific ionization produced along the path of the charged particle is plotted as a function of the particle energy, minimum ionization reveals itself as a broad dip, bounded on one side by a rather sharp rise for decreasing particle energy, and on the other by a gradual rise for increasing particle energy. As compared with this curve, the curve for stopping power versus particle energy has about the same shape up to the point of minimum ionization, but then rises more rapidly with increasing particle energy because of the occurrence of additional energy

loss by bremsstrahlung. For singly charged particles in ordinary air, the minimum ionization is about 50 ion pairs per centimeter of path. In general, it is proportional to the density of the medium and to the square of the charge of the particle [32].

ionization, primary. In collision theory, it is the ionization produced by the primary particles as contrasted to the "total ionization," which includes the "secondary ionization" produced by delta rays. In counter tubes, it is the total ionization produced by incident radiation without gas amplification [39].

ionization, secondary. Ionization produced by delta rays [39].

ionization, specific. Number of ion pairs per unit length of path of ionization radiation in a medium, e.g., per centimeter of air or per micron of tissue [39].

ionization, total. The total electric charge on the ions of one sign produced by radiation in the process of losing its kinetic energy. For a given gas, the total ionization is closely proportional to the initial energy and is nearly independent of the nature of the ionizing radiation. It is frequently used as a measure of radiation energy [39]. Also, the total number of ion pairs produced by an ionizing particle along its entire path [48].

ionization chamber. An instrument designed to measure a quantity of ionizing radiation in terms of the charge of electricity associated with ions produced within a defined volume [39].

ionization density. Number of ion pairs per unit volume [39].

ionization path (or track). The trail of ion pairs produced by an ionizing particle in its passage through matter [39].

ionization path, mean free (*see* mean free path).

ionization potential (*see* binding energy, electron).

ionizing energy. The average energy lost by an ionizing particle in production of an ion pair in a gas. It is slightly different for each type of particle, each particle energy, and each gas; although for air, electrons, protons, and alpha particles possess values lying between 32 eV and 35.6 eV [32]. The accepted value as of 1957 (International Commission on Radiological Units and Measurements) is 34 eV for medium energy electrons in air. A synonym is energy lost per ion pair. Thus, since all the kinetic energy of a gamma photon is ultimately lost through ionization (if the medium is large enough) the number of ion pairs produced will be approximately the photon energy in eV divided by 34 [35].

ionizing event. Any occurrence of a process in which an ion or group of ions is produced [39].

ionizing particle(s), directly. Charged particles, such as electrons, protons, and alpha particles, that directly produce ion pairs in their passage through a substance. They have considerably greater kinetic energy than the ionizing energy appropriate to the medium [32]. Thus, the term does not refer to neutrons or gamma photons, although in the latter case some primary ionization occurs [35]. (See also ionizing particle(s), indirectly.)

ionizing particle(s), indirectly. Uncharged particles, such as neutrons and photons, that can liberate directly ionizing particles or initiate a nuclear transformation [5] (*see also* ionizing particle(s), directly).

ionizing radiation (*see* radiation, ionizing).

ionizing radiation scattering (*see* scattering).

ionosonde. A high-frequency radio utilizing an antenna that concentrates the radiation directly above the installation [6].

ionosphere. That part of the atmosphere, extending from about 70 to 500 kilometers, in which ions and free electrons exist in sufficient quantities to reflect electromagnetic waves [36]. That part of the atmosphere where ions and electrons are present in quantities sufficient to affect the propagation of radio waves. The ionosphere is categorized into D-region, E-region, and F-region at altitudes of approximately 40 to 90, 90 to 160, and above 160 km, respectively [38].

ion pair. Two particles of opposite charge, usually referring to the electron and positive atomic or molecular residue resulting after the interaction of ionizing radiation with the orbital electrons of atoms [39]. (*See also* ionization.)

I_{pp}. Symbol for primary photocurrent.

IR. Abbreviation for infrared.

irradiance. *1.* The incident thermal energy per unit time per unit area. The unit of irradiance is cal/cm^2/sec [38]. *2.* The radiant fluence on a receiver surface, expressed in watts/cm^2 [40].

irradiation. Exposure of matter to radiation [50].

isobar (nuclear). Any one of the several nuclides having the same number of nucleons in their nuclei but different combinations of protons and neutrons, and hence having approximately the same atomic mass but different atomic numbers [35].

isobaric. Constant pressure condition [38].

isobaric spin quantum number (*see* quantum number, isobaric spin).

isodamage curve. A plot of the radius of effect versus height of burst for a given weapon yield, target, and degree of damage [37].

isodiaphere. Any one of several different nuclides having the same difference between the number of neutrons and protons in their nuclei [32] (*see also* isotone(s); isotope(s)).

isodose lines. Dose or dose-rate contours. In fallout, contours plotted on a radiation field within which the dose rate or the total accumulated dose is the same [50]. (*See also* contour method.)

isodose rate line (*see* contour method; dose rate contour line).

isointensity contour (*see* contour method; dose rate contour line).

isomer(s). Nuclides having the same number of neutrons and protons but capable of existing, for a measurable time, in different quantum states with different energies and radioactive properties [39]. The state of lowest energy is the ground state. Those of higher energies are metastable states. The isomer of higher energy often decays to one with lower energy by the process of isomeric transition [32].

isomorphous substances. Substances that form crystals of similar shape [1].

isotone(s). Nuclides having the same number of neutrons in their nuclei but differing in number of protons [39] (*compare with* isomer(s); isotope(s)).

isotope(s). Forms of the same element having identical chemical properties but differing *a.* in their atomic masses due to different numbers of neutrons in their respective nuclei and *b.* in their nuclear properties [36]. For example, hydrogen has three isotopes with masses of 1 unit for hydrogen, 2 units for deuterium, and 3 units for tritium. The first two of these are stable or nonradioactive, but the third, tritium, is a radioactive isotope. Both of the common isotopes of uranium, uranium–235 and uranium–238, are radioactive, emitting alpha particles, but their half–lives are different. Furthermore, uranium–235 is fissionable by neutrons of all energies, but uranium–238 will undergo fission only with neutrons of high energy [49]. The term isotope should not be used as a synonym for nuclide [39]. (*Compare with* isomer(s); isotone(s).)

isotope dilution analysis. A method of chemical analysis for a component of a mixture, based on the addition to the mixture of a known amount of labeled component of known specific activity, followed by isolation of a quantity of the component and measurement of the specific activity of that sample [39].

isotope separation. Process in which a mixture of isotopes of an element is separated into its component isotopes, or in which the abundance of isotopes in such a mixture is changed [39].

isotropy. The degree of spherical symmetry in the direction of travel of particles or photons [12].

jerk. A unit of energy equal to 10^{16} ergs [35].

jitter effect. Instability of the signal on a radar indicator [38].

j–j coupling. Coupling in which the interaction is primarily between orbital and spin angular momenta of the same particle. The orbital angular momentum (ℓ) and the spin angular momentum (s) combine to form the total angular momentum (j) for the particle. The total angular momentum (j) of a system of particles (e.g., an atom) is the sum of the j values of the several particles. The s values of the different particles and the ℓ values of the different particles do not couple together; thus, there is no L or S quantum number of the system as defined under Russell–Saunders coupling [4]. (*See also* shell structure of the atom.)

JNACC. Abbreviation for joint nuclear accident coordinating center.

joint nuclear accident coordinating center (JNACC). A combined Defense Nuclear Agency and Department of Energy centralized agency for exchanging and maintaining information concerned with radiological assistance capabilities and coordinating assistance activities, when called upon, in connection with accidents involving radioactive materials [36].

joule. The unit for work and energy, equal to 1 newton expended along a distance of 1 meter [39].

K–. Prefix referring to the innermost (K) electron shell of an atom, or an electron of that shell (*see* shell structure of the atom).

K–capture (*see* capture, electron).

K–electron (*see* shell structure of the atom).

K–electron capture (*see* capture, electron).

K–shell (*see* shell structure of the atom).

kappa meson (*see* meson).

Kelvin scale. The absolute temperature scale for which the zero is $-273^{\circ}C$. Conversion from centigrade to Kelvin is made by adding 273 to the centigrade reading [38].

kerma. The sum of the initial kinetic energies of all charged particles liberated by indirectly ionizing particles in a volume, divided by the mass of matter in that volume [39]. The sum of the kinetic energies includes not only the kinetic energy these charged particles expend in collision, but also the energy they radiate in bremsstrahlung. The energy of any charged particle is also included when this energy is produced in secondary processes occurring within the volume element. Thus, the energy of Auger electrons is part of this energy [5].

kerma rate. The rate of change of kerma with respect to time [5].

kernel. A known function occurring in an integral equation [48].

kernel, diffusion. A kernel used in the integral equation to define total flux at a point due to sources (e.g., neutrons) either distributed in space individually or in a line, plane, concentric sphere, etc. The form of the kernel depends on the geometry [4].

kernel, slowing–down. A generalization of diffusion kernels in which the slowing–down density from a distributed source is expressed in terms of slowing–down kernels, which represent the probability that a neutron will go from one position to another while slowing down through a specified energy range [48].

keV. Abbreviation for kilo–electron volts [25].

kill probability. A measure of the probability of destroying a target [36].

kiloton (energy) (KT). Defined strictly as 10^{12} calories (or 4.2×10^{19} ergs). This is approximately the amount of energy that would be released by the explosion of 1 kiloton (1,000 tons) of TNT [49]. (KT refers to yield, whereas kt is the normal metric convenfor 1,000 tons of weight.) (*See also* TNT equivalent.)

kiloton weapon. A nuclear weapon, the yield of which is measured in terms of thousands of tons of trinitrotoluene [TNT] explosive equivalents, producing yields from 1 to 999 kilotons [36] (*see also* nominal weapon; subkiloton weapon).

kinetic energy. The energy possessed by a mass because of its motion [39].

kinetic energy, relativistic. The kinetic energy of a relativistic particle [32].

Klein–Nishina formula. A formula that expresses the cross section of an unbound electron for scattering of a photon in the Compton effect, as a function of energy of the photon. The term usually refers to the integral Klein–Nishina formula, which gives the total cross section for the process. The differential Klein–Nishina formula gives the differential cross section for scattering at a given angle. Because of the confidence with which photon–electron interactions can be interpreted (by using the Klein–Nishina formula), the Compton effect is important in the analysis of energy and polarization of gamma rays from many sources [39].

K/L ratio. The ratio of the number of internal conversion electrons from the K–shell to the number of internal conversion electrons from the L–shell, emitted in the deexcitation of a nucleus [32].

knock–on atom. "Knock–on" is a term used when an atom or particle in a solid recoils after collision with an energetic particle, such as a neutron, fission fragment, ion, or atom moving through the solid. The knocked–on atom or particle may be displaced from its lattice position and may possess sufficient energy to displace other atoms or particles [12].

knot. A nautical mile per hour, equal to 1.1516 statute miles/hour [35].

kT cross section (*see* cross section, kT).

L–. Prefix referring to the second (L) electron shell of an atom, or an electron of that shell (*see* shell structure of the atom).

L–capture. A synonym for L–electron capture, the latter term being preferred [32] (*see* capture, electron).

L–electron (*see* shell structure of the atom).

L–electron capture (*see* capture, electron).

L–meson (*see* meson).

L–particle (*see* meson).

L–shell (*see* shell structure of the atom).

labeled compound. A compound consisting, in part, of labeled molecules. By observations of radioactivity or isotopic composition, this compound or its fragments may be followed through physical, chemical, or biological processes [39].

labeled molecule. A molecule containing one or more atoms distinguished by nonnatural isotopic composition (with radioactive or stable isotopes) [39].

lambda particle (*see* hyperon).

Lambert's absorption law (Bouguer law). A law relating to the absorption of electromagnetic radiation in passing through homogeneous materials. If I_o is the original radiant intensity, and I_α the intensity after passing through a thickness x of the material whose absorption coefficient is α, Lambert's law states that $I_\alpha = I_o e^{-x}$ [4]. (*See also* extinction coefficient.)

Larmor radius. The radius of a circle in which an electron of constant energy would turn due to a perpendicular constant magnetic field [45].

laser. Acronym for light amplification by stimulated emission of radiation. The laser region is that portion of the spectrum that includes ultraviolet, visible light, and infrared [39].

latchup. Regenerative device action in transistors or circuits in which an undesired stable condition is attained [38]. An undesirable, stable mode of circuit operation that, once initiated, can only be altered by the removal of external power [53]. (*See also* saturation, circuit.)

latent neutrons (*see* neutrons, latent).

latent period. The period or state of seeming inactivity between the time of exposure of tissue to an injurious agent and response [39].

lattice. The pattern defined by an orderly crystalline structure in a material [38].

launcher. A structural device designed to support and hold a missile in position for firing [36].

launching site. Any site or installation with the capability of launching missiles from surface to air or surface to surface [36].

laydown (weapon). A weapon employment concept that requires weapon survival upon ground impact following release from low-flying delivery aircraft and delayed fuzing and firing of the weapon in order to permit safe escape of the aircraft [37].

LD_{50} (radiation dose). Abbreviation for median lethal dose (*see* dose, median lethal).

LE. Abbreviation for low explosive.

lead equivalent. The thickness of lead affording the same attenuation, under specified conditions, as the material in question [39].

leakage current. An undesirable reverse current across a semiconductor junction [38].

lens charge. One of a series of explosive charges comprising the outer layer of the HE sphere of an implosion weapon, used to generate a spherical implosion shock wave [37].

lepton. One of a class of light elementary particles (having small mass). Specifically, an electron, a positron, a neutrino, an antineutrino, a muon, or an antimuon [39]. (*See also* baryon, meson.)

lesion. A hurt, wound, or local degeneration [39].

LET. Abbreviation for linear energy transfer.

lethal dose (*see* dose, lethal).

lethal gust envelope. The boundary of the area in any given plane within which the gust-loading effects from an explosion inflict sufficient structural damage to destroy a given aircraft [37].

lethal nuclear environment. Any quantitative definition of the minimum level of a nuclear environment that results in sure kill of the target [37]. (*See also* environment, nuclear; sure-kill level.)

lethal time, median (*see* median lethal time).

lethargy (neutrons). The lethargy of a neutron is defined as

$$e^{(E_i/E)}$$

where E_i is the initial energy of the neutron, and E is its energy at any given point in the slowing-down process [4].

leukemia. A disease in which there is great overproduction of white blood cells, or a relative overproduction of immature white cells, and great enlargement of the spleen. The disease is variable, at times running a more chronic course in adults than in children. It can be produced in some animals by long-continued exposure to low doses of ionizing radiation [39].

light meson (*see* meson).

limited war (*see* war, limited).

linac. Acronym for linear accelerator.

linear. The relationship existing between two quantities such that the change in one quantity is exactly and directly proportional to the change in the other quantity. The quantities and ranges involved must be clearly specified [42].

linear absorption coefficient (*see* absorption coefficient).

linear accelerator (linac). A device for accelerating charged particles. It employs alternate electrodes and gaps arranged in a straight line, so proportioned that when potentials are varied in the proper amplitude and frequency, particles passing through the waveguide receive successive increments of energy [39].

linear circuit. An electronic circuit in which voltages and currents can be continuously variable [38].

linear energy transfer (LET). The measure of the ability of biological material to absorb ionizing radiation. It is the average radiation energy per unit length locally imparted to the medium (or biological material) by a charged particle of specified energy [29]. The term "locally imparted" may refer either to a maximum distance from the track of the particle, beyond which losses are no longer considered local, or to a maximum value of discrete energy loss by the particle, beyond which losses are no longer considered local. In either case the limits chosen (i.e., the maximum distance or maximum value of discrete energy) should be specified. The concept of linear energy transfer is different from that of stopping power. The former refers to energy imparted within a limited volume; the latter refers to loss of energy regardless of where that energy is absorbed [35].

linear stopping power (*see* stopping power).

line of sight, electronic. The path traversed by electromagnetic waves that is not subject to reflection or refraction by the atmosphere [36].

lip height. The height above the original surface to which earth is piled around the crater formed by an explosion [49].

liquid drop nucleus model (*see* nucleus model, liquid drop).

L/M ratio. The ratio of the number of internal conversion electrons from the L-shell to the number from the M-shell, emitted per unit time in the deexcitation of a nucleus [32] (*see also* K/L ratio).

loading (physics). The forces imposed upon an object [38].

local (or early) fallout (*see* fallout).

localization, selective (biology). Accumulation of a particular nuclide to a significantly greater degree in certain cells or tissues [39] (*see also* absorption ratio, differential).

local war. Obsolete term for limited war (*see* war, limited).

lock on. Signifies that a tracking or target-seeking system is continuously and automatically tracking a target in one or more coordinates (e.g., range, bearing, elevation) [36].

logarithmic energy decrement per collision (average) of a neutron (*see* lethargy).

logic circuit. An electronic circuit in which voltages and currents assume discrete, quantized values [44].

longitudinal wave (*see under* waves (ground motion), types of).

loop (electrical). A closed path or circuit over which an electric signal can circulate [38].

lossy devices. Devices that convert portions of the input energy into heat, which is lost to the surrounding medium [53].

lossy field coupling. Coupling of an electromagnetic field into an electrical system so that part of the energy is lost due to radiation [53] (*see also* coupling).

Love waves (*see under* waves (ground motion), types of).

low airburst (*see* burst, types of nuclear).

low explosive (LE). An explosive that, when used in its normal manner, deflagrates or burns rather than detonates [37] (*contrast with* high explosive).

low-Z. Expression for a material having a low atomic number, i.e., one that is relatively light and therefore one in which X-rays will deposit relatively little energy (*contrast with* high-Z).

L-S coupling (*see* Russell-Saunders coupling).

luminescence. Emission of light produced by the action of biological or chemical processes or by radiation, or any other cause except high temperature, which produces incandescence [29].

lumped parameter. A single constant that is electrically equivalent to the total of that type of distributed constant existing in a coil or circuit [46].

M–. Prefix referring to the third (M) electron shell of an atom, or an electron of that shell (*see* shell structure of the atom).

M–electron (*see* shell structure of the atom).

M–shell (*see* shell structure of the atom).

Mach front (*see* Mach stem).

Mach number. The ratio of the velocity of a body to that of sound in the surrounding medium [36].

Mach reflection (*see* Mach stem).

Mach region (*see* Mach stem).

Mach stem. The shock front formed by the fusion of the incident and reflected shock fronts from an explosion. The term is generally used with reference to a blast wave, propagated in the air, reflected at the surface of the earth. In the ideal case, the Mach stem is perpendicular to the reflecting surface and slightly convex (forward). Also called Mach front [36]. (Or Mach region and the process is often termed Mach reflection). (*See also* triple point.)

Mach wave (*see* Mach stem).

mache unit. An uncommon unit of radioactivity equivalent to 3.6×10^{10} curie [35].

macroscopic cross section (*see* cross section).

macroscopic slowing–down power (*see* lethargy; slowing–down power).

magic nuclei. Nuclei in which the number of protons or neutrons (or both) correspond to a magic number(s) (*which see*). Such nuclei do not follow the general rules of gamma emission, as the filled nuclear shells reduce the possible number of unfilled energy levels and hence limit the number of possible transitions. Thus, magic nuclei resemble light nuclei with the first level approximately 1 MeV above the ground–state level and with the levels widely spaced [4].

magic number(s). One of a group of integers corresponding to the observation that a nuclide having its number of protons and/or neutrons equal to one of these integers has greater–than–average stability and also may possess other exceptional properties, e.g., higher binding energies. Some of the so–called magic numbers are 2, 8, 14, 20, 28, 50, 82, and 126 [32]. (*See also* magic nuclei.)

magnetic conjugate points (*see* conjugate points).

magnetic coupling. Energy departed to (or voltage induced in) a loop of finite area due to a change in flux linkages within the loop [38].

magnetic field (H–field). The magnetic component of an electromagnetic wave. Also the field produced by a current in a wire, loop, antenna, etc. Also the field produced by a magnetic material. The magnitude of the magnetic field vector (H) is magnetic field strength measured in amperes/meter [53].

magnetic moment (particle). Measure of magnetizing force that is usually associated with the intrinsic spin and orbital motion, if any, of an elementary particle or atomic system.

magneton (*see* Bohr magneton).

magnitude, order of (*see* order of magnitude).

Maienschein spectrum. Experimentally measured energy spectra from fission process of nuclear weapons. Named for F. Maienschein [45].

majority carrier. In semiconductors, the type of carrier that constitutes more than half the total number of carriers. The majority carriers are electrons in an N-type semiconductor and holes in a P-type semiconductor [38].

major nuclear power (*see* nuclear power).

MaRV. Acronym for maneuverable reentry vehicle.

