GLOSSARY OF PHYSICS

COMPILED AND EDITED BY

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With the Collaboration of a Large
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PREFACE

This Glossary had its origin in a collection of definitions compiled in card-catalogue form and kept in the office of the Physics Department for the use of students of Coe College. Crude as it was, it proved indispensable and was so much in demand that the desirability of wider circulation became apparent. The matter was taken up with officers of the American Physical Society, whose Executive Council recommended it to the attention of the Division of Physical Sciences of the National Research Council. In 1933 the Division appointed the following Advisory Committee on a Glossary of Physical Terms:

A. W. Hull, General Electric Company,
L. W. McKeehan, Yale University,
F. K. Richtmyer, Cornell University,
G. W. Stewart, University of Iowa,
L. D. Weld, Coe College (Chairman).

Upon the recommendation of this committee, its chairman was asked to assume responsibility for the preparation of the Glossary and was authorized to secure the co-operation of such other physicists in various fields as he might find practicable. Further, the Division made a grant of funds toward the cost of compilation.

In accordance with the suggestions of the Advisory Committee, the following were chosen and kindly consented to act as special consultants: K. T. Bainbridge, J. W. Beams, J. A. Becker, Louis Brand, G. Breit, P. W. Bridgman, W. G. Cady, George A. Campbell, W. L. Cheney, George L. Clark, E. U. Condon, J. F. Couch, H. L. Curtis, W. P. Davey, Bergen Davis, C. J. Davisson, W. E. Deming, N. E. Dorsey, A. Ellett, H. E. Farrer, Harvey Fletcher, W. E. Forsythe, N. H. Frank, Thornton C. Fry, Ross Gunn, E. L. Hall, Karl F. Herzfeld, J. C. Hubbard, A. L. Hughes, L. R. Ingersoll, Thomas H. Johnson, Loyd A. Jones, E. H. Kennard, A. L. Kimball, A. F. Kovarik, Charles A. Kraus, R. B.

Lindsay, L. B. Loeb, Theodore Lyman, L. W. McKeehan, W. D. MacMillan, Ernest Merritt, F. L. Mohler, R. S. Mulliken, Leigh Page, H. L. Rietz, H. N. Russell, F. A. Saunders, J. P. C. Southall, C. F. Talman, R. C. Tolman, E. P. T. Tyndall, J. H. Van Vleck, Oswald Veblen, Bertram E. Warren, Willibald Weniger, W. P. White, Anthony Zeleny.

As the work of compilation developed, it became obvious that, owing to limitations of time, among other things, it would be impracticable to make sure of complete agreement among the various persons concerned on each of the many definitions and statements. Accordingly, upon recommendation of the Advisory Committee, the Division of Physical Sciences turned over to the compiler entire responsibility for completing the Glossary, and for its editing and publication.

The descriptive character of the Glossary has been emphasized from the first, with deliberate intent to avoid any presumption of framing exhaustively accurate definitions or of authoritatively standardizing the use or the meanings of terms. The sole purpose is to give information as to actual usage, and in such form as to be intelligible to students as well as to specialists. Any further undertaking would be beyond the resources available. The compiler is keenly aware that many defects and omissions have been inevitable. For these he assumes entire responsibility, and bespeaks constructive criticisms from any who may be in position to offer them. It should be mentioned that the material here included has been abridged from a much larger collection of terms, some 40 per cent of which, less important or more familiar, are omitted to conserve space. The compiler will be glad to co-operate with anyone seeking information in regard to terms or definitions.

The references appearing with many definitions are intended merely to supplement the information given, usually by citing literature in which the corresponding subject is discussed or in which the term finds typical usage. *The references do not necessarily represent the original source of the term or the authority for the definition.* Nor is it intimated that they are the best possible references.

The compiler wishes to express his sincere appreciation to the members of the Advisory Committee for their assistance in

formulating plans for the Glossary; to the consultants for their generous assistance and many helpful suggestions; and to Dr. G. S. Fulcher for valuable advice with regard to editorial details. The occasional help and advice of many others is also gratefully acknowledged.

L. D. W.

CEDAR RAPIDS, IOWA.,
October, 1937.

ABBREVIATIONS

(Special or Technical)

Å angstroms.
abamp abamperes.
a.c. or a.-c. (n. or adj.) alternating current, alternating-current.
Acous. Soc. Comm. Rep. Report of the Committee on Acoustical Standardization, Acoustical Society of America.
A.I.E.E. Comm. Rep. Report on Proposed American Standard Definitions of Electrical Terms, Standards Committee of American Institute of Electrical Engineers.
amp amperes.
Ann. d. Phys. *Annalen der Physik.*
Astrophys. J. Astrophysical Journal.
B.B.S. Bulletin of the Bureau of Standards.
Bell Syst. Tech. J. Bell System Technical Journal.
B.S.J.R. Bureau of Standards Journal of Research.
Btu British thermal units.
C. centigrade.
cal calories.
c.g.s. centimeter-gram-second (system of units).
cm centimeters.
c.m. center of mass.
Compt. rend. *Comptes rendus.*
cp candle power.
cyc cycles.
d.c. or d.-c. (n. or adj.) direct current, direct-current.
deg degree (of angle or of temperature).
div. divergence.
Elec. Eng. Electrical Engineering.
e.m.f. electromotive force.
e.m.u. electromagnetic units.
e.s.u. electrostatic units.
ev electron-volts.
F. Fahrenheit.
f farads.
g grams.
Geophys. Mag. Geophysical Magazine.
h.-f. high-frequency.
hp horsepower.
I.C.T. International Critical Tables.
Illum. Eng. Nomenc. Illuminating Engineering Nomenclature and Photometric Standards.
I.R.E. Comm. Rep. Report of the Standards Committee of the Institute of Radio Engineers.

Abbreviations

J. Am. Chem. Soc. Journal of the American Chemical Society.
J.A.I.E.E. Journal of the American Institute of Electrical Engineers.
J. Chem. Phys. Journal of Chemical Physics.
J. de phys. Journal de physique.
J. École Polyt. Journal de l'École Polytechnique.
J. Frank. Inst. Journal of the Franklin Institute.
J.O.S.A. Journal of the Optical Society of America.
J. Phys. Chem. Journal of Physical Chemistry.
J. Rheol. Journal of Rheology.
J.S.I. Journal of Scientific Instruments.
J. Wash. Acad. Journal of the Washington Academy.
K. Kelvin (scale).
kc kilocycles.
kg kilograms.
km kilometers.
kv kilovolts.
m meters.
mev million electron-volts.
mf microfarads.
mg milligrams.
mh millihenrys.
mm millimeters.
N.T.P. normal temperature and pressure.
p.d. potential difference.
Phil. Mag. Philosophical Magazine.
Phil. Trans. Philosophical Transactions.
Phys. Rev. Physical Review.
Phys. Zeits. Physikalische Zeitschrift.
Proc. Am. Acad. Proceedings of the American Academy of Arts and Sciences.
Proc. Camb. Phil. Soc. Proceedings of the Cambridge Philosophical Society.
Proc. I.R.E. Proceedings of the Institute of Radio Engineers.
Proc. Nat. Acad. Sci. Proceedings of the National Academy of Sciences.
Proc. Roy. Soc. Proceedings of the Royal Society (London).
Rev. Mod. Phys. Reviews of Modern Physics.
r.m.s. radical mean square.
rpm revolutions per minute.
R.S.I. Review of Scientific Instruments.
Smiths. P. T. Smithsonian Physical Tables.
Trans. A.I.E.E. Transactions of the American Institute of Electrical Engineers.
Trans. Electrochem. Soc. Transactions of the Electrochemical Society.
v volts
Wied. Ann. Wiedemanns Annalen.
Zeits. f. Phys. Zeitschrift für Physik.

GLOSSARY OF PHYSICS

A

(Please note purpose of references as explained in preface.)

abampere. The c.g.s. electromagnetic unit of current, *viz.*, that current which, in a one-turn circular conductor of 1-cm radius in a vacuum, produces a magnetic intensity of 2π oersteds at the center of the circuit. Equal to 10 absolute amp. (See A.I.E.E. Comm. Rep., 1932.)

Abbe prisms. One of several prism combinations devised by Abbe for various purposes, *e.g.*, those used in the prism binocular and in the Abbe refractometer. (See Taylor, College Manual of Optics, 1924, p. 87.)

abcoulomb. The c.g.s. electromagnetic unit of electric charge or quantity, defined as that quantity of electricity which is carried past any point of a circuit in 1 sec when the current is 1 abamp. Equal to 10 absolute coulombs. (See A.I.E.E. Comm. Rep., 1932.)

aberration. An error, or deviation from ideal. 1. (Astron.) *Aberration of light* is an apparent angular displacement of a star due to the earth's orbital motion. Its maximum value, the *aberration angle* or *aberration constant*, is about 20.5″. 2. (Geom. opt.) Lack of point-to-point correspondence between an object and its image. *Spherical aberration* includes various faults of an optical image with monochromatic light, such as lack of sharpness, coma, astigmatism, curvature, lack of flatness, and distortion. 3. (*Chromatic.*) The effect of dispersion upon the distinctness of optical images. *Cf. zonal aberration.*

abfarad. The c.g.s. electromagnetic unit of capacitance, corresponding to 1 abcoulomb per abvolt. Equal to 10^9 f. (See A.I.E.E. Comm. Rep., 1932.)

abhenry. The c.g.s. electromagnetic unit of inductance (or mutual inductance), *viz.*, that of a circuit in which the variation of current at the rate of 1 abamp/sec induces an e.m.f. of 1 abvolt. Equal to 10^{-9} henry. Because its c.g.s. dimensional value is 1 cm, it has been called the *centimeter* of inductance. (See A.I.E.E. Comm. Rep., 1932.)

abohm. The c.g.s. electromagnetic unit of resistance; defined as the resistance of a conductor which, when a constant current of 1 abamp flows through it, maintains a p.d. of 1 abvolt between its terminals. Equal to 10^{-9} absolute ohm. (See A.I.E.E. Comm. Rep., 1932.)

absolute temperature. Temperature as reckoned from a zero corresponding to the entire absence of translational molecular

motion, on either the hydrogen constant volume or the Kelvin scale. *Absolute zero* is approximately −273.2°C. or −459.8°F.

absolute units. 1. A system of units defined in terms of phenomena of supposedly universal occurrence, rather than in terms of the properties of special substances or systems. *E.g.*, Planck's system of absolute units, in which the units of mass, length, time, and temperature are so chosen that the gravitational constant, the velocity of light, the Planck constant, and the ideal gas constant all have the numerical value unity. 2. Dynamic units defined without reference to gravity, *e.g.*, the dyne and the erg.

absorption. 1. A process in which a fluid, liquid or gaseous, passes into the interstices of a porous substance and is held there by adsorption or capillarity. 2. The transformation, into other forms, of the energy of any emission as it passes through a material substance. 3. (*Dielectric.*) The persistence of a measurable electric polarization exhibited by many dielectrics after the electric intensity responsible for the polarization has been reduced to zero. *Cf. electret, residual charge.*

absorption coefficient. The fractional rate at which the flux density of an emission diminishes by absorption, in respect to the thickness of medium traversed; expressed by the equation

$$\mu = \frac{-\frac{dI}{dx}}{I},$$

where I = flux density, x = thickness. The *mass absorption coefficient* is similarly defined, except that the mass per unit area of medium replaces the thickness x. For a substance of density ρ, this coefficient is therefore equal to μ/ρ. *Cf. transmission coefficient, scattering c., extinction c., absorption index.*

absorption discontinuity. A discontinuity in the absorption coefficient of a substance as a function of wave length, corresponding to a spectral absorption line and often associated with anomalies in other variables such as the refractive index. *Cf. anomalous dispersion.*

absorption edge, a. limit. The wave length or frequency corresponding to an abrupt discontinuity in the intensity of an x-ray absorption spectrum, which gives the appearance of a sharp "edge" in the photograph of such a spectrum. *Cf. band edge.*

absorption factor. 1. One minus the attenuation factor. 2. The ratio of the energy flux in a diffracted x-ray beam in the powder method to that which it would have without absorption by the powdered material.

absorption hygrometer. One of several types of hygrometer dependent upon the elongation or shrinkage of a hair or similar organic structure with changes of humidity.

absorption index. The value of the ratio $\mu\lambda/4\pi n$ for any medium traversed by radiation of wave length λ for which the refractive index is n and the absorption coefficient is μ. (See I.C.T., 1926, v. 1, p. 34.)

absorption spectrum. The spectrum of radiation which has passed through some selectively absorbing substance, *e.g.*, of white light after passage through a vapor or a solution.

absorptivity. The fraction of the radiant energy of a given character, normally incident upon the surface of a body, which is absorbed by the substance of that body. For an ideal black body, its value would always be unity. Syn. *absorptive power* (obsolescent). (See Richtmyer, Int. to Modern Phys., 1928, p. 182.)

abvolt. The c.g.s. electromagnetic unit of electromotive force or potential; defined as that p.d. through which 1 erg of work is required to transfer 1 abcoulomb of electricity. Equal to 10^{-8} absolute volt.

abwatt. A unit of power, corresponding to 1 abamp through a potential difference of 1 abvolt and equal to 10^{-7} watt.

acceleration. 1. (*Linear.*) The time rate of change of linear velocity, *i.e.*, the derivative of the linear velocity with respect to time. 2. (*Angular.*) The time rate of change of angular velocity, or its derivative with respect to time.

accommodation coefficient. The degree to which reflected or re-evaporated molecules, on the average, "accommodate" their energy to that of the surface which they strike; measured by the ratio of the observed heat less from a surface to the theoretical heat loss which would take place if all the gas molecules came to thermal equilibrium with the surface. *Cf. accumulation coefficient.* (See Loeb, Nature of a Gas, 1931, p. 274; Blodgett and Langmuir, *Phys. Rev.* 40, 78, 1932.)

accumulation coefficient. The ratio of the rate at which adsorbed molecules accumulate on a surface to the rate at which they strike. *Cf. accommodation coefficient,* used by Taylor to denote the quantity here defined. (See Taylor, Treatise on Phys. Chem., 1924, v. 2, p. 976.)

accumulation time. In the theory of radiation, the time supposedly required for the accumulation of a quantum of radiant energy, before it can be released.

accumulator. Syn. *storage cell, secondary cell.*

achromatic. 1. *In re* an optical system: having the same focal length for two distinct wave lengths, and hence approximately free from chromatic aberration in this range. *Cf. apochromatic.* 2. *In re* a color: devoid of hue. Such a color is often called a *gray.*

acoustic absorptivity. The ratio of the sound energy absorbed by a surface to that incident upon it. *Cf. equivalent absorption.* (See Acous. Soc. Comm. Rep., 1934.)

acoustic compliance. A quantity which, in the propagation of sound, enters into the acoustic reactance in a manner analogous to that in which electrical capacitance enters into electrical reactance. It is equal to the square of the cross section of the conduit divided by the bulk modulus of the medium. Its reciprocal is the *acoustic stiffness.* Syn. *acoustic capacitance. Cf. acoustic imped-*

ance. (See Acous. Soc. Comm. Rep., 1934.)

acoustic impedance. A complex quantity used *in re* the propagation of sound across any surface. It is a combination of a real term, the *acoustic resistance*, corresponding to internal friction and responsible for the dissipation of energy, and an imaginary component, the *acoustic reactance*, depending upon the inertia and the elasticity of the medium; both are expressed in acoustic ohms. (See Acous. Soc. Comm. Rep., 1934.)

acoustic inertance. A quantity which, in the propagation of sound, enters into the acoustic reactance in a manner analogous to that in which inductance enters into electrical reactance. It is equal to the mass of the body of medium divided by the square of the cross section of the conduit in which it is contained. *Cf. acoustic impedance.* (See Richardson, Sound, 1929, p. 223.)

acoustic ohm. A unit of acoustic resistance, reactance, or impedance, corresponding to 1 bar of sound pressure per cm^3/sec of volume velocity. (See Acous. Soc. Comm. Rep., 1934.)

acoustic radiometer. An apparatus for measuring acoustic flux density. (See Rogers, *Phys. Rev.* 45, 208, 1934.)

acoustic reactance. *Cf. acoustic impedance.*

acoustic reflectivity. The ratio of the flux density of the sound reflected from a surface to that incident upon it. (See Acous. Soc. Comm. Rep., 1934.)