Marx generator. A high-voltage generator or pulser that charges a bank of capacitors in parallel and discharges them in series [53].

mass. The material equivalent of energy, different from weight in that it neither increases or decreases with gravitational force [39]. The mass on a body is defined by Newton's second law of motion, F = ma, where F is the force acting on a body, m is its mass, and a is acceleration. In other words, the mass of a body is that property that determines the acceleration that body will have when it is acted on by a force. If the velocity u of a body approaches the speed of light c, the restricted theory of relativity states that the mass then increases; that is

$$m = m_o(1 - u^2/c^2)^{-1/2}$$

where m_o is the rest mass of the body. Rest mass of a body is the mass at zero velocity [35].

mass, atomic. The mass of a neutral atom of a nuclide, usually expressed in terms of "atomic mass units" [39]. The atomic weight of any element is approximately equal to the total number of protons and neutrons in its nucleus [29].

mass absorption coefficient (*see* attenuation coefficient, mass).

mass attenuation coefficient (*see* attenuation coefficient, mass).

mass attenuation coefficient, pair-production (*see* attenuation coefficient, mass).

mass defect. Differences between the mass of a nuclide and the mass number of the nuclide [48] (*see also* binding energy, nuclear).

mass-energy absorption coefficient (*see* absorption coefficient, mass-energy).

mass-energy equation (*see* mass-energy equivalence).

mass-energy equivalence. The mass-energy equivalence or mass-energy equation is the statement developed by Albert Einstein that the mass of a body is a measure of its

energy content. This is an extension of his 1905 restricted (or special) theory of relativity. The statement was subsequently verified experimentally by measurements of mass and energy in nuclear reactions. The equation, usually shown as $E = mc^2$, shows that when the energy of a body changes by an amount, E (no matter what form the energy takes), the mass m of a body will change by an amount equal to E/c^2. The constant c is the speed of light in a vacuum; hence c^2 may be regarded as the conversion factor relating units of mass and energy. This equation predicted the possibility of releasing enormous amounts of energy by the conversion of mass to energy [29].

mass–energy relation (*see* mass–energy equivalence).

mass–energy transfer coefficient. The linear energy transfer coefficient of a material for indirectly ionizing particles divided by the density of the material [35].

mass equation, relativistic (*see* mass–energy equivalence).

mass formula, empirical. A mass formula of Bohr and Wheeler, which has less theoretical foundation than the semiempirical mass formula but greater freedom for adjustment to fit empirical data [32].

mass number. The number of nucleons (protons and neutrons) in the nucleus of an atom [39].

mass stopping power (*see* stopping power).

matter. Any physical entity that possesses mass [35].

maximum credible accident. The worst accident in a reactor or nuclear energy installation that, by agreement, need be taken into account in devising protection measures [39].

maximum permissible dose (*see* dose, maximum permissible).

maximum permissible concentration (*see* concentration guide, radioactivity).

mean free path. The average distance that particles of a specified type (including photons) travel before a specified type (or types) of interaction occurs in a given medium. The mean free path may thus be specified for all interactions (i.e., total mean free path) or for particular types of interaction such as scattering, capture or ionization [39]. In each case $\lambda_k = 1/N\sigma_k$), where k is a subscript to indicate the process, N is the number of particles or nuclei per cubic centimeter, and σ_k is the cross section for the specified process under consideration [32]. When considering photons, or quanta of energy, as opposed to neutrons, which are particles with mass, the mean free path is defined as the reciprocal of the linear attenuation coefficient of the material that the photons are traversing. Mean free path is also called mean path length or relaxation length [7].

mean free path, transport. Where Fick's law is applicable, transport mean free path is three times the diffusion coefficient of neutron flux. Transport mean free path is also defined as a modified mean free path used to correct for the persistence of velocities and anisotropy of scattering [32]. (*See also* diffusion equation.)

mean lethal dose (*see* dose, median lethal).

mean life (nuclear). The average time during which a given type of atom, nucleus, subatomic particle, or photon exists in a particular form. Examples are the mean life of mesons before undergoing transformation; of diffusion neutrons before being captured; of excited nuclei or atoms before losing their energy of excitation; and of atoms of a radionuclide before undergoing radioactive transformation. For a radionuclide, the mean life is the reciprocal of the disintegration constant [32].

mean path length (*see* mean free path).

median lethal dose (*see* dose, median lethal).

median lethal time. Median lethal time is the time required, following administration of a specified dose of radiation, for death of 50 percent of the individuals in a large group of animals or organisms [32].

megaton weapon. A nuclear weapon, the yield of which is measured in terms of millions of tons of trinitrotoluene [TNT] explosive equivalents [36].

mesic. A mesic atom or molecule is one in which a meson has become temporarily attached to the nucleus of the atom, or of one of the atoms of the molecule [4] (*see also* fusion, cold).

meson. One of a class of medium-mass, short-lived elementary particles with a mass between that of the electron and that of the proton [39]. Mesons are classified as mu mesons (muons), pi mesons (pions), or K-mesons (kaons) and may have electron charge units of −1, 0, or +1. All of the known mesons are unstable. The mu mesons and the pi mesons are commonly referred to as light mesons, or L-particles, with rest masses of 200 to 300 amu and the K-mesons are referred to as heavy mesons, or K-particles, with rest masses of approximately 967 amu. Light mesons result from the decay of heavy mesons on coming to rest and also from the split-up of atomic nuclei. They are rarely absorbed by atomic nuclei. Heavy mesons result from the split-up of atomic nuclei, and they are present also in cosmic radiation. K-mesons react strongly with matter and decay into lighter mesons when coming to rest [34].

meson, heavy (K-meson) (*see* meson).

meson, light (L-meson) (*see* meson).

meson theory. The meson theory of nuclear forces, due originally to M. Yukawa, postulates the existence of a particle, now called a meson, the exchange of which between two nucleons is responsible for the force between them. These mesons may be positive, negative, or neutral, and are presumed to be identical with pi mesons [32]. (*See also* meson.)

metabolism. The sum of all physical and chemical processes by which living organized substance is produced and maintained and by which energy is made available for the use of the organism [39].

metal-oxide-semiconductor (MOS) transistor. A field-effect transistor consisting of a silicon chip, a silicon oxide, and a metal contact [38].

metastable state. An excited nuclear state having a half-life long enough to be observed [39].

metastatic electron (*see* electron, metastatic).

meteorological data. Meteorological facts pertaining to the atmosphere, such as wind, temperature, air density, and other phenomena that affect military operations [36].

method of moments (*see* moments, method of).

MeV. Abbreviation for mega electron volt; unit of energy commonly used in nuclear physics, equal to one million electron volts (eV). Approximately 200 MeV of energy are produced for every nucleus that undergoes fission [35].

MHD. Abbreviation for magnetohydrodynamics.

micron (μ). A synonym for micrometer, i.e., 10^{-6} meter.

microscopic cross section (*see* cross section, microscopic).

migration area. One-sixth the mean square distance that a neutron travels from its birth in fission until its absorption in a medium that is assumed to be of infinite extent [32]. (*See also* diffusion length.)

migration length. The square root of the migration area [32].

militarily significant fallout (*see* fallout, militarily significant).

military nuclear power (*see* nuclear power).

minimum ionization (*see* ionization, minimum).

minimum residual radioactivity weapon (*see under* weapon, nuclear).

minimum normal burst altitude (*see* altitude, minimum normal burst).

minimum safe distance (nuclear). The sum of the radius of safety and the buffer distance [36].

minimum warning time (nuclear). The sum of system reaction time and personnel reaction time [36].

minority carrier. The type of carrier that constitutes less than half the total number of carriers in a semiconductor. The minority carriers are holes in an N-type semiconductor and electrons in a P-type semiconductor [38].

minority-carrier lifetime. The time period starting with the creation of a minority carrier and ending with its being recombined [38].

Minuteman. A three-stage, solid-propellant ballistic missile that is guided to its target by an all-inertial guidance and control system. The missiles are equipped with nuclear warheads and designed for deployment in hardened and dispersed underground silos. With the improved third stage and the post-boost vehicle, the Minuteman III missile can deliver multiple independently targetable reentry vehicles and their penetration aids to multiple targets. Designated as LGM-30 [36].

mirror point. A point at which a charged particle, moving in a spiral path along the lines of a magnetic field, is reflected back as it enters a stronger magnetic field region. The actual location of the mirror point depends on the direction and energy of motion of the charged particle and the ratio of the magnetic field strengths. As a result, only those particles satisfying the requirements of the existing situation are reflected [49].

MIRV. Acronym for multiple independently targetable reentry vehicle.

mission critical. A designation given to a system, subsystem, component, etc. that must function within certain limits in order for the overall system, of which it is a part, to perform its mission [53].

mission profile. The sequence of events followed by a system in the performance of its mission [44].

MKSA electromagnetic system of units. An absolute system of units based on the meter, kilogram, and second. It is extended to the electrical units by the measurement of current by its magnetic effect, and the measurement of potential difference by the power per unit current. The mechanical units of the system are developed by means of the usual equations of mechanics, where unity is used as the proportionality factor in each equation, and a new unit of force, the newton, is used [35].

MLD. Abbreviation for median lethal dose (*see* dose, median lethal).

mobility (electronics). The ease with which carriers move through a semiconductor either through random motion or when they are subjected to electric forces [38].

moderate risk (nuclear) (*see* risk, moderate (nuclear)).

moderation (*see* slowing down).

moderator. Material used to moderate or slow down neutrons from the high energies at which they are released [39].

molar volume (*see* molecular volume).

mole (*see* gram molecular weight).

molecular stopping power (*see* stopping power).

molecular (or molar) volume. Volume occupied by one mole of a gas. It is numerically equal to the molecular weight of a gas divided by its density. For any gas this is 22.414 liters at standard temperature and pressure. The number of individual molecules present in a molecular volume, which is the same for all gases, is called the Avogadro number or Avogadro's constant [35].

molecular weight. The sum of the atomic weights of all the atoms in a molecule [39] (*see also* gram molecular weight).

molecule. Smallest quantity of a compound that can exist by itself and retain all properties of the original substance [39].

moments, method of. Method used to obtain numerical solutions of the Boltzmann transport equation. The distribution of particles from a point source may be expanded as functions or moments of distance from the source, angle, and energy. Enough terms are taken in the expansion to give the desired accuracy. The method of moments is used to solve problems in gamma transport and neutron transport [35].

momentum. A vector of the motion of the mass of a body. Momentum is measured by the product of mass and velocity, even at relativistic velocities. The momentum of a photon is Planck's constant divided by the wavelength of the photon in centimeters [35]. (*See also* de Broglie relation.)

monatomic gas. A gas that, in its natural state, consists of single atoms; thus, the atoms may be correctly described as molecules [35].

monitoring (radiological). The procedure or operation of locating and measuring radioactive contamination by means of survey instruments that can detect and measure (as dose rates) ionizing radiations. The individual performing the operations is called a monitor [49].

monochromatic radiation. Electromagnetic radiation of a single wavelength, or radiation in which all the photons have the same energy [39].

monoenergetic radiation. Radiation of a given type (alpha, beta, neutron, gamma, etc.) in which all particles or photons originate with and have the same energy [39].

Monte Carlo method. A method of solution of a group of physical problems by means of a series of statistical experiments that are performed by applying mathematical operations to random numbers [38]. It can provide numerical solutions to a variety of problems, including neutron transport and gamma transport. The results of the Monte Carlo method for neutron and gamma problems give the distribution of the radiations as a function of distance from a given source, energy, angle, and time. It can also predict secondary radiation produced by the initial neutrons or gammas as a function of distance, energy, angle, and time. The assumptions in the Monte Carlo method for neutron or gamma problems are: (a) the processes involved are completely random and (b) all processes and their probabilities of occurrence are known. In order to solve such a problem an initial geometry must be assumed. An initial energy and an initial direction (angle) for a particle at the source is randomly chosen. The particle is followed until it has a collision. The collision itself and the nature of the collision, such as scattering or absorption, are determined at random. The distance from the source and the time, as well as the energy and the angle, at this point in space are noted. The particle acquires a new energy and a new direction, which are also randomly determined. This process is continued for this particle until some predetermined limits, usually on the energy of distance from the source, are reached. Then another particle is chosen at the source, and the whole process is repeated. In this way, histories of many particles are built up until there are sufficient statistics to provide a numerical solution to the problem [35].

MOS. Acronym for metal–oxide–semiconductor [38].

Mott scattering (*see* scattering formula, Mott).

mound. The roughly hemispherical upwelling of water appearing after a deep underwater high-explosive test if the bubble arrives at the surface intact, but with no appreciable oscillation [43].

MRV. Abbreviation for multiple reentry vehicle.

multiplication constant (or factor). The ratio of the number of neutrons present in a reactor at a given time to the number present one finite lifetime earlier. The multiplication constant minus one is called the excess multiplication constant. (Without changing the value of this ratio, it can be applied either to neutrons of one given energy, or to all neutrons.) If this ratio is one, a steady chain reaction proceeds; if less, the reaction will die out; if greater, the reactor is increasing its reactivity [32].

multiplying chain reaction (*see* chain reaction).

muon. Synonym for mu meson (*see* meson).

muonium. A term applied to a bound system consisting of a positive mu meson and an electron [4].

mutation. Alteration of the usual hereditary pattern, usually sudden [39].

N–. Prefix referring to the fourth (N) electron shell of an atom, or an electron of that shell (*see* shell structure of the atom).

N–electron (*see* shell structure of the atom).

N–shell (*see* shell structure of the atom).

N–type. Semiconductor material that has had certain impurities added so that there are excess electrons available for conduction, i.e., whose majority carriers are electrons [38].

N–unit. That quantity of neutron radation measured in a condenser R–meter that will produce the same amount of ionization as 1 roentgen of X–rays [39].

nano. A prefix (symbol n) such that the unit formed from the use of this prefix with a basic unit is 10^{-9} times the basic unit. Thus, 1 nanosecond is 10^{-9} second [35].

natural frequency (*see* frequency, natural).

natural radiation (*see* radiation, background).

natural radioactivity (*see* radiation, background).

nautical mile. A measure of distance equal to one minute of arc on the earth's surface. The United States has adopted the international nautical mile equal to 1,852 meters or 6,076.11549 feet [36].

negative phase (of a shock wave). The period during which the pressure falls below ambient and then returns to the ambient value [36] (*see also* positive phase).

negatron. Name sometimes given to negatively charged electrons, as opposed to positrons [35]. (*see* electron).

negligible risk (nuclear) (*see* risk, negligible (nuclear)).

neoplasm. A new growth of cells, which is more or less unrestrained and not governed by the usual limitations of normal reproduction. *Benign*: some degree of growth restraint and no spread to distant parts. *Malignant:* growth invades tissues or spreads to distant parts, or both [39].

net (communications). An organization of stations capable of direct communications on a common channel or frequency [36].

neutrino. A neutral particle of very small rest mass originally postulated to account for the continuous distribution of energy among particles in the beta–decay process [39]. Because of its properties, the neutrino has negligible interactions with matter. The symbol ν is often used for the neutrino [32].

neutron. An electrically neutral elementary particle of approximately unit mass (i.e., the mass of a proton) that is present in all atomic nuclei, except those of ordinary (light) hydrogen. Neutrons are required to initiate the fission process, and large numbers of neutrons are produced by both fission and fusion reactions in nuclear explosions [50].

The term neutron is often modified by an adjective to roughly indicate the energy range. Care must be used since these energy ranges can overlap and have changed in the past.

neutrons, delayed. The somewhat less than 1 percent of the fission neutrons that are emitted after the (99 percent) prompt neutrons [2]. Delayed neutron emission is possible only if the excitation energy of the product nucleus exceeds the neutron binding energy for that nucleus. The chemistry of the delayed neutron emitter is that of the beta activity [32].

neutrons, epicadmium. Neutrons with energies above the cadmium cutoff of approximately 0.4 eV [35].

neutrons, epithermal. Neutrons with energies just above those of thermal neutrons, i.e., between a few hundredths eV and about 100 eV [48].

neutrons, fast. Typically, neutrons with energy exceeding 10 keV (this energy threshold has not been standardized) [38]. (Other references give considerably higher thresholds.)

neutrons, fission. Neutrons emitted as a result of nuclear fission. Prompt fission neutrons are those that are emitted during fissions. Delayed fission neutrons are those emitted by fission products [32].

neutrons, integral fast. Neutrons with energy greater than 4,000 eV [22].

neutrons, intermediate. Neutrons with energy in the range of 100 to 100,000 eV [48].

neutrons, latent. In nuclear reactor theory, latent neutrons is a term that has been applied to those radioactive fission products that give rise to the delayed neutrons. In calculating reactivities, these are of great importance. At any given time, the neutron density is thus mathematically a function of the number of fissions occurring and the density of latent neutrons (i.e., the density of fission-product nuclei of a type that will shortly emit delayed neutrons) [4].

neutrons, prompt. Neutrons generated by the fission and fusion reactions of a nuclear weapon burst [38]. All of the neutrons produced from the fusion process and over 99 percent of the fission neutrons are produced almost immediately, probably within less than a microsecond after the initiation of the explosion [2]. (*See also* neutrons, delayed.)

neutrons, resonance. For a specified nuclide or element, neutrons that have energies in the region where the cross section of the nuclide or element is particularly large because of the occurrence of a resonance [32]. This energy range is roughly from 1 to 10,000 eV.

neutrons, slow. Neutrons having kinetic energies from thermal energy to about 100 eV [48]. The expression "slow neutrons" is sometimes erroneously used as a synonym for thermal neutrons, which are much less energetic [32].

neutrons, thermal. Neutrons in thermal equilibrium with their surroundings. At room temperature their mean energy is about 0.025 eV [38].

neutron binding energy (*see* binding energy, neutron).

neutron capture (*see* capture, neutron).

neutron cross section (*see* cross section).

neutron density. The number of neutrons per unit volume. Partial densities may be defined for neutrons characterized by such parameters as speed and direction [32].

neutron excess. The number of neutrons in a nucleus in excess of the number of protons [32].

neutron fission cross section (*see* cross section, neutron fission).

neutron fluence (*see* fluence, neutron).

neutron flux, integrated (*see* fluence, neutron).

neutron flux measurement. The measurement of the number and energy of neutrons that pass into surrounding media during a nuclear detonation [15].

neutron generator. A pulsed reaction source of the ion-accelerated type [37].

neutron-induced activity. Radioactivity induced in the ground or an object as a result of direct irradiation by neutrons [36] (*see also* radioactivity, induced).

neutron magnetic moment (*see* magnetic moment).

neutron number. The number of neutrons in a nucleus, equal to the difference between the mass number and the atomic number. When it is desired to indicate explicitly the neutron number in the symbol of a nuclide, the number is added as a subscript following the element symbol; thus, $_{26}Fe^{59}_{33}$ has 33 neutrons [34].

neutron radiative capture (*see* capture, neutron radiative).

Nevada Test Site (NTS). The continental area for the conduct of nuclear tests, under the control of the Department of Energy (formerly AEC), located northwest of Las Vegas, Nevada, within the boundaries of the Las Vegas Bombing and Gunnery Range, formerly called the Nevada Proving Ground (NPG) [37].

nitrogen capture gamma rays (*see* gamma ray(s), nitrogen capture).

nominal weapon. A nuclear weapon producing a yield of approximately 20 kilotons [36]. This is very approximately the energy yield of the bombs exploded over Japan and in the Bikini tests of 1946 [49]. (*See also* kiloton weapon; subkiloton weapon.)

non-ideal shock wave (*see* shock wave, non-ideal).

nonlinear zone (watershock). A wedge-shaped zone in water, which increases as the range from the burst point increases, and within which anomalous reflections affect the underwater pressure history [38].

nonsustaining chain reaction (*see* chain reaction).

Normal distribution (*see* Gaussian distribution).

normal uranium (*see* uranium, normal).

Nth country. A reference to additions to the group of powers possessing nuclear weapons —the next country of a series of acquire nuclear capabilities [36].

nuclear airburst (*see under* burst, types of nuclear).

nuclear battery. A nuclear (or atomic) battery or radioisotopic generator is a small power generator that converts the heat released during radioactive decay directly into electricity. These generators generally produce only a few watts of electricity and use thermoelectric or thermoionic converters. Some also function as electrostatic converters to produce a small voltage [29].

nuclear binding energy (*see* binding energy, nuclear).

nuclear bomb (*see* bomb, nuclear).

nuclear bonus effects (*see* bonus effects, nuclear).

nuclear burst (*see* burst, types of nuclear).

nuclear collateral damage (*see* collateral damage, nuclear).

nuclear column (*see* column, nuclear).

nuclear compound (*see* compound, nuclear).

nuclear damage (*see* damage, nuclear).

nuclear danger coefficient (*see* danger coefficient, nuclear).

nuclear defense (*see* defense, nuclear).

nuclear detonation (*see* detonation, nuclear).

nuclear detonation detection and reporting system (NUDETS). A system deployed to provide surveillance coverage of critical friendly target areas and indicate place, height of burst, yield, and ground zero of nuclear detonations [36].

nuclear disintegration (*see* disintegration).

nuclear disintegration energy (*see* dinsintegration energy).

nuclear efficiency (*see* efficiency, nuclear).

nuclear energy (*see* energy, nuclear).

nuclear energy level (*see* energy level, nuclear).

nuclear environment (*see* environment, nuclear).

nuclear excitation (*see* excitation, nuclear).

nuclear excitation function (*see* excitation function (nuclear)).

nuclear exoatmospheric burst (*see under* burst, types of nuclear).

nuclear explosion (*see* explosion, nuclear).

nuclear fission (*see* fission).

nuclear forces (*see* forces, nuclear).

nuclear fusion (*see* fusion).

nuclear generation time (*see* generation time (nuclear)).

nuclear geometry (*see* geometry, nuclear).

nuclear ground state (*see* ground state).

nuclear growth curve (*see* growth curve, nuclear).

nuclear incident (*see* incident, nuclear).

nuclear isomer (*see* isomer).

nuclear magneton (*see* Bohr magneton).

nuclear mean life (*see* mean life (nuclear)).

nuclear nations. Military nuclear powers and civil nuclear powers [36] (*see also* nuclear power).

nuclear number (*see* mass number).

nuclear parity (*see* parity, nuclear).

nuclear particle (*see* particle, nuclear).

nuclear photodisintegration (*see* photodisintegration, nuclear).

nuclear potential energy (*see* potential energy, nuclear).

nuclear potential scattering (*see* scattering potential).

nuclear power. Not to be used without appropriate modifier. A *civil nuclear power* is a nation that has potential to employ nuclear technology for development of nuclear weapons but has deliberately decided against doing so. A *major nuclear power* is any nation that possesses a nuclear striking force capable of posing a serious threat to

every other nation. A *military nuclear power* is a nation that has nuclear weapons and the capability for their employment [36]. (*See also* nuclear nations.)

nuclear radiation (*see* radiation, nuclear).

nuclear radiation, initial (*see* radiation, initial (nuclear)).

nuclear radiation, residual (*see* radiation, residual).

nuclear radiation environment (*see* environment, nuclear radiation).

nuclear radiation yield (*see* yield, nuclear radiation).

nuclear reactions, inverse (*see* inverse nuclear reactions).

nuclear reactor (*see* reactor, nuclear).

nuclear resonance scattering (*see* scattering, resonance).

nuclear shot (*see* shot (nuclear)).

nuclear stability odd–even rule (*see* odd–even rule, nuclear stability).

nuclear surface burst (*see under* burst, types of nuclear).

nuclear survivability (*see* survivability).

nuclear survivability level (*see* survivability level, nuclear).

nuclear test (*see* test, nuclear).

nuclear transmutation (*see* transmutation, nuclear).

nuclear underground burst (*see under* burst, types of nuclear).

nuclear underwater burst (*see under* burst, types of nuclear).

nuclear vulnerability (*see* vulnerability, nuclear).

nuclear warfare (*see* warfare, nuclear).

nuclear warhead (*see* warhead).

nuclear weapon (*see* weapon, nuclear).

nuclear weapon accident (*see* accident, nuclear weapon(s)).

nuclear weapon deficiency (*see* deficiency, nuclear weapon).

nuclear weapon degradation (*see* degradation, nuclear weapon).

nuclear weapon incident (*see* incident, nuclear).

nuclear weapon surety (*see* surety, nuclear weapon).

nuclear yield (*see* yield).

nuclei, even–even (*see* even–even nuclei).

nuclei, even–odd (*see* even–odd nuclei).

nucleon. The common name for a constituent particle of the atomic nucleus. It is applied to protons and neutrons, but it is intended to include any other particle that is found to exist in the nucleus [36].

nucleon number. Synonym for mass number [32].

nucleus (nuclear). The small, central, positively charged region of an atom, which carries essentially all the mass. Except for the nucleus of ordinary light hydrogen, which is a single proton, all atomic nuclei contain both protons and neutrons. The number of protons determines the total positive charge, or atomic number: this is the same for all the atomic nuclei of a given chemical element. The total number of neutrons and protons, called the mass number, is closely related to the mass or weight of the atom. The nuclei of isotopes of a given element contain the same number of protons, but different numbers of neutrons. They thus have the same atomic number, and so are the same element, but they have different mass numbers and masses. The nuclear properties, e.g., radioactivity, fission, neutron capture, etc., of an isotope of a given element are determined by both the number of neutrons and the number of protons [49].

nucleus, compound. Of the neutrons produced in fission a large number are inevitably captured by nonfissionable nuclei. As a result of neutron capture, the nucleus is converted into a new species known as a "compound nucleus," which is in a high–energy (or excited) state. The excess energy may then be emitted, almost instantaneously, as gamma radiations [2].

nucleus, recoil (*see* recoil nucleus).

nucleus model, independent particle. A nuclear model based on the postulate that each nucleon moves independently in the field corresponding to the average positions of the rest of the nucleons. When supplemented with other postulates, including the Pauli exclusion principle and the existence of strong spin–orbit coupling, this model has been quite successful in explaining many empirical features of nuclei, such as shell structure, magic numbers, nuclear moments, and nuclear isomerism [32].

nucleus model, liquid–drop. A model in which the atomic nucleus is imagined to behave much like a drop of liquid. It is useful in explaining many general features of atomic masses and nuclear reactions [35].

nucleus model, single particle (*see* nucleus model, independent particle).

nuclide. All nuclear species, both stable (about 270) and unstable (about 500), of the chemical elements, as distinguished from the two or more nuclear species of a single chemical element that are called isotopes [36]. Nuclides are distinguished by their atomic number, atomic mass, and energy state [29]. To be regarded as a distinct nuclide, the atom must be capable of existing for a measurable time (generally larger

than 10^{-10} second). Thus nuclear isomers are considered different nuclides, whereas promptly decaying excited nuclear states and unstable intermediates in nuclear reactions are not so considered [32]. (*See also* element; isobar (nuclear); isodiaphere; isomer(s); isotone(s); isotope(s).)

nuclide, shielded. A nuclide of charge higher by one unit than a stable nuclide of the same mass number. Such a nuclide cannot be formed by (it is "shielded" from) the negative beta decay from the normal state of a parent; hence, when it appears as a fission product, it is regarded with high probability as a primary fission product [32].