acoustic resistance. *Cf. acoustic impedance.*

actinic. *In re* radiation: capable of producing chemical change, as in the photographic action of light.

actinium series. One of the principal radioactive series, beginning with actinium.

actinometer. 1. An instrument for measuring the actinic value of a given light or other radiation. 2. An instrument for measuring the flux density of solar radiation.

action. 1. A magnitude defined as twice the time integral of the kinetic energy of a system, the variable time being measured from an arbitrary zero up to the time in question. Thus:

$$S = 2\int_{t_0}^{t} E_{kin}dt.$$

It may be interpreted as twice the mean kinetic energy during the interval, multiplied by the duration of the interval. *Cf. least-action principle.* 2. In relativity dynamics, action is represented by the formula:

$$S = \int_{t_0}^{t}\left(\sum \dot{q}p\right)dt,$$

or

$$S = \int_{t_0}^{t}\left(\sum \dot{q}\frac{\partial L}{\partial \dot{q}}\right)dt;$$

in which the $\dot{q}$'s and p's are generalized velocities and generalized momenta and L the Lagrangian function, and the summation extends over all the degrees of freedom.

activity. 1. A measure of the intensity of the emission from a radioactive substance, in terms of observable effects. 2. An excited state in a gas, due to ionization. 3. Syn. *power.* (Obs.) 4. (*Optical.*) The property of producing

optical rotation. 5. (Chem.) The concentration of free ions of a given type, *e.g.*, hydrogen.

adhesion. An interaction between the surfaces of two closely adjacent bodies, which causes them to cling together, as paint or a lead-pencil mark *adheres* to a wall or to paper. *Cf. cohesion.*

adiabatic. 1. A term used to characterize any process which takes place without transfer of heat to or from the body concerned. 2. Taking place under conditions prescribed in the statement of the (quantum) *adiabatic hypothesis.* 3. (n.) The graph representing an adiabatic process.

adiabatic equation. A characteristic equation relating the quantities which define the state of a body during an adiabatic change.

adiabatic hypothesis. A hypothesis of the quantum theory, set forth by Ehrenfest, to the effect that, if the motion of a mechanical system is initially adjusted in accordance with the appropriate quantum condition and if the motion is very gradually changed, it continues to operate under the same quantum condition with the same set of quantum numbers. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, pp. 176 ff.)

admittance. The reciprocal of the impedance of an electric circuit. (See A.I.E.E. Comm. Rep., 1932.)

adsorption. A term applied to the phenomena connected with the adherence of molecules of a foreign substance to the surface of a solid or a liquid. *Cf. absorption, sorption.*

aeolotropic, eolotropic. Not isotropic; having different properties in different directions, as a crystal. Syn. *anisotropic.*

aerodynamics. That branch of dynamics which treats of the forces exerted by air or other gases upon bodies exposed to them.

aerofoil. A blade or wing set in such a way as to experience a lifting force as it moves through the air, *e.g.*, the wing of an airplane. *Cf. hydrofoil.*

afterflow. The persistence of plastic flow in a solid after the external forces primarily responsible for it have ceased to act. *Cf. elastic aftereffect.* (See Nádai, Plasticity, 1931, p. 26.)

afterglow. 1. A luminosity which persists in a rarefied gas after the passage of an electrodeless discharge through it. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, pp. 443 ff.) 2. Syn. *phosphorescence.* (Rare.)

aggregation. The collection of molecules composing any portion of matter. *State of aggregation* denotes the condition of the body as dependent upon the relative positions and motions of the molecules, *e.g.*, liquid, gaseous, etc. *Cf. phase* (2).

agonic line. The line on the earth's surface, at all points of which the magnetic declination is zero.

Airy experiment. A celebrated observation by Airy (1871) to the effect that the aberration of light is independent of the medium filling the telescope with which the observation is made. (See Robertson, Int. to Phys. Optics, 1929, p. 389.)

albedo. The reflection factor of a diffusely reflecting surface; esp. of a celestial object, as a planet.

allochromatic. A term used to characterize crystals which have photoconductivity on account of dispersed microscopic or submicroscopic particles occurring naturally or as a result of exposure to certain radiations. *Cf. idiochromatic.* (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 311.)

allotropy, allotropism. The property, possessed by many substances, of existing in different modifications, called *allotropic* forms, *e.g.*, carbon, which presents itself as diamond, as graphite, or in the amorphous form of soot. *Cf. polymorphism.*

alpha, beta, gamma, . . . form or state. Terms used to distinguish the different isomers of the same composition or different allotropic modifications of an element. *E.g.*, these states of iron depend upon its temperature, and only the alpha iron is highly magnetic. (See Williams, Magnetic Phenomena, 1930, p. 161; Wheeler, *Phys. Rev.* 41, 331, 1932.)

alpha, beta, gamma, . . . lines. The lines of a spectral series, arranged in the order of increasing frequency. *E.g.*, the $L\beta$ line is the second line of the L series of an element. If the line is a doublet, the components are designated $L\beta_1$, $L\beta_2$; etc.

alpha-ray spectrum. A separation of alpha particles of different speeds, usually by the magnetic field alone, but in some cases by both magnetic and electric fields. *Cf. mass spectrograph.* (See Cockroft, *J. S. I.* 10, 71, 1933.)

alpha rays. A corpuscular emission from certain types of radioactive atom, each particle emitted consisting of a completely ionized helium atom, *i.e.*, of a helium nucleus.

alternation law. The first of the Kossel-Sommerfeld (spectroscopic) laws. (See Meggers, *J.O.S.A.* 9, 355, 1924.)

altimeter. An instrument, resembling an aneroid barometer, which indicates the altitude of an airplane above the ground station at which it was set at zero.

ambipolar. Operating in both of two opposite directions at once, *e.g.*, the current in an electrolytic cell, in which there are ions moving in both directions. (See Emeleus, Cond. of Elec. through Gases, 1930, pp. 39, 49.)

Amici prism. A combination of three triangular prisms, *viz.*, an isosceles flint-glass prism included between two equal crown-glass prisms, the refracting angles being such as to produce dispersion without deviation. Used in direct-vision spectroscopes, etc. (See Martin, Optical Meas. Instr., 1924, p. 151.)

ammeter. An instrument for measuring electric currents in amperes.

amorphous. Devoid of regular structure, esp. of crystalline structure.

ampere. The practical unit of electric current. The *absolute ampere* is one-tenth of the abampere. The *international ampere* is the value of a steady current which would deposit 0.00111800 g

of silver per sec from a solution of silver nitrate. *Cf. coulomb.* The ratio of the international to the absolute ampere is about 0.99995. (See A.I.E.E. Comm. Rep., 1932; Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

ampere-hour. The quantity of electricity which flows past any point of a conductor carrying a current of 1 amp, in 1 hr; equal therefore to 3600 coulombs.

Ampère law. The law appears in two equivalent forms: 1. The magnetic intensity due to a current i (abamperes) in an element of length dl, at any point P distant r from it, is

$$dH = ipdl/r^3 = i \sin\theta\, dl/r^2,$$

in which p is the normal from the point P to the line of the element dl, and θ is the angle between dl and the line r joining it to P. Syn. *Laplace law. Cf. Biot-Savart law.* 2. The line integral of the magnetic intensity over any closed path in a magnetic field is equal to 4π times the total electric current i, in abamperes, linked with the path; so that if a unit magnetic pole is carried around the path, the work done is $4\pi i$ (ergs). *Cf. Maxwell-Ampère law.* (See Page and Adams, Prin. of Elec., 1931, pp. 242, 258; Richtmyer, Int. to Modern Phys., 1928, p. 82.)

Ampère rule. The well-known rule for the clockwise direction of the magnetic field surrounding a wire carrying an electric current, as viewed by one looking in the direction of the current.

ampere-turn. A unit of magnetomotive force, corresponding to the effect of a current of 1 amp traversing one turn or winding. *Cf. gilbert.*

Ampèrian current, A. whirl. An electric current in a resistanceless circuit in an atom or a molecule, accounting for its magnetic moment.

amplification factor. The negative of the ratio of any small change of plate potential, in a triode, to the change in grid potential necessary to offset it and keep the plate current constant. *Cf. van der Bijl equation.* (See I.R.E. Comm. Rep., 1933.)

amplitude. One-half the complete range of any symmetrical vibration or periodic variation; *e.g.*, a pendulum swinging through an angle of 10 deg has an amplitude of 5 deg. In an asymmetric vibration, the amplitude usually expresses the maximum displacement from the normal or neutral state during the cycle.

analyzer. An apparatus, *e.g.*, a Nicol prism, for detecting and testing the properties of polarized light. *Cf. harmonic analyzer.*

anastigmatic. Free from astigmatism for narrow, oblique pencils.

anemograph. A recording anemometer. The record is called an *anemogram.* (See Kodaira, *Geophys. Mag.* 7, 1, 1933.)

anemometer. An instrument for measuring the velocity of the wind.

aneroid. Free from liquids or fluid parts, as an aneroid barometer, calorimeter, etc.

angle of contact. The angle which a liquid surface makes with the submerged part of the solid surface with which it is in contact, as in a capillary tube.

angle of friction. The angle whose tangent is the friction coefficient. *Cf. angle of repose.*

angle of repose. 1. The angle of inclination assumed by the surface of a loose material, such as sand in a pile, when in equilibrium with gravity. 2. By some writers, syn. *angle of friction.*

angle of separation. *In re* a sphere or a cylinder moving transversely through a fluid: the angle between an outward-drawn radius to any point of the line of separation and the direction of advance of the body.

angle of slip. The angle between surfaces of slip or shear and the direction of stress during flow or during the plastic deformation of a solid. (See Nádai, Plasticity, 1931, p. 90.)

angle variable. One of a set of dimensionless, independent variables pertaining to a dynamic system and so related to it that, among other properties, the system returns to the same configuration when any one of the variables, varying separately, changes its value by unity. Used in astronomy and atomic dynamics. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 118.)

angstrom. A unit of length, equal to 10^{-8} cm, used in expressing wave lengths of light, etc. Syn. *tenth-meter.*

Ångström coefficient. The coefficient A in Ångström's formula for the scattering coefficient for dust in the atmosphere, *viz.*, $S = A\lambda^{-B}$; in which λ is the wave length and B ranges from 0 to 4 for different sized particles. Syn. *turbidity coefficient.*

angular impulse. The time integral of a torque, esp. when applied for a short time; measured by the change in angular momentum which it would impart to a free mass if acting about a principal axis.

angular magnification. The ratio of the tangent of the angle with the optic axis made by a ray upon emergence from an optical instrument to the tangent of the angle for the corresponding (conjugate) incident ray; or, approximately, the ratio of the angles themselves. *Cf. magnifying power.* (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 351.)

anhysteretic. Taking place without hysteresis; applied to magnetization under certain conditions. (See Spooner, Properties and Testing of Magnetic Materials, 1927, p. 14.)

anion. One of the negative ions moving toward the anode in an electrolytic cell or a discharge tube. *Cf. cation.*

anneal. To stabilize the internal structure of a solid substance, *e.g.*, glass or a metal, by protracted heating followed by slow cooling.

annihilation radiation. Radiation produced by the collision and mutual annihilation of an electron and a positron, and usually consisting of two quanta for each such encounter, moving in opposite directions. (See Richardson and Kurie, *Phys. Rev.* 50, 999, 1936.)

anode. That electrode from which positive ions are dispersed or toward which negative ions are

collected, within an electrolytic cell, discharge tube, or similar apparatus. *Cf. cathode.*

anode drop. An abrupt fall of electric potential at the anode of an electrolytic cell or vacuum tube. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 401.)

anode rays. Positively charged particles in a vacuum tube, which have their origin in the anode. They are of atomic dimensions, being derived, apparently, from metallic salts on the anode. (See Thomson, Rays of Positive Electricity, 1921, p. 142.)

anolyte. The solution surrounding the anode in an electrolytic cell. *Cf. catholyte.*

anomalous dispersion. An inversion of the usual change of refractive index with wave length in the vicinity of an absorption band.

anticathode. A plate or block of metal placed opposite the cathode in an x-ray tube to intercept the cathode rays. Syn. *target.*

anticyclone. A rotary atmospheric disturbance, turning in the opposite direction from a cyclone about a center of high pressure.

antinode. A point, line, or surface, between two nodes of a vibrating body, at which the amplitude has a maximum value. Syn. *loop.*

antiparallel. Extending or moving in parallel lines but in opposite directions.

antiresonance. A condition which, in a divided oscillatory circuit, is the antithesis of the resonance condition and for which the oscillation amplitude is reduced to zero.

aperiodic. 1. Devoid of periodicity or rhythm. 2. Syn. *deadbeat.*

apertometer. A device, due to Abbe, for measuring the numerical aperture of microscope objectives. (See Hardy and Perrin, Prin. of Optics, 1932, p. 503.)

aperture. 1. Any opening, as in a screen. 2. The diameter of the entrance-pupil of an objective. 3. (*Angular.*) The angle subtended at the focal point of an optical instrument by the diameter of the entrance-pupil. 4. (*Relative.*) In a telescope or a camera: the ratio of the focal length of the objective to the diameter of the entrance-pupil; it determines the photographic speed of the objective. Syn. *F-number.* (See Hardy and Perrin, Prin. of Optics, 1932, p. 73.) *Cf. numerical aperture.*

aperture angle. The angle subtended by the radius of the entrance-pupil of an optical instrument at the (axial) object-point.

aplanatic. 1. *In re* a lens: free from spherical aberration for a given point on the axis. 2. *In re* an optical system: free from spherical aberration as in (1) and also fulfilling the sine condition of Abbe.

apochromatic. *In re* an optical system: more highly corrected than an ordinary achromatic lens, *i.e.*, achromatized for more than two wave lengths.

apparent candle power. A measure of the equivalent luminous intensity of an extended source of light at a specified distance, *viz.*, the candle power of a point source which would produce the same illumination at the same distance.

apparent diameter. The angle subtended at the eye of the observer by the diameter of any object. Syn. *angular diameter.*

apparent power. The product of the effective e.m.f. and the effective current in an a.-c. circuit. Multiplied by the power factor, it gives the average power. *Cf. volt-ampere.* (See Karapetoff, The Electric Circuit, 1912, p. 56.)

apparent volume in solution. The volume of a solution minus the volume of the pure solvent entering into it at the same temperature. *Apparent specific volume in solution:* the apparent volume in solution per unit mass (mol or gram) of solute. *Cf. Masson equation.* (See Weld, *Phys. Rev.* 7(2), 44, 1916; Scott, *J. Phys. Chem.* 35, 2315, 1931.)

apse, apsis. A point on a central orbit at which the tangent is perpendicular to the radius vector from the center of force, or at which the radius vector has a maximum or a minimum value. Pl., *apsides;* adj., *apsidal.* (See Prescott, Mech. of Particles and Rigid Bodies, 1929, p. 373.)

Arago spot. A bright point which, owing to diffraction, appears at the center of the shadow of a sphere or other object casting a circular shadow in light from a point source. (See Becknell and Coulson, *Phys. Rev.* 20(2), 607, 1922.)

arc spectrum. The spectrum of a substance produced with light from an electric arc into which the substance is introduced.