NUDETS. Acronym for nuclear detonation detection and reporting system.

O–. Prefix referring to the fifth (O) electron shell of an atom, or an electron of that shell (*see* shell structure of the atom).

O–electron (*see* shell structure of the atom).

O–shell (*see* shell structure of the atom).

Oak Ridge alloy (*see* oralloy).

odd–even rule, nuclear stability. A rule concerning the numbers of photons (Z) and neutrons (N) forming a nucleus, stating that the stability of the nucleus depends on the odd or even character of Z and N. The odd–even law may be expressed as follows [4]:

Most stable:	Z even; N even (even–even nuclei)
Moderately stable:	Z even; N odd (even–odd nuclei) Z odd; N even (odd–even nuclei)
Least stable:	Z odd; N odd (odd–odd nuclei).

offset distance (nuclear). The distance the desired ground zero or actual ground zero is offset from the center of an area target or from a point target [36].

one–point safe. A term used to describe the degree of safety in a nuclear weapon. A characteristic of a nuclear weapon that, upon undergoing one–point detonation initiated anywhere in the HE system, has a probability of no greater than one in a million of producing a nuclear yield in excess of 4 pounds TNT equivalent [37].

one–tenth period (radioactivity). That period of time such that 90 percent of the radioactive atoms have decayed. It is equal to $\ln 10/\lambda_c$, where λ_c is the disintegration constant; or about 3.322 $T_{1/2}$, where $T_{1/2}$ is the half–life. The nine–tenths period, similarly is that period of time during which 10 percent of the atoms have decayed. It is equal to $1.111/\lambda_c$, or about $0.1520T_{1/2}$ [4].

opacity (optical). The reciprocal of transmission or transmittance of a particular optical path [48].

operations, radiological. Employment of radioactive materials or radiation–producing devices to cause casualties or restrict the use of terrain. Includes the intentional employment of fallout from nuclear weapons [36].

optimum depth of burst (*see* depth of burst (or burial), optimum).

optimum height of burst (*see* height of burst, optimum).

oralloy. A uranium metal enriched in its content of the uranium–235 isotope, one of the primary fissionable materials used in nuclear weapons. The name "oralloy" was derived from "Oak Ridge alloy" and when used without qualification normally means uranium enriched to 93.5 percent in the uranium–235 isotope [37]. (*See also* uranium, enriched.)

order of magnitude. An order of magnitude is a numerical comparison expressed as a multiple of some unit (usually 10) taken as a standard; for example, 10, 100, and 1,000 are different by 1, 2, and 3 orders of magnitude, respectively [28].

overinitiation. A condition in a nuclear warhead that may occur during or immediately after exposure to a neutron fluence, such as that resulting from a nearby nuclear detonation. This is the phenomenon wherein there is a excess of neutrons present in the fissile material at the time first criticality is achieved, which will result in disassembly before the required degree of supercriticality is attained by the implosion. The result of overinitiation is a reduction in the nuclear yield, the degree of which is dependent upon the fission density in the nuclear material at the time of the intended detonation [37].

overlay defense. Exo– (outside) atmospheric defense against ballistic missiles.

overpressure. The pressure resulting from the blast wave of an explosion. It is referred to as "positive" when it exceeds atmospheric pressure and "negative" during the passage of the wave when resulting pressures are less than atmospheric pressure [36]. The transient pressure, usually expressed in pounds per square inch, exceeding existing atmospheric pressure manifested in the blast wave from the explosion. During some period of the passage of the wave past a point, the overpressure is negative [38]. The variation of overpressure with time depends on the energy yield of the explosion, the distance from the point of burst, and the medium in which the weapon is detonated [49]. (*See also* overpressure, peak.)

overpressure, free air. The unreflected pressure, in excess of the ambient atmospheric pressure, created in the air by the blast wave from an explosion [36] (*see also* overpressure; overpressure, peak).

overpressure, peak. The maximum value of overpressure at a given location that is generally experienced at the instant the shock (or blast) wave reaches that location [36].

overpressure impulse (*see* impulse).

P–. Prefix referring to the sixth (P) electron shell of an atom, or an electron of that shell (*see* shell structure of the atom).

P–electron (*see* shell structure of the atom).

P–shell (*see* shell structure of the atom).

P–type. Semiconductor material that has had certain impurities added so that there is an excess of holes available for conduction [38].

P wave (*see under* waves (ground motion), types of).

packing fraction. The ratio of the mass defect to the mass number of a nuclide, which is related to the nuclear binding energy through the mass–energy equivalence [48] (*see also* binding energy, nuclear).

pair formation, internal. A process of deexcitation of an excited nucleus in which an electron–positron pair is formed in the coulomb field of the nucleus. The process is competitive with (and related to) normal internal conversion, and also competitive with gamma–ray emission [4].

pairing energy. A measure of the degree of binding of an even number of identical nucleons as compared to that of an odd number of identical nucleons. The even number will be bound more tightly [4].

pair production. An absorption process for X–rays and gamma rays in which the incident photon is annihilated in the vicinity of the nucleus of the absorbing atom, with subsequent production of an electron and positron pair. This reaction only occurs for incident photon energies exceeding 1.02 MeV [39]. Pair production is one of three distinct processes by which a photon can effect the emission of an electron from matter, the other processes being the photoelectric effect and the Compton effect [35]. (*See also* gamma ray(s).)

PAL. Acronym for permissive action link.

parasitic capture (*see* capture, parasitic).

parent (*see* radioactive series).

parity (particle physics). In the mathematical description of particles and their interactions, it is possible to describe particles so that, if all the coordinates (x, y, and z) are reversed and made negative, the resulting description will either be identical to or have exactly the negative value of the previous description. This mathematical property is called parity, and it is either even or odd, depending on whether the resulting description remains positive or turns negative [24].

parity, nuclear (weapon). A condition at a given point in time when opposing forces possess nuclear offensive and defensive systems approximately equal in overall combat effectiveness [36].

particle. A minute constituent of matter, generally one with a measurable mass, although photons are often treated as particles. The primary particles involved in radioactivity

are alpha particles, beta particles, neutrons, and protons [29]. (*See also* particle(s) elementary.)

particle(s), elementary (or fundamental). Particles of which all matter and radiation are composed. All are short-lived, do not exist independently under normal conditions (except electrons, protons, and neutrinos in the form of cosmic rays), and are of less than atomic size. Originally this term was applied to any particles that could not be further subdivided; now it is applied to nucleons (protons and neutrons), electrons, mesons, antiparticles, strange particles, and (often) photons. It does not include alpha particles or deuterons [29].

particle(s), ionizing (*see* ionizing particle(s), directly; ionizing particle(s), indirectly).

particle, lambda (*see* hyperon).

particle, nuclear. A consituent particle of an atomic nucleus, such as a proton or neutron. The term is sometimes applied to particles emitted by a nucleus such as alpha particles, positrons, electrons, and neutrinos) and to mesons [35].

particle, recoil (*see* recoil particle).

particle, relativistic. A particle with a velocity so large that its relativistic mass (mass in motion) exceeds its rest mass by an amount that is significant for the computation or other considerations at hand [32] (*see also* mass-energy equivalence; velocity, relativistic).

particle fluence (*see* fluence, neutron).

particle physics (high-energy physics). A field of science studying the particles that make up the fine structure of matter. It is so called because of the fact that particle beams of extremely high energy are needed in most of its pertinent experiments [24].

particle radiation (*see* radiation, particle).

partition of energy. The distribution of the total energy released in the detonation of a nuclear weapon among the various effects mechanisms, e.g., nuclear radiation, thermal radiation, and blast. This distribution is dependent upon the design of the weapon and the medium in which it is fired, and it varies with the time after the instant of detonation [37]. (*See also* yield, nuclear.)

passive elements (electrical systems). Mainly filter devices and circuits that remove portions of the energy spectrum not needed by system operation [38].

path, ionization (*see* ionization path).

path, mean free (*see* mean free path).

Pauli exclusion principle. The statement that any wave function involving several identical particles must be antisymmetric (i.e., they must change sign) when the coordinates, including the spin coordinates of any identical pair, are interchanged. The principle applies to fermions, but not to bosons. If the particles in a system can be considered as occupying definite quantum states, it follows from the principle that no

more than one particle of a given kind can occupy a particular state (i.e., can have an identical set of quantum numbers); hence the name, exclusion principle. Since electrons, protons, and neutrons are fermions, the Pauli exclusion principle must be used in the assignment of particles to quantum states in theories of atomic and nuclear structure [32]. (*See also* quantum statistics; shell structure of the atom.)

payload (missile). The warhead, its container, and activating devices in a military missile. The satellite or research vehicle of a space probe or research missile [36].

peak overpressure (*see* overpressure, peak).

peak prompt gamma (*see* gamma peak prompt).

PENAIDS. Acronym for penetration aids.

penetration aids (PENAIDS). Techniques and/or devices employed by offensive aerospace weapons to increase the probability of penetration of enemy defenses [36]. Used in conjunction with ballistic missile attack to make destruction of the reentry vehicle more difficult by confusing the defensive forces. RV penetration aids include decoys, chaff, and electronic jammers.

penetrometer. A simple device for measuring the penetration power of a beam of X-rays or other penetrating radiation by comparing transmission through various absorbers [29].

perigee. The point at which a satellite orbit is the least distance from the center of the gravitational field of the controlling body or bodies [36] (*see also* apogee).

periodic table. An arrangement of chemical elements in order of increasing atomic number. Elements of similar properties are placed one under the other, yielding groups and families of elements. Within each group there is a gradation of chemical and physical properties but, in general, a similarity of chemical behavior. From group to group, however, there is a progressive shift of chemical behavior from one end of the table to the other [39].

period of vibration. The time for one complete cycle of oscillation or vibration [38].

permanent complete incapacitation (*see* incapacitation, permanent complete).

permanent effects. Changes in material properties that persist for a time long compared with the normal response of the system of which the material is a part [38].

permissive action link (PAL). A device included in or attached to a nuclear weapon system to preclude arming and/or launching until the insertion of a prescribed discrete code or combination. It may include equipment and cabling external to the weapon or weapon system to activate components within the weapon or weapon system [36].

permittivity. The permittivity of an isotropic medium, for which the directions of the electric displacement and the electric field intensity are the same at any point in the medium, is the magnitude of the electric displacement density at that point, divided by that of the electric field intensity there [35] (*see also* permittivity, relative).

permittivity, free space. The value of permittivity in a vacuum. In any fixed system of rationalization and of units, the permittivity of free space is a universal electric constant [35].

permittivity, relative. The relative permittivity of an isotropic medium, for which the direction of the electric displacement and the electric field intensity are the same, at any point in the medium, is the magnitude of the electric displacement at that point, divided by the product of the electric field intensity there and the permittivity of free space. Synonyms are dielectric constant, relative dielectric constant, and specific inductive capacity. The relative permittivity is equal to the ratio of the permittivity of the medium to the permittivity of free space. Since it is dimensionless, it has the same value in all systems of units. The relative permittivity of any material is the ratio of the capacitance or capacitivity of a given configuration of electrodes, with the material as a dielectric, to the capacitance or capacitivity of the same electrode configuration with a vacuum (or air for most practical purposes) as the dielectric between the electrodes [4].

personnel blast effect (*see* blast effect).

Pershing. A mobile surface-to-surface inertially guided missile of solid-propellant type. It possesses a nuclear warhead capability and is designed to support the ground forces with the attack of long range ground targets. Designated as XMGM-31A [36].

phantom (tissue). A volume of material approximating as closely as possible the density and effective atomic number of tissue. Ideally a phantom should behave in respect to absorption of radiation in the same manner as tissue. Radiation dose measurements made within or on a phantom provide a means of determining the radiation dose within or on a body under similar exposure conditions. Some materials commonly used in phantoms are water, Masonite, pressed wood, plexiglass, and beeswax [39].

phantom loop. Communication circuit derived from two other communication circuits or from one other circuit and ground, with no additional wire lines [53].

phenomenon. Any event of scientific interest capable of being scientifically described and explained; for example, a nuclear weapon detonation with a description and explanation of each effect that occurs following such a detonation [40].

phonon. A quantum of thermal energy in a crystal lattice. Phonons provide a convenient concept of "particles" of thermal energy. Like photons they are capable of being annihilated, created, scattered, etc. by interactions with electrons and the crystal lattice [4].

phosphorescence. Emission of radiation by a substance as a result of previous absorption of radiation of shorter wavelength. In contrast to fluorescence, the emission may continue for a considerable time after cessation of the exciting irradiation [39].

photocurrent. A flow of excess charge carriers generated in a material or device by ionizing radiation [38].

photocurrent, primary. Current that flows across a semiconductor junction as a result of ionization [38].

photocurrent, secondary. The primary photocurrent in a transistor can be of sufficient magnitude to forward bias the base–emitter junction and hence cause "normal" current to flow. The collector current thus produced is called the secondary photocurrent [38].

photocurrent, steady-state primary. The constant primary photocurrent that would be observed to flow across a semiconductor junction under continuous irradiation [38].

photodisintegration, nuclear. Synonym for photonuclear reaction [35].

photoelectric. Pertaining to the effect of electromagnetic radiation (usually light) in causing a photoconductive, photoelectromagnetic, photoemissive, or photovoltaic effect. Basically, all these effects result from the liberation of bound electrons by photons [4].

photoelectric constant. A constant associated with photoemission. It is equal to the ratio h/e, where h is Planck's constant and e is the charge on an electron [4].

photoelectric effect (atomic). The process whereby a gamma–ray or X–ray photon, with energy somewhat greater than that of the binding energy of an electron in an atom, transfers all of its energy to the electron, which is removed from the atom. Since the photon involved in the photoelectric effect loses all its energy to the electron, it ceases to exist [49]. The magnitude of the photoelectric effect per atom increases with the atomic number of the material through which gamma rays pass, and decreases very rapidly with increasing energy of the photon [2]. This effect is one of the main processes by which X– and gamma rays interact with matter, at least in cases where photon energy is on the order of a few hundred keV or less [4]. (*See also* gamma ray(s).)

photoelectric equation. Einstein's equation connecting the kinetic energy of an escaped photoelectron with the quantized energy of the incident radiation and the photoelectric work function for the substance used [4].

photoelectric threshold. The quantum of energy $h\nu_0$ that is just enough to release an electron from a given system in the photoelectric effect. The corresponding frequency ν_0 and the wavelength λ_0 are the threshold frequency and wavelength, respectively. For example, in the surface photoelectric effect, the threshold $h\nu_0$ for a particular surface is the energy of a photon, which, when incident on the surface, causes the electron to emerge with zero kinetic energy [39].

photoelectric work function. The energy a photon must possess to cause the ejection of a photoelectron (an electron) from a metal [35].

photoelectron. An electron emitted in the photoelectric effect [32].

photoemissive effect. The ejection of electrons from a substance as a result of radiation falling on it; a process more commonly designated by the (originally broader) term, photoelectric effect [48].

photofission. Nuclear fission resulting from bombardment by photons. Photofission has a threshold value of 7.5 MeV (i.e., the photon must have an energy of at least 7.5 MeV). Photofission cross sections are in general less than 0.001 barn [4].

photomeson. A meson, usually a pi meson, ejected from a nucleus by an impinging photon [32].

photon. A unit or "particle" of electromagnetic radiation, possessing a quantum of energy that is characteristic of the particular radiation. For gamma rays the photon energy is usually expressed in million electron volt (MeV) units [49]. Photons have an effective momentum but no mass or electrical charge [29].

photoneutron. A neutron released from a nucleus in a photonuclear reaction [32].

photonuclear reaction. A nuclear reaction induced by a photon [32].

pig. A heavily shielded container (usually lead) used to ship or store radioactive materials [50].

piece parts. The individual items that constitute circuits or modules. Piece parts include resistors, capacitors, connectors, and integrated circuits [53]. (*See also* component.)

pi meson (*see* meson).

PIN junction. This type of diode has intrinsic (undoped) semiconductor material between the P– and N–doped materials [38] (*see also* N–type; P–type).

pion. Synonym for pi meson (*see* meson).

pit. The components of a warhead located within the inner boundary of the high–explosive assembly but not including safing materials [37].

pitchblende. A mineral containing uranium [28].

planar diffused. A technique for manufacturing semiconductor devices by introducing dopant elements into the semiconductor wafers by selective diffusion from the surface. All junction–surface intersections are protected from the ambient atmosphere by a passivation layer, typically silicon oxide, grown on the device structure [38].

Planckian radiation. The energy distribution of the radiation emitted by a blackbody radiator. The spectrum is determined by the temperature and is given by Planck's radiation law [38]. An ideal blackbody is defined as a material that absorbs all of the incident radiation and reflects none. Since the energy absorbed by such a body would increase its temperature if no energy were emitted, a blackbody, or perfect absorber, would also be a perfect emitter. A typical laboratory blackbody is approximated by a hollow container completely closed, except for a small hole, through which radiation can enter or leave. If this cavity is kept at a constant temperature, that is, maintained as an isothermal cavity, then the radiation in any one direction is the same as the radiation in any other direction. It is also the same at any point inside the cavity. Hence, the energy distribution is a function only of the temperature of the cavity [35]. (*See also* Planck's radiation law; Stefan–Boltzmann law.)

Planck's constant (h). A universal constant equal to the ratio of the energy of a photon to its frequency (6.6×10^{27} erg–sec); also equal to 2π times the Dirac h [35].

Planck's radiation law. The intensity of radiation I_λ of a blackbody at wavelength (per unit increment in wavelength) may be written

$$I_\lambda = \frac{c_1 \lambda^{-5}}{e^{c_2/\lambda T_o} - 1}$$

where c_1 and c_2 are constants with numerical values 3.7403 x 10^8 microwatts per cm^2 per 0.01 zone of spectrum and 14,384 micron degrees, respectively, and T_o is the absolute temperature of the blackbody. The constants c_1 and c_2 are called the first and second radiation constants. This law replaced both the Wien radiation law, which was accurate only at low values of λT_o, and the Rayleigh–Jeans distribution, which was accurate only at long wavelengths. The development of this law was the first use of the quantum theory of light; i.e., the concept that energy emitted by the blackbody was in small discrete packets called photons. Both the Stefan–Boltzmann law and the Wien displacement law may be derived from this relationship [4].

plastic deformation. That deformation from which a deformed object does not recover upon removal of the deforming forces [38].

plastic range (materials). The stress range in which a material will not fail when subjected to the action of a force, but will not recover completely, so that a permanent deformation results when the force is removed [36].

plastic zone (crater). The region beyond the rupture zone associated with crater formation resulting from an explosion in which their is no visible rupture but in which the soil is permanently deformed and compressed to a a high density [36]. (*See also* rupture zone.)

Plowshare. A nonmilitary program whose purpose was to explore the possible peaceful uses of atomic energy.

plume. A relatively broad jet or spout of water (from an underwater explosion) that disintegrates into a spray as it travels through the air. It always has a dense fluid core. As it falls back into the water, it forms a radioactive pool as well as the base surge. Emission plumes occur in the deep part of the intermediate depth range and in the deep and very deep burst depths [37]. (*See also* base surge; column, nuclear; crown (cloud).)

plutonium. An artificially produced active material. The 239 isotope is used primarily in nuclear weapons [37]. (*See also* source and special (SS) nuclear material; uranium.)

PNP. A three–layer semiconductor structure that constitutes a bipolar transistor [38] (*see also* N–type and P–type).

point source (radiation). The limit of the size of a radiation source as it approaches a point of zero dimensions. Actually, a point source cannot exist, but when a radiation source is separated from an observer by a great distance, it approaches a point source in the limit [35].

point target (nuclear). A target in which the ratio of radius of damage to target radius is equal to or greater than 5 [36].

poisons, fission. Fission fragments that have appreciable capture cross section for neutrons. A famous example is Xe^{135}, which has an absorption cross section of 3.5 million barns for slow neutrons [32].

Poisson distribution. A probability frequency distribution that describes all random processes where probability of occurrence is small and constant (for instance, the disintegration of atomic nuclei). It applies to nearly all observations made in nuclear

physics. It is an approximation of the binomial distribution where $p << 1$, z is very large, and the mean value of x, given by $m = pz$, is constant (*see* binomial distribution *for explanation of symbols*). In this distribution

$$P_x = \frac{z^x p^x e^{-pz}}{x!} = \frac{m^x e^{-m}}{x!} .$$

Note that the Poisson distribution is a one-parameter distribution (m) as opposed to the normal distribution. A plot of P_x versus x must be represented by a histogram, since x can assume only integral values (for instance, the number of counts obtained in a given time from a radioactive sample). The standard distribution is $m^{1/2}$ [35].

Polaris. An underwater/surface-launched, surface-to-surface, solid-propellant ballistic missile with inertial guidance and nuclear warhead. Designated as UGM-27:

UGM-27A--1,200 nautical mile range

UGM-27B--1,500 nautical mile range

UGM-27C--2,500 nautical mile range.

From [36].

polarization. The term used to describe the orientation of the time-varying electric or magnetic field vector in an electromagnetic wave. If this vector is confined to a plane containing the direction of propagation of the wave, the wave is plane polarized. If the vector rotates around the direction of propagation as an axis but remains constant in magnitude, the wave is circularly polarized. If the amplitude does not remain constant, so that the end of the vector traces out an ellipse, then the wave is elliptically polarized. If the direction of the rotation of the vector is clockwise as one looks along the direction of propagation, then the wave is said to be of right-handed circular or elliptical polarization. If the reverse is true, it is left-handed [48]. Also, the process of bringing about a partial separation of electrical charges of opposite sign in a body by the superposition of an external field or confining the electric field to one plane [45].

polarization, impact. The partial polarization exhibited by radiation produced by the impact of particles on a material, such as impact fluorescence [4].

polymerization. Union of two or more molecules of a compound to form a more complex molecule [39].

pool, radioactive. A disk-like pool of radioactive water near the surface formed by a water-surface or subsurface nuclear explosion. The pool gradually expands into an annular form, then reverts to a larger irregular disk shape at later times with a corresponding diffusion of radioactivity [50].

popcorning. The ejection of dust particles from certain types of surfaces upon absorption of the thermal radiation emitted by a nuclear detonation [38].

Poseidon. A two-stage, solid propellant ballistic missile capable of being launched from a specially configured submarine operating in either its surface or submerged mode. Designated as UGM-73. The missile is equipped with inertial guidance, nuclear warheads, and a maneuverable bus that has the capability to carry up to 14 reentry bodies that can be directed to as many as 14 targets [36].

positive phase (of a shock wave). The period during which the pressure rises very sharply to a value that is higher than ambient and then decreases rapidly to the ambient pressure [36]. That portion of the blast wave in which pressures are above ambient atmospheric pressure [38]. (*See also* negative phase; shock wave.)

positron. Particle equal in mass to the electron and having an equal but positive charge [39]. A positron is emitted in some radioactive disintegrations and is formed in pair production by the interaction of high-energy gamma rays with matter [29]. It is a short-lived particle, usually combining with an electron and giving rise to annihilation radiation [35].

positron emission conditions. A conditional relationship for the emission of positrons from nuclei, given by the relation

$$M_A - M_B \geq 2\, m_e$$

where M_A and M_B are the atomic weights of the parent and product elements and m_e is the electron rest mass (equal to 0.51 MeV) [4].

positronium. A quasi-stable system consisting of a positron and an electron bound together. Its set of energy levels is similar to that of the hydrogen atom. However, because of the different reduced mass, the frequencies associated with its spectral lines are approximately half of those of the corresponding hydrogen lines. The mean life of positronium is at most about 10^{-7} second, its existence being terminated by electron-positron annihilation [32].

potential, ionization (*see* binding energy, electron).

potential, Yukawa (*see* Yukawa potential).

potential difference. Work required to carry a unit positive charge from one point to another [39].

potential energy. The energy inherent in a mass because of its special relation to other masses [39].

potential energy, nuclear. The average total potential energy of all of the nucleons in a nucleus due to the specifically nuclear forces between them, but excluding the electrostatic potential energy [32].

potting. The complete immersion or encapsulation of devices or circuitry in an insulating compound. Potting typically is used in TREE work to reduce the effects of leakage currents caused by radiation-induced air ionization [38].

power, radiant (*see* radiant power).