Archimedes principle. States that the buoyant force of a liquid upon a partly or wholly submerged body is equal to the weight of the displaced liquid, and acts vertically upward through the center of displacement.

areal moment of inertia. The surface integral of the products of the elements of a plane area by the squares of their respective distances from an axis of reference in the plane of the figure. *Cf. sectional moment of inertia, polar moment of inertia.*

armature. 1. A removable part of a magnetic circuit, of ferromagnetic material and usually of low reluctance; *e.g.,* a bar of iron placed across the poles of a magnet. 2. That part of a generator or motor, or other electromagnetic device, upon whose relative motion with respect to the main magnetic field the operation of the device depends.

astatic. Coming to rest indifferently, without any particular orientation; *e.g.,* an *astatic pair,* composed of two parallel, equally magnetized needles, rigidly connected, with their like poles in opposite directions.

astigmatism. The property of being *astigmatic,* as a lens or a mirror, *i.e.,* having different focal power in different meridians. In an astigmatic bundle of rays, the rays do not all intersect at one point. Astigmatism of the eye is mainly due to lack of sphericity in the cornea, which has different curvature in different meridians. *Cf. stigmatic.*

Aston dark space. 1. A thin, nonluminous region of the discharge in a vacuum tube which sometimes is observed between the cathode glow and the cathode it-

self. Syn. *primary dark space.* (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 342.) 2. Aston also discovered a dark space next to the anode. (*Ibid.*, p. 402.)

astrophysics. The physics of astronomical bodies and regions.

athermanous. Opaque to infrared. *Cf. diathermanous.*

atmosphere. 1. The air. 2. Any gaseous medium. 3. A unit of pressure, defined as the pressure of 76 cm of mercury at 0°C. under standard gravity. Equal to about 1,013,250 dynes/cm^2.

atmospheric. 1. (adj.) Pertaining to the atmosphere. 2. (n.) An electrical disturbance or stray produced by conditions in the atmosphere. (See I.R.E. Comm. Rep., 1933.)

atom form factor. 1. A quantity occurring in the expression for the intensity of an x-ray beam reflected by a crystal, whose value depends upon the varying configuration of the electrons in the crystal atoms relative to the center of the atom, as well as upon the angle of incidence and the wave length of the x-rays. Syn. *atomic scattering factor, atomic structure factor, structure amplitude factor, f-value. Cf. F-value.* 2. A quantity used in a manner similar to (1), but in reference to the scattering of either x-rays or electrons by gases. *Cf. form factor.*

atomic absorption coefficient. The absorption coefficient of an element divided by the number of atoms per unit volume. (See Compton and Allison, X-Rays in Theory and Experiment, 1935, p. 10.)

atomic domain. One of the simplest space-filling polyhedrons which contain the contacting spheres used to represent the atoms in a crystal. *Cf. domain.* (See Owen and Yates, *Phil. Mag.* 15, 472, 1933.)

atomic frequency. A natural frequency of vibration ascribed to the atoms composing a solid, and associated with the elastic constants of the solid. Syn. *characteristic frequency.* (See Loeb, Nature of a Gas, 1931, p. 385.)

atomic heat. The product of the atomic mass of an element by its specific heat; or the thermal capacity of 1 gram atom of the element. *Cf. Dulong-Petit law* (1), *Debye characteristic temperature.*

atomic number. The number assigned to any element in the complete series of elements, arranged in the order of the complexity of the atom; supposed to represent the number of electrons surrounding the nucleus. Syn. *Moseley number. Cf. Moseley law, mass number.*

atomic refraction. The product of the specific refractive power of an element by its atomic weight. *Cf. molar refraction.*

atomic scattering coefficient. *In re* the scattering of a stream of electrons in traversing a substance: the scattered electron current per unit solid angle in any direction, per atom of scattering material, per unit incident electron current. (See Jordan and Brode, *Phys. Rev.* 43, 113, 1933.)

atomic scattering factor. Syn. *atom form factor* (1).

atomic stopping power. *In re* the effect of different elements upon

the motion of alpha particles: the quantity

$$S \cdot Z^{-\frac{4}{3}},$$

in which S is the stopping power relative to oxygen and Z, the atomic number. Its value is approximately 0.23 for all elements. (See Kovarik and McKeehan, Radioactivity, 1925, pp. 49, 71.)

atomic structure factor. Syn. *atom form factor* (1).

atomic susceptibility. The specific or mass susceptibility of an element, multiplied by its atomic weight. (See Smiths. P. T., 1929, p. 365.)

atomic volume. The volume of 1 gram atom of an element in the solid state.

attenuation. The falling off of the flux density, as of radio waves, with distance from their source, due to any cause.

attenuation factor. A measure of the transparency of a layer of absorbing medium for an emission traversing it. It is the ratio of the flux density I of the emergent emission to the flux density I_0 of the incident emission. For an exponentially absorbed emission, the value of the factor, for thickness x of a medium whose absorption coefficient is μ, is $e^{-\mu x}$. Syn. *transmission factor. Cf. absorption coefficient, absorption factor.*

audio frequency. A vibration frequency within the range of human tone perception.

audio-oscillator. A generator of a.c.'s within the audible frequency range.

Auger effect. The liberation of two electrons from different levels of an atom by a single x-ray quantum; a somewhat rare phenomenon first observed in argon. (See Auger, *J. de phys.* 6, 205, 1925; Loeb, Nature of a Gas, 1931, p. 126.)

aureole. The hazy, less luminous, outer portion of an electric arc, often of a different color from that of the core.

auroral line. A green line in the spectrum of the aurora borealis at wave length 5577 Å, undoubtedly due to a "forbidden" transition in oxygen. The line has been produced artificially by Kaplan. (See White, Int. to Atomic Spectra, 1934, p. 267; Kaplan, *Phys. Rev.* 48, 800, 1935.)

autocollimator. A telescope provided with a transparent scale in its objective focal plane, by means of which angles subtended by distant objects may be directly read. (See Wagner, Experimental Optics, 1929, p. 111.)

autoelectronic emission. Syn. *field emission, cold emission.* (See de Bruyne, *Phys. Rev.* 35(2), 172, 1930.)

auto-ionization. An automatic dissociation of a molecule, which occurs when the sum of its vibrational and electronic energies exceeds the energy necessary for dissociation. (See Shenstone, *Phys. Rev.* 38, 873, 1931; White, *ibid.*, 38, 2016, 1931.)

autophotoelectric. Relates to the hypothesis, due to Richardson, that thermionic emission is a form of photoelectric effect, in which the radiation comes from the hot substance itself. (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 214.)

autotransformer. A transformer of which the primary windings, or part of them, are connected differentially in series with the secondary and which has the effect of stabilizing the secondary voltage against variations in the primary voltage. (See Weinland, *R.S.I.* 3, 11, 1932.)

auxiliary circle. The circle which has for its diameter the major axis of an elliptical orbit. (See Prescott, Mech. of Particles and Rigid Bodies, 1929, p. 525.)

available energy. That part of the energy of a body or of a system which is in such form that mechanical work may be derived from it.

average life. Syn. *decay modulus.*

Avogadro law. States that at equal temperatures and pressures, equal volumes of all gases contain the same number of molecules. *Cf. Loschmidt number.*

Avogadro number. The number of atoms in a gram atom of any element, or the number of molecules in a mol of any pure substance. Its value is approximately 6.064×10^{23}. (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

axial magnification. The ratio of the interval between two adjacent image-points on the axis of an optical instrument to the interval between the corresponding axial object-points. Syn. *depth magnification.* (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 349.)

axial ratio. The ratio between the length of the arbitrary unit of measure along one axis of a crystal to that used along some other axis.

axis of instantaneous rotation. A straight line about which any rigid body in motion may be regarded as rotating at any instant. *Cf. conjugate points* (2). Syn. *instantaneous axis.*

azeotropic. *In re* a liquid mixture: in such proportion as to have a constant boiling point, the distillate having the same composition as the original liquid. This property is known as *azeotropism.*

azimuth. 1. Position as measured by an angle reckoned around some fixed point or pole, *e.g.*, the azimuth of a particle moving in an orbit, or (astron.) of a star in the sky reckoned around the horizon from the south point. 2. *In re* elliptically polarized light: the direction of the vibration plane of the light which would result if the phase difference corresponding to the ellipticity were reduced to zero without altering the amplitudes of the components.

azimuthal quantum number. A quantum number associated with angular motion, which must be an integer for any allowed stationary state of a particle moving subject to a central field.

B

(*Please note purpose of references as explained in preface.*)

Babinet absorption rule. States that positive, uniaxial crystals have greater absorption for the extraordinary component, negative crystals for the ordinary component, of the light doubly.

refracted by them. (See Groth, Optical Properties of Crystals, 1910, p. 236.)

Babinet principle. States that two diffraction screens, one of which is exactly the negative of the other, produce identical diffraction patterns. (See Wood, Phys. Optics, 1929, p. 238.)

Babo law. States that the vapor pressure of a dilute solution of given concentration bears approximately a constant ratio to that of the pure solvent as the temperature changes. (See Planck, Treatise on Thermodynamics, 1927, p. 206.)

Back-Goudsmit effect. A phenomenon analogous to the Paschen-Back effect but produced by a weak magnetic field upon the spectrum lines of an element having a nuclear magnetic moment. (See Back and Goudsmit, *Zeits. f. Phys.* 47, 174, 1928.)

backing pump. Syn. *fore pump.*

backlash. The imperfect rectification of an a.c. by a thermionic valve, due to the presence of positive ions produced in the gas by the impact of thermoelectrons. (See Campbell and Ritchie, Photoelectric Cells, 1930, p. 144.)

balance method. A method of measurement in which the quantity to be measured is by adjustment so related to the known quantity with which it is compared that the scale reading of the indicating instrument becomes zero; as in the use of a balance or of a Wheatstone bridge. Syn. *null method, zero m.*

balanced. 1. *In re* a circuit: having equal e.m.f.'s and equal currents in its main branches. 2. *In re* an electric network: having two conjugate branches, *e.g.*, a Wheatstone bridge. 3. *In re* a periodic variable: one whose average value is zero, *e.g.*, a simple harmonic a.c. or voltage. (See A.I.E.E. Comm. Rep., 1932.)

balayage. An ideal process in which all of the matter contained within a given volume is deposited upon the surface in such a way that the gravitational potential due to the surface distribution at all points outside the surface is equal to that due to the original volume distribution. The concept was utilized by Poincaré. (See MacMillan, Theory of the Potential, 1930, p. 313.)

ballistic. 1. Pertaining to projectiles. 2. A term applied to an instrument which indicates the effect of an impact or of a sudden rush of energy; as a ballistic pendulum or galvanometer.

Balmer series. A series of lines in the hydrogen spectrum, found by Balmer (1885) to be made up of frequencies progressing in proportion to the sequence of numbers

$$\left(\frac{1}{2^2}-\frac{1}{3^2}\right),\quad \left(\frac{1}{2^2}-\frac{1}{4^2}\right),\quad \left(\frac{1}{2^2}-\frac{1}{5^2}\right),\ \ldots\ .$$

Over 30 lines have been identified in this series.

band. 1. One of the broad stripes characteristic of molecular spectra. They are really sequences of spectrum lines so closely spaced as to require high resolution to detect them. 2. Any sequence or range of frequencies. 3. A bright or a dark streak or stripe

due to interference or diffraction. Syn. *fringe.*

band edge, b. head. The frequency toward which the lines in any one band of a band spectrum appear to be concentrated.

band elimination. *In re* a wave filter: the transmission of an entire range of frequencies with the exception of a limited portion, or band, having transmitted portions on either side of it. (See Acous. Soc. Comm. Rep., 1934.)

band-pass. *In re* a wave filter: having the property of transmitting only a certain band or range of frequencies. *Cf. high-pass, low-pass.*

banked winding. A mode of winding h.-f. coils, in which single turns are wound successively one outside the other in a flat spiral and the entire coil built of such spirals side by side. This reduces the effect of distributed capacitance. (See I.R.E. Comm. Rep., 1933.)

bar. *Cf. barye.*

Barkhausen effect. A succession of abrupt changes of magnetization in a smoothly varying magnetizing field; discovered by H. Barkhausen. (See *Phys. Zeits.* 20, 401, 1919.)

Barkhausen-Kurz oscillator. A type of triode oscillator in which oscillations of frequencies ranging from 3×10^8 to 15×10^8 are generated, apparently by the movements of filament electrons passing back and forth through the positive grid and finally settling upon it. (See McIlwain and Brainerd, H.-F. Alternating Currents, 1931, p. 263.)

Barnett effect. The magnetization of a body by rotating it, without applied magnetic field. *Cf. Einstein-deHaas effect.* (See Barnett, *Phys. Rev.* 6(2), 239, 1915 and *Rev. Mod. Phys.* 7, 129, 1935.)

barograph. A recording barometer.

barostat. A pressure regulator, or an arrangement to maintain a constant pressure.

barye, bar. The c.g.s. absolute unit of pressure, *viz.*, 1 dyne/cm^2. The *megabarye* or *megabar* is one million *baryes*, and equals about 0.987 atm. NOTE.—Some writers designate 10^6 *baryes* as a *bar*, and the *barye* as a *microbar*. (See Smiths. P. T., 1929, p. 435.)

basal plane. A plane in a crystal parallel to the principal plane of symmetry.

Baumé scale. One of two arbitrary hydrometer scales, used, respectively, for liquids of specific gravity less than unity and greater than unity. (See Smiths. P. T., 1929, p. 109.)

beam interferometer. A form of stellar interferometer in which the effective distance between the slits is increased by means of mirrors mounted on a rigid beam beyond the edge of the objective. First used by Michelson to measure apparent diameters of stars. (See Baker, Astronomy, 1933, p. 398.)

beat. A maximum or minimum of intensity arising from the interference of two wave trains of unequal frequency.

beat tone. A musical tone due to beats, produced by the interference of two h.-f. wave trains, as

in radio reception. *Cf. combination tone, difference t.*

Beattie-Bridgman equation. An empirical characteristic equation for fluids, as follows:

$$pv^2 = RT\left(1 - \frac{c}{vT^3}\right)\left[v + B\left(1 - \frac{b}{v}\right)\right] - A\left(1 - \frac{a}{v}\right);$$

in which R, A, B, a, b, c are constants determined by experiment for each substance. (See Beattie and Bridgman, *J. Am. Chem. Soc.* 49, 1665, 1927.)

Beau de Rochas cycle. The thermodynamic cycle of the ordinary, four-stroke, internal combustion engine; commonly called the *Otto cycle.*

Beckmann thermometer. A mercurial thermometer having a very large bulb and a very fine bore; used for measurements of small temperature differences.

Becquerel effect. An e.m.f. observed in a circuit having two identical electrodes immersed in an electrolyte, when the electrodes are unequally illuminated. *Cf. photovoltaic.* (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 5.)

Becquerel membrane. A semipermeable membrane produced *in situ* by a chemical reaction, *e.g.*, by the contact of solutions of sodium sulphide and silver nitrate. (See Freundlich, Colloid and Capillary Chem., 1922, p. 272.)

Becquerel rays. The radioactive emission from uranium compounds, discovered by Becquerel in 1896 and consisting of beta and gamma rays from products of uranium.

bel. A unit used to express the relationship between two amounts of power (acoustic, electric, etc.) as an interval on a logarithmic scale. The number of bels in such an interval is the common logarithm of the ratio of the two powers compared; therefore the bel is the value of that interval for which the ratio is 10:1. Acoustically it is used to express differences in sound sensation level. Named for Alexander Graham Bell. *Cf. decibel, neper.* (See A.I.E.E. Comm. Rep., 1932; Acous. Soc. Comm. Rep., 1934.)

Belfils bridge. A type of resonance bridge used to ascertain the harmonic purity of an electric wave train. (See Brown, Radio Frequency Elec. Meas., 1931, p. 316.)

bench photometer. Any one of various types of photometer, the parts of which are arranged on an optical bench.

bending moment, b. torque. The torque which exists at any point in a bent, elastic rod, and to which the bending is due. Syn. *flexural moment, f. torque. Cf. stress couple.*

Bernoulli equation. An equation which expresses the total head of a flowing liquid, as follows:

$$e + \frac{p}{\rho g} + \frac{v^2}{2g} = H;$$

in which e is the elevation above an arbitrary datum, p the pressure, ρ the density, v the speed of flow, g the acceleration of gravity, and H the total head. The *Bernoulli law* states that for an unimpeded flow this total head H is constant. The equation ap-

pears also in other forms adapted to various situations.

Bessel equation. A linear differential equation of the form

$$x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} + (x^2 - a^2)y = 0,$$

the solutions of which are expressible as power series in x known as *Bessel's functions* or *Bessel's integrals*. Important in problems of heat conduction, etc.

beta-ray spectrum. *Cf. alpha-ray spectrum* (similarly defined). (See Rutherford, Chadwick, and Ellis, Radiations from Radioactive Substances, 1930, pp. 341 ff.)

beta rays. An emission of electrons from the atoms of an element in radioactive transformation; proceeding in part directly from the nucleus and in part from the x-ray levels of the outer electron system. (See Rutherford, Chadwick, and Ellis, Radiations from Radioactive Substances, 1930, pp. 347 ff.)

beta transformation. A radioactive transformation in which the atomic nucleus loses an electron (beta particle).

bias. A permanent negative potential applied to the grid of a vacuum tube.

biaxial. Having two different optic axes.

binding energy. A quantity of energy supposed to be released upon the formation of an atom or a molecule from alpha particles, protons, electrons, etc., at the expense of the total mass. *Cf. packing effect.*

bioluminescence. The emission of light by living organisms, as the firefly, certain fungi, and many marine forms. (See Harvey, Nature of Animal Light, 1920.)

biophysics. A term used in reference to the physical processes taking place in living organisms.