Poynting vector. A vector that represents the direction and amount of energy flow at a point in a wave at a given instant in time [46].

precursor (airblast). An air pressure wave that moves ahead of the main blast wave for some distance as a result of a nuclear explosion of appropriate yield and low burst height over a heat absorbing (or dusty) surface. The pressure at the precursor front increases more gradually than in a true (or ideal) shock wave, so that the behavior in the precursor region is said to be nonideal [36].

precursor burst. A detonation that precedes the main attack to soften the enemy's defenses [40].

preinitiation. The initiation of the fission chain reaction in the active material of a nuclear weapon at any time earlier than that at which either the designed or the maximum compression or degree of assembly is attained [36]. Preinitiation is not to be confused with predetonation. In the basic operating principles of atomic warheads, at the time when detonation is desired, it is required first to compress the nuclear material to a volume and density that is supercritical. Then a supply of neutrons is injected to insure proper initiation of the nuclear reaction and to result in maximum fission yield for the weapon. If, however, sufficient neutrons are present at the time when the nuclear material reaches criticality, but before it can become supercritical, then the reaction will be initiated too early, that is, preinitiated, and result in a greatly reduced weapon yield [35].

pressure, reflected. The total pressure that results instantaneously at the surface when a blast or shock wave traveling in one medium strikes another medium, e.g., at the instant when the front of a blast wave in air strikes the ground or a structure. If the medium struck (e.g., the ground or the structure) is more dense than that in which the shock wave is traveling (e.g., air), the reflected pressure is positive (compression). If the reverse is true (e.g., when a shock wave in the ground or water strikes the air surface) the reflected pressure is negative (rarefaction or tension) [49]. (*See also* reflection factor.)

pressure front (*see* shock front).

primary blast effect (*see* blast effect).

primary device (*see* device, nuclear).

primary fission products (*see* fission fragments).

primary fission yield (*see* fission yield, independent).

primary radiation (*see* radiation, primary).

principal quantum number (*see* quantum number; shell structure of the atom).

principle of equivalence of mass and energy (*see* mass–energy equivalence).

probable error. Adjective to range, deflection, height of burst, etc., which is the dimension within which the error is just as likely to occur as not, i.e., a median error (*see also* error, horizontal).

proliferation (nuclear weapons). The process by which one nation after another comes into possession of, or into the right to determine the use of nuclear weapons, each potentially able to launch a nuclear attack upon another nation [36].

prompt critical (*see* critical).

prompt fission neutrons (*see* neutrons, prompt).

prompt gamma ray(s) (*see* gamma ray(s), prompt).

prompt neutrons (*see* neutrons, prompt).

prompt radiation (*see* radiation, prompt).

protium. A name sometimes applied to the hydrogen isotope of mass 1 to distinguish it from deuterium and tritium [39].

proton. Elementary nuclear particle with a positive electric charge equal numerically to the charge of the electron and a mass of 1.007277 mass units [39]. It is identical physically with the nucleus of the ordinary light hydrogen atom. All atomic nuclei contain protons [49].

proton, negative. Synonym for antiproton [35].

proton binding energy (*see* binding energy, proton).

proton to electron mass ratio. The ratio of the proton mass to the electron rest mass (approximately 1,836) [35].

prototype. A model suitable for evaluation of design, performance, and production potential [36].

punch-through. Breakdown mechanism in transistors caused by an arc discharge at the junction [38].

punch-through voltage. The transistor collector-to-base voltage at which the space-charge layer of the collector has widened until it touches the emitted junction [46].

purpura. Large hemorrhagic spots in or under the skin or mucous tissues [39].

pusher. A hollow shell that surrounds the tamper in an implosion system. Its purpose is to transmit the shock wave to nuclear components [37].

Q–. Prefix referring to the seventh (Q) electron shell of an atom, or an electron of that shell (*see* shell structure of the atom).

Q–electron (*see* shell structure of the atom).

Q–shell (*see* shell structure of the atom).

quality (radiation). A term used for the approximate characterization of radiation with regard to its penetrating power, for example, the energy of its photons [32]. The characteristic spectral energy distribution of X–radiation. It is usually expressed in terms of effective wavelengths of half–value layers of a suitable material; e.g., up to 20 kV, cellophane; 20 to 120 kVp, aluminum; 120 to 400 kVp, copper; over 400 kVp, tin [39]. (*See also* energy, effective.)

quality factor. The linear–energy–transfer–dependent factor by which absorbed doses are multiplied to obtain (for radiation protection purposes only) a quantity that expresses––on a common scale for all ionizing radiations––the effectiveness of the absorbed dose [39] (*see* RBE *for distinction; see also* dose equivalent).

quantization (physics). The condition in which values of various physical quantities are limited to certain discrete or noncontinuous values. Such quantities are said to be quantized. An example is the energy of a nucleus, which may take only a certain number of values––these are the nuclear energy levels [35]. (*See also* quantum.)

quantize. To divide a variable quantity into a definite number of discrete values. It is to restrict or constrain a variable quantity so that it occupies discrete values or positions [35].

quantum. An observable quantity is said to be "quantized" when its magnitude is, in some or all of its range, restricted to a discrete set of values. If the magnitude of the quantity is always a multiple of a definite unit, then that unit is called the quantum (of the quantity). For example, the quantum or unit of orbital angular momentum is h, and the quantum of energy of electromagnetic radiation of frequency ν is $h\nu$. In field theories, a field (or the field equations) is quantized by application of a proper quantum–mechanical procedure. This results in the existence of a fundamental field particle, which may be called the field quantum. Thus, the photon is a quantum of the electromagnetic field, and in nuclear field theories the meson is considered the quantum of the nuclear field [39].

quantum number. A number assigned to one of the various values of a quantized quantity in its discrete range. The quantum numbers arise from the mathematics of the wave equations. When the quantity has a quantum, the quantum number is the number of such quantums. A state may be described by giving a sufficient set of compatible numbers. In the customary formulations, each quantum number is either an integer (which may be positive, negative, or zero) or an odd half–integer [32].

quantum number, inner. The vector sum of the orbital quantum number and the spin quantum number for an atom. Also occasionally the inner quantum number is applied to an individual particle, in which case the term is synonymous with the total angular momentum quantum number of a particle [4]. (*See also* shell structure of the atom.)

quantum number, isobaric spin. A nuclear quantum number based on the view that the proton and the neutron are different states of the same elementary particle, the

nucleon. The nucleon is assigned an isobaric spin quantum number of 1/2, and its two possible orientations, +1/2 and −1/2, are assigned to the neutron and proton, respectively. The isobaric spin vectors of all the nucleons in a nucleus combine in the same manner as do angular momentum vectors to yield a total isobaric spin vector. There is evidence that isobaric spin is conserved in some nuclear reactions [32].

quantum number, total spin (*see* j–j coupling).

quantum statistics. The statistics of the distribution of particles of a given type among the various possible energy values, taking quantization of the latter into account. In the Fermi–Dirac statistics, no more than one of a set of identical particles may occupy a particular quantum state, whereas in the Bose–Einstein statistics, the occupation number is not limited in any way. Particles described by these statistics are sometimes called fermions and bosons, respectively. No particle has been found to be neither a fermion nor a boson. All known fermions have total angular momenta $(n + 1/2)h$, where n is zero or an integer, h is Planck's constant; all known bosons have angular momenta $n\hbar$ ($\hbar$ is the Dirac h). At sufficiently high temperatures, where a large number of energy levels are excited, both quantum statistics reduce to the classical Maxwell–Boltzmann statistics. The basis of the two quantum statistics is the observation that any wave function that involves identical fermions is always antisymmetric with respect to interchange of the coordinates, including spin, of any two of the fermions; whereas for identical bosons, the wave function is always symmetric [32].

quantum theory. The concept that energy is radiated intermittently in units of definite magnitude called quanta, and absorbed in a like manner [39]. It is the statement by Planck that the energy of radiation emitted or absorbed is directly proportional to its frequency, and is concentrated in units, or quanta, each having 6.6×10^{-27} erg. This value is known as Planck's constant, usually designated by h. Hence, if ν is the frequency and E is the energy, then $E = h\nu$ [29]. (*See also* Planck's radiation law.)

quantum yield. The number of photon–induced reactions of a specified type per photon absorbed. In the photoelectric effect, the quantum yield is more commonly called the photoelectric efficiency (or quantum efficiency). In photochemistry it is the ratio of the number of reactions induced both directly and indirectly by light to the number of photons absorbed; a quantum yield greater than unity indicates a chain reaction [32].

rad. Unit of absorbed dose of radiation. One rad represents the absorption of 100 ergs of nuclear (or ionizing) radiation per gram of the absorbing material or tissue [36 (1979 edition)]. When specifying dose, the absorbing material must be indicated, e.g., C, Si, tissue [38]. This unit is presently being replaced in scientific literature by the gray (Gy), which is numerically equal to the absorption of 1 joule of energy per kilogram of matter [50].

RadDefense. Acronym for radiological defense (*see* defense, radiological).

radex. Acronym for radiation exclusion.

radex plot. The predicted or observed distribution of radioactivity in the air at a specified altitude or on the earth's surface [37].

radiac. An acronym derived from the words "*ra*dioactivity, *d*etection, *i*ndication *a*nd *c*omputation" and used as an all-encompassing term to designate various types of radiological measuring instruments or equipment. (This word is normally used as an adjective.) [36].

radiant energy. The energy of electromagnetic radiation, such as radio waves, thermal radiation, X-rays, and gamma rays [39].

radiant exposure. The total amount of thermal radiation energy received per unit area of exposed surface, generally expressed in calories per square centimeter [49] (*see* thermal exposure, *which is preferred*).

radiant exposure, critical. The thermal exposure required for a particular effect on a material. The unit of critical radiant exposure is calories per square centimeter [38].

radiant power. Time rate of radiant energy emission. The useful units of radiant power are KT/sec or cal/sec [38].

radiating atom (*see* atom, radiating).

radiative capture (*see* capture, radiative).

radiation. *1.* The emission and propagation of energy through space or through a material medium in the form of waves; for instance, the emission and propagation of electromagnetic waves, or of sound and elastic waves. *2.* The energy propagated through space or through a material medium as waves; for example, energy in the form of electromagnetic waves or of elastic waves. The term radiation or radiant energy, when unqualified, usually refers to electromagnetic radiation. Such radiation commonly is classified according to frequency as hertzian, infrared, visible (light), ultraviolet, X-ray, and gamma ray (*see* photon). *3.* By extension, corpuscular (having the nature of a particle) emissions, such as alpha and beta radiation, or rays of mixed or unknown type, as cosmic radiation [39]. (*See also* radiation, electromagnetic; radiation, ionizing; radiation, nuclear; photon; gamma ray(s), intensity of; thermal radiation.)

radiation, annihilation (*see* annihilation radiation).

radiation, background. Nuclear (or ionizing) radiation arising from within the body and from the surroundings to which individuals are always exposed [36]. Also called natural

radiation or radioactivity [29]. The main sources of the natural background radiation are potassium–40 in the body; potassium–40 and thorium, uranium, and their decay products (including radium) present in rocks and oil; and cosmic rays [49].

radiation, blackbody (*see* Planckian radiation).

radiation, Cerenkov (*see* Cerenkov radiation).

radiation, characteristic (discrete). Radiation originating from an atom after removal of an electron or excitation of the nucleus. The wavelength of the emitted radiation is specific, depending only on the nuclide and particular energy levels involved [39].

radiation, debris. Ionizing radiation emitted after the first few hundred microseconds after the burst. It is primarily gamma–ray and beta radiation [38].

radiation, electromagnetic. Radiation made up of oscillating electric and magnetic fields and propagated with the speed of light. Includes gamma radiation; X–rays; ultraviolet, visible and infrared radiation; and radar and radio waves [36]. Also designated as EM radiation and EMR. (*See also* EMP.)

radiation, fission product. Radiation resulting from the radioactive decay of fission products [37].

radiation, gamma (*see* gamma ray(s)).

radiation, gamma, intensity of (*see* gamma ray(s), intensity of).

radiation, induced. Radiation produced as a result of exposure to radioactive materials, particularly the capture of neutrons [36]. Apparently a synonym for induced radioactivity. (*See also* contamination (radioactive); neutron–induced activity; radiation, residual (nuclear).)

radiation, initial (nuclear). The radiation, essentially neutrons and gamma rays, resulting from a nuclear burst and emitted from the fireball within 1 minute after burst [36]. It includes neutrons and gamma rays given off at the instant of the explosion, gamma rays produced by the interaction of neutrons with weapon components and the surrounding medium, and the alpha, beta, and gamma rays emitted by the fission products and other weapon debris during the first minute following the burst [38]. In contrast to residual radiation, its delivery to persons and objects on the earth's surface is terminated by the removal of the source (products in the nuclear cloud) from within effective radiation range of the earth by the rising cloud [36]. (*See also* radiation, prompt; radiation, residual (nuclear).)

radiation, intensity of gamma rays (*see* gamma ray(s), intensity of).

radiation, internal. Nuclear radiation (alpha and beta particles and gamma radiation) resulting from radioactive substances in the body [36]. Important sources are iodine–131 in the thyroid gland and strontium–90 and plutonium–239 in the bone [49].

radiation, ionizing. Any particulate or electromagnetic radiation capable of producing ions, directly or indirectly, in its passage through matter. Alpha and beta particles produce ion pairs directly, while gamma rays and X–rays liberate electrons as they

traverse matter, which in turn produce ionization in their paths [50]. Any radiation consisting of directly or indirectly ionizing particles or a mixture of both [5].

radiation, monochromatic (*see* monochromatic radiation).

radiation, nuclear. Particulate and electromagnetic radiation emitted from atomic nuclei in various nuclear processes. The important nuclear radiations, from the weapons standpoint, are alpha and beta particles, gamma rays, and neutrons. All nuclear radiations are ionizing radiations, but the reverse is not true; X-rays, for example, are included among ionizing radiations, but they are not nuclear radiations since they do not originate from atomic nuclei [36].

radiation, particle. Radiation in the form of particles (i.e., neutrons, electrons, alpha particles, beta particles) as opposed to electromagnetic radiation [37].

radiation, primary. Radiation direct from a source. It is neither scattered nor secondary radiation [35]. (*See also* radiation, secondary; scattering (radiation).)

radiation, prompt. The gamma rays produced in fission and as a result of other neutron reactions and nuclear excitation of the weapon materials appearing within a second or less after a nuclear explosion. The radiations from these sources are known either as prompt or instantaneous gamma rays [36]. Radiation produced by the primary fission or fusion process during the first second following the burst, as distinguished from the radiation from fission products, their decay chains, and other later reactions [29]. [*Note:* The definition taken from Reference 36 does not include prompt neutrons, which are usually thought of as part of the prompt radiation.] (*See* neutrons, prompt, gamma ray(s) prompt.)

radiation, recoil. Disintegration radiations accompanied by a recoil movement of a disintegrating nucleus [35] (*see also* knock-on atom).

radiation, residual (nuclear). Nuclear radiation caused by fallout, radioactive material dispersed artificially, or irradiation that results from a nuclear explosion and persists longer than 1 minute after burst [36]. Nuclear radiation, chiefly beta particles and gamma rays, that persists for some time following a nuclear explosion. The radiation is emitted mainly by the fission products and other bomb residues in the fallout, and to some extent by earth and water constituents and other materials in which radioactivity has been induced by the capture of neutrons [49]. (*See also* contamination (radioactive); radiation, induced; radiation, initial (nuclear); radioactivity, residual.)

radiation, secondary. Particles or photons produced by the interaction with matter of a radiation regarded as primary. Examples are secondary cosmic rays, photoelectrons, Compton recoil electrons, delta rays, the electrons liberated from a dynode of a photomultiplier tube when struck by an electron accelerated from the preceding dynode, recoil protons from neutron-proton collisions, and bremsstrahlung [32].

radiation, synchrotron. Electromagnetic radiation emitted by a high-energy electron moving in a magnetic field [38].

radiation, tertiary. Radiation produced after a secondary radiation particle undergoes a secondary process [30].

radiation, thermal (*see* thermal radiation).

radiation, transient. A pulse or burst of radiation whose pulse width at half-maximum intensity generally ranges from nanoseconds to a few milliseconds [38].

radiation density constant. A constant associated with blackbody radiation. It is the total energy density of the radiation [4].

radiation detector (*see* detector, radiation).

radiation dose (*see* dose, radiation).

radiation dose rate (*see* dose rate, radiation).

radiation front. Limits of the hot gases of the nuclear fireball [49].

radiation hygiene. Synonym for radiological health [39] (*see* health, radiological).

radiation injury (*see* radiation sickness).

radiation intensity (*see* intensity, radiation).

radiation law, Planck's (*see* Planck's radiation law).

radiation length. The mean path length required for the reduction, by the factor 1/e, of the energy of relativistic charged particles as they pass through matter. Such particles lose their energy mainly by radiating [32]. (*See also* bremsstrahlung.)

radiation scattering (*see* scattering, radiation).

radiation sickness. An illness resulting from excessive exposure to ionizing radiation. The earliest symptoms are nausea, vomiting, and diarrhea, which may be followed by loss of hair, hemorrhage, inflammation of the mouth and throat, and general loss of energy [36]. In severe cases, where the radiation exposure has been relatively large, death may occur within 2 to 4 weeks. Those who survive 6 weeks after the receipt of a single dose of radiation may generally be expected to recover [49].

radiation syndrome. The complex of symptoms characterizing the disease known as radiation injury, or radiation sickness, resulting from excessive exposure of the whole (or a large part) of the body to ionizing radiation [49] (*see* radiation sickness).

radio-. Prefix to terms related to radioactivity, radium, and radiant energy.

radio blackout (*see* blackout).

radio flash. Synonymous with EMP [45].

radioactive (*see* radioactivity).

radioactive chain (*see* radioactive series).

radioactive cloud (*see* cloud, nuclear).

radioactive contamination (*see* contamination (radioactive)).

radioactive decay (*see* decay (radioactive)).

radioactive decay law (*see* decay law, radioactive).

radioactive decay scheme (*see* decay scheme, radioactive).

radioactive disintegration (*see* decay (radioactive); disintegration, nuclear).

radioactive displacement laws (*see* displacement laws (radioactivity)).

radioactive equilibrium (*see* equilibrium, radioactive).

radioactive fallout (*see* fallout).

radioactive half-life (*see* half-life).

radioactive isotope (*see* radioisotope).

radioactive pool (*see* pool, radioactive).

radioactive series. (*see* series, radioactive).

radioactivity. The spontaneous emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the nuclei of an unstable isotope [36]. The property of certain nuclides of undergoing a spontaneous nuclear transformation in which the nucleus emits particles and/or gamma rays, or undergoes spontaneous fission, or in which the atom emits X-rays or Auger electrons following orbital electron capture or internal conversion [38]. As a result of the emission of radiation, the radioactive isotope is converted (or decays) into the isotope of a different (daughter) element, which may or may not also be radioactive. Ultimately, as a result of one or more stages of radioactive decay, a stable (nonradioactive) end product is formed [49]. (*See also* decay (radioactive); radioactive series; *topics under* disintegration.)

radioactivity, artificial. Manmade radioactivity produced by particle bombardment or electromagnetic irradiation, as opposed to natural radioactivity [39].

radioactivity, background (*see* radiation, background).

radioactivity, induced. Radioactivity produced in certain materials as a result of nuclear reactions, particularly the capture of neutrons, which are accompanied by the formation of unstable (radioactive) nuclei. In a nuclear explosion, neutrons can induce radioactivity in the weapon materials, as well as in the surroundings (e.g., by interaction with nitrogen in the air and with sodium, manganese, aluminum, and silicon in soil and seawater) [49]. Apparently a synonym for induced radiation.

radioactivity, natural (*see* radiation, background).

radioactivity, residual. Nuclear radiation that results from radioactive sources and which persists for longer than 1 minute. Sources of residual radioactivity created by nuclear explosions include fission fragments and radioactive matter created primarily by neutron activation, but also by gamma and other radiation activation. Other possible sources of residual radioactivity include radioactive material created and dispersed by means other than nuclear explosion [36].

radioactivity concentration guide (*see* concentration guide, radioactivity).

radiobiology. That branch of biology that deals with the effects of radiation on biological systems [39].

radiochemistry. The aspects of chemistry connected with radionuclides and their properties, with the behavior of minute quantities of radioactive materials by means of their radioactivity, and the use of radionuclides in the study of chemical problems [39].

radioelement. An element containing one or more radioactive isotopes [29].

radiography. The making of shadow images on photographic emulsion by the action of ionizing radiation. The image is the result of the differential attenuation of the radiation in its passage through the object being radiographed [39].

radioisotope. A radioactive isotope, which is an unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation [29] (*see also* decay, radioactive; isotope).

radiological. Of or pertaining to radioactive materials (*see* defense, radiological; health, radiological; operations, radiological; radsafe; survey, radiological; warfare, radiological).

radiological monitoring (*see* monitoring (radiological)).

radiology. That branch of medicine that deals with the diagnostic and therapeutic applications of radiant energy, including X-rays and radionuclides [39].

radionuclide. Acronym for radioactive nuclide [35].

radioresistance. Relative resistance of cells, tissues, organs, or organisms to the injurious action of radiation. The term may also be applied to chemical compounds or to any substances [39]. (*See also* radiosensitivity.)

radiosensitivity. Relative susceptibility of cells, tissues, organs, organisms, or any living substance to the injurious action of radiation. Radioresistance and radiosensitivity are used in a comparative sense, rather than in an absolute one [39]. (*See also* radioresistance.)

radiosonde. A balloon-borne instrument for the simultaneous measurement and transmission of meteorological data, consisting of transducers for the measurement of pressure, temperature, and humidity; a modulator for the conversion of the output of the transducers to a quantity that controls a property of the radiofrequency signal; a selector switch, which determines the sequence in which the parameters are to be transmitted; and a transmitter, which generates the radiofrequency carrier [50].

radius, Bohr (*see* Bohr radius).

radius of damage. The distance from ground zero at which there is a 0.50 probability of achieving the desired damage [36].

radsafe. Acronym for radiological safety. General term used to cover the training, operations, and equipment used to protect personnel from potential overexposures to nuclear radiation during nuclear tests [50].

rainfall (nuclear). The water that is precipitated from the base surge clouds after an underwater burst of a nuclear weapon. This rain is radioactive and presents an important secondary effect of such a burst [36] (*see also* rainout).

rainout. Radioactive material in the atmosphere brought down by precipitation [36]. The removal of radioactive particles from a nuclear cloud by precipitation when this cloud is within a rain cloud [49] (*see also* rainfall (nuclear); snowout; washout).

range (distance). *1.* The distance between any given point and an object or target. *2.* Extent or distance limiting the operation or action of something, such as the range of an aircraft, ship, or gun [36].