Biot-Savart force. Syn. *Lorentz electromotive force.* (See Einstein, Meaning of Relativity, 1923, p. 46.)

Biot-Savart law. States that the magnetic intensity due to a current i (abamperes) in an infinitely long, straight wire, at a point distant p from the wire, is

$$H = \frac{2i}{p}.$$

Cf. Ampère law, from which it follows. (See Page and Adams, Prin. of Electricity, 1931, p. 249.)

bipartition angle. The angle between a beam of x-rays passing through a layer of material and the conical surface (the *bipartition cone*) which contains the paths of half the electrons ejected from the layer by the rays. (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 407.)

bipolar electrode. A conducting partition placed across an electrolytic cell, so that one surface acts as an anode and the other as a cathode. (See Newman, Electrolytic Conduction, 1931, p. 385.)

biprism. A glass prism of almost 180-deg vertex angle, devised by Fresnel, to produce a virtual-image double source for Young's interference experiment; applied also to similar devices for producing double-image fields in spectrophotometers, etc.

biquartz. A plate made of two semicircular pieces, one of dextrogyrate, the other of levogyrate

quartz, of equal thickness, and cemented together along the diameter; used for demonstrating polarization tints. (See Tutton, Natural History of Crystals, 1924, p. 255.)

birefringence. Syn. *double refraction.*

bismuth spiral. A coil of bismuth wire, the magnetoresistance effect in which is used as a measure of the magnetic field intensity. (See Spooner, Properties and Testing of Magnetic Materials, 1927, pp. 205, 219.)

Bitter pattern, B. bands. Syn. *powder pattern* (2).

black body. A body whose reflectivity is zero for radiation of all frequencies. Only an ideal, it is approximated experimentally by a nearly closed cavity with a small opening or slit. *Cf. Hohlraum.*

black-body constant. Syn. *Stefan-Boltzmann constant.*

black-body function. 1. The product σT^4, representing the emissive power of a black body at absolute temperature T, in accordance with the Stefan-Boltzmann law; σ being the S.-B. constant. 2. The function expressing the value of $dE_\lambda/d\lambda$ in the Planck equation.

black-body radiation. The radiation from a black body at a given temperature. Syn. *cavity radiation, Planckian r., black r. Cf. Wien laws, Planck equation.*

black-body temperature. The temperature of any body as indicated by a radiation pyrometer which has been calibrated by the use of a black body. *Cf. brightness temperature.* (See Burgess and LeChatelier, Measurement of High Temperatures, 1912, p. 242; Bidwell, *Phys. Rev.* 3(2), 439, 1914.)

Blackburn pendulum. An apparatus consisting of a pendulum which may swing with different periods in two directions at right angles. Used in studying harmonic motions. *Cf. Lissajous curves.*

blocking layer. The surface of contact between a metal and a semiconductor (*e.g.*, copper and cuprous oxide), which acts as a rectifier and, when illuminated, is the seat of a photovoltaic e.m.f. Syn. *barrier layer. Cf. photronic cell.* (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 363; Linford, *Rev. Mod. Phys.* 5, 34, 1933.)

blue glow. 1. A type of thermoluminescence emitted by certain metallic oxides, *e.g.*, MgO and BeO, when heated. (See Nichols and Howes, *J.O.S.A.* 6, 42, 1922.) 2. The bluish luminosity of the gas near the cathode in a Geissler tube, esp. when the gas is air.

blur circle. The circular intersection of a screen, as the retina, with a conical pencil of rays from a point source whose image does not lie exactly upon the screen. Syn. *circle of diffusion.*

body-centered. *In re* a unit cell of crystal structure: having an atom at its center of figure. Syn. *space-centered.*

Bohr atom. *Cf. Rutherford-Bohr atom.*

Bohr frequency rule. Syn. *frequency condition.* (See Pauling and Goudsmit, Structure of Line Spectra, 1930, p. 6.)

Bohr-Grotrian diagram. One form of diagrammatic representation of the energy levels in an atom. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 207.)

Bohr orbit. One of the supposed electronic "orbits" in the atom as conceived by Bohr. *Cf. Rutherford-Bohr atom.*

boiling point (of a liquid). The temperature at which the maximum vapor pressure of the liquid is in equilibrium with the superimposed pressure. If the latter is the normal atmospheric pressure (760 mm), this temperature is the *normal boiling point.*

boiling-point constant. *Cf. boiling-point law.*

boiling-point law. States that the boiling point of a solvent is elevated by the addition of a nonvolatile solute in proportion to the molar concentration of the solute. The *boiling-point constant* is the elevation in boiling point produced by adding 1 mol of a solute to 1000 g of solvent. *Cf. freezing-point law, van't Hoff law.*

bolograph. A recording bolometer; or the photographic record produced by it. The latter has also been called *bologram.*

bolometer. A very sensitive type of metallic resistance thermometer, used for measurements of thermal radiation. Devised by Langley.

Boltzmann constant. The (molar) ideal gas constant divided by the Avogadro number. Its value is about 1.371×10^{-16} erg/deg. (See Loeb, Kinetic Theory of Gases, 2d ed., pp. 28 ff.; Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

Boltzmann engine. An ideal thermodynamic apparatus operating in cycles and having imprisoned radiation corresponding to a working substance; visualized by Boltzmann in the theoretical deduction of the Stefan-Boltzmann law. (See Richtmyer, Int. to Theoretical Phys., 1928, p. 194.)

Boltzmann entropy hypothesis. The assumption that the entropy of a system of material particles is proportional to the logarithm of the statistical probability of the distribution. *Cf. H function.* (See Darrow, *Rev. Mod. Phys.* 1, 90, 1929.)

Boltzmann factor. A correction factor applied to calculated line intensities in spectra due to thermal excitation. *Cf. excitation function* (2).

Boltzmann principle. *In re* the equilibrium distribution of particles subject to thermal agitation in a field of force: states that the number of particles per unit volume at any point in the field is

$$N = N_0 e^{-\frac{E}{kT}},$$

in which E is the potential energy of a particle at that point, N_0 is the number where E is zero, T is the absolute temperature, and k is the Boltzmann constant. Syn. *concentration law. Cf. law of atmospheres.*

bomb calorimeter. A fuel calorimeter in which the combustion takes place inside a "bomb."

bond force constant. The Hooke-law force constant for infinitesimal extension or compression of a chemical bond in a molecule; a

concept used in the treatment of the normal vibrations of a molecule. (See Badger, *J. Chem. Phys.* 2, 128, 1934.)

bond moment. The dipole moment associated with a chemical bond in a polar molecule. Syn. *binding moment.* (See Smyth and McAlpine, *J. Chem. Phys.* 1, 190, 1933.)

bonding power. A measure of the effect, positive or negative, contributed by a shared electron in a molecule to the attraction or repulsion between atoms in the molecule.

Borda mouthpiece. A type of reentrant orifice, *viz.*, a tube extending inward from a discharge orifice, which has the effect of modifying the conditions of flow.

Bosanquet law. States that the magnetic flux, in maxwells, in a magnetic circuit is equal to the magnetomotive force, in gilberts, divided by the magnetic reluctance, as formerly expressed in oersteds. (*Cf. oersted* (2).) Also known as the *Rowland law.* (See Bosanquet, *Phil. Mag.* 15, 205, 1883.)

Bose-Einstein statistics. A system of statistical analysis of the distribution of gas molecules or of radiation quanta and their momenta, based upon the number of elementary compartments of ordinary space and of momentum space having each a given number of the respective entities. *Cf. classical statistics, Fermi-Dirac s.* (See Darrow, *Rev. Mod. Phys.* 1, 90, 1929.)

Bouguer formula. A formula for the variation of gravity with altitude. If g_0 is the sea-level value at the latitude of the station, R the radius of the earth at that station, ρ the local crust density and ρ_m the mean density of the earth, then the value of gravity at the altitude h is given by

$$g = g_0\left(1 - \frac{2h}{R} + \frac{3h\rho}{R\rho_m}\right).$$

This formula has been criticized and amended by Faye (*Compt. rend.* 90, 1443, 1880).

Bourdon gauge. A pressure gauge depending upon the deformation of a curved tube of elastic metal, of elliptic cross section, to the interior of which the pressure is applied.

Boyle-Charles law. A combination of Boyle's law for the pressure-volume relation and Charles's law for the temperature-volume relation in an ideal gas, *viz.*,

$$pv = p_0v_0(1 + at).$$

Cf. ideal gas law.

Boyle law. The statement, attributed to Robert Boyle (1662), that in a body of gas maintained at constant temperature, the volume and the pressure vary in inverse ratio, *i.e.*, have a constant product. Syn. *Mariotte law.*

brachistochrone, brachystochrone. The path of constraint along which a particle, under the action of a given force, will move from one given point to another given point in the least time. *Cf. constrain.* (See Page, Int. to Theoretical Phys., 1928, p. 161.)

Brackett series. A spectral series in the infrared of the hydrogen spectrum, whose frequencies are multiples of

$$\left(\frac{1}{4^2} - \frac{1}{n^2}\right);$$

where $n = 5, 6, 7, \cdots$. *Cf. Paschen series.*

Bragg angle. The glancing angle for x-rays at the reflecting planes of a crystal. *Cf. Bragg law.*

Bragg law. An expression for the condition under which a system of parallel atomic layers in a crystal will reflect a beam of x-rays with maximum intensity. If d is the distance between the layers, θ the glancing angle, and λ the wave length of the x-rays, the condition is

$$2d \sin \theta = N\lambda;$$

in which N must be a whole number.

Bragg-Pierce law. States that the true atomic absorption coefficient (scattering omitted) of an element of atomic number Z for x-rays of wave length λ is represented by

$$\mu_a = CZ^4\lambda^{5/2};$$

the value of C changing abruptly at wave lengths of absorption lines. (See Bragg and Pierce, *Phil. Mag.* 28, 626, 1914.) Bragg later changed the exponent of λ to 3 (*Ibid.* 29, 407, 1915).

Bragg reflection. The reinforced reflection of x-rays from the successive atomic planes of a crystal, or of electrons from the grating-like structure of its surface. *Cf. Bragg law.*

branch. 1. Part of the series of lines forming a single band in a band spectrum; the two branches proceed in opposite directions from a common zero line. 2. One of the subdivisions of a radioactive series due to transformations of different types. *Cf. branching ratio.* 3. A conductor joining any two given points of an electric network.

branching ratio. The ratio between the numbers of atoms of a radioactive element which undergo two different types of transformation, the one emitting an alpha particle, the other a beta particle. *Cf. branch* (2).

branching rule. States that each term of the spectrum of a singly ionized atom gives rise to two groups of terms of consecutive multiplicity in the spectrum of the neutral atom; except the singlet terms, which give rise only to doublets. Formulated by Landé and Heisenberg. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 313.)

Braun tube. An early type of cathode-ray oscillograph tube requiring a potential of several thousand volts for operation.

Bravais-Miller index. One of the four numbers (h, k, f, l) used to designate any set of parallel planes in a crystal belonging to the hexagonal system. *Cf. Miller index.*

Brewster law. States that the polarizing angle of a reflecting dielectric for light of any wave length is equal to the angle whose tangent is the refractive index of the dielectric for that wave length. Discovered by Brewster in 1815.

brightness. "The quotient of the luminous intensity of a surface measured in a given direction, by the area of this surface projected on a plane perpendicular to the direction considered." (Quoted from Illum. Eng. Nomenc., 1932.)

brightness temperature. The temperature that is obtained for non-

black bodies with an optical pyrometer calibrated to give the correct temperature of a black body. It is always less than the true temperature. *Cf. black-body temperature.*

brilliance. That attribute of any color which permits it to be classed as equivalent to some member of the series of achromatic colors, or grays. Thus bright red is more *brilliant* than dark red.

Brillouin effect. A pair of spectral satellites appearing in radiation scattered by liquids, one on each side of the unmodified line at a separation of about 0.04 Å. Also known as the *Debye-Sears effect. Cf. Raman effect.*

Brillouin zone. A continuous ensemble of all energies and wave functions which may be obtained from one atomic energy level in a metallic-crystal lattice. (See Bouckaert, Smoluchowski, and Wigner, *Phys. Rev.* 50, 58, 1936.)

Brinell hardness. The hardness of a substance as measured by the force which must be exerted upon it by a rigid sphere of given radius to produce an indentation of given area. *Cf. sclerometer.*

British thermal unit. A unit, defined as that quantity of heat which is required to raise the temperature of 1 lb of water 1°F. Equivalent to about 252 (g) cal.

Bronson resistance. A high resistance consisting of two electrodes in a gas made conducting by a constant source of ionization.

Brownian movement. An erratic, zigzag motion exhibited by very small particles suspended in a liquid or a gaseous medium, due to the thermal agitation of the molecules of the medium. Discovered by Brown (a botanist) in 1827. (See Einstein, Brownian Movement, 1926.)

brush discharge. An electric discharge in a gas, intermediate between a glow discharge and a spark, and composed partly of minute sparks. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 532.)

Buckley gauge. A type of ionization gauge for measuring very low gas pressures.

bulk modulus. The ratio of the pressure to which an elastic substance is subjected to the decrease in volume per unit volume. Syn. *pressure modulus.*

bumping. Sudden, explosive ebullition.

Bunsen coefficient. The solubility of a given gas in a given liquid at N.T.P., expressed in terms of volume of gas absorbed per unit volume of the solution. (See Couch, Dict. of Chem. Terms, 1920.)

Bunsen screen. A photometer screen consisting of a diaphragm of paper or parchment with a translucent central spot.

burst (cosmic-ray). A sudden, intense ionization, apparently due to some effect of cosmic rays upon matter, and often giving rise to great numbers of ion pairs at once. Syn. *Stoss* (Ger.). *Cf. shower.* (See Locher, *Phys. Rev.* 44, 779, 1933; Swann, *Phys. Rev.* 44, 1025, 1933.)

by-pass condenser. A condenser used to provide an a.-c. path of comparatively low impedance around a circuit element. (See A.I.E.E. Comm. Rep., 1932.)

C

(Please note purpose of references as explained in preface.)

Callendar equation. A characteristic equation for steam, given by Callendar in the form

$$v = \frac{RT}{p} + b - c,$$

in which b is a constant and c a function of T.

Callendar-Griffiths bridge. A type of slide-wire resistance bridge especially designed for use in resistance thermometry. (See Page and Adams, Prin. of Electricity, 1931, p. 189.)

calorescence. The transformation of infrared radiant energy into visible light, as by focusing infrared rays upon a thin plate of platinum until it becomes white hot.

calorie. 1. A unit, defined as the quantity of heat required to raise the temperature of 1 g of water from 15 to 16°C. 2. One thousand times the above unit.

calorimeter. Any one of several types of apparatus used for the purpose of measuring quantities of heat. *Cf. ice calorimeter, steam c., water c.*

calorimetric coefficients. Six quantities which express the rates of absorption of heat by a body of fluid during reversible changes of its volume, pressure, and temperature, *viz.*,

$$\left(\frac{\partial q}{\partial p}\right)_v, \left(\frac{\partial q}{\partial v}\right)_p, \left(\frac{\partial q}{\partial T}\right)_v, \left(\frac{\partial q}{\partial T}\right)_p, \left(\frac{\partial q}{\partial p}\right)_T, \left(\frac{\partial q}{\partial v}\right)_T.$$

In these T is the temperature; q, quantity of heat; v, volume; p, pressure; and the subscripts denote that the corresponding quantity is to be kept constant. *Cf. thermoelastic coefficients, thermometric c.* (See Page, Int. to Theoretical Phys., 1928, p. 259.)

camber. The ratio of the sagitta (maximum ordinate) of an arc to the length of the chord; a term applied to the streamlined contours of aerofoils or similar surfaces.

Campbell-Colpitts bridge. A shielded a.-c. bridge for the measurement of capacitance, using a substitution method. (See Campbell, *Elec. World and Engineer* 43, 647, 1904; Shackelton and Ferguson, *Bell Syst. Tech. J.* 7, 82, 1928.)

canal rays. An emission consisting of positive ions which have passed through openings in the cathode of a gas-discharge tube. (See Thomson, Rays of Positive Electricity, 1921, p. 3.)

candle. The unit of luminous intensity generally used. The *international candle* was established in 1909 by the national standards laboratories of the U. S., Great Britain, and France and adopted in 1921 by the International Commission on Illumination. The *U. S. candle*, defined in terms of a group of 45 carbon-filament lamps at the National Bureau of Standards, agrees with the international candle within the limits of observational error.

candoluminescence. The luminescence of an incandescent body, as distinguished from the visible radiation due to temperature alone. (See Nichols, Howes, and

Wilber, *Carnegie Institution Pub.* 384.)

canonical. *In re* the mathematical statement of a physical law: expressed in the simplest completely general form possible.

capacitance. The ratio of the quantity of electricity q accumulated in charging a conductor to the accompanying change in its potential V, *i.e.*, the value of dq/dV. Syn. *capacity*. *Cf. farad, distributed capacitance, acoustic compliance.*

capacitance bridge. An arrangement resembling a Wheatstone bridge and used for the comparison of capacitances by a somewhat similar method.

capacitance coefficient. *In re* one of a system of neighboring conductors: the capacitance of the given conductor when all the others are kept at zero potential. (See A.I.E.E. Comm. Rep., 1932.)

capacitor. A condenser of fixed capacitance, used as a standard or as a capacitance load.

capacity. (Elec.) Syn. *capacitance.* (Obsolescent.)

capillarity. A class of phenomena dependent upon the interaction of molecular forces at the junction of the interface between a liquid and a gas or between two liquids, with a solid surface; *e.g.*, the elevation or depression of a liquid in a capillary tube.

capillary constant. *In re* two liquids of densities ρ_1, ρ_2, having the mutual surface tension T: the product $(\rho_1 - \rho_2)Tg$, in which g is gravity. (See I.C.T., 1926, v. 1, p. 35.)

capillary electrometer. An electrometer whose action depends upon the effect of a p.d. on the surface tension at the interface between two liquids in a capillary tube. *Cf. electrocapillarity.*

Carcel unit. A French unit of luminous intensity, defined as one-tenth of the output of the Carcel lamp, which burns colza oil. It is approximately 0.96 international candle.

cardinal points. The focal points, the principal points, and the nodal points of a lens or of a symmetrical optical instrument.

Carey-Foster bridge. A type of Wheatstone-bridge circuit for measuring the difference between two nearly equal resistances, in which the two ratio arms are coils connected by a slide wire.

Carhart-Clark cell. *Cf. Clark cell.*

Carnot-Clausius equation. The equation $\oint \frac{dq}{T} = 0$, in which dq is the quantity of heat taken in by a body, or a system, during an infinitesimal, reversible change of state and T is the absolute thermodynamic temperature of the system while it is receiving dq. The changes of state form a reversible closed cycle.

Carnot cycle. A closed cycle of reversible changes in the state of a body, consisting of an isothermal expansion, an adiabatic expansion, an isothermal compression, and an adiabatic compression in the cyclic order stated. The concept was introduced by Carnot in 1824.

Carnot theorems. Two propositions of thermodynamics: 1. No heat engine working between two temperatures can have greater efficiency than a reversible engine working between those temperatures. 2. The efficiency of any

reversible heat engine working between two temperatures is independent of the nature of the engine or of the working substance and depends only upon the temperatures.

cascade. An arrangement of condensers, analogous to the series arrangement of battery cells, in which the higher potential plate of each is connected to the lower of the next.

cascade (x-ray) tube. A high-voltage vacuum tube used in the production of hard x-rays or of high-speed ion beams, in which the total voltage is divided by constructing the tube in several sections. (See Coolidge, *J. Frank. Inst.* 202, 693, 1926; Tuve, Breit, and Hafstad, *Phys. Rev.* 35(2), 66, 1930.)

Cassegranian mirror. A convex second mirror placed in front of the concave objective in one form of reflecting telescope. It produces an image in a tube inserted at the center of the objective mirror, where the eyepiece is located.

catacaustic. A caustic produced by reflection.

cataphoresis. The movement of solid particles in liquid suspension under the action of an e.m.f. *Cf. electrophoresis, electro-endosmosis.*

catenary. The curve assumed by a perfectly flexible, uniform chain hanging in equilibrium between two points of support.

cathetometer. A form of comparator, consisting of a reading telescope or microscope mounted horizontally and movable along a vertical scale.

cathode, kathode. That electrode from which electrons or negative ions are dispersed, or toward which positive ions are collected, within an electrolytic cell, discharge tube, or similar apparatus. *Cf. anode.*

cathode dark space. That portion of the glow discharge in a Crookes tube lying between the cathode glow and the negative glow; so called because it is nonluminous. Syn. *Crookes dark space.*

cathode drop. An abrupt fall of electric potential at the cathode of an electrolytic cell or a vacuum tube.

cathode glow. A luminosity which immediately surrounds the cathode in a gas-discharge tube when operating at moderately low pressures, and which increases in extent as the pressure is further reduced.

cathode rays. An emission from the cathode of a discharge tube, consisting of electrons supplied by the cathode itself and projected at right angles to its surface. The term is usually restricted to the emission from a cold cathode in a gas-filled tube at high potentials and does not include thermions or photoelectrons.

cathodic disintegration. The abrasion of a cathode through the ejection of its atoms in its bombardment by positive ions in a vacuum tube. *Cf. sputter.*

cathodoluminescence. Luminescence excited by cathode rays.

cathodophosphorescence. Phosphorescence excited by cathode rays. *Cf. cathodoluminescence.*

cathodothermoluminescence. Thermoluminescence resulting from some change, other than a rise in temperature, produced in a sub-

stance by exposure to cathode rays.

catholyte, katholyte. The solution surrounding the cathode in an electrolytic cell. *Cf. anolyte.*

cation, kation. One of the positive ions moving toward the cathode in an electrolytic cell or a gas-discharge tube. *Cf. anion.*

Cauchy dispersion formula. An approximate empirical formula for the refractive index n as a function of the wave length, λ:

$$n = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \cdots,$$

in which A, B, C, . . . are constants depending upon the refracting medium. *Cf. Sellmeier dispersion formula.*

causality, causation. The doctrine that there necessarily exists an actual cause-and-effect connection between related phenomena, such that the same conditions must always bring about the same results. Syn. *determinism.*

caustic. A surface which envelops an astigmatic bundle of rays or of normals to the wave surface; as of light reflected from a curved mirror. In a turbid medium it becomes visible as a hollow, luminous cusp. *Cf. catacaustic, diacaustic.*

Cavendish experiment. The measurement of the gravitation constant by means of a torsion balance, originally carried out by Cavendish.

cavitation. The formation of a partial vacuum in a liquid, due to the separation of its parts in the process of flow; or the separation of gases from the liquid, with the formation of gas-filled spaces or bubbles. (See Gibson, Hydraulics and Its Applications, 1925, p. 590.)

cavity radiation. Syn. *black-body radiation.*

Celsius scale. The original of the centigrade scale, but inverted, *i.e.*, with freezing point at 100° and boiling point at 0°.

cent. A musical interval, or ratio between frequencies, whose value is the 1200th root of 2. It follows that the interval between any two successive notes of the equally tempered scale is the 100th power of the cent (expressed as 100 cents). (See Acous. Soc. Comm. Rep., 1934.)

center of acceleration. A point in a plane body, moving in its plane, at which the acceleration is momentarily zero. (See Brand, Vectorial Mech., 1930, p. 266.)

center of area. *In re* a plane figure: that point which corresponds to the center of mass of an infinitely thin, uniform plate whose boundaries coincide with those of the plane figure.

center of buoyancy. Syn. *center of displacement.*

center of collineation. That point through which pass all straight lines joining conjugate points of a spherical refracting surface or of a thin lens. For the former it is the center of curvature and for the latter, the optical center.

center of displacement. *In re* a body submerged or partially submerged in a fluid: that point which coincides with the center of mass of the body of fluid thereby displaced. Syn. *center of buoyancy.*

center of figure, c. of volume. *In re* any three-dimensional space figure: that point which coincides with the center of mass of a body formed by constructing the figure out of homogeneous material.

center of gravity. The c.m. of a centrobaric body. *Center of gravity* and *center of mass* have come to be synonymous in common usage; but in a nonuniform gravitational field a *center of gravity*, in its true sense, exists only for centrobaric bodies.

center of inertia. Syn. *center of mass.*

center of mass. *In re* any body or system of bodies: a point such that if any plane be passed through it, the mass moments (*cf. moment* (2)), with respect to it, of the portions on opposite sides of the plane are equal. Syn. *center of inertia, centroid. Cf. center of gravity.*

center of oscillation. One of two conjugate points of a gravity pendulum, of which the other is the center of suspension. *Cf. Huygens pendulum law.*

center of percussion. One of two conjugate points of a free body acted upon by an impulse, the other of which lies on the axis of instantaneous rotation.

center of pressure. *In re* a surface exposed to pressure, *e.g.*, when immersed in a fluid: the point of application of the single resultant force to which the effect of the pressure is equivalent.

center of suspension. One of two conjugate points of a gravity pendulum, of which the other is the center of oscillation. *Cf. Huygens pendulum law.*

centimeter. 1. One $\frac{1}{100}$ of a meter. 2. The c.g.s. electrostatic unit of capacitance. It is the capacitance of an isolated spherical conductor of radius 1 cm; equal to about

$$1.113 \times 10^{-12} \text{ f.}$$

3. Syn. *abhenry.* 4. A *centimeter of mercury* is a unit of pressure equal to about 1333.2 bars.

central orbit. An orbit traversed by a body under the influence of a force directed toward a fixed center.

centrifugal force. The kinetic reaction exerted by a body constrained to move in a curved path, and due to inertia.

centrifugal moment, c. torque. 1. The integrated torque of the centrifugal forces of all the particles of a freely rotating body with respect to any line through its center of mass perpendicular to the axis of rotation. 2. In general, the torque of a centrifugal force with respect to any given line.

centripetal force. The force which constrains a moving body to follow a curved path rather than a straight line; the equilibrant of the centrifugal force.

centrobaric. Having a true center of gravity. A rigid body is centrobaric if the resultant gravitational attraction of an external particle for it is equivalent to a single force which always passes through one point fixed relatively to the body (its center of mass), irrespective of its orientation and position. *E.g.*, a homogeneous sphere or spherical shell is centrobaric, but bodies in general are not. Syn. *baricentric.*

centrode. The curve traced by the instantaneous center of a plane body as it moves in any manner in its own plane. (See Prescott, Mech. of Particles and Rigid Bodies, 1929, p. 110.)

centroid. Syn. *center of mass.*

centroid diagram. A diagrammatic scheme for the comparison of atomic electron energy levels in successive elements. (See White, Int. to Atomic Spectra, 1934, p. 350; Mack, Laporte, and Lang, *Phys. Rev.* 31(2), 748, 1928.)

c.g.s. system. The centimeter-gram-second system of physical units, *i.e.*, those based upon these fundamental units of length, mass, and time. *E.g.*, the erg is a c.g.s. unit of work.

Chadwick-Goldhaber effect. The dissociation of an atomic nucleus by the absorption of gamma rays. (See Chadwick and Goldhaber, *Nature* 134, 237, 1934.)

channeled spectrum. A spectrum containing interference bands, produced by light which has been reflected from two parallel surfaces, such as those of a thin glass plate. (See Williams, *Phys. Rev.* 18(1), 280, 1904 and 27(1), 27, 1908; Gamble and Pfund, *J.O.S.A.* 23, 416, 1933.)

characteristic conductivity. *In re* a photoelectric cell: the value of

$$\frac{di/dE}{i},$$

where E is the voltage on the cell and i is the current at constant illumination; expressed as the percentage increase in current per volt increase in impressed e.m.f. (See Campbell and Ritchie, Photoelectric Cells, 1930, p. 78.)

characteristic energy. 1. Syn. *eigenenergy.* 2. The term has also been used for *proper energy.*

characteristic equation. An equation connecting the variables used to define the physical state of a body, such as volume, pressure, and temperature, *e.g.*, the van der Waals equation, with constants characteristic of the gas.

characteristic frequency. Syn. *atomic frequency.*

characteristic function. 1. (Opt.) The optical length of a ray in an optical instrument, expressed as a function of the co-ordinates of its end points. 2. Syn. *eigenfunction.*

characteristic number, c. value. Syn. *eigenvalue.*

characteristic surface. The (three-dimensional) graph of a characteristic equation.

characteristic temperature. *Cf. Debye characteristic temperature.*

charge-mass ratio. The ratio of the electric charge carried by an electrified particle or ion to the mass of the particle. Syn. *specific charge.*

Charles law. States that the coefficients of expansion of all perfect gases are equal, their common value being such as to indicate that the volume varies in direct proportion to the absolute temperature. First discovered by Charles in 1787. Syn. *Gay Lussac law.*

Chattock gauge. A type of differential manometer, utilizing the difference in pressure of two columns of liquid of nearly equal density. (See Bond, Int. to Fluid Motion, 1925, p. 34.)

chemical equivalent. The atomic weight of an element, or the radicular weight of an ion, divided by its valence.

chemiluminescence, chemicoluminescence. Luminescence produced by chemical action, *e.g.*, the emission of light due to the slow oxidation of phosphorus at ordinary temperatures.

Chladni plate. A metal plate of regular form, which, when set into vibration by means of a violin bow or otherwise, exhibits nodal lines in various symmetrical patterns.

choke coil. A coil of low resistance and comparatively small reactance, usually coreless, introduced in a circuit to retard transients.

Christiansen filter. A device consisting of a coarse powder of some homogeneous, isotropic, transparent solid between parallel glass plates, the interstices being filled with a liquid whose refractive index is equal to that of the powder for a certain wave length. This wave length only is then transmitted without deviation and can be brought to a focus by a lens. (See Christiansen, *Wied. Ann.* 23, 298, 1884 and 24, 439, 1885; Denmark and Cady, *J.O.S.A.* 25, 330, 1935.)

chromatic color. A color which exhibits hue.

chromatic scale. Syn. *equally tempered scale.*

chromaticity. A term qualitatively descriptive of a color and dependent upon both hue and saturation, but without reference to brilliance. (See Rep. Comm. on Colorimetry, *J.O.S.A.* 6, 527, 1922.)

chromel. An alloy of nickel and chromium, of high resistivity and high melting point; used for resistance coils.

chronograph. A mechanism for recording time signals on a revolving drum or moving tape; used for the precise measurement of time intervals. *Cf. chronoscope.*

chronoscope. 1. A type of chronograph which measures short intervals of time by comparison with the period of a tuning fork or similar vibrator. 2. Any short-interval timer, as a stop watch.

circle of least confusion. The small, round spot which, on account of aberration effects, constitutes the smallest image of a point source which can be formed by an uncorrected lens.

circuit. 1. (*Electric.*) A conductor, or group of conductors, so arranged and connected or coupled as to be capable of conducting an electric current or system of currents when supplied with suitable e.m.f.'s. 2. (*Magnetic.*) A closed tube or multiply connected region, the surface of which is everywhere tangential to the magnetic induction; or a series of bodies approximately filling such a region. The field magnet and armature core of a motor form a typical magnetic circuit. *Cf. Bosanquet law.*

circuit driver. A source of h.-f. e.m.f., esp. of the vacuum-tube-controlled type, for experimental use. Syn. *radio-frequency generator.* (See Brown, Radio Frequency Elec. Meas., 1931, p. 355.)

circuital. *In re* a vector point function: having a circuitation not equal to zero; not lamellar. Syn. *rotational.*

circuitation. The line integral of a vector point function taken around a closed path. (See A.I.E.E. Comm. Rep., 1932.)

circular mil. A unit of area, used in expressing the cross sections of wires, and equal to the area of a circle 0.001 in. in diameter.

circular polarization. Polarization in which the cycle is a circle. *Cf. polarization cycle.*

circulation. 1. *In re* any closed path within a fluid: the line integral of the tangential component of the velocity of the fluid taken around the closed path. (See Page, Int. to Theoretical Phys., 1928, p. 201.) 2. Syn. *circuitation.* (See A.I.E.E. Comm. Rep., 1932.)