Rankine temperature scale. The temperature scale having the same divisions as the Fahrenheit scale (180 degrees between the boiling and freezing points of water) and for which the zero equals the absolute zero on the Fahrenheit scale, i.e., Rankine temperature equals Farenheit temperature plus 460 degrees [35].

rare earth. Any of the series of very similar metals ranging in atomic number from 57 to 71 [39].

rarefaction wave. When a shock wave in a medium strikes the interface between this medium and a less dense medium, part of the energy of the shock wave induces a shock wave in the less dense medium. The remainder of the energy forms a rarefaction or tensile wave that travels back through the denser medium [38]. (*See also* shock wave.)

rawin. Radar wind sounding tests that determine the patterns of winds aloft by radar observation of a balloon [50].

rawinsonde. Meteorological measurements by combined rawin and radiosonde techniques [50].

Rayleigh waves (*see under* waves (ground motion), types of).

RB. Abbreviation for reentry body.

RBE (relative biological effectiveness). A factor used to compare the biological effectiveness of absorbed radiation doses due to different types of ionizing radiation [50]. The ratio of the number of rads of gamma (or X–) radiation of a certain energy which will produce a specified biological effect to the number of rads of another radiation required to produce the same effect is the relative biological effectiveness of the latter radiation [36]. For radiation protection RBE has been superseded by quality factor [50].

reaction, chain (*see* chain reaction).

reaction(s), inverse nuclear (*see* inverse nuclear reactions).

reaction, nuclear. An induced nuclear disintegration, i.e., a process occurring when a nucleus comes into contact with a photon, an elementary particle, or another nucleus [32].

reaction, photonuclear (*see* photonuclear reaction).

reaction, thermonuclear (*see* thermonuclear).

reaction energy (nuclear). In the disintegration of a nucleus, it is equal to the sum of the kinetic or radiation energies of the reactants minus the sum of the kinetic or radiant energies of the products. If any product of a specified reaction is in an excited nuclear state, the energy of subsequently emitted gamma radiation is not included in the sum. The "ground-state nuclear reaction energy" is the reaction energy when all reactant and product nuclei are in their ground states. (Symbol: Q_o) [39].

reaction rate. In chemical kinetics, the time derivative of the concentration of a given species is called the reaction rate of that species; it is also called the velocity or speed of the reaction [38].

reactivity. A parameter ρ giving the deviation from criticality of a nuclear chain-reacting medium such that positive values correspond to a supercritical state and negative values to a subcritical state [39].

reactor, breeder. A reactor that produces more fissile material than it consumes, i.e., has a conversion ratio greater than unity [39].

reactor, converter. A reactor that produces fissile atoms from fertile atoms, but has a conversion ratio less than one [39].

reactor, nuclear. A facility in which fissile material is used in a self-supporting chain reaction (nuclear fission) to produce heat and/or radiation for both practical application and research and development [36]. An apparatus in which nuclear fission may be sustained in a self-supporting chain reaction. A reactor includes fissionable material (fuel) such as uranium or plutonium, and moderating material (except fast reactors), and usually includes a reflector to conserve escaping neutrons, provision for heat removal, and measuring and control elements. The terms "pile" and "reactor" have been used interchangeably, with reactor now becoming more common. These terms usually are applied only to systems in which the reaction proceeds at a controlled rate, but they also have been applied to bombs [39].

recoil, aggregate. The ejection, from the surface of a sample, of a cluster of atoms attached to one atom that is recoiled as the result of alpha particle emission. Although the phenomenon may be quite common, the amount of matter thus carried away is so small as to be undetectable unless it is strongly radioactive. It is observed with strong preparations of alpha-active materials of high specific activity (such as nearly pure polonium compounds) as a migration of a small fraction of the radioactivity onto uncontaminated nearby surfaces [39].

recoil atom (*see* atom, recoil).

recoil electron (*see* Compton effect).

recoil nucleus. A nucleus that recoils as a result of a collision with a nuclear particle or, as in radioactivity, as the result of the ejection of a particle or photon from it [32] (*see also* radiation, recoil).

recoil particle. A particle that has been set into motion by a collision or by a process involving the ejection of another particle. Examples are Compton recoil electrons, recoil nuclei in alpha decay, and fission fragments [32].

recoil radiation (*see* radiation, recoil).

recombination (ions). The return of an ionized atom or molecule to the neutral state [39].

recombination (semiconductors). A process by which a hole–electron pair is annihiliated, usually by direct combination of a free electron with a free hole, by capture of a free electron by an excited center containing a hole, or by capture of a free hole by an excited center containing an electron. Recombination transitions of these types may be radiative [38].

recombination center (semiconductors). In some electron–hole recombinations the electron (hole) in the conduction band does not make a direct transition to the valence band but first occupies an intermediate state in the forbidden gap called a recombination center, which is associated with lattice imperfections or chemical impurities [38].

recovery (radiobiology). The return toward normal of a particular cell, tissue, or organism after radiation injury [39].

recovery rate. The rate at which recovery takes place after radiation injury. It may proceed at different rates for different tissues (differential recovery rate). Tissues recovering at slower rates will ultimately suffer greater damage from a series of successive irradiations. This differential effect is considered in fractionated radiation therapy if the neoplastic tissues have a slower recovery rate than surrounding normal structures [39].

reduced mass, electron. The reduced mass of the electron (in the hydrogen atom) is the product of the rest mass of the electron and the atomic mass of the hydrogen proton, divided by the atomic mass of hydrogen [35]. The value of approximately 9.1×10^{-28} gram is very nearly equal to the rest mass of an electron.

reentry body (RB). A term used by the Air Force and Navy to identify that part of a ballistic missile or other vehicle that reenters the earth's atmosphere after flight above the sensible atmosphere. When used as a general term by the Navy, it implies that the body contains a warhead and its associated components, and its mission is to ultimately detonate on a predetermined target [37]. (*See also* reentry vehicle.)

reentry system (RS). An Air Force and Navy term to identify that portion of a ballistic missle designed to place one or more reentry vehicles or bodies on terminal trajectories so as to arrive at selected targets. Penetration aids, spacers, deployment modules, and associated programming control and sensing devices are included in the reentry system [37].

reentry vehicle (RV). That part of a space vehicle designed to reenter the earth's atmosphere in the terminal portion of its trajectory [36] (*see also* reentry body).

reentry vehicle, nuclear. An Air Force term to identify an item that is a component of a space vehicle, guided missile, projectile, rocket, or the like and which is designed to reenter the earth's atmosphere. It may include or form a portion of the outer case of the weapon of which it is a component. It may include or be designed to include a nuclear warhead and fuzing, arming, and triggering devices. It may include devices for programming, correlating, sequencing, deployment, survival, target sensing, safing, and vehicle–booster separation. It may have the capability of trajectory attitude and stabilization control [37]. (*See also* warhead.)

reflected shock wave (*see* shock wave, reflected).

reflection coefficient. The ratio between a charge weight required to produce a given overpressure at a given distance in free air and a charge weight that is burst near a reflecting surface and provides the same overpressure at the same radial distance in the far Mach region. This ratio is used as an indicator of the reflecting properties of a surface and will be a maximum of 2 for an ideal reflector [18]. (*See* reflection factor *for distinction*).

reflection factor. The ratio of the total (reflected) pressure to the incident pressure when a shock (or blast) wave traveling in one medium strikes another [49]. For airblast propagation normal to the reflecting surface, values range from 2 (for weak shocks) to 8 (for strong shocks). (*See* reflection coefficient *for distinction*.)

reflector. A material surrounding a critical system for the purpose of scattering neutrons back into the active material of the core, thus reducing the rate of neutron loss and increasing the fission rate. In nuclear weapons it is called a tamper (*which see*) because it performs the additional function of delaying the expansion of the exploding mass [37].

refraction. Bending of an electromagnetic or sound wave path when it traverses a region whose propagation characteristics are a function of position [38].

relative biological effectiveness (*see* RBE).

relative permittivity (*see* permittivity, relative).

relative stopping power (*see* stopping power).

relativistic. Pertaining to basic properties, especially mass, that are functions of velocities approaching the speed of light. (*See also* kinetic energy, relativistic; particle, relativistic; velocity, relativistic.)

relativity theory. Any theory that uses a principle that postulates the equivalance of the description of the universe, in terms of physical laws, by various observers, or for various frames of reference. The special (or restricted) theory of relativity is a theory developed by Albert Einstein in 1905, which is of great importance in atomic and nuclear physics. It is especially useful in studies of objects moving with speeds approaching the speed of light. Two of the results of the theory with specific application in nuclear physics are statements (a) that the mass of an object increases with its velocity, and (b) that mass and energy are equivalent [29]. The two basic postulates of the restricted, or special, theory of relativity may be stated as follows: (a) the physical laws are the same in all coordinate systems that are moving relative to each other

with unaccelerated motion; (b) the velocity of light in a vacuum is the same in all coordinate systems so moving. The principle of equivalence extended the special to the general theory of relativity. This principle may be stated as follows: for any particle in a gravitational field, it is possible to replace mathematically the effect of the field by a transformation of the axes of the coordinate system (e.g., from a coordinate system moving with unaccelerated motion to one under acceleration) [32]. (*See also* mass–energy equivalence.)

relaxation length (*see* mean free path).

rem (roentgen equivalent mammal (or man)). One rem is the quantity of ionizing radiation of any type that, when absorbed by man or other mammal, produces a physiological effect equivalent to that produced by the absorption of 1 roentgen of X–ray or gamma radiation [36]. It is a special unit of biological radiation dose equivalent that provides an indication of the extent of biological injury (of a given type) that would result from the absorption of nuclear radiation [50]. Thus, the rem is a dose unit of biological effect, whereas the rad is a unit of absorbed energy dose, and the roentgen (for X– and gamma rays only) is one of exposure [2]. The number of rems of radiation is equal to the number of rads absorbed multiplied by the RBE of the given radiation (for a specified effect). The rem is also the unit of dose equivalent, which is equal to the product of the number of rads absorbed multiplied by the quality factor and the distribution factor for the radiation. The unit is presently being replaced by the sievert (Sv) [50].

rep [obsolete]. The absorbed dose of radiation was originally expressed in terms of a unit called the rep, an acronym for roentgen equivalent physical. It was used to denote a dose of about 97 ergs of any nuclear radiation absorbed per gram of body tissue [2]. (*See* rad; gray.)

residence time. The time during which radioactive material remains in the atmosphere following the detonation of a nuclear device. It is usually expressed as a half–time, since the time for all material to leave the atmosphere is not well known [29]. (*See also* fallout.)

residual contamination (*see* contamination, residual).

residual gamma rays (*see* gamma ray(s), residual).

residual radiation (or radioactivity) (*see* radiation, residual (nuclear)).

residue, weapon. The extremely hot, compressed gaseous residues formed at the instant of the explosion of a nuclear weapon. The temperature is several tens of million degrees (Kelvin) and the pressure is many millions of atmospheres [49]. (*See also* debris, weapon (nuclear).)

resistance, forward. The value of the ratio of the forward voltage to the current flowing through the PN junction when that same forward voltage is applied to it. The value varies with forward voltage [38].

resonance (nuclear physics). A phenomenon whereby particles, such as neutrons, at specific kinetic energies exhibit a very high interaction probability with nuclei. Cross sections for neutron capture and scattering, for example, exhibit peaks at these so–called resonance energies and have relatively low values between the peaks [29].

resonance capture (*see* capture, resonance).

resonance energy. The kinetic energy of an incident particle (expressed in the laboratory system) that makes the total energy of the system composed of the incident particle and the target nucleus close to the energy of a nuclear level of the compound nucleus [39].

resonance neutrons (*see* neutrons, resonance).

response. The action of an object under the applied loading [38].

response, target (nuclear). The effect on men, material, and equipment of blast, heat, light, and nuclear radiation resulting from the explosion of a nuclear weapon [36].

rest mass. The mass of a particle at rest. It is the mass in the classical, or Newtonian, sense; i.e., it does not include the additional mass, which, according to the relativistic mass equation, is acquired by a particle or body in motion [32].

rest-mass energy. The energy equivalent of the rest mass of a particle [32]. If the particle is annihilated, an amount of energy equal to the rest mass times the square of the speed of light is released [48].

restricted theory of relativity (*see* relativity theory).

retinal burn. A permanent eye injury caused when the retinal tissue of the eye is excessively heated by, for example, the focused image of a nuclear fireball [38].

retrofit. The redesign of a system, subsystem, or component to meet new requirements [40].

rho meson (*see* meson).

ringing. The oscillatory behavior of an object in response to a rapidly applied load [42].

ringing frequency. The frequency of oscillation of the sensor in response to a transient forcing function. The ringing frequency is a function of the mass and the spring constants of the system [42].

rise time. For blast waves, the time interval from blast wave arrival to the time of peak overpressure [38]. For EMP or other electrical signals, the time required for a signal pulse to rise from 10 to 90 percent of its final steady-state value or peak value [41].

risk, degree of (nuclear). As specified by the commander, the risk to which friendly forces may be subjected from the effects of the detonation of a nuclear weapon used in the attack of a close-in enemy target; acceptable degrees of risk under differing conditions are emergency, moderate, and negligible [36] (*see also* risk, emergency; risk, moderate; risk, negligible).

risk, emergency (nuclear). A degree of risk where anticipated effects may cause some temporary shock, casualties, and may significantly reduce the unit's combat efficiency [36].

risk, moderate (nuclear). A degree of risk where anticipated effects are tolerable, or at worst, a minor nuisance [36].

risk, negligible (nuclear). A degree of risk where personnel are reasonably safe, with the exceptions of dazzle or temporary loss of night vision [36].

roentgen. A unit of exposure dose of gamma (or X–) radiation. In field dosimetry, 1 roentgen is essentially equal to 1 rad [36]. Roentgen is defined precisely as the quantity of gamma–ray or X–ray radiations that will produce electrons (in ion pairs) with a total charge of 2.58×10^{-4} coulomb in 1 kilogram of dry air under standard conditions. An exposure of 1 roentgen results in the deposition of about 94 ergs of energy in 1 gram of soft body tissue. Hence, an exposure of 1 roentgen is approximately equivalent to an absorbed dose of 1 rad in soft tissue [50].

roentgen equivalent mammal (or man) (*see* rem).

roentgenography. Radiography by means of X–rays [39].

roentgenology. That part of radiology that pertains to X–rays [39].

Roentgen rays. X–rays [39].

roll–up. The process for orderly dismantling of facilities no longer required in support of operations and available for transfer to other areas [36].

ROSES. Acronym for recorder and oscilloscope sealed environment systems (used in nuclear underground tests).

RS. Abbreviation for reentry system.

rupture zone (crater). The region immediately adjacent to the [true] crater boundary in which the stresses produced by the explosion have exceeded the ultimate strength of the medium. It is characterized by the appearance of numerous radial cracks of various sizes [36]. (*See also* plastic zone (crater).)

Russell–Saunders coupling. Interaction between the resultant spin angular momenta and the resultant orbital angular momenta of two or more different particles (also called L–S coupling). The orbital angular momentum and the spin angular momentum of the individual particles are added separately to obtain the resulant spin and orbital vectors. These resultant vectors are then added to obtain the total angular momentum of the system. The spin and orbital vector values of the individual particles do not couple together; thus, there is no definite total angular momentum for an individual particle, as in j–j coupling [48].

Rutherford. An obsolete unit of radioactivity equivalent to 10^6 disintegrations per second [39].

Rutherford atom. An early and fundamental model of the atom, proposed by Sir Ernest Rutherford. Later experimentation showed it to be correct. This model visualizes a concentrated, positively charged nucleus that represents the major part of the atom's mass. Surrounding the nucleus are negatively charged electrons equal in number to the atomic number, which is itself equal to the positive charge on the nucleus [35].

RV. Abbreviation for reentry vehicle.

Rydberg constant. A constant appearing in the expression for the wave numbers of various atomic spectra [35].

S wave (*see under* waves (ground motion), types of).

Sachs' scaling. Sometimes used to refer to airblast scaling (*see* scaling law).

safe burst height (*see* height, safe burst).

Safeguard. A ballistic missile defense system [36].

safety, radiological (*see* radsafe).

salted weapon (*see under* weapon, nuclear).

sarcoma. Malignant neoplasm composed of cells imitating the appearance of the supportive and lymphatic tissues [39].

saturation, circuit. That process in which a circuit is locked in a stable state that often remains after the radiation pulse has subsided (not latchup) [38].

saturation region (radiation). That range of radiation intensities that produces signals in circuitry sufficient to cause electrical saturation of semiconductor components, but in which the photocurrents remain linear with exposure rate [42].

SBEMP. Abbreviation for surface burst EMP.

scaled height of burst (SHOB) (*see* height of burst, scaled).

scaling law (or factor). A mathematical relationship that permits the effects of a nuclear explosion of given energy yield to be determined as a function of distance from the explosion (or from ground zero), provided the corresponding effect is known as a function of distance for a reference explosion, e.g., of 1-kiloton energy yield [36]. The energy of the reference explosion is usually taken to be 1 kiloton. Some of the blast parameters that can be scaled are overpressure, dynamic pressure, time of arrival of blast wave, and duration [2]. In addition, scaling factors based on ambient pressure and temperature can be used to scale blast parameters to standard temperature and pressure conditions (15°C at sea level).

scaling wind. An idealized representation of the winds aloft in the atmosphere, used to draw fallout contours [37].

scattered radiation (*see* scattering, radiation).

scattered X-rays (*see* X-rays, scattered).

scattering, backward (*see* scattering, forward).

scattering, coherent. Scattering of photons or particles in which there are definite phase relationships between the incoming and the scattered waves. Ordinary scattering (*see* scattering, Raleigh) is coherent. With coherent scattering interference occurs between the waves scattered by two or more scattering centers. The total intensity is the vector sum of the amplitudes of the various waves [39].

scattering, Compton (*see* Compton scattering; Compton effect).

scattering, elastic. Scattering in which there is no change in the total kinetic energy of translation or total internal energy of the participating systems (*see also* scattering, inelastic).

scattering, forward. Scattering of a particle in a general forward direction, i.e., scattering where the scattering angle measured from the original path of the particle is less than 90 degrees. Backward scattering is where the scattering angle measured from the original path of the particle is greater than 90 degrees. However, backscattered particles can result from several scattering processes that individually are forward scattering events (and vice versa) [4].

scattering, inelastic. Scattering in which the total kinetic energy of a two-particle system is decreased, and one or both of the particles is or are left in an excited state [38] (*see also* scattering, elastic).

scattering, incoherent. Scattering that is not coherent (*see* scattering, coherent).

scattering, Mott (*see* scattering formula, Mott).

scattering, potential. Scattering due to the effect of the nuclear field (the nuclear potential) on the incoming particle [32]. The interior of the nucleus is not disturbed, in contrast to resonant scattering. (*See also* scattering, resonance.)

scattering, radiation. The diversion of radiation (thermal, electromagnetic, or nuclear) from its original path as a result of interaction or collisions with atoms, molecules, or larger particles in the atmosphere or other media between the source of radiation (e.g., a nuclear explosion) and a point some distance away. As a result of scattering, radiation (especially gamma rays and neutrons) will be received at such a point from many directions instead of only from the direction of the source [36]. Change of direction of movement of subatomic particles or photons as a result of a collision of interaction [39]. (*See various topics under* scattering.)

scattering, Rayleigh (gamma rays). Elastic coherent scattering of gamma rays from the tightly bound orbital electrons of an atom. The scattering angle is very small for higher energies (little energy lost), and the process is trivial as compared to Compton scattering. For lower energies and for high-Z scattering material, it must be taken into account [4].

scattering, resonance. Scattering of particles at energies close to resonance levels. In these cases a very short-lived compound nucleus can be formed, and the same kind of particle re-emitted, before any other competing process can occur [4]. (*See also* scattering, potential.)

scattering, self-. Scattering of radioactive radiations by the body of the substance emitting the radiation. Self-scattering may outweigh self-absorption and may increase the measured activity over that expected for an idealized, weightless sample [32].

scattering, Thomson. Scattering of electromagnetic radiation by free charged particles. Scattering by electrons is interpreted classically as a process in which some of the energy of the primary radiation is reduced because the electrons radiate when accelerated in the transverse electric field of the radiation [48].

scattering amplitude. A quantity closely related to the intensity of scattering of a wave by a central force field, such as that of a nucleus. It is a function of the square root of the scattering cross section [32].

scattering angle. The angle between the initial path in the laboratory frame of reference of a particle or photon and the path after it has been scattered. Large scattering angles indicate relatively large energy losses [35].

scattering coefficient. A proportionality constant that corresponds exactly to absorption coefficient, except that the process involved is scattering rather than absorption. Units are identical to absorption coefficient units. A clear distinction is not always made between energy lost to a beam by the two mechanisms; for instance, the total absorption coefficient takes account of scattering energy losses as well as absorption energy losses [4]. (*See also* absorption coefficient; extinction coefficient.)

scattering coefficient, atomic. The measure of the ability of a given material to scatter an electron beam passing through it. The coefficient is equal to the scattered electron current in a definite direction per atom, per unit solid angle for each unit of the incident electron beam [4].

scattering coefficient, Compton. That fractional decrease in the energy of a beam of X- or gamma radiation in an absorber due to the energy carried off by scattered photons in the Compton effect [39].

scattering cross section, differential (*see* cross section, differential scattering).

scattering formula, Mott. Formula that gives the differential cross section for the scattering of identical particles due to a coulomb interaction as in neutron–neutron, proton–proton, or deuteron–deuteron scattering [32].

scattering length. A parameter appearing in the analysis of neutron–proton scattering at low energies. In the limit of low energies the scattering cross section approaches that of an impenetrable sphere whose radius is equivalent to scattering length [48]. Also known as the Fermi intercept [4].

scattering mean free path (*see* mean free path).

scavenging. The selective removal of material from the radioactive cloud from a nuclear explosion by inert substances, such as earth or water, introduced into the fireball. The term is also applied to the process of removal of fallout particles from the atmosphere by precipitation [49]. (*See also* rainfall (nuclear); rainout; snowout; washout.)

Schrödinger constant. Constant for a fixed nucleus given by two times the electron rest mass (or reduced electron mass for the hydrogen atom) divided by the square of the Dirac h (1.64×10^{27} erg^{-1} cm^{-2}) used in the Schrödinger wave equation [35].

Schrödinger wave equation. General wave equation that describes the motion of an elementary material particle [35].

Schrödinger wave function. A function of the coordinates that determine the state of a system. It satisfies the Schrödinger wave equation. For a particle or a photon, the square of the wave function is proportional to the probability that the particle will be at a particular point at a particular time [32].

scintillation. Random fluctuations in the magnitude and direction of an electromagnetic wave as it traverses an inhomogeneous medium [38]. A flash of light produced by ionizing radiation in a fluor or a phosphor, which may be crystal, plastic, gas, or liquid [50].

scram. Emergency stopping of a nuclear reactor, usually by dropping safety rods [39].

sea-launched ballistic missile. A ballistic missile launched from a submarine or surface ship [36].

secondary blast effect (*see* blast effect).

secondary (nuclear device) (*see* device, nuclear).

secondary electron (*see* electron, secondary).

secondary photocurrent (*see* photocurrent, secondary).

secondary radiation (*see* radiation, secondary).

secondary X-rays (*see* X-rays, secondary).

secular equilibrium (*see* equilibrium, radioactive).

seismic detection. The recognition of low-amplitude vibrations in the earth's crustal layer as a means of identifying, for example, a nuclear explosion [37].

seismic waves (*see* ground waves; waves (ground motion), types of).

self-absorption. Absorption of radiation by the body of the substance emitting the radiation. It reduces the radiation level and thus the necessity for shielding [32].

self-scattering (*see* scattering, self-).

semiconductor devices. Devices that use material that has a conductivity between that of a good conductor and a good insulator. Transistors, diodes, and integrated circuits belong to this class of devices [38].

semiconductor junction. Two adjacent semiconductor materials that differ in the polarities of their majority carriers [38].

sensor. Equipment that detects, and may indicate, and/or record objects and activities by means of energy or particles emitted, reflected, or modified by objects [36].