Clairaut-Helmert formula. A formula for the variation of gravity with latitude λ:

$$g = 978.00(1 + 0.005310 \sin^2 \lambda).$$

(See Newman and Searle, Gen. Properties of Matter, 1929, p. 50.)

Clapeyron equation. A formula expressing the latent heat H of a vapor with the increase in volume during vaporization, in work units, thus:

$$H = T\frac{\partial p}{\partial T}(v - v_0);$$

$v - v_0$ is the increase of volume, p and T are pressure and temperature. Also called the *Clausius-Clapeyron equation.* (See Tamman and Mehl, States of Aggregation, 1925, p. 9.)

Clark cell. A standard cell for measurements of e.m.f., having positive and negative electrodes of mercury and zinc amalgam, respectively, with zinc sulphate as the electrolyte. The *Carhart-Clark cell* is a modification of the Clark cell, having a lower temperature coefficient.

classical. In accordance with long accepted theory; esp., the dynamics of Newton, as opposed to the more recent relativistic, quantum, or wave theories.

classical statistics. A system of statistical analysis of the distribution of gas molecules or of radiation quanta and their momenta, based upon the number of these respective entities in any given elementary compartment of ordinary space or of momentum space. *Cf. Bose-Einstein statistics, Fermi-Dirac s.* (See Darrow, *Rev. Mod. Phys.* 1, 90, 1929.)

Clausius-Clapeyron equation. *Cf. Clapeyron equation.*

Clausius equation. 1. A differential equation connecting the specific heat at constant pressure, C_p, of a fluid body, with its volume v:

$$\left(\frac{\partial C_p}{\partial p}\right)_\Theta = -\Theta\left(\frac{\partial^2 v}{\partial \Theta^2}\right)_p,$$

in which p is the pressure and Θ the (Kelvin) absolute temperature. (See Goodenough, Prin. of Thermodynamics, 1920, p. 103.) An analogous and equally important relation is

$$\left(\frac{\partial C_v}{\partial v}\right)_\Theta = \Theta\left(\frac{\partial^2 p}{\partial \Theta^2}\right)_v.$$

2. An equation relating to equilibrium between a liquid and its saturated vapor:

$$s' - s = \Theta\frac{d}{d\Theta}\left(\frac{H}{\Theta}\right),$$

in which s and s' are the specific heats of liquid and vapor, respectively, and H is the heat of vaporization. 3. An empirical,

characteristic gas equation, of the form

$$\left[p + \frac{a}{T(v + c)^2}\right](v - b) = RT,$$

which has been found to represent the behavior of some gases somewhat better than either the Boyle or the van der Waals equation. (See Jeans, Dynamic Theory of Gases, 1916, p. 166.)

Clausius-Mosotti law. A relation between the density ρ and the dielectric constant κ of a given dielectric:

$$\frac{\kappa - 1}{(\kappa + 2)\rho} = \text{constant}.$$

It is closely connected with the polarizability, and is allied to the Lorenz-Lorentz relation. (See Loeb, Kinetic Theory of Gases, 1927, p. 398; Keyes and Kirkwood, *Phys. Rev.* 36, 754, 1930.)

cleanup. The gradual disappearance of gases from a discharge tube during its operation. *Cf. getter.*

cleavage. The tendency of a crystalline substance to split along definite planes, called *cleavage planes*, which correspond to the layers of atoms making up the crystalline structure.

cloud chamber. A closed space containing saturated water vapor which, upon sudden expansion, reveals the presence of condensation nuclei by the visible droplets formed upon them; or in which rapidly moving particles are revealed by the streaks of droplets, or *tracks*. Syn. *expansion chamber, fog c. Cf. Wilson c.*

cloud track. A row or streak of droplets formed in a cloud chamber by the passage through it of an ionizing particle, whose path is thus revealed. *Cf. Wilson chamber.*

cluster. A group of atoms held together by the electric attraction of a charged ion, but not in permanent chemical union. (See Loeb, Kinetic Theory of Gases, 1927, p. 452.)

coaggregation. The union of fog particles into drops of appreciable size, as in the formation of rain in a cloud.

Coehn law. States that in the phenomenon of electric osmosis between dielectrics, the substance having the greater dielectric constant becomes charged to a potential higher than that of the other by an amount proportional to the difference in their dielectric constants. (See Richards, *Phys. Rev.* 22(2), 122, 1923.)

coercimeter. An instrument for measuring the coercive force of magnetic materials. (See Potter and Coleman, *R.S.I.* 7, 499, 1936.)

coercive force. The magnetic intensity required to reduce the magnetic induction in a previously magnetized material to zero. If the material has been magnetized to saturation this quantity is called the *coercivity.*

coercivity. *Cf. coercive force.*

coherence. A relation between two wave trains, such that when brought into coincidence they are capable of producing interference phenomena. The maximum path difference for which interference persists is the *coherence length.*

coherer. A cell containing a granular conductor between two elec-

trodes, which becomes highly conducting only when subjected to an electric field; formerly used as a detector.

cohesion. That property of a substance which enables it to cling together in opposition to forces tending to separate it into parts. *Cf. adhesion.*

coincidence method. A method of timing a periodic phenomenon by observing coincidences between the occurrences of the phenomenon in question and those of one whose period is known, *e.g.*, the vibration of a pendulum.

cold emission. Syn. *field emission.*

collector. 1. An exploring electrode or probe, esp. in a vacuum tube. 2. Syn. *Faraday cylinder.* 3. An apparatus for measuring the vertical potential gradient of the atmosphere. (See *U. S. Weather Bureau Circular* M.)

collimator. An optical apparatus, the purpose of which is to furnish a beam of parallel rays of light. A common form consists of a lens, having a small opening or slit at its principal focus.

collision. An encounter between atoms, molecules, ions, electrons, etc., in which some mutual influence is exerted, generally with an exchange of energy. In a *collision of the first kind* one particle *A* loses kinetic energy while the other, *B*, gains kinetic, excitation, or ionization energy. In a *collision of the second kind*, a particle *A*, excited or ionized, loses excitation or ionization, instead of kinetic, energy, *B* being energized as in the first case. (See Duffendack and Thomson, *Phys. Rev.* 43, 106, 1933.) *Cf. elastic collision.*

collision damping. An effect upon the amplitude or phase of the radiation from an atom due to collision with other atoms, which results in one type of broadening of the spectrum lines. (See White, Int. to Atomic Spectra, 1934, p. 427.)

collision probability. *In re* collisions of electrons with the atoms of a gas: the number of collisions per unit electron current, per unit path length, per unit pressure at 0°C. (See Brode, *Rev. Mod. Phys.* 5, 257, 1933.)

colloid. A substance in the colloidal state. Typical colloids are smoke, gelatine solution, starch solution, albumen, and very finely divided gold in suspension.

colloidal solution. A mixture which contains ingredients in the colloidal state; in contradistinction to a true or "molecular" solution.

colloidal state. The finely divided state of matter dispersed in solids, liquids, or gases, the particles of which have diameters ranging approximately between 10^{-7} cm and 10^{-5} cm. In liquids or gases the particles remain suspended indefinitely but do not pass through very fine filters.

color. A term used *in re* those attributes of visual sensation which do not depend upon shape, size, or other spatial characteristics of the image. Thus if two uniform circular disks of equal size and at equal distances do not look alike, that fact is due to a difference in one or more of the

three attributes of color, namely, hue, saturation, and brilliance.

color temperature. *In re* a source of radiation: the temperature of a black body in color match with it. A definite color temperature can be assigned only to radiators whose energy distribution does not differ greatly from that of a black body. *Cf. Planckian color.* (See Davis, *B.S.J.R.* 7, 660, 1931.)

colorimetry. The measurement of color. Such a measurement may be made directly in terms of the three attributes of color, *viz.*, hue, saturation, and brilliance; or directly in terms of the physical characteristics of the stimulus, such as spectral energy distribution, intensity, modal wave length, spectral purity, etc.

columnar ionization. 1. A term used *in re* the properties of ionized gases in tubes or columns as differing from those of gases uniformly ionized throughout. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 1, p. 28.) 2. Also frequently applied to the ionization of gases by alpha particles. (See Jaffe, *Ann. d. Phys.* 42, 303, 1913; *Phys. Zeits.* 30, 849, 1929.)

coma. One of the types of spherical aberration, due to the asymmetry of a bundle of rays of finite aperture.

combination defect. A discrepancy arising from the application of the combination principle to certain molecular spectra, and explained on the assumption that the initial or the final rotational energy levels are close doubles. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 419; Mulliken, *Phys. Rev.* 30(2), 785, 1927.)

combination line. An atomic spectral line produced by a transition between two multiplet energy levels. *Cf. intercombination line.* (See White, Int. to Atomic Spectra, 1934, p. 175.)

combination principle. An expression of the fact that the existence of spectral lines can be predicted by calculating the quantum energy, and hence the frequency, resulting from the transition of an electron from one stable state to another. First stated in an empirical form by Ritz. *Cf. Ritz principle.* (See Gibbs, *Rev. Mod. Phys.* 4, 278, 1932.)

combination series. A series of spectral lines formed in accordance with the combination principle of Ritz. (See White, Int. to Atomic Spectra, 1934, p. 15.)

combination tone. A subjective tone produced by the simultaneous sounding of two or more physical tones. *Cf. beat tone, difference t., summation t.* (See Richardson, Sound, 1929, p. 61.)

combining equivalent. Of a chemical element: its atomic weight divided by its valence. *E.g.*, the *combining equivalent* of magnesium is $24.32 \div 2 = 12.16$. In the case of a radical the radicular weight is divided by the valence; *e.g.*, for SO_4, the *combining equivalent* is $96.06 \div 2 = 48.03$.

commutator. Any device for reversing the direction of an electric current or for interchanging the connections to a circuit.

comparator. An instrument for the accurate measurement of moderate

distances, usually consisting of a telescope or a microscope arranged to move laterally along a scale.

compensation theorem. States that if the impedance Z_B of any branch B of a network, in which the current is I_B, is altered by an amount ΔZ_B, the resulting change ΔI in the current I at any point of the network is equal to the current which would be produced at that point by a counter e.m.f. $-I_B \Delta Z_B$ introduced into the branch B. (See Shea, Transmission Networks and Wave Filters, 1930, p. 56.)

compensator. An apparatus, the original form of which was designed by Babinet, for the measurement of the phase difference between the two components of elliptically polarized light. *Cf. Soleil plate.*

complementary acceleration. An acceleration which must be vectorially added to the sum of the acceleration of a moving particle with respect to a body of reference and the absolute acceleration of the body of reference, to give the absolute acceleration of the particle. It is equal to twice the vector product of the angular velocity of the body of reference and the linear velocity of the particle with respect to it (theorem of Coriolis). Syn. *Coriolis acceleration.* (See Brand, Vectorial Mech., 1930, p. 286; Deimel, Mech. of the Gyroscope, 1929, p. 7.)

complementary colors. Two colors which, when mixed additively in proper proportions, produce the sensation of white.

complex ion. The result of the combination of a positive ion with an uncharged molecule. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 1, p. 61.)

complex spectrum. A spectrum containing multiplet lines. (See Slater, *Phys. Rev.* 34(2), 1293, 1929; Condon, *Phys. Rev.* 36, 1121, 1930 and 37, 1025, 1931.)

complexion. Any specified set of values of the co-ordinates and momenta for the molecules or other particles composing a system, treated as a distribution of the particles among the phase-space elements. (See Page, Int. to Theoretical Phys., 1928, p. 280.)

compound-wound. *In re* the field magnet of a motor or a generator: having its windings partly in series and partly in parallel with the external or line circuit. *Cf. series-wound, shunt-wound.*

compressibility. The reciprocal of the bulk modulus. Also called *compressibility coefficient.* (See I.C.T., 1926, v. 1, p. 35.)

Compton effect. A phenomenon of the scattering of x-rays or gamma rays by the electrons in matter, in which the scattered radiation is characterized by a systematically smaller frequency and quantum value with increasing deviation from the original direction. A spectrum line whose frequency is thus altered is called a *modified line,* while that part of the radiation of any frequency which is scattered without change of frequency gives rise to an *unmodified line* of the *Compton spectrum.* (See Compton, *Phys. Rev.* 21(2), 483, 1923; Ruark and Urey,

Atoms, Molecules, and Quanta, 1930, p. 84.)

Compton electron. An electron having momentum due to the impact of a high-energy radiation quantum. Syn. *recoil electron. Cf. Compton effect.* (See Richardson and Kurie, *Phys. Rev.* 50, 999, 1936.)

Compton equation. An expression for the Compton shift, *viz.*,

$$\Delta\lambda = \frac{h}{mc}(1 - \cos\theta),$$

in which θ is the scattering angle, m the electronic mass, h the Planck constant, and c the electromagnetic constant. (See Compton, *Phys. Rev.* 22(2), 409, 1923; Ross and Kirkpatrick, *Phys. Rev.* 45, 223, 1934.)

Compton shift, C. wave length. The change in wave length of an x-ray quantum upon scattering by impact with an electron. *Cf. Compton effect, C. equation.*

concave grating. An optical grating ruled on a concave, spherical, reflecting surface, which not only acts as a grating, but serves also to focus the image of the slit without the use of lenses. Such gratings were first constructed by Rowland.

concavo-convex. Having two curved surfaces, of which one, the concave, has greater curvature than the other, which is convex; applied esp. to lenses. Syn. *concave-meniscus.*

concentration cell. An electrolytic cell whose e.m.f. is due to a difference in concentration between different parts of the electrolyte.

condensation coefficient. The ratio of the total volume of the molecules of a gas to the volume of the gas; a term due to Loschmidt. (See Graetz, Recent Developments in Atomic Theory, 1923, p. 14.)

condensation pump. Any air pump acting on the principle which uses the impact of a stream of vapor to compress a gas to such a pressure that a fore pump can take hold, the vapor being removed from the compression space by condensation.

condenser. 1. An apparatus for changing a vapor into the liquid state. 2. A device consisting of two electrical conductors, usually in the form of metal plates, separated by a small thickness of dielectric, which has the effect of largely increasing the capacitance of each conductor. 3. A system of strongly converging lenses used to concentrate the light on the object or slide in a projector.

conditioned observation. An observation upon a quantity or upon quantities subject to rigorous theoretical conditions. *Cf. equation of condition.*

conductance. 1. The reciprocal of electric resistance. 2. Knudsen uses the term in an analogous manner as applying to the case of flow of rarefied gases in tubes.

conductance dispersion. A variation of the equivalent conductance of an electrolyte for an a.c. of varying frequency. (See Newman, Electrolytic Conduction, 1931, p. 368.)

conductimeter. An apparatus for measuring the electrical conductivities of substances, esp. of liquids.

conduction electron. One of the electrons, supposedly from the outer levels of the atoms, which are concerned with the electrical conduction in a metal. The energy levels in which these electrons are found are called *conduction levels.* (See Skinner, *Phys. Rev.* 45, 370, 1934.)

conductivity. 1. (*Thermal.*) The facility with which heat flows through a conductor, as measured by the quantity of heat transmitted per unit time, per unit temperature gradient along the direction of flow, per unit cross-sectional area. 2. (*Electric.*) The facility with which a substance conducts electricity, as measured by the current density per unit potential gradient in the direction of flow. It is the reciprocal of the resistivity. Syn. *specific conductance.* (See I.C.T., 1926, v. 1, p. 35.)

cone of friction. A conical surface, within which always lies the line of the resultant of the friction between two surfaces and the normal force pressing them together. Its half-angle is the *angle of friction.* (See Prescott, Mech. of Particles and Rigid Bodies, 1929, p. 104.)

cone of rupture. A double conical surface along which a solid cylinder, when subjected to severe longitudinal compression, tends to crack and slip. *Cf. slip surface.* (See Nádai, Plasticity, 1931, p. 113.)

configuration interaction. The perturbing effect of one arrangement of electrons in the atom (as represented by the assigned quantum numbers) upon another such arrangement, so that the energy levels and spectral terms corresponding to the two arrangements are altered with respect to their values when no such interaction exists. (See Condon, *Phys. Rev.* 36, 121, 1930; Ufford, *Phys. Rev.* 40, 974, 1932.)

conical refraction. The transformation of a ray of light into a hollow cone by refraction, at a suitable angle of incidence, in a biaxial crystal. (See Edser, Light, 1928, p. 540.)

conjugate branches. Two branches of an electric network, so related that an e.m.f. in one produces no current in the other. *Cf. balanced* (2). (See A.I.E.E. Comm. Rep., 1932.)

conjugate points. 1. (Opt.) Two points of an optical system such that each is the image of the other. 2. (Dyn.) Two points of a rigid body, on opposite sides of the c.m. and in line with it, such that if the body, when free, is given an impulse in a transverse line through either point, it begins to rotate about an axis through the other. *Cf. center of percussion, axis of instantaneous rotation, Huygens pendulum law.*

consequent pole. A magnetic pole in excess of the usual two on a magnetized body.

conservation. The preservation of a constant amount, as of mass, of momentum, or of energy.

conservation of areas. A general principle of kinematics, illustrated by Kepler's second law of planetary motion (*cf. Kepler laws*). (See Silberstein, Vectorial Mech., 1913, p. 66.)

conservative field. A field of force such that, if a particle moves from one point to another within the field, the work done depends only upon its initial and its final position, and not upon the path which it follows. (See Brand, Vectorial Mech., 1930, p. 369.)

conservative system. A system of bodies acted upon only by forces within the system, so that the total dynamical energy of the system remains constant.

consistency. 1. The approximate agreement between results of measurements on the same quantity. *External consistency* refers to the agreement between final adjusted results obtained by different observers or different methods; *internal consistency*, to that between results of repeated single measurements of the same series. (See Birge, *Phys. Rev.* 40, 207, 1932). 2. That quality of a material which depends upon its viscosity, plasticity, viscidity, etc.

consolute. Miscible or mutually soluble in all proportions. *Cf. critical solution temperature.*

constant-deviation prism. A triangular prism so designed that the deviation of a ray of light entering it by one face and leaving it by another after internal reflection at the third face is always equal to the angle between the two refracting faces. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 584.)

constantan. An alloy of 60 per cent Cu and 40 per cent Ni, used for resistance coils because of its very low temperature coefficient of resistance. *Cf. manganin.* (See *Bureau of Standards Circular* 100.)

constrain. To limit to a predetermined position or path. A body has *constrained motion* when restricted by material barriers to move in a given line, *e.g.*, a railroad train along its track.

contact potential difference. A difference of electric potential which develops between two dissimilar conductors when they are placed in contact; first observed by Volta. Syn. *Volta effect. Cf. Volta law, intrinsic contact p.d.*

continuous spectrum. A spectrum which exhibits no structure and appears to represent a continuous variation of wave length from one end to the other, *e.g.*, the spectrum of an incandescent solid.

contour. 1. The geometrical form of a surface, esp. as indicated by its plane sections. 2. The wave-length-intensity curve for a particular line or band of the spectrum.

contraction coefficient. *Cf. vena contracta.*

convection. Circulation in a fluid of nonuniform temperature, due to differences of density.

convergence. 1. A negative divergence; *e.g.*, for the gravitational field within a material substance of density ρ it is $-4\pi\rho$. 2. The increasing density of spacing of the lines in a spectral series as the series limit is approached with decreasing wave length. 3. (Math.) The property of converging, as an algebraic series.

convergence factor. The coefficient B in the square term of the quadratic function:

$$\nu = \nu_0 + AN + BN^2,$$

representing the frequency of the spectral line of ordinal number N

in a rotation-vibration spectral band. ν_0 is the frequency corresponding to the zero line.

conversion coefficient. An abstract fraction which represents the probability that a gamma-ray quantum, emitted from the nucleus of a radioactive atom, will give up its energy in releasing an electron from one of the outer levels. The *K conversion coefficient* is the probability that the release will take place at the *K* level, etc. (See Ellis and Aston, *Proc. Roy. Soc.* 129, 180, 1930.)

conversion factor. A number by which the numerical value of a physical quantity as expressed in one set of units must be multiplied in order to obtain its numerical value as expressed in another similar set of units of different size. Syn. *change ratio.*

converter. One of several types of machine consisting of an electric generator driven by an electric motor, with the purpose of changing the service in some respect; as from a.-c. to d.-c. (motor generator or rotary converter), to a different frequency (frequency converter), to a different number of phases (phase converter), etc. (See A.I.E.E. Comm. Rep., 1932.)

convexo-concave. Having two curved surfaces, of which one, the convex, has greater curvature than the other, which is concave; applied esp. to lenses. Syn. *convex-meniscus.*

Coolidge tube. A type of x-ray tube, the distinctive feature of which is a cathode containing a hot filament to furnish cathode-ray electrons by thermionic emission. *Cf. Lenard tube.*

co-ordinate. 1. One of the quantities specified in defining the position of a point or the value of a point function. 2. In general, one of a set of variables used to express the condition or the behavior of a physical system, as pressure, volume, temperature, entropy, time, etc. In this broader sense they are often termed *generalized co-ordinates.* (See Page, Int. to Theoretical Phys., 1928, p. 169.)

co-ordination lattice. A crystal lattice in which each ion bears the same relation to the adjacent ions in all three co-ordinate directions, so that the identity of the molecule becomes ambiguous.

co-ordination rule. Describes the process whereby the magnetic sublevels of a multiplet (spectral line) in weak fields are co-ordinated with the magnetic levels of the component vectors in strong fields. As the field changes, the co-ordinated levels merge. Similar rules exist also for other types of coupling. (See Breit, *Phys. Rev.* 28(2), 334, 1926.)

Corbino effect. A form of the Hall effect in which, when a current is sent from center to circumference of a metal disk through a magnetic field normal to the disk, there is also a current flowing circumferentially. Discovered by Corbino in 1911. (See Campbell, Galvanomagnetic and Thermomagnetic Effects 1923, p. 125.)

core. 1. A mass of iron or other ferromagnetic material placed within a coil to enhance the magnetic flux, as in an electromagnet. 2. The inner metal base

or heating element of a thermionic filament, which is covered with a thermionically active coating, usually of barium and strontium oxide. 3. The inner portion of a nonhomogeneous carbon-arc electrode. 4. The inner, intensely brilliant portion of the arc itself. *Cf. aureole.* (See Darrow, *J.O.S.A.* 10, 474, 1925.) 5. Syn. *Rumpf, kernel* (2).

core loss. Loss of power through magnetic hysteresis or eddy currents.

Coriolis force. The force corresponding to the complementary acceleration to which the Coriolis theorem refers. (See Haas, Int. to Theoretical Phys., 1925, v. 1, p. 45.)

Coriolis theorem. *Cf. complementary acceleration.*

Cornu prism. A 60-deg quartz prism divided into halves, of right- and left-handed quartz, respectively, in order to neutralize the effect of optical rotation. (See Wood, Phys. Optics, 1929, p. 480; Forsythe and Barnes, *R.S.I.* 1, 569, 1930.)

cornu spiral. The limiting curve approached by a succession of vector lines whose lengths and directions represent, respectively, the amplitudes and phases of the light vibrations reaching any point from successively more remote areas of a wave front. (See Preston, Theory of Light, 5th ed., p. 297; Robertson, Int. to Phys. Optics, 1929, pp. 221 ff.)

corona. 1. The result of a partial electric breakdown in a gas, such as a brush discharge or a glow discharge. 2. A spectral ring sometimes observed surrounding the sun or the moon; caused by the diffraction of light by suspended matter in the air. Not to be confused with *halo.* 3. (Astron.) An extended, luminous, gaseous envelope which constitutes the outermost portion of the sun.

corona voltmeter. An apparatus for the measurement of high peak voltages by the formation of a corona. (See Whitehead and Isshiki, *Trans. A.I.E.E.* 40, 1201, 1921; Brooks and Defandorf, *B.S.J.R.* 1, 589, 1928.)

correction factor. A constant coefficient, multiplication by which renders a functional expression approximately the correct representation of a variable, whereas before it was only proportional to the variable.

correlation. A quantitative relationship between two variables which, while suggesting some connection between them, is not established with sufficient definiteness to take on a clear-cut functional character. An abstract number measuring the closeness of such a connection is called a *correlation coefficient.* (See Rietz, Math. Statistics, 1927, pp. 77 ff.)

correspondence principle. A relation assumed, in Bohr's radiation theory, to exist between the observed intensities and frequencies of a molecular or atomic spectrum and the radiations which would be emitted by an oscillator in accordance with classical theory. (See Tolman, Statistical Mech., 1926, p. 91; Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 171.)

corresponding states. *Cf. law of corresponding states.*

cosine emission law. States that the rate of emission or diffuse reflection of radiant energy in a given direction from any element of area of a perfectly diffusing surface is proportional to the cosine of the angle of emission, measured between the emitted ray and the normal to the surface; a condition which holds rigorously only for a black body. Syn. *Lambert law.*

cosine photometer. A photometer in which the illumination of one surface to be compared is varied, in accordance with the cosine emission law, by varying its orientation. (See Walsh, Photometry, 1926, p. 182.)

cosmic radiation, c. rays. A type of very penetrating radiation of unknown origin, apparently traversing interplanetary space in all directions, and detected by the ionization which it produces in electroscopes, ion counters, etc.

Cotton balance. An apparatus for measuring magnetic intensity. A horizontal wire carrying a known current is suspended, at right angles to the horizontal field, from one arm of a balance, and the resulting vertical force on the wire thus measured. (See Cotton and Dupouy, *Congrès international d'électricité* 3(2E), 208, 1932; Scott, *Phys. Rev.* 46, 633, 1934.)

Cotton-Mouton effect. The acquisition of double refraction by some pure liquids when subjected to a magnetic field whose direction is transverse to the beam of light, a magneto-optical effect investigated by Cotton and Mouton in 1905. Syn. *magnetic double refraction. Cf. Cotton-Mouton law, Kerr effect* (1). (See Skinner, *Phys. Rev.* 29(1), 541, 1909; Beams, *Rev. Mod. Phys.* 4, 160, 1932.)

Cotton-Mouton law. (*Cf. Cotton-Mouton effect.*) If n_p and n_s are the refractive indices for light polarized in planes parallel and perpendicular, respectively, to the magnetic intensity H, then

$$n_p - n_s = C\lambda H^2.$$

Here C is constant for any fixed temperature and any fixed (air) wave length λ; it is called the *Cotton-Mouton constant* for the given substance, wave length, and temperature, and may be + or −. (See Beams, *Rev. Mod. Phys.* 4, 133, 1932.)

coulomb. The practical unit of quantity of electricity. The *absolute coulomb* is one-tenth of the abcoulomb. The *international coulomb* is the international ampere-second, *i.e.*, that quantity of electricity whose transfer accompanies the electrolytic deposit of 0.001118 g of silver from a solution of silver nitrate. The ratio of the international to the absolute coulomb is about 0.99995, and either is approximately equal to 3×10^9 e.s.u. charge. (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

Coulomb field. An electric field due to a charge acting as if concentrated at a point, so that the field intensity is inversely proportional to the square of the radial distance from that point.

Coulomb law. A law which expresses the attraction or repulsion between two electric charges or two magnetic poles as proportional to the product of the charges or pole strengths and

inversely proportional to the square of the distance between them. (Coulomb also stated certain basic laws of friction.)

coulombmeter, coulometer. An instrument for the measurement of a quantity of electricity by the amount of electrodeposition produced from an electrolyte. Syn. *voltameter.*

counter electromotive force. An e.m.f. which affects a circuit in the direction opposite to that of the current; due to such influences as self-induction, electrolytic polarization, etc. Syn. *back electromotive force.*

counting tube. An ionization chamber used for counting electrons or other ionizing particles. *Cf. Geiger counter, Geiger-Müller counter, ion counter.*

couple. 1. (Dyn.) A system composed of, or equivalent to, two equal, antiparallel forces. 2. (Elec.) A pair of metals placed in contact, as a voltaic couple or a thermocouple. 3. (v.) *Cf. coupling.*

coupling. 1. A juxtaposition of two electric circuits, such that their mutual relationship permits variations of current in one circuit to affect the e.m.f. in the other. *Cf. coupling coefficient.* 2. An interaction between one of the electrons of an atom and other parts of the atomic electron system. 3. In general, any interaction between two or more systems.

coupling coefficient. 1. An abstract fraction relating to the closeness of coupling of two circuits A, B. If f_1 is the fraction of the inductance of A that is shared with B, and f_2 the fraction of the inductance of B that is shared with A, the *inductive coupling coefficient* is the mean proportional of f_1 and f_2. The *capacitative coupling coefficient* is defined in an analogous way. (See Page and Adams, Prin of Electricity, 1931, p. 502.) 2. In general, an abstract constant entering into the equations of motion of two coupled systems, and dependent upon the mutual effect of one upon the other. (See Richardson, Sound, 1929, p. 56.)

covibration. A resonant vibration, *i.e.*, a natural vibration of the same frequency as the stimulating or exciting impulses. *Cf. forced vibration.*

covolume. A term sometimes used to denote the volume of the space throughout which a gas is distributed, minus the volume of the molecules themselves. The factor $v - b$ in the van der Waals equation may be considered as representing this quantity.

critical angle. *Cf. total reflection.*

critical coefficient. The ratio of the critical temperature of a substance to its critical pressure. (See Couch, Dict. of Chem. Terms, 1920.)

critical concentration. The relative proportion in the mutual solution of two partially immiscible liquids in the vicinity of their interface when the critical solution temperature is reached, but before they become mutually diffused. (See Couch, Dict. of Chem. Terms, 1920.)

critical constants. *Cf. critical state.*

critical damping. The degree of damping which must be applied

to a body, displaced against a potential or an elastic force, in order just to prevent its oscillating upon returning to its neutral condition. For a condenser circuit, the critical damping corresponds to the relation $R^2 = 4L/C$, in which R, L, C are resistance, inductance, and capacitance, respectively.

critical frequency. 1. Syn. *threshold frequency.* 2. The frequency of an intermittent illumination which is just sufficient to prevent a sensation of flicker. (See Ives, *J.O.S.A.* 6, 254, 1922.)

critical potential. The p.d. in volts, corresponding to the energy in electron-volts, required either to excite or to ionize an atom or a molecule; *i.e.*, either the radiation potential or the ionizing potential of the atom or molecule. (See Compton and Mohler, Critical Potentials, 1924; Ruark and Urey, Atoms, Molecules, and Quanta, 1930, pp. 75 ff.)

critical range. The range of temperature between two transitions in a metal, as iron or steel, *e.g.*, between the recalescence points. (See Berliner, *B.B.S.* 19, 347, 1923.)

critical solution temperature. The temperature below which each of two liquids is only partially soluble in the other (*conjugate solution*), but above which they are consolute. Syn. *consolute temperature.* (See Couch, Dict. of Chem. Terms, 1920.)

critical speed. Syn. *parabolic velocity.* (See Brand, Vectorial Mech., 1930, p. 403.)

critical state. A condition of a substance such that the liquid and the vapor state are identical. For a pure substance, this occurs only at a particular temperature (the *critical temperature*) and pressure (the *critical pressure*). A substance above its critical temperature will not separate into two fluid phases, however great the pressure applied. For water the critical temperature is 374°C., the critical pressure, 217 atm, while the *critical density* is 0.329 g/cm^3. These are its *critical constants.*

critical temperature. *Cf. critical state.*

critical velocity of flow. The speed at which a smooth, streamline flow of a liquid or a gaseous substance breaks into a turbulent flow or eddy. *Cf. Reynolds laws.*

critical wave length. The wave length corresponding to the critical or threshold frequency in a quantum process brought about by radiation.

Crookes dark space. Syn. *cathode dark space.*

Crookes radiometer. An apparatus consisting of a set of vanes polished on one side, blackened on the other, and delicately pivoted to rotate by the inequality of gas pressure on opposite sides when exposed to radiation.

Crookes tube. One of various early forms of vacuum tube, used by Sir William Crookes in his studies of electrical discharge at low pressures.