SEP. Abbreviation for spherical error probability (*see* error probability, spherical).

separation energy. Synonym for binding energy of a proton, neutron, or alpha particle [32] (*see also* binding energy).

Sergeant. A mobile, inertially guided, solid-propellant, surface-to-surface missile, with nuclear warhead capability, designed to attack targets up to a range of 75 nautical miles. Designated as MGM-29A [36].

series, radioactive. A succession of nuclides, each of which transforms by radioactive disintegration into the next nuclide in the series until a stable nuclide results. The first member is called the parent and the subsequent members are called daughters or decay products. The final stable daughter is called the end product [39].

severe damage (*see* damage, nuclear).

SGEMP. Abbreviation for system-generated EMP (*see* EMP, system-generated).

shake. A nonstandard unit of time used in nuclear physics, equal to 10^{-8} second [38]. The generation time in fission by fast neutrons is roughly 1 shake [11].

shear (wind). Unless the term "velocity shear" is used, wind shear refers to differences in direction (directional shear) of the wind at different altitudes [49].

shear Mach wave (*see under* waves (ground motion), types of).

shear wall. A wall (or partition) designed to take a load in the direction of the plane of the wall, as distinct from lateral loads perpendicular to the wall. Shear walls may be designed to take lateral loads as well [49].

shear wave (*see under* waves (ground motion), types of).

shed. A shed is a unit of nuclear cross section equal to 10^{-24} barn, or 10^{-48} cm^2 [35].

shell structure of the atom. A formerly accepted theory as to the structure of an atom postulated electrons moving about a nucleus somewhat as the planets move about the sun in the solar system. For purposes of visualization, it is still convenient to think of the electron as a point mass revolving around a much larger mass, the nucleus. From this standpoint, the electrons will be found to occupy quantized energy levels (called orbits or orbitals) that define certain energy bands. These bands are referred to as shells. These shells possess increasingly greater "radii" measured from the nucleus, as their electrons possess more energy. The innermost shell is designated the K-shell; following are L-, M-, N-, O-, P-, and Q-shells, with a maximum allowed number of electrons per shell, respectively of 2, 8, 18, 32, 32, 18, 8. The electrons are designated as K-electron, etc. The number of electrons in a shell is limited according to the Pauli exclusion principle. As the elements increase in atomic number Z (the number of positively charged protons in the nucleus and hence also the number of electrons possessed by the neutral atom), they generally fill the shells in an orderly fashion, but discrepancies occur because electrons relatively far out from the nucleus are screened from the charge on the nucleus and effectively "see" a smaller nuclear charge. This screening causes the discrepancies from a normal filling of the shells based on predicted energy levels of the electrons. More recent theories regard the electron as a cloud or charge and refer to probability densities instead of electron orbits. A probability density of a particle is the probability that it may be found in a specific place or volume at a given time. Each possible electron orbital is uniquely designated by a set of four numbers called quantum numbers (no two electron orbitals or positions have the same set, according to the Pauli exclusion principle), which occur naturally in equations of quantum mechanics, and by their magnitude and sign govern such properties of the electrons as energy, position probability, and angular momentum [4].

shell structure, nucleus. Nucleus shell structure explains the arrangement of the quantum states of nucleons of a given kind in a nucleus in groups of approximately the

same energy. Each such group is called a shell, and the number of nucleons in each shell is limited by the Pauli exclusion principle. A closed shell is one containing the maximum number of nucleons. A nucleus having all of its nucleons of either or both kinds in closed shells possesses greater than average stability [32]. The nuclear shell structure is very nearly analogous to the electronic shell structure of the atom [35]. (*See also* nucleus model, independent particle; shell structure of the atom; magic nuclei.)

shield or shielding. *1.* Material of suitable thickness and physical characteristics used to protect personnel from radiation during the manufacture, handling, and transportation of fissionable and radioactive materials. *2.* Obstructions that protect personnel or materials from the effects of a nuclear explosion [36]. Any material or obstruction that absorbs (or attenuates) radiation and thus tends to protect personnel or equipment from the effects of a nuclear explosion. A moderately thick layer of any opaque material will provide satisfactory shielding from thermal radiation, but a considerable thickness of material of high density may be needed for gamma radiation shielding [50]. (*See also* attenuation.) *3.* Electrically continuous housing for a facility, area, or component, used to attenuate impinging electric and magnetic fields both by absorption and reflection [53].

shielding calculations (nuclear radiations). Calculations of the proper thickness and configuration of a shield for the reduction of radiation levels to a desired value is very difficult for high-intensity sources, and especially for distributed sources. The most common methods for gamma radiation are the Monte Carlo method and the moments method. For neutrons, diffusion theory and neutron slowing-down theory are used. Except for the simplest cases, results are, however, only approximate, even when computers are used [4].

SHOB. Abbreviation for scaled height of burst (*see* height of burst, scaled).

shock. Term used to describe a destructive force moving in air, water, or earth caused by detonation of a nuclear detonation [50].

shock front. The boundary between the pressure disturbance created by an explosion (in air, water, or earth) and the ambient atmosphere, water, or earth [36]. The boundary at which the medium being traversed by a shock or blast wave undergoes abrupt changes in velocity, pressure, and temperature [38].

shock strength. The ratio of the peak blast wave overpressure plus the ambient pressure to the ambient pressure [37].

shock tube. A hollow cylindrical or rectangular duct, in which a shock wave is generated for the purpose of investigating the effects of concussion phenomena similar to those produced by blast from a nuclear explosion, including reflection, refraction, diffraction, Mach stem formation, etc. Existing tubes are constructed of metal, have circular or rectangular cross sections, vary from several feet to 250 feet in length, and utilize compressed gas for the generation of shock. The tubes may be built of other materials and the shock may be generated by other means (i.e., by solid or gaseous explosives) [37]. (*See also* shock wave.)

shock wave. The continuously propagated pressure pulse formed by the blast from an explosion in air, under water, or under ground [36]. The steep frontal compression or

pressure discontinuity that rapidly advances through a medium because of a sudden application of pressure to the medium. Its form depends on the magnitude of the pressure and the displacement of the medium as the wave progresses. In soil the shock wave is commonly referred to as the ground shock; in water, the water shock; and in air, the airblast or blast [38]. A classical or ideal shock wave is a shock wave or moving pressure discontinuity that has the following characteristics: (a) as the shock front passes a given point, the pressure in the medium rises abruptly from ambient to its peak value; (b) after the passage of the shock front, the pressure in the medium decays exponentially to its ambient value; the period during which the pressure in the medium decays from peak to ambient is called the "positive phase;" (c) after the pressure in the medium decays to ambient, it continues to decay below ambient and then returns to the ambient value; the period during which the pressure in the medium is below ambient is called the "negative phase." A classical shock wave is sometimes called an ideal or classical weak shock wave to distinguish it from a non-ideal and a strong shock wave [2]. (*See also* blast wave.)

shock wave, direct. A shock wave traveling through the medium in which the explosion occurred, without having encountered an interface [37]. (*See* airblast-induced ground transmitted motion *for distinction.*)

shock wave, induced. The shock wave that is induced in a medium when a shock wave traveling in another medium crosses the interface between the two media [37] (*see under* airblast-induced ground direct motion; airblast-induced ground transmitted motion).

shock wave, non-ideal. A shock wave that does not cause the pressure in the medium to rise abruptly from ambient to its peak value as the front of the shock wave passes a given point. The pressure in the medium may rise gradually or in two or more jumps as the front of the shock wave passes a given point [2]. (*See also* precursor (airblast).)

shock wave, reflected. When a shock wave traveling in a medium strikes the interface between this medium and a denser medium, part of the energy of the shock wave induces a shock wave in the denser medium and the remainder of the energy results in the formation of a reflected shock wave that travels back through the less dense medium [36]. (*See* rarefaction wave *for distinction.*)

shock wave, strong. A shock wave that resembles a classical shock wave in form except that it does not have the negative phase of the classical shock wave. A strong shock wave causes the pressure in the medium to rise abruptly from ambient to its peak value as the shock front passes a given point. The pressure in the medium then decays exponentially, but never decays to a pressure below ambient [2].

shot (nuclear). An explosion of a nuclear weapon or nuclear device, in either combat or test; called also an event, detonation, or burst [37].

sievert (Sv). A recently introduced ICRP measure of dose equivalent that takes into account the quality factor of different types of ionizing radiation. One sievert equals 100 rem [50].

sigmoid curve. S-shaped curve, often characteristic of a dose-effect curve in radiobiological studies [39].

signal–to–noise ratio. The ratio of the amplitude of the desired signal to the amplitude of noise signals at a given point in time [36].

significant nuclear yield (*see* yield, significant nuclear).

silo. An underground launch facility for a missile [37].

simulation (nuclear weapon effect). To produce the effect of a nuclear burst on a particular material or device by means other than an actual nuclear explosion [38].

single particle nucleus model (*see* nucleus model, independent particle).

skin burns (*see* burns).

skin depth. Depth of penetration in a material at which an electromagnetic wave is attenuated to $1/\epsilon$ of its value at the surface (where ϵ is the value of its permittivity). Usually, the skin depth is sufficiently small that, for ordinary configurations of good conductors, the value obtained for a plane wave falling on a plane surface is a good approximation [12].

skin effect. The tendency of alternating current to concentrate in the surface layer of a conductor. The effect increases with frequency, and serves to increase the effective resistance of the conductor [46].

skyshine. Radiation, particularly gamma rays from a nuclear explosion, reaching a target from many directions as a result of scattering by the oxygen and nitrogen in the intervening atmosphere [49].

slant range. The line–of–sight distance between two points not at the same elevation relative to a specified datum [36]. The direct distance between an explosion and a point [38]. (*See* ground range *for distinction.*)

slick. The trace of an advancing shock wave seen on the surface of reasonably calm water as a circle of rapidly increasing size that appears darker than the surrounding water. It is observed, in particular, following an underwater explosion [49]. (*See also* crack.)

slowing–down. Decrease in energy of a nuclear particle [32]. The term is used primarily in the case of neutrons. It is also called moderation of neutrons [4].

slowing–down area. In an infinite homogeneous medium, one–sixth the mean square distance between the neutron source and the point where the neutron reaches a given energy. In Fermi theory, slowing–down area is the age [32]. (*See also* Fermi age.)

slowing–down density. At a given energy and time, the number of neutrons per unit volume per unit time that are going from an energy greater than the given energy to an energy lower than the given energy [32] (*see also* kernel, slowing–down).

slowing–down kernel (*see* kernel, slowing–down).

slowing–down length. The square root of the slowing–down area. It is also the square root of the Fermi age [32].

slowing-down power. The average loss in natural logarithm of energy (average increase in lethargy) of a neutron per unit distance traveled by the neutron in the substance [32].

slow neutrons (*see* neutrons, slow).

Snell's law. The sines of the angle of incidence and the angle of refraction bear a constant ratio to each other for any two given media (the angles of incidence and refraction are the angles that the incident and refracted ray make, respectively, with the perpendicular to the surface). If the first medium is air, this ratio is called the index of refraction or the refraction index of the second medium [45].

snowout. The removal of radioactive particles from a nuclear cloud by precipitation when this cloud is within a snow cloud [49] (*see also* rainfall (nuclear); rainout; washout).

snowplow effect. When the particles of a nuclear reaction collide with adjacent particles "at rest" in the surrounding medium, some of their translational kinetic energy is transferred to the particles struck. The struck particles are accelerated and collide with other particles. Kinetic energy is transported to greater distances. Unlike the "random walk" of photons, the particles move in a preferred direction, on the average, away from the center of the explosion to regions of lower pressure. This action is termed the "snowplow" effect [11].

soft. When referring to radiations, an adjective that indicates the less energetic or penetrating radiations of a given type, e.g., soft X-rays. (in general, the longer the wavelength the softer the radiation.) When referring to a facility or system, an adjective that indicates the facility or system is not very resistant to nuclear weapon effects.

softness. A relative specification of the quality or penetrating power of X-rays or gamma rays [39].

soft target. A military objective that is considered to have minimal capability for resisting weapon effects [37].

somatic cell (*see* cell, somatic).

sonic. Of or pertaining to sound or the speed of sound [36] (*see also* sound, speed of).

sound, speed of. The speed at which sound travels in a given medium under specified conditions. The speed of sound at sea level in the international Standard Atmosphere is 1,108 ft/sec, 658 knots, 1,215 km/hr [36]. (*See also* subsonic; transonic; supersonic; hypersonic.)

source and special (SS) nuclear material. Two categories of essential substances used in the production of nuclear components for nuclear weapons, listed in the Atomic Energy Act of 1954 as "Source Material" and "Special Nuclear Material" [from 37]:

- *Source Material. (1)* Uranium, thorium, or any other material that is determined by the Commission puruant to the provisions of section 61 to be source material; or *(2)* ores containing one or more of the foregoing materials, in such concentration as the Commission may by regulation determine from time to time.

- *Special Nuclear Material. (1)* Plutonium, uranium enriched in the isotope 233 or the isotope 235, and any other material that the Commission, pursuant to the provisions of section 51, determines to be special nuclear material, but does not include source material; or *(2)* any material artificially enriched by any of the foregoing, but does not include source material. Also called active material.

(*See* plutonium; uranium.)

space charge. The electric charge carried by a cloud or stream of electrons or ions in a vacuum or a region of low gas pressure, when the charge is sufficient to produce local change in the potential distribution [38].

spallation. The removal of fragments from the back surface of a material due to localized stresses, frequently thermal stresses [37]. Also, a term used to denote a nuclear reaction induced by high-energy bombardment and involving the ejection of more than two or three particles (neutrons, protons, deuterons, alpha particles, etc.) [39].

spark chamber. An instrument for detecting and measuring the paths of elementary particles. It is analogous to the cloud chamber and bubble chamber. It consists of numerous electrically charged metal plates mounted in a parallel array, the spaces between the plates being filled with an inert gas. Ionizing radiation causes sparks to jump between the plates along the radiation path through the chamber [29]. (*Compare with* bubble chamber; cloud chamber.)

Spartan. A nuclear surface-to-air guided missile formerly deployed as part of the Safeguard ballistic missile defense weapon system. It is designed to intercept strategic ballistic reentry vehicles in the exoatmosphere [36].

special nuclear material (*see* source and special (SS) nuclear material).

specific activity (*see* activity, specific).

specific gamma-ray constant (*see* gamma-ray constant, specific).

specific ionization (*see* ionization, specific).

spectral distribution. The distribution of energy by wavelength over the electromagnetic spectrum [38] (*see also* spectrum).

spectrograph, mass. A device for analyzing a substance in terms of the ratios of mass to charge of its components, usually restricted to devices that produce a focused mass spectrum of lines on a photographic plate [39].

spectrometer, mass. A device similar to the mass spectrograph but designed so that the beam constituents of a given mass-to-charge ratio are focused on an electrode and detected or measured electrically [39].

spectrum. A visual display, a photographic record, or a plot of the distribution of the intensity of radiation of a given kind as a function of its wavelength, energy, frequency, momentum, mass, or any related quantity [39].

spectrum, atomic. The spectrum of radiation from an atom resulting from internal changes. An example is an electron in its transition from one shell to another [35].

spectrum, electromagnetic. The range of frequencies of electromagnetic radiation from zero to infinity. It is divided into 26 alphabetically designated bands [36].

spectrum, energy. A description of the relative magnitudes of various energy components or energy ranges of electromagnetic radiation or particles [38].

spectrum, fission. The distribution in energy of the fission neutrons [32] (*see* fissioning distribution *for distinction*).

spherical error probability (*see* error probability, spherical).

spin. One of the properties of atomic particles is angular momentum, or spin. Many particles behave as if they were spinning on a central axis, but only certain values of this spin appear. In terms of the basic unit of spin, most particles have 0, 1/2, or 1 unit. The product of this spin and the Dirac h gives the angular momentum of the particle. The half-integral spin particles, such as the electron, proton, and neutron, obey an exclusion "law" that "forbids" the existence of more than one of them in the same place. The integral spin particles, such as the photon and meson, obey no such law [24].

spin quantum number (*see* shell structure of the atom).

spin quantum number, isobaric (*see* quantum number, isobaric spin).

spray dome. The mound of water spray thrown up into the air when the shock wave from an underwater detonation of a nuclear weapon reaches the surface [36].

Sprint. A high acceleration, nuclear surface-to-air guided missile formerly deployed as part of the Safeguard ballistic missile defense weapon system. It is designed to intercept strategic ballistic reentry vehicles in the endoatmosphere [36].

SREMP. Abbreviation for source region EMP.

SS material (*see* source and special (SS) nuclear material).

squib. A small pyrotechnic device that may be used to fire the igniter in a rocket or for some similar purpose. Not to be confused with a detonator that explodes [36].

stable (atomic or nuclear system). Incapable of spontaneous changes, i.e., not radioactive [48].

stage (missile). An element of the missile or propulsion system that generally separates from the missile at burnout or cutoff. Stages are numbered chronologically in order of burning [36].

standard, radioactive. A sample of radioactive material, usually with a long half-life, in which the number and type of radioactive atoms at a definite reference time is known. In may be used as a radiation source for calibrating radiation measurement equipment [39].

standard deviation (*see* deviation, standard).

statcoulomb (electrostatic unit of charge). That quantity of electric charge that, when placed in a vacuum 1 cm distant from an equal and like charge, will repel it with a force of 1 dyne (abbreviated esu). Preferred name for this unit is franklin (Fr) [39].

static margin (aerodynamics). The distance between the center of mass and the center of pressure of an aerodynamic body. It is positive when the center of pressure is farther to the rear. For positive values the body is aerodynamically stable, and for negative values it is unstable [35].

steady state. Constant with time.

Stefan–Boltzmann constant (*see* Stefan–Boltzmann law).

Stefan–Boltzmann law. The law that the emitted radiant flux density (or radiance) of a blackbody is proportional to the fourth power of its absolute temperature; the constant of proportionality, the Stefan–Boltzmann constant, is equal to 5.672×10^{-5} erg/cm^2 ·deg^4·sec. Also called the fourth–power law [4].

sterility (biological). Temporary or permanent incapability to reproduce [39].

stochastic (or random) variables. Variable quantities with a definite range of values, each of which, when chosen at random, can be attained with a definite probability [4].

stockpile. Weapons and components, the custody of which has been transferred from DOE to DOD with the following exceptions: (a) weapons and components that have been transferred by DOD to DOE; (b) weapons and components that have been placed by the DOD in retired status; or (c) weapons and components that have been dropped from accountability due to expenditure or loss [37].

stockpile to target sequence (STS). *1.* The order of events involved in removing a nuclear weapon from storage, and assembling, testing, transporting, and delivering it on the target. *2.* A document that defines the logistical and employment concepts and related physical environments involved in the delivery of a nuclear weapon from the stockpile to the target. It may also define the logistical flow involved in moving nuclear weapons to and from the stockpile for quality assurance testing, modification, and retrofit, and the recycling of limited life components [36].

stopping altitude (*see* altitude, stopping).

stopping equivalent (*see* stopping power).

stopping power. Loss of energy of charged particles in a medium regardless of where that energy is absorbed. It is different from the concept of linear energy transfer, which refers to energy imparted within a limited volume [5]. Stopping power is a measure of the effect of a substance upon the kinetic energy of a charged particle passing through it. There are several specific stopping powers, such as linear stopping power, mass stopping power, atomic stopping power, and molecular stopping power, which are defined below [39]:

- *Linear* stopping power is the energy loss per unit distance
- *Mass* stopping power is the energy loss per unit surface density traversed

- *Atomic* stopping power of an element is the energy loss per atom, per unit area normal to the particle's motion
- *Molecular* stopping power of a compound is similarly defined in terms of molecules (it is very nearly, if not exactly, equal to the sum of the atomic stopping powers of the constituent atoms).

Relative stopping power is the ratio of the stopping power of a given substance to that of a standard substance, commonly aluminum, oxygen, or air. The stopping equivalent for a given thickness of a substance is that thickness of a standard substance capable of producing the same energy loss. The air equivalent is the stopping equivalent in terms of air at 15°C and 1 atmosphere as the standard substance [32]. It should be noted that stopping power denotes energy lost due to ionization. For some purposes it is desirable to consider stopping power with the exclusion of bremsstrahlung losses. In this case, the stopping power must be multiplied by an appropriate factor that is less than unity [5].

storage time. In transistors, the time interval between the cessation of base overdrive and the increase of collector voltage to 10 percent of its final value [52].

strange particles. A class of very short-lived elementary particles that decay more slowly than they are formed, indicating that the production process and decay process result from different fundamental reactions. They include mu mesons, K-mesons, and hyperons [29].

strategic air warfare. Air combat and supporting operations designed to effect, through the systematic application of force to a selected series of vital targets, the progressive destruction and disintegration of the enemy's war-making capacity to a point where the enemy no longer retains the ability or the will to wage war. Vital targets may include key manufacturing systems, sources of raw material, critical material, stockpiles, power systems, transportation systems, communication facilities, concentrations of uncommitted elements of enemy armed forces, key agricultural areas, and other such target systems [36].

stratosphere. The layer of the atmosphere above the troposphere in which the change of temperature with height is relatively small [36] (*see also* atmosphere).

streaming. The increased transmission of electromagnetic or particular radiation through a medium resulting from the presence of extended voids or other regions of low attenuation [39].

stress. The force acting in a unit area of a solid [41].

strike, first. The first offensive move of a war. (Generally associated with nuclear operations.) [36].

strike, second. The first counterblow of a war. (Generally associated with nuclear operations.) [36].

strike capability, second. The ability to survive a first strike with sufficient resources to deliver an effective counterblow. (Generally associated with nuclear weapons.) [36].

strong shock wave (*see* shock wave, strong).

STS. Abbreviation for stockpile–to–target sequence.

subatomic particle. Same as elementary particle.

subcritical. The state of a given fission system when the specified conditions are such that a less than critical mass of active material is present [37] (*see* critical; supercritical).

subcritical mass. An amount of fissionable material insufficient in quantity or of improper geometry to sustain a fission chain reaction [37].

subkiloton weapon. A nuclear weapon producing a yield below 1 kiloton [36] (*see also* kiloton weapon; nominal weapon).

submarine–launched missile (*see* sea–launched ballistic missile).

sublevels (or suborbits) of the shells of atoms. An atom is usually pictured very simply by a central core or nucleus containing protons and neutrons, surrounded by electrons spinning in orbits or "shells" (*see* shell structure of the atom). Actually, to understand atomic structure, one must go beyond this simple picture of the atom and examine sublevels (or suborbits) of the shells. The sublevels are designated by the letters s, p, d, and f [27].

suborbits of the shells of atoms (*see* sublevels of the shells of atoms).

subsonic. Of or pertaining to speeds less than the speed of sound [36] (*see also* sound, speed of).

subsurface burst (*see* burst, types of nuclear).

subsystem (electronics). A major functional assembly within a system that performs a specific function; usually used to describe a portion of a system larger than an assembly, but smaller than the total system [53].

supercritical. A term used to describe the state of a given fission system when the quantity of fissionable material is greater than the critical mass under the existing conditions. A highly supercritical system is essential for the production of energy at a very rapid rate so that a nuclear explosion may occur [49]. (*See also* critical; subcritical.)

supersonic. Of or pertaining to speed in excess of the speed of sound [36] (*see also* sound, speed of).

sure–kill level. A set of environmental conditions under which it is 100 percent certain that the system mission cannot be executed [38] (*see also* lethal nuclear environment).

sure–safe level. A set of environmental conditions under which it is 100 percent certain that the system mission can be completed [38].

surety, nuclear weapon. Materiel, personnel and procedures that contribute to the security, safety, and reliability of nuclear weapons and to the assurance that there will be no nuclear weapon accidents, incidents, unauthorized weapon detonations, or degradation in performance at the target [36].

surface burst (*see* burst, types of nuclear).

surface intersection burst (*see* burst, types of nuclear).

surface waves (*see under* waves (ground motion), types of).

surface zero (SZ) (*see* ground zero).

surge (*see* base surge).

survey, radiological. The directed effort to determine the distribution and dose rates of radiation in an area [36]. Evaluation of the radiation hazards incident to the production, use, or existence of radioactive materials or other sources of radiation under specific conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment [39].

survey meter. A portable instrument, such as a Geiger counter or ionization chamber, used to detect nuclear radiation and to measure the dose rate [49].

survivability. The capability of a system to avoid and/or withstand a manmade hostile environment without suffering abortive impairment of its ability to accomplish its designated mission [37] (*see also* vulnerability).

survivability level, nuclear. A quantitative description of the maximum values of nuclear environment parameters that a system can be exposed to without suffering abortive impairment of its ability to accomplish its designated mission [37].

susceptibility. The degree to which a device, equipment or weapons system is open to effective attack due to one or more inherent weaknesses [36]. The degree to which a system or a portion of the system is degraded by an external, hostile stimulus [53].

sustaining chain reaction (*see* chain reaction).

synchrocyclotron. A cyclotron that compensates for the relativistic mass increase of the particles as they reach high energy by reducing the accelerating frequency so as to match exactly the slower revolutions of the accelerated particles [39].

synchrotron. An accelerator in which particles are accelerated around a circular path by radiofrequency electric fields. The magnetic guiding and focusing fields are increased synchronously to match the energy gained by the particles so that the orbit radius remains constant [39]. (*See also* cyclotron; synchrocyclotron.)

synchrotron radiation (*see* radiation, synchrotron).

synergistic target response. A response in which the total damage to a target is more severe than the sum of the damages that would be caused by each individual nuclear effect acting separately [37].

system (electrical). A collection of subsystems, assemblies, and/or components that function together in a coherent way to accomplish a basic mission [53].

system (electrical) description. Any or all of the following that describe a system [53]:

- *Functional description* -- How the various parts and the whole function to perform its purpose (here, the reference for interaction is internal to the system)
- *Operational description* -- How the system is *used* to accomplish its mission including operator actions required, mission scenarios, etc. (here, the reference for interaction is external to the system)
- *Physical description* -- Which subsystems are located in which box or rack, etc.; box or rack location; box dimensions, cabling layout; grounding, bonding, conduits, cable ways; etc.
- *Electrical description* -- Schematic(s), parts list, wiring diagram, component specifications.

system-generated EMP (SGEMP) (*see* EMP, system-generated).

tactical nuclear weapon employment (*see* employment, tactical nuclear weapon).

tamper. A heavy material surrounding the active material in a nuclear weapon for the purpose of holding the supercritical assembly together longer by its inertia, and also for the purpose of reflecting neutrons and thus increasing the fission rate of the active material [37] (*see also* reflector).

tap. A unit of measurement equal to 1 dyne-sec/cm^2 often used to quantify X-ray impulse [35].

target theory (hit theory). A theory explaining some biological effects of radiation on the basis that ionization, occurring in a discrete volume (the target) within the cell, directly causes a lesion that subsequently results in a physiological response to the damage at that location. One, two, or more "hits" (ionizing events within the target) may be necessary to elicit the response [39].

telecommunication. Any transmission, emission, or reception of signs, signals, writing, images, sounds, or information of any nature by wire, radio, visual, or other electromagnetic systems [36].

temperature, blackbody. Often it is convenient to define the temperature of a blackbody source in terms of the photon energy, kT, where k is Boltzmann's constant and T is the temperature of a blackbody in ^{o}K. kT has the dimensions of energy and occurs naturally in the theories of molecular motion and the quantum theory of blackbody radiation. The energy unit most frequently given to kT is the electron volt, eV. A 1-keV blackbody has a temperature of 11.6 x 10^6 ^{o}K [13].

temperature gradient (ocean). At sea, a temperature gradient is the change of temperature with depth; a positive gradient is a temperature increase with an increase in depth [36].

tensile wave (*see* rarefaction wave).

tenth-value thickness. The thickness of a specified material that will decrease the intensity (or dose) of gamma radiation to one-tenth of the amount incident upon it. Two tenth-value thicknesses will reduce the dose received by a factor of 10 x 10, i.e., 100, and so on. The tenth-value thickness of a given material depends on the gamma-ray energy, but for radiation of a particular energy it is roughly inversely proportional to the density of the material [49].

terminal phase. That portion of the trajectory of a ballistic missile between reentry into the atmosphere or the end of the midcourse phase and impact or arrival in the vicinity of the target [36].

tertiary blast effect (*see* blast effect).

tertiary radiation (*see* radiation, tertiary).

test bed. A configuration designed, developed, and procured specifically for the firing or drop test programs to simulate the nuclear and HE section of a warhead and capable of accommodating an instrumentation package and war reserve warhead components [37].

test, nuclear. A test carried out to supply information required for the design and improvement of nuclear weapons and/or to study the phenomena and effects associated with nuclear explosions [50]. Some of the types of tests are as follows [37].

1. DOE Test.

   a. *One-point safety test.* A test conducted to verify that the detonation of the high explosive of a nuclear weapon by initiation at any one point has a probability of no greater than one in one million of producing a nuclear yield in excess of 4 pounds TNT equivalent.

   b. *Proof test.* A test conducted to determine or verify the yield of nuclear weapons or to ascertain the performance of the various weapon components. These weapons are those that are already in the stockpile or are candidates for stockpiling.

   c. *Weapon development test.* A test that is basically a physics experiment. It is conducted to verify new theories and techniques associated with a particular device and to obtain a deeper insight into nuclear weapon design phenomenology.

2. DOD Test.

   a. *Nuclear weapon effects test (NWET).* A test conducted to determine (1) the effects of nuclear detonations upon environments, materials, equipment, structures, and personnel, or (2) the effects of environments on nuclear weapons or detonations.

   b. *Operational test.* A test conducted to check the functioning of a military system in the system's own nuclear environment in which it is designed to operate. The objectives are to establish confidence in the system and to provide information for development of tactics and doctrine associated with the system.

thermal cross section (*see* cross section, thermal).

thermal energy (nuclear explosion). The energy emitted from the fireball as thermal radiation. The total amount of thermal energy received per unit area at a specified distance from a nuclear explosion is generally expressed in calories per square centimeter [36]. (*See also* thermal radiation.)

thermal energy yield (or thermal yield) (*see* yield, thermal).

thermal exposure. The total normal component of thermal radiation striking a given surface throughout the course of a [nuclear] detonation; expressed in calories per square centimeter and/or megajoules per square meter [36].

thermal imagery (infrared). Imagery produced by measuring and recording electronically the thermal radiation of objects [36].

thermal line. A horizontal radial line on the surface of the earth originating at ground zero, along which measurements of thermal radiation from an explosion are taken [37] (*see also* blast line).

thermal neutrons (*see* neutrons, thermal).

thermal pulse. The thermal radiant power versus time pulse from a nuclear weapon detonation [36] (*see also* radiant power).

thermal radiation. *1.* The heat and light produced by a nuclear explosion. *2.* Electromagnetic radiations emitted from a heat or light source as a consequence of its temperature; it consists essentially of ultraviolet, visible, and infrared radiations [36]. Electromagnetic radiation from a nuclear weapon, emitted in the wavelength range from 0.2 micron in the ultraviolet, though the visible, to 12 microns in the infrared (although, strictly speaking, the term radiant energy includes all EM radiations) [38]. Thermal radiation from an airburst or surface burst is emitted in two pulses from the fireball. In the first pulse, when the temperature of the fireball is extremely high, ultraviolet radiation predominates; in the second pulse, the temperatures are lower and most of the thermal radiation lies in the visible and infrared regions of the spectrum [50]. From a high-altitude burst, the thermal radiation is emitted in a single, short pulse that is of short duration below about 270,000 feet but increases at greater burst heights [49].

thermal X-rays (*see* X-rays, thermal).

thermal yield (*see* yield, thermal).

thermomechanical damage. Physical damage caused by heating from the deposition of radiation energy in a material [40].

thermonuclear. An adjective referring to the process (or processes) in which very high temperatures are used to bring about the fusion of light nuclei, resulting in the liberation of energy [36] (*see also under* weapon, nuclear).

Thomson scattering (*see* scattering, Thomson).

threshold detector (*see* detector, threshold).

threshold dose (*see* dose, threshold).

threshold energy. In endothermic nuclear reactions, the energy limit for an incident particle or photon below which a particular reaction will not occur. More generally, the energy limit for an incident particle or photon below which any given nuclear reaction (exothermic or endothermic) cannot be observed; it is sometimes called the practical threshold energy. It is frequently determined by coulomb barrier effects [32].

threshold, photoelectric (*see* photoelectric threshold).

throwout (*see* ejecta).

time of flight. The time in seconds from the instant a weapon is fired, launched, or released from the delivery vehicle or weapon system to the instant it strikes or detonates [36].

tissue equivalent material. Material made up of the same elements in the same proportions as they occur in a particular biological tissue. In some cases, the equivalence may be approximated with sufficient accuracy on the basis of effective atomic number [39].

Titan. A liquid-propellant, two-stage, rocket-powered intercontinental ballistic missile equipped with a nuclear warhead. The Titan 1, designated as HGM-25, was guided by radio-inertial guidance. The Titan 2, the LGM-25C, is guided by all-inertial guidance and equipped with a higher yield warhead. The system is for deployment in a hardened and dispersed configuration [36 (1972 edition)].

TNT effects equivalence. The expressing of the effect of a particular phenomenon of a nuclear detonation in terms of the amount of TNT that would produce the same effect [38].

TNT equivalent. A measure of the energy release from the detonation of a nuclear weapon, or from the explosion of a given quantity of fissionable or fusionable material, in terms of the amount of trinitrotoluene which would release the same amount of energy when exploded [36]. The TNT equivalent is usually stated in kilotons or megatons. The basis of the TNT equivalence is that the explosion of 1 ton of TNT is assumed to release 10^9 calories of energy [50].

tolerance dose (*see* dose, tolerance).

torr. Unit of pressure equal to 1 millimeter of mercury, or approximately 132.7 pascals.

total cross section (*see* cross section, total).

total electron binding energy (*see* binding energy, total electron).

tracer, isotopic. The isotope or nonnatural mixture of isotopes of an element that may be incorporated into a sample to permit observation of the course of that element, alone or in combination, through a chemical, biological, or physical process. The observations may be made by measurement of radioactivity or of isotopic abundance [39].

track. In subatomic physics, the visual manifestation of the path of an ionizing particle in a chamber or photographic emulsion [39].

transfer coefficient, mass-energy (*see* mass-energy transfer coefficient).

transient effects. Changes in material properties that persist for a time shorter than or comparable to the normal response time of the system of which the material is a part [38]. Transient effects are such that the affected component, subsystem, or system will, in principle, recover during its functional lifetime. System malfunction can result, however, since transient effects often cause permanent effects in the system [37].

transient radiation effects on electronics (TREE) (*see* TREE).

transient upset (*see* upset, transient).

transistor. A semiconductor device that uses a small current to control a much larger current [38].

transit dose (*see* dose, transit).

transition, isomeric. The process by which a nuclide decays to an isomeric nuclide (i.e., one of the same mass number and atomic number) of lower quantum energy. Isomeric

transitions, often abbreviated I.T., proceed by gamma-ray and/or internal conversion electron emission [39].

transition probability. The probability per unit time that a system in one state will undergo a transition to another state. For radioactive transitions the transition probability is called the disintegration constant [32].

transition zone (region). A zone extending above the earth's surface in which the weapon phenomenon of interest from a burst in the zone will be modified by the presence of the earth's surface [37] (*see* burst, types of nuclear).

transmission factor (nuclear). The ratio of the dose inside the shielding material to the outside (ambient) dose. Transmission factor is used to calculate the dose received through the shielding material [36]. (*See also* half thickness; shield or shielding.)

transmissivity. Concerning radiation incident upon the boundary between two media, transmissivity is the ratio of the radiation transmitted through the boundary to the component of radiation normal to the boundary [35] (*see also* transmissivity, atmospheric).

transmissivity (or transmittance), atmospheric. The fraction (or percentage) of the thermal exposure received at a given location after passing through the atmosphere, relative to that which would have been received at the same location if no atmosphere were present [49].

transmutation, nuclear. Artificially induced modification (nuclear reaction) of the constituents of certain nuclei, thus giving rise to different nuclides [36]. Any process in which a nuclide is transformed into a different nuclide, or more specifically, transformed into a different element by a nuclear reaction [39].

transonic. Of or pertaining to the speed of a body in a surrounding fluid when the relative speed of the fluid is subsonic in some places and supersonic in others. This is encountered when passing from subsonic to supersonic speeds and vice versa [36]. (*See also* sound, speed of.)

transport cross section (*see* cross section, transport).

transport mean free path (*see* mean free path, transport).

transport theory. A generalized mathematical method for treating the diffusion of neutrons or the attenuation of gamma radiation. Neutron diffusion theory is a special case of transport theory, in which there are no boundaries, and in which neutron flux distribution is isotropic. Transport theory considers the directions of the particles or photons, and thus six coordinates (three of velocity and three of position) are required. The Boltzmann equation is the basic equation, but approximations permitted by Fick's law are not used. Transport calculations are usually complex and require computers [4]. (*See also* diffusion equation.)

transverse electric field (*see* electric field, transverse).

transverse wave (*see under* waves (ground motion), types of).

trapped radiation. Electrically charged particles moving back and forth in spirals along the north–south orientation of the earth's magnetic field between mirror points, called conjugate points. Negatively charged particles drift eastward as they bounce between northern and southern conjugate points and positively charged particles drift westward, thus forming shells or belts of radiation above the earth. The source of the charged particles may be natural, from solar activity (often called Van Allen belts), or artificial, resulting from high–altitude nuclear detonations [50].

trapping. That process in which a free charge carrier is captured and, once captured, has a greater probability of being reexcited to a free state than of recombining with a carrier of the opposite polarity [38].

trapping center. A site in a solid at which a free electron or hole may be captured, and in which the charge carrier, once captured, has a greater probability of being thermally reexcited to a free state than of recombining with a carrier of the opposite sign [38]. (*See* trapping.)

TREE (transient radiation effects on electronics). The class of effects, either transient or permanent, that transient radiations from nuclear detonations, principally gamma rays and neutrons, have upon electronics. (Transient in TREE modifies radiation, not effects; TREE includes both transient and permanent effects.) [40].

TREES. Acronym for transient radiation effects on electronic systems [38].

Trident. A general descriptive term for the sea–based strategic weapon system consisting of the highly survivable nuclear–powered Trident submarine, long–range Trident ballistic missiles, and the integrated refit facilities required to support the submarine and missile subsystems as well as associated personnel [36].

Trident I. A three–stage, solid propellant ballistic missile capable of being launched from a Trident submarine either surfaced or submerged. It is sized to permit backfit into Poseidon submarines and is equipped with advanced guidance, nuclear warheads and a maneuverable bus which can deploy these warheads to separate targets. It is capable of carrying a full payload to 4000 nautical miles with greater ranges achievable in reduced payload configurations. Designated as UGM–96 [36].

Trident II. A solid propellant ballistic missile capable of being launched from a Trident submarine. It is larger than the Trident I missile and will replace these missiles in Trident submarines in the mid–1980s. It will provide the option to deploy a higher throw weight, more accurate submarine–launched ballistic missile [36].

triple point. The intersection of the incident, reflected, and fused (or Mach) shock fronts accompanying an air burst. The height of the triple point above the surface, i.e., the height of the Mach stem, increases with increasing distance from a given explosion [36]. (*See also* Mach stem.)

tritium. The radioactive hydrogen isotope having one proton and two neutrons in the nucleus (symbol $^{3}_{1}H$ or T) [39] (*see also* deuterium).

triton. The nucleus of tritium, the hydrogen isotope of mass number 3, used as a nuclear projectile or as a product of a nuclear reaction [39].

tropopause. The transition zone between the stratosphere and the troposphere. The tropopause normally occurs at an altitude of about 25,000 to 45,000 feet in polar and temperate zones, and at 55,000 feet in the tropics [36]. (*See also* atmosphere.)

troposphere. The lower layers of the atmosphere, in which the change of temperature with height is relatively large. It is the region where clouds form, convection is active, and mixing is continuous and more or less complete [36] (*see also* atmosphere).

tropospheric scatter. The propagation of electromagnetic waves by scattering as a result of irregularities or discontinuities in the physical properties of the troposphere [36].

true crater (*see* crater, true).

tuballoy (TU). A term of British origin for uranium metal containing uranium–238 and uranium–235 in natural proportions, i.e., normal uranium. The term is considered ambiguous and its use is discouraged. This term is sometimes applied to depleted uranium [37]. (*See also* uranium, depleted; uranium, normal.)

tube, boron counter. A counter tube filled with boron trifluoride and/or having electrodes coated with boron or boron compounds used for detecting slow neutrons [39].

tube, electron multiplier. A tube in which small electron currents are amplified by a cascade process employing secondary emission [39].

tube, photomultiplier. An electron multiplier tube in which the electrons initiating the cascade originate by photoelectric emission [39].

tumor. In its general sense, a swelling. The term is often synonymous with neoplasm. A malignant tumor is capable of metastasizing [39].

two–man rule. A system designed to prohibit access by an individual to nuclear weapons and certain designated components by requiring the presence at all times of at least two authorized persons each capable of detecting incorrect or unauthorized procedures with respect to the task to be performed. Also referred to as the two–man concept or two–man policy [36].

Two–W or 2W concept. The concept that the explosion of a weapon of energy yield W on the earth's surface produces (as a result of reflection) blast phenomena identical to those produced by a weapon of twice the yield (i.e., 2W) of a burst in free air, i.e., away from any reflecting surface [49].

types of burst (*see* burst, types of nuclear).

UGT. Abbreviation for underground test (nuclear).

ultraphotic rays. Electromagnetic radiation that extends beyond the visible region of the spectrum at either the low- or high-frequency end; i.e., ultraviolet and infrared radiation [4].

ultraviolet. Electromagnetic radiation of wavelengths between the shortest visible violet (about 3,850 angstroms) and soft X-rays (about 100 angstroms) [50].

uncertainty principle, Heisenberg (*see* Heisenberg uncertainty principle).

underground burst (*see* burst, types of nuclear).

underlay defense. Endo- (within) atmospheric defense against ballistic missiles.

underwater burst (*see* burst, types of nuclear).

unit of electric charge (*see* electric charge, unit of).

unwarned exposed. The vulnerability of friendly forces to nuclear weapon effects. In this condition, personnel are assumed to be standing in the open at burst time, but have dropped to a prone position by the time the blast wave arrives. They are expected to have areas of bare skin exposed to direct thermal radiation, and some personnel may suffer dazzle [36]. (*See also* warned exposed; warned protected.)

upset (electronics). Impairment of proper operation that is *not* due to burnout or other permanent damage to one or more components. Systems that have been upset may spontaneously return to proper operation or may require some operator action, such as resetting a circuit breaker or reloading information into memory [53].

upset, circuit. A circuit response that causes some electrical subsystem or system to malfunction temporarily [38]. An unexpected circuit response; a temporary circuit malfunction [53].

upset, operational (electronics). Usually implies some temporary impairment of operation that does not result in permanent damage, but which causes a significant disturbance or perturbation to the normal operation [53].

upset, transient (EMP/TREE). A term used to describe an undesired system effect or degradation induced by a short-duration or transient excitation. The term is frequently used to cover all types of such undesired EMP effects on electronics that are not considered as permanent damage [53].

upthrust. Deformation material pushed up around a crater, but not dissociated from the earth media by a nuclear blast [38].

uranium. Metallic element that can be processed into a form suitable for producing nuclear reactions. Uranium-235 is fissionable by both slow (thermal) neutrons and fast (high-energy) neutrons, but uranium-238 and uranium-234 are fissionable only by fast neutrons. Since uranium-234 is present in such small amounts and is not fissionable by slow neutrons, its presence can be ignored. The uranium-235 isotope, on the other hand, is plentiful enough to be important [28]. (*See also* source and special (SS) nuclear material.)

uranium, depleted. Uranium depleted in the uranium–235 isotope. The composition is in the range of 99.28 to 99.85 percent uranium–238 and less than 0.711 percent uranium–235 with a trace of uranium–234 [37]. (*See also* tuballoy.)

uranium, enriched. Uranium that has been enriched in the uranium–235 isotope. Various grades of enriched uranium are used; however, oralloy (*which see*) is the most common. Oralloy has a composition of 92.9 to 94.0 percent uranium–235, 6.0 to 7.0 percent uranium–238, and a trace of uranium–234 [37].

uranium, normal. Uranium of the composition that occurs in nature. It consists of approximately 99.28 percent uranium–238, 0.7115 percent uranium–235, and a trace of uranium–234 [37]. (*See also* tuballoy (TU).)

vacancy. An empty lattice site in a crystalline material [38].

valence. Number representing the combining or displacing power of an atom; number of electrons lost, gained, or shared by an atom in a compound; number of hydrogen atoms with which an atom will combine, or which it will displace [39]. The valence of an element is the ratio of the atomic weight to the equivalent weight [35].

valence electron. Electron that is gained, lost, or shared in a chemical reaction [39].

validation. Corroboration of a hypothesis on a sound or authoritative basis. In the case of nuclear hardening it is to corroborate that a specified level of survivability has been achieved. This is generally accomplished by those organizations that officially sanction the hardness (survivability) of the system with the customer as a witness [53].

Van de Graaff accelerator. An electrostatic machine in which electrical charge is carried into the high-voltage terminal by a belt made of an insulating material moving at high speed. The particles are then accelerated along a discharge path through a vacuum tube by the potential difference between the insulated terminal and the grounded end of the accelerator [39].

variability. The manner in which the probability of damage to a specific target decreases with the distance from ground zero; or, in damage assessment, a mathematical factor introduced to average the effects of orientation, minor shielding and uncertainty of target response to the effects considered [36].

variance. In statistics, the square of the standard deviation [35].

vehicle. A self-propelled, boosted, or towed conveyance for transporting a burden on land, sea, or through air or space [36].

Vela. Title of nuclear test program to improve nuclear detection capability [37].

Vela Uniform. Seismic program related to systems for detection of nuclear explosions [37].

velocity, relativistic. A velocity sufficiently large that the values of some properties of a particle having this velocity are significantly different from the values of the same properties when the particle is at rest. The property of most interest is the mass. For many purposes, the velocity is relativistic when it exceeds about one-tenth the velocity of light [32]. (*See also* mass-energy equivalence; particle, relativistic.)

venting. The escape through the surface to the atmosphere of gases or radioactive products from a subsurface high-explosive or nuclear detonation [37].

verification. *1.* To establish the truth or accuracy of something such as a mathematical or computer model. In the case of nuclear hardening, to prove the truth of a level of survivability of a part, component, or system by a definitive test, experiment, or other evidence [53]. *2.* In arms control, any action involving inspection, detection, and identification, taken to ascertain compliance with agreed measures [36].

very high. DOD term for a height above 50,000 feet [36].

very low. DOD term for a height below 500 feet [36].

visibility range (or visibility). The horizontal distance (in kilometers or miles) at which a large, dark object can just be seen against the horizon sky in daylight [36].

visible. That portion of the electromagnetic spectrum occurring between 0.4 and 0.7 micron. The term luminous also is applied to radiation in this region [38].

volt. The unit of electromotive force [39].

voltage, forward (semiconductor). The voltage applied to a PN junction, which forward biases the junction [38].

volume, atomic. The ratio of the atomic weight of an element in grams to its density in grams per cubic centimeter [35].

vulnerability. *1.* The susceptibility of a nation or military force to any action by any means through which its war potential or combat effectiveness may be reduced or its will to fight diminished. *2.* The characteristics of a system which cause it to suffer a definite degradation (incapability to perform the designated mission) as a result of having been subjected to a certain level of effects in an unnatural (manmade) hostile environment [36]. (*See also* survivability.)

vulnerability, nuclear. The inability of a system to withstand a nuclear environment caused by enemy or friendly action and continue to perform acceptably and to accomplish its designated mission. It is arrived at by knowledge of the components or system nuclear susceptibility in a defined nuclear environment [37]. (*See also* vulnerability.)

vulnerability program. A program to determine the degree of, and to remedy insofar as possible, any existing susceptibility of nuclear weapon systems to enemy countermeasures, accidental fire, and accidental shock [36].

vulnerability ratio (electronics). A ratio that expresses the degree of hardness or softness of a circuit that has been analyzed for exposure to a specified threat level. The vulnerability ratio can be the ratio of the threat-level current to the current that will cause circuit failure. In this case a ratio equal to or greater than one indicates a soft circuit [53].

vulnerability study. An analysis of the capabilities and limitations of a force in a specific situation to determine vulnerabilities capable of exploitation by an opposing force [36].

war, general. Armed conflict between major powers in which the total resources of the belligerents are employed, and the national survival of a major belligerent is in jeopardy [36].

war, limited. Armed conflict short of general war, exclusive of incidents, involving the overt engagement of military forces of two or more nations [36].

war, total nuclear. Obsolete term for general war (*see* war, general).

warfare, nuclear. Warfare involving the employment of nuclear weapons [36].

warfare, radiological. The use of radioactive material to deny areas to military and civilian populations [37].

warhead. That part of a missile, projectile, torpedo, rocket, or other munition which contains either the nuclear or thermonuclear system, high-explosive system, chemical or biological agents or inert materials intended to inflict damage [36]. The warhead and its missile carrier taken together is defined as the weapon or weaponized warhead.

warm X-rays (*see* X-rays).

warned exposed. The vulnerability of friendly forces to nuclear weapon effects. In this condition, personnel are assumed to be prone with all skin covered and with thermal protection at least that provided by a two-layer summer uniform [36]. (*See also* unwarned exposed.)

warned protected. The vulnerability of friendly forces to nuclear weapon effects. In this condition, personnel are assumed to have some protection against heat, blast, and radiation such as that afforded in closed armored vehicles or crouched in fox holes with improvised overhead shielding [36].

washout. The removal of radioactive particles from a nuclear cloud by precipitation when this cloud is below a rain (or snow) cloud [49] (*see also* rainfall (nuclear); rainout; snowout).

water, activated. A transient, chemically reactive state created in water by absorbed ionizing radiation [39].

water, heavy. Popular name for water containing significantly more than the natural proportion (1 in 6,500) of heavy hydrogen (deuterium) atoms to ordinary hydrogen atoms. Heavy water is used as a moderator in some reactors because it slows down neutrons effectively and also has a low cross section for absorption of neutrons [29].

watt. The unit of power equal to 1 joule per second [39].

waves (ground motion), types of. A nuclear burst on or near the earth's surface can produce various types of ground motion waves (*see* ground wave), as defined herein:

- *body (bodily elastic) waves.* Waves propagated in the interior of a body, i.e., compression and shear waves, the P and S waves of seismology [51].
- *compression (dilatational, irrotational, longitudinal) wave.* The propagation of dilatational (or irrotational) disturbances. The P wave of seismology. The term longitudinal wave rigorously applies only to plane waves [51].

- *compression Mach wave.* The compression wave formed by the leading edge of a superseismic airblast wave [51].
- *longitudinal wave* (*see* compression wave).
- *Love waves.* A special case of elastic surface waves propagated along the stress–free surface of a layered medium. So named because Love was first to examine the case of a single layer over a semi–infinite half–space. Both SV and SH motions are present in contrast to Rayleigh waves [51].
- *P wave* (*see* compression wave).
- *Rayleigh waves.* A special case of elastic surface waves propagated along the stress–free surface of a homogeneous medium. So named because this classic problem was first examined by Rayleigh. The waves are polarized so that the particles of the medium move in vertical planes parallel to the direction of the wave motion. Surface displacements follow an elliptical retrograde motion with the maximum horizontal displacement about two–thirds that in the vertical direction. Rayleigh wave theory does not describe the movement of the earth during passage of seismic surface waves [51]. (*See also* Love waves.)
- *shear Mach wave.* The shear wave formed by the leading edge of a super–seismic or trans–seismic airblast wave [51].
- *shear (rotational, equivoluminal, transverse) wave.* The propagation of rotational (or equivoluminal) disturbances. The S wave of seismology. The term transverse wave applies rigorously only to plane waves. In seismology when the S wave is plane polarized so that all the particles move horizontally during its passage it is denoted as SH; when the particles move in vertical planes containing the direction of propagation, the wave is denoted as SV [51].
- *surface waves.* Waves transmitted along the interface between two media, e.g., as special cases Rayleigh and Love waves. So named because the the disturbance is large confined to the neighborhood of the boundary [51].
- *S wave* (*see* shear wave)
- *transverse wave* (*see* shear wave).

wave equation, Schrödinger (*see* Schrödinger wave equation).

wave impedance. The ratio of electric field intensity to magnetic field intensity at the point of observation. Expressed in ohms [53].

wave motion. The transmission of a periodic motion of vibration through a medium or empty space. *Transverse:* wave motion in which the vibration is perpendicular to the direction of propagation. *Longitudinal:* wave motion in which the vibration is parallel to the direction of propagation [39].

wave train. A series of alternating crests and troughs of a wave system resulting from a surface disturbance [38].

wavelength. The distance between two similar and successive points on an alternating wave, e.g., between maxima [38].

wavelength, effective. The wavelength of monochromatic X-rays that undergoes the same percentage attenuation in a specified filter as the heterogeneous beam under consideration [32].

wavelength, electron (*see* electron wavelength).

weapon, nuclear. A device in which the explosion results from the energy released by reactions involving atomic nuclei, either fission or fusion or both [36]. Means the same as atomic weapon as that term is defined in Section 11d, Public Law 703, 83rd Congress, *viz.*, any device utilizing atomic energy, exclusive of the means for transporting or propelling the device (where such means is a separable and divisible part of the device), the principal purpose of which is for use as, or for development of, a weapon, weapon prototype, or a weapon test device [38]. Any device in which the explosion results from the energy released by reactions involving atomic nuclei, either fission or fusion, or both. Thus, the A- (or atomic) bomb and the H- (or hydrogen) bomb are both nuclear weapons. It would be equally true to call them atomic weapons, since the energy of atomic nuclei is involved in each case. However, it has become more or less customary, although it is not strictly accurate, to refer to weapons in which all the energy results from fission as A-bombs. In order to make a distinction, those weapons in which part of the energy results from thermonuclear (fusion) reactions of the isotopes of hydrogen have been called H-bombs or hydrogen bombs [50]. See specific types of weapons below.

- *atomic bomb (or weapon).* Same as fission weapon.
- *boosted fission weapon.* A weapon in which neutrons produced by thermonuclear reactions serve to enhance the fission process. The thermonuclear energy represents only a small fraction of the total explosion energy [49].
- *clean weapon.* A nuclear weapon in which measures have been taken to reduce the amount of residual radioactivity relative to a "normal" weapon of the same energy yield [37]. (*See also* dirty weapon; minimum residual radioactivity weapon; salted weapon *below.*)
- *controlled effects nuclear weapons.* Nuclear weapons designed to achieve variation in the intensity of specific effects other than normal blast effect [36].
- *convertible weapon.* A type of insertable nuclear component weapon that has both a nuclear capability when the special nuclear materials are emplaced and a valid conventional capability when the special nuclear materials are removed [37].
- *dirty weapon.* One that produces a larger amount of radioactive residues than a "normal" weapon of the same yield [2]. It is a fission weapon or any other weapon that would distribute relatively large amounts of radioactivity upon explosion, as distinguished from a fusion weapon [29].
- *dummy weapon.* An inert weapon having the same external configuration and identical ballistic characteristics as the weapon that it represents [37].
- *enhanced radiation weapon.* Weapon designed to produce significantly more and/or higher energy output(s) of neutrons, or X-rays or gamma rays, or a combination thereof, than a normal weapon of the same total yield. For clarity, the type of radiation being enhanced may be specified, e.g., enhanced neutron radiation weapon [37].

- *finished weapon.* A nuclear weapon that has been determined and certified by DOE as technically satisfactory and available for delivery to the stockpile [37].
- *fission weapon.* A term sometimes applied to a nuclear weapon that utilizes only fission energy.
- *free-fall weapon.* A weapon that has no apparatus or device (such as a parachute) to retard its rate of fall after release of the weapon in air [37].
- *hydrogen bomb.* Same as thermonuclear weapon.
- *insertable nuclear component (INC) weapon.* Nuclear weapon from which all the special nuclear materials can be removed, in a simple, safe, and reversible manner, by personnel in the field for storage separate from the weapon [37]. If the weapon also has a conventional capability it is called a convertible weapon.
- *laydown weapon.* A weapon designed to detonate at some finite time after it comes to rest on land or water [37].
- *maneuver weapon.* A weapon withdrawn from storage for use in various military training operations, such as assembly, loading, and air maneuvers [37].
- *minimum residual radioactivity weapon.* A nuclear weapon designed to have optimum reduction of unwanted effects from fallout, rainout, and burst-site radioactivity [36].
- *operational suitability test weapon (OST unit).* A weapon produced by the DOE and transferred to the DOD on a reimbursable basis. The purpose of the transfer is for Service evaluation with a given system of delivery on a selected target. It is common for an OST unit to contain certain dummy or mockup assemblies in lieu of active material counterparts [37].
- *retarded-fall weapon.* A weapon that is slowed from the normal free-fall acceleration rate by a parachute to allow the delivery aircraft sufficient time to escape the hazards created by detonation of the weapon [37].
- *salted weapon.* A nuclear weapon that has, in addition to its normal components, certain elements or isotopes that capture neutrons at the time of the explosion and produce radioactive products over and above the usual radioactive weapon debris [36].
- *Service-produced weapon.* A nuclear weapon, less nuclear components and warhead, produced by an agency of the DOD and for which the DOD maintains accountability [37].
- *suppressed radiation weapon.* A type of clean weapon that uses design technology or techniques to reduce the prompt radiation emitted during explosion, or to reduce activation of any surrounding matter, or a combination thereof [37].
- *thermonuclear weapon.* A weapon in which very high temperatures are used to bring about the fusion of light nuclei, such as those of hydrogen isotopes (e.g., deuterium and tritium) thereby causing a release of energy. The temperatures required are obtained by means of fission [36]. Since the energies released are much higher, relative to the mass involved, than even in fission reactions, extremely destructive weapons of a moderate size can be made. Fusion reactions are not spontaneous. A fission reaction must be used to generate the extremely high temperatures required to initiate the reactions.

Thermonuclear weapons do not result in contaminating fission products as do fission weapons; i.e., they are "clean" weapons, except for the fissionable material required to detonate them [4].

- *training weapon.* A weapon produced for purposes of instruction and organizational training and usually containing no HE components [37].

weapon debris (*see* debris, weapon (nuclear)).

weapon residue (*see* residue, weapon).

weapons system. A weapon and those components required for its operation. (The term is not precise unless specific parameters are established.) [36].

weight, atomic. The weighted mean of the masses of the neutral atoms of an element expressed in atomic mass units [39]. The relative mass of an atom of the given element. As a basis of reference, the atomic weight of the common isotope of carbon (carbon–12) is taken to be exactly 12; the atomic weight of hydrogen (the lightest element) is then 1.008. Hence, the atomic weight of any element is approximately the mass of an atom of that element relative to the mass of a hydrogen atom [49]. (*See also* mass, atomic.)

Wilson cloud (*see* cloud, condensation).

Wilson cloud chamber (*see* cloud chamber).

wind shear. A change of wind direction and magnitude [36].

whole–body irradiation. Exposure of the body to ionizing radiation from external radiation sources. Critical organs for the whole body are the lens of the eye, the gonads, and the red–blood–forming marrow. As little as only 1 cm^3 of bone marrow constitutes a whole–body exposure. Thus, the entire body need not be exposed to be classed as a whole–body exposure [50].

wooden bomb. A concept which pictures a weapon as being completely reliable and having a infinite shelf life while at the same time requiring no special handling, storage, or surveillance [36].

work function, photoelectric (*see* photoelectric work function).

working point. In underground testing, the location of the nuclear device, from which distances can be measured.

worldwide (or delayed) fallout (*see* fallout).

worst case (EMP). The condition of electromagnetic coupling into a system so that all the energy contained in the incident field is transferred to the system without loss. The orientation of the system with respect to the incident wave (or pulse) is such that maximum coupling occurs [46].

X-radiation (*see* X-rays).

X-ray pancake. A layer of air, about 30,000 feet thick at a mean altitude of roughly 270,000 feet, which becomes incandescent by absorption of the thermal X-rays from explosions above 270,000 feet altitude. The heated air emits thermal radiation (of longer wavelengths) in a single pulse of several seconds duration [49].

X-rays. High-frequency electromagnetic radiation (wavelengths of approximately 0.1 to 100 angstroms, which overlap the lower portion of the gamma-ray spectrum) produced by any of three processes: radiation from a heated mass (e.g., a blackbody); deceleration of a charged particle; electron transitions between atomic energy levels, usually excited by incident beams of high-energy particles, resulting in characteristic discrete energy levels [38]. In nuclear reactions, it is customary to refer to photons originating in the extranuclear part of the atom as X-rays. X-rays are sometimes called roentgen rays after their discoverer, W.C. Roentgen [39]. X-rays are often designated as "hard" or "hot" for high-energies, "warm" for moderate energies, and "soft or "cold" for low energies. (The energy ranges for these designations are classified and have changed in the past.)

X-rays, characteristic. Electromagnetic radiations emitted as a result of rearrangements of the electrons in the inner shells of atoms. The spectrum of the radiation consists of lines that are characteristic of the element in which the X-rays are produced [32].

X-rays, continuous. Electromagnetic radiations of continuous spectral distribution, as opposed to characteristic X-rays. The wavelengths of the continuous X-rays vary from a minimum, corresponding to a photon energy equal to the maximum kinetic energy of the incident particles, to indefinitely large values [32].

X-rays, scattered. X-rays that, during their passage through a substance, have been deviated in direction and modified by an increase in wavelength; i.e., a decrease in photon energy [4].

X-rays, secondary. X-rays emitted by any matter irradiated with primary X-rays. Fast-moving electrons are generated by the photoelectric, Compton, or pair-production process, and these electrons then generate secondary X-rays [4].

X-rays, thermal. The electromagnetic radiation, mainly in the soft (low-energy) X-ray region, emitted by the debris of a nuclear weapon by virtue of its extremely high temperature [36]. This electromagnetic radiation is also referred to as the primary thermal radiation. It is the absorption of this radiation by the ambient medium, accompanied by an increase in temperature, which results in the formation of the fireball (or other heated region), which then emits thermal radiation [49].

x-unit (or XU). *1.* A unit used in expressing the wavelengths of X-rays or gamma-rays. It is about 10^{-11} cm or 10^{-3} angstrom [32]. *2.* A device used in nuclear weapons to provide energy to initate the nuclear system detonation [37].

yield, nuclear. The energy released in the detonation of a nuclear weapon, measured in terms of the kilotons or megatons of trinitrotoluene required to produce the same energy release. Yields are categorized as (a) very low (<1 kiloton), (b) low (1 to 10 kilotons), (c) medium (>10 to 50 kilotons), (d) high (>50 to 500 kilotons), (e) very high (>500 kilotons) [36]. The total energy yield is manifested as nuclear radiation (including residual radiation), thermal radiation, and blast and shock energy, the actual distribution depending upon the medium in which the explosion occurs and also upon the type of weapon and the time after detonation [49]. (*See also* nominal weapon; TNT equivalent.)

yield, blast. That portion of the total energy of a nuclear explosion that manifests itself as a blast or shock wave. Blast is often expressed in terms of overpressure [37]. (*See* yield.)

yield, equivalent fission. Fission yield plus a fictitious "yield" derived from factors that take into account residual radioactivity produced by a nuclear explosion other than that caused by fission reactions. These fission equivalency factors depend on the composition of weapon debris (weapon structural material, components, etc.) and on the method used to calculate fission equivalency. When the calculational method is not otherwise specified, it is understood to be based on integrated radiation dose from 0.1 hour (after detonation) to infinity. Equivalent fission yield provides a means of comparing the amount of residual radioactivity produced by a nuclear weapon [37].

yield, nuclear radiation. That portion of the total energy of a nuclear explosion that appears as neutrons, and alpha, beta, gamma, and X-ray radiation. This energy is measured in calories or kilotons [37]. (*See* yield.)

yield, significant nuclear. The energy released through nuclear fission or fusion equivalent to or greater than the energy released by detonation of 4 pounds of TNT [37].

yield, thermal. Electromagnetic radiation from a nuclear weapon, which is emitted in the wavelength range from 0.2 micron in the ultraviolet through the visible to 12 microns in the infrared [37]. The part of the total energy yield of a nuclear explosion that is received as thermal energy usually within a minute or less. In an airburst, the thermal partition (i.e., the fraction of the total explosion energy emitted as thermal radiation) ranges from about 0.35 to 0.45. The trend is toward the smaller fraction for low yields or low burst heights and toward the higher fraction at high yields or high bursts. Above 100,000 feet burst height, the fraction increases from about 0.45 to 0.6, and then decreases to about 0.25 at burst altitudes of 160,000 to 260,000 feet. At still greater burst heights, the fraction decreases rapidly with increasing altitude. The thermal energy may be expressed in calories, ergs, or in terms of the TNT equivalence [49].

yield determining targets. The target elements in a complex that, by interaction of hardness and distance, determine the yield and location of recommended ground zero that will give the desired damage to the complex [37].

Yukawa potential. A function used to describe the meson field about a nucleus. The Yukawa potential is employed rather frequently as one shape of a nuclear-potential well that can be used in attempts to fit theory with experimental results; for example, in high-energy scattering [32]. (*See also* forces, nuclear.)

Z. Symbol for atomic number of an element, i.e., the number of protons in the nucleus (*see also* high–Z; low–Z).

Zeeman effect. The splitting of spectral lines into two or more discrete components when an external magnetic field is applied. The frequency intervals between the split spectral lines are, in most cases, quite accurately proportional to the magnetic field. The group of lines resulting from a single spectral line is called a Zeeman pattern [35].

zero point. The location of the center of a burst of a nuclear weapon at the instant of detonation. The zero point may be in the air or on or beneath the surface of land or water, dependent upon the type of burst, and it is thus to be distinguished from ground zero [36].

zero–rest–mass particle. A zero–rest–mass particle is a particle existing in nature that has energy and momentum but no rest–mass. The possibility of such a particle existing makes no sense from a classical viewpoint, but is admissible in relativity theory. Thus, a zero–rest–mass particle must necessarily travel with the speed of light [35].

zone I (nuclear). A circular area, determined by using minimum safe distance I as the radius and the desired ground zero as the center, from which all armed forces are evacuated. If evacuation is not possible or if a commander elects a higher degree of risk, maximum protective measures will be required [36].

zone II (nuclear). A circular area (less zone I), determined by using minimum safe distance II as the radius and the desired ground zero as the center, in which all personnel require maximum protection. Maximum protection denotes that armed forces personnel are in "buttoned up" tanks or crouched in foxholes with improvised overhead shielding [36].

zone III (nuclear). A circular area (less zones I and II), determined by using minimum safe distance III as the radius and the desired ground zero as the center, in which all personnel require minimum protection. Minimum protection denotes that armed forces personnel are prone on open ground with all skin areas covered and with an overall thermal protection at least equal to that provided by a two–layer uniform [36].

zoning (EMP). A process of locating or placing the more susceptible items into locations of less severe or intense operating environment. Also, the dissection of a complex configuration into smaller, conformal regions, which may be more readily analyzed and tested for EMP vulnerability [53].

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ATTN: D503-B202, Main Tech Library

Rockwell International Corp
ATTN: TIC D096-4D0 AJD1

Rockwell International Corp
ATTN: Document Control

Rockwell International Corp
ATTN: Dept 56-LAD Library
ATTN: Tech Info Ctr

Sci Systems, Inc
2 cys ATTN: Document Control

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

S-CUBED
ATTN: D. Grine
ATTN: J. Barthel
ATTN: K. Pyatt
ATTN: Library
ATTN: R. Lafrenz
ATTN: T. Riney

Science Applications Intl Corp
ATTN: Document Control
ATTN: Fac Scty Supv, B. Krause
ATTN: H. Wilson
ATTN: M. McKay
ATTN: Tech Library

Sciences Applications Intl Corp
ATTN: Security Office

Science Applications Intl Corp
ATTN: Document Control

Science Applications Intl Corp
ATTN: R. Hillendahl

Science Applications Intl Corp
ATTN: Fac Scty Supv
ATTN: J. McGahan
ATTN: Security Officer
ATTN: W. Layson

Science Applications Intl
ATTN: B. Elyea, Security Office

Science Applications, Inc
ATTN: D. Maxwell

Scientific Services, Inc
ATTN: Document Control

Southwest Research Institute
ATTN: A. Wenzel
ATTN: W. Baker

Sperry Corp
ATTN: Document Control
ATTN: Engrg Library, C. Marcox

Sperry Corp
ATTN: J. Inda

Sperry Corp
ATTN: C. Marcoux A16

SRI International
ATTN: G. Abrahamson
16 cys ATTN: Library

SRI International
3 cys ATTN: Document Control

System Development Corp
ATTN: Document Distribution Mail Drop 41-41

System Planning Corp
ATTN: Rsch Library, L. Glickson

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Technology, Inc
ATTN: Document Control

Teledyne Brown Engineering
ATTN: F. Leopard
ATTN: MS-12 Tech Library

Terra Tek, Inc
ATTN: Library
ATTN: S. Green

Tetra Tech, Inc
ATTN: L. Hwang

Texas Instruments, Inc
ATTN: D. Manus

TRW Electronics & Defense Sector
ATTN: D. Baer
ATTN: J. Farrel
ATTN: M. Seizew
ATTN: R. Plebuch
ATTN: Tech Info Ctr
2 cys ATTN: N. Lipner
2 cys ATTN: Tech Library

General Electric Co
ATTN: S. Matlin
ATTN: Tech Inf Ctr for L. Chasen

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

TRW Electronics & Defense Sector
ATTN: CADM, 524/43
ATTN: E. Wong
ATTN: F. Florence
ATTN: P. Dai

TRW, Inc
ATTN: Tech Library, L. Moore

Union Carbide Corp
ATTN: L. Phillips

Weidlinger Assoc, Consulting Engrg
ATTN: T. Deevy

Weidlinger Assoc, Consulting Engrg
ATTN: J. Wright
ATTN: M. Baron

Weidlinger Assoc, Consulting Engrg
ATTN: J. Isenberg

Weidlinger Assoc, Consulting Engrg
ATTN: A. Misovec