Crova wave length. That wave length in the spectrum of a radiator at any given temperature T whose intensity i_λ varies at the same relative rate as does the

intensity I of the total radiation or of a specified portion of it; *i.e.*, the value of λ for which

$$\frac{di_\lambda/dT}{i_\lambda} = \frac{dI/dT}{I}.$$

(See Smiths. P. T., 1929, p. 261.)

cryogenic. Pertaining to low temperatures or to apparatus for producing them.

cryoscopic. Pertaining to the freezing points of liquids or to their determination.

cryostat. A thermostat for use at very low temperatures.

crystal analysis. The study of the arrangement of atoms, ions, or molecules in crystals, chiefly by x-ray methods, aided by the theory of space groups. *Cf. crystallography.*

crystal detector. A rectifier consisting of a conducting crystal, *e.g.*, of galena or silicon, against which presses a sharp steel point. The device has marked nonsymmetrical resistance.

crystal diamagnetism. Abnormal and anisotropic diamagnetism observed in crystals of a few substances, *e.g.*, bismuth. (See Goetz and Focke, *Phys. Rev.* 45, 170, 1934.)

crystal grating. A crystal suitably mounted to serve as a diffraction grating, *e.g.*, for x-rays.

crystal spectrograph. An instrument for photographing the spectrum formed by using a crystal, *e.g.*, calcite, as the diffracting system.

crystal system. A group which includes all crystals containing the same number and kind of planes of symmetry. There are six crystal systems: *isometric* or *cubical, tetragonal, orthorhombic, monoclinic, triclinic, hexagonal; q.v.*

crystallography. That branch of physical science which deals with the geometrical form of crystals. *Cf. crystal analysis.*

crystalloidal state. A condition of a substance, in liquid form, in which its largest particles, either single molecules or polymers, are too small to be caught on the finest filters. Substances in this state are known as *crystalloids. Cf. colloidal state.*

crystalloluminescence. The emission of light upon the precipitation of crystals from a solution.

cube photometer. An integrating photometer similar in principle to the sphere photometer but employing a cubical instead of a spherical cavity. (See Walsh, Photometry, 1926, p. 225.)

cubical. 1. (Cryst.) Syn. *isometric* (1). 2. Having reference to volume, esp. in *cubical expansion.*

cumulative method. A method of measurement in which a multiple of the unknown quantity is measured and the result divided by the multiplier; as in finding the period of a pendulum by timing 100 successive swings.

curie. A unit quantity of radium emanation or radon, defined as that quantity which is in equilibrium with 1 g Ra. Its volume at N.T.P. is about 0.63 mm^3.

Curie balance. A torsion balance used to measure the force on a nonferromagnetic body in a nonuniform magnetic field. Devised by P. Curie, 1895.

Curie constant. The product of the atomic or molar magnetic susceptibility of a paramagnetic substance obeying the Curie law by the absolute temperature.

Curie law. States that the magnetic susceptibility of a paramagnetic substance varies inversely as the absolute temperature. (P. Curie, 1895.) Not generally valid. *Cf. Curie constant, Curie-Weiss law.*

Curie point. The temperature chosen to characterize the change from ferromagnetic to paramagnetic behavior, when this does not correspond to an allotropic transformation. It may be interpreted graphically in terms of the temperature-magnetization curve or as a constant temperature in the Curie-Weiss law. Syn. *magnetic transformation temperature.*

Curie-Weiss law. States that the magnetic susceptibility of a paramagnetic substance varies inversely as the excess of its temperature above a certain fixed temperature characteristic of the substance, *viz.*, the *Curie point.* It is valid only for temperatures above this point. (P. Weiss, 1907.) *Cf. Curie law.*

curl. A vector differential operator, much used in physics, which, applied to a vector point function F, is denoted by the symbol $\nabla \times F$ and read "curl F" or "del cross F." If the three components of the vector F are iF_1, jF_2, kF_3, then the operator is defined by the determinant

$$\nabla \times F = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ F_1 & F_2 & F_3 \end{vmatrix}.$$

current density. The magnitude of a current per unit cross-sectional area; in the case of the electric current, it is commonly expressed in amperes per square centimeter.

current refraction. A change in the direction of an electric current at an interface between two conductors of different conductivity. (See Karapetoff, The Electric Circuit, 1912, p. 29.)

curve of buoyancy. *Cf. surface of buoyancy.*

cybotaxis. The space arrangement of molecules in a liquid, with orientation simulating crystalline structure but without stability or permanence at any point. Studied by the x-ray diffraction patterns of the liquid. Adj. *cybotactic. Cf. liquid crystal.* (See Davey, A Study of Crystal Structure and Its Applications, 1934, chap. 16; Stewart, *J. Chem. Phys.* 2, 147, 1934.)

cyclone. 1. A large area of atmospheric disturbance, characterized by a slow, spirally inward rotation of the air about a center of low pressure, counterclockwise in the northern hemisphere, and moving slowly in a northeasterly direction. 2. A tornado. (Colloq.)

cyclotron. An apparatus for imparting high speeds to electrons or ions by causing them to move in semicircular paths in a magnetic field, with an acceleration and increased radius every 180 deg due to an electric field alternating in synchronism with their motion. Syn. *magnetic resonance accelerator.* (See Lawrence and Livingston, *Phys. Rev.* 37, 1707, 1931; 38, 834, 1931; 40, 19, 1932; Livingston, *R.S.I.* 7, 55, 1936.)

D

(Please note purpose of references as explained in preface.)

d-electron. An orbital electron whose energy state is denoted by the azimuthal quantum number 2. *Cf. D-state.*

D lines. The two principal lines of the sodium spectrum, which form a doublet; distinguished as D_1 (5895.93 Å) and D_2 (5889.96 Å). *Cf. Fraunhofer lines.*

D-state, D-level. The state of an atom in which the azimuthal quantum number is 2. *Cf. S-, P-, F-states.*

d'Alembert principle. 1. States that all the forces acting upon parts of a system form, with the inertia reactions against acceleration, an equilibrating set of forces on the system as a whole. Newton's third law may thus be regarded as applying to cases in which there is acceleration, the reactions due to inertia functioning as opposing forces and setting up a condition of kinetic equilibrium. First explicitly stated by d'Alembert in 1742. (See Brand, Vectorial Mech., 1930, p. 409; Lamb, Dynamics, 1929, p. 151.) 2. The principle that any displacement of a particle subject to constraints is necessarily perpendicular to the resultant of the constraining reactions.

Dalton law. States that when several gases which have no chemical action upon each other are mixed in the same enclosure, the pressure of the mixture is equal to the sum of the pressures which the gases would separately exert if each in turn were confined in the same space; and further, the saturated vapor pressure of two or more liquids exposed separately in the same closed space, each in equilibrium with its liquid, is, within limits, equal to the sum of the separate vapor pressures. Based upon the experiments of Dalton (1802).

damping coefficient. 1. *In re* a train of damped oscillations: the logarithmic decrement divided by the period, or multiplied by the frequency. (See A.I.E.E. Comm. Rep., 1932.) 2. The force required, per unit speed, to propel a particle, an ion, an electron, etc., through a resisting medium. *Cf. Stokes law* (1). (See Newman and Searle, General Properties of Matter, 1929, p. 300.)

damping constant. A constant factor appearing in the exponent of the time function of an exponentially damped variable. *E.g.*, the current in an inductive circuit after the sudden removal of a steady e.m.f. is

$$i = i_0 e^{-\frac{Rt}{L}};$$

here the damping constant is R/L. *Cf. decay coefficient.* (See I.R.E. Comm. Rep., 1933.)

damping factor. The ratio of the amplitude of any one of a series of damped oscillations to that of the following one. Syn. *decrement.*

Darcy law. States that the velocity of flow of a fluid in a porous medium, due to inequality of pressure, is proportional to the pressure gradient. *Cf. permeability* (2).

dark conduction. Residual electrical conduction in a photosensitive substance when not illuminated.

dark discharge. An electrical discharge (in a gas) which has no visible luminosity. Syn. *dark current.*

d'Arsonval galvanometer. A form of d.-c. galvanometer, consisting of a narrow, rectangular coil freely suspended so as to turn between the poles of a fixed, permanent magnet.

Darwin-Ewald-Prins law. A somewhat complicated expression for the diffraction pattern formed by the reflection of x-rays from a crystal; developed independently but in essentially equivalent forms by Darwin and Ewald and subsequently modified by Prins. (See Compton and Allison, X-Rays in Theory and Experiment, 1935, pp. 365 ff.)

dasymeter. A thin glass bulb used in determining the density of gases by observing the buoyant force upon it, as a sinker is used with liquids.

Davisson-Germer experiment. An experiment in which was first observed the diffraction of a stream of electrons at the surface of a metallic crystal, thus providing evidence in support of the wave-mechanical theory of electrons. *Cf. de Broglie wave.* (See Davisson and Germer, *Phys. Rev.* 30(2), 705, 1927.)

day. 1. (*Mean solar.*) The average interval, during the year, between successive meridian passages of the sun. It is the basic unit of time used in physics. 2. (*Sidereal.*) The period of the earth's complete rotation on its axis, equal to 23 h 56 m 4.09054 s mean solar time. 3. (*Lunar.*) The period between successive meridian transits of the moon, averaging about 24 h 50.5 m mean solar time.

daylight factor. The ratio of the daylight illumination at any point in a building to the simultaneous illumination under the open sky. (See Walsh, Photometry, 1926, p. 365.)

deadbeat. Coming to rest without oscillation, as the indicator of a highly damped galvanometer. Syn. *aperiodic* (2).

de Broglie equation. An expression for the wave length of the de Broglie wave associated with a moving electron:

$$\lambda = \frac{h}{mv} = 10^{-8}\ \text{cm}\sqrt{\frac{150\ \text{volts}}{V}};$$

in which V is the potential drop, in volts, necessary to give the electron its speed and energy, mv is the momentum of the electron, and h the Planck constant. *Cf. electron wave length.* (See Debye, Interference of Electrons, 1936, p. 13.)

de Broglie frequency. The frequency associated with the energy of a moving electric particle, and equal to that energy divided by the Planck constant. *Cf. de Broglie wave, de Broglie equation.* (See Jauncey, Modern Phys., 1932, p. 518.)

de Broglie wave. A wave or wave group assumed in wave mechanics to be associated with an elementary particle (electron, proton). Syn. *electron wave, phase wave. Cf. de Broglie equation, de Broglie frequency.*

Debye characteristic temperature. The temperature at which the atomic heat of a simple cubic

crystal attains the value 5.67 calories per degree. According to Einstein, it is given by the formula $T_D = h\nu_m/k$, in which ν_m is the maximum frequency in the vibration spectrum (atomic frequency), h is the Planck constant, and k is the Boltzmann constant. First introduced in connection with the variation of specific heat with temperature. (See Harvey, *Phys. Rev.* 44, 133, 1933.)

Debye effect. A selective absorption of Hertzian waves in certain dielectric media, due presumably to the existence of molecular dipoles.

Debye factor. *Cf. Debye-Waller factor.*

Debye function. An expression for the specific heat of a monatomic crystalline solid at absolute temperature T, *viz.*,

$$C_v = 9nk\left(\frac{T}{T_D}\right)^3 \int_0^{\frac{T_D}{T}} \frac{x^4 e^x dx}{(e^x - 1)^2},$$

in which n is the number of atoms, k the Boltzmann constant, and T_D the Debye characteristic temperature. (See Slater, *Phys. Rev.* 50, 931, 1936.)

Debye-Scherrer ring, D.-S. circle. Syn. *powder pattern, Hull ring.* (See Debye, Interference of Electrons, 1931, p. 17.)

Debye-Sears effect. Syn. *Brillouin effect.*

Debye temperature factor. Syn. *Debye-Waller factor.* (See Blake, *Rev. Mod. Phys.* 5, 175, 1933.)

Debye-Waller factor. The quantity M appearing in the Debye relation $F = fe^{-M}$ between the F-value and the f-value of an atom in a crystal. Debye's calculation of M was later modified by Waller. Syn. *Debye temperature factor. Cf. atom form factor.* (See Davey, A Study of Crystal Structure and Its Applications, 1934, p. 14; Goetz and Hergenrother, *Phys. Rev.* 40, 147, 1932.)

decade bridge. A type of Wheatstone bridge in which the values of the ratio coils are decimal multiples of an ohm, so that when the bridge is balanced, the value of the unknown is a decimal multiple or a decimal fraction of the bridge reading.

decalescence. The reverse of recalescence; *i.e.*, an abrupt decrease in the rate of temperature rise as heat is applied to the metal, indicating an endothermic structural change.

decay coefficient. A constant factor appearing in the exponent of the time function of decay for such phenomena as radioactivity, which obey the exponential law. *E.g.*, the intensity of a radioactive emission of any type is given by an equation of the form

$$I = I_0 e^{-\lambda t},$$

in which λ is the decay coefficient. *Cf. half-value period, average life, decay modulus, disintegration constant.*

decay modulus. *In re* any variable which diminishes or "decays" exponentially, *e.g.*, radioactivity: the time required for the variable to diminish to $1/e$ or 36.97 per cent of its original value. It is equal to 1.443 times the half-value period, and is the reciprocal of the decay coefficient. Syn. *average life.*

decibel. A power-interval unit equal to $\frac{1}{10}$ bel, therefore corresponding to the power ratio $10^{\frac{1}{10}}:1 = 1.259$. Commonly used

in expressing acoustic sensation level differences. (See A.I.E.E. Comm. Rep., 1932; Acous. Soc. Comm. Rep., 1934.)

declination. 1. (*Mag.*) The angle between the horizontal component of the earth's magnetic field at any point and the geographic meridian through that point, measured east or west from the north. 2. (Astron.) The angle made by a line from the observer to any celestial object, as a star, with the plane of the celestial equator; positive if north, negative if south.

declinometer. An instrument for measuring magnetic declination, consisting essentially of a delicately suspended magnet in connection with a transit for obtaining the true meridian.

decrement. 1. A decrease in the value of a variable quantity; a negative increment. 2. Syn. *damping factor. Cf. logarithmic decrement.*

decrement factor. The exponential factor, diminishing with time, which appears in an equation representing a damped oscillation. *E.g.*, the discharge current of a condenser with initial charge Q is

$$i = \frac{a^2 + b^2}{b} Q e^{at} \sin bt,$$

in which a and b are constants. Here e^{at} is the decrement factor. *Cf. logarithmic decrement.*

decrement gauge. A pressure gauge in which the pressure or the density of a gas is measured by its effect in damping the movements of an oscillating disk or fiber. *Cf. molecular gauge.* (See Newman and Searle, General Properties of Matter, 1929, p. 216.)

decremeter. An instrument for measuring the logarithmic decrement of an electric oscillation.

deformability. The electric or dipole moment induced in a molecule by an electric field of unit intensity. Syn. *polarizability.* (See Smyth, Dielectric Constant and Molecular Structure, 1931, p. 14; also Fajans, Radioactive Elements and Isotopes, 1931, p. 68, for remarks on the deformability of ions.)

degenerate system. 1. A vibratory physical system, one or more of whose periodic variables have ceased to vary through an increase of its period to infinity. 2. In quantum mechanics, a system which has several distinct wave functions corresponding to the same energy level. (See Condon and Morse, Quantum Mech., 1929, p. 136; Slater, *Phys. Rev.* 26(2), 419, 1925.)

degradation. 1. (Of energy.) Any process whereby available energy becomes unavailable, as by conversion into heat. If the unavailable energy is allowed to escape, the term *dissipation* is more apt to be used. 2. (Of radiation.) The transformation of radiation of given type into a form having lower frequency and lower quantum energy, as in the Compton effect. *Cf. Stokes law* (2).

degree of freedom. One of the independent ways in which a body or a system may alter its position, the configuration of its parts, or more generally, its state. A system has as many degrees of

freedom as there are independent variables required to define its position or condition. *E.g.*, a system composed of two points has six degrees of freedom, one for each of the three co-ordinates of each point.

delta function. Syn. *Dirac function.*

delta rays. A name given by J. J. Thomson to electrons emitted by substances when bombarded by alpha particles. (See Kovarik and McKeehan, Radioactivity, 1925, p. 58.)

demagnetizing factor, d. coefficient. The factor by which the magnetization must be multiplied to give the oppositely directed magnetic intensity associated therewith (demagnetizing field). In an ellipsoid with uniform magnetization, this factor has the same value at every point.

demagnetizing field. That component of the magnetic intensity in a ferromagnetic body which is due to the magnetization of the body itself and which depends only upon its magnetization and shape. *Cf. demagnetizing factor.*

demodulator. A detector for h.-f. carrier telephone signals.

densitometer. A form of photometer used especially for measuring the density of silver deposits on photographic plates or films.

density. 1. The ratio of the mass of a specimen of a substance to the volume of the specimen. 2. In general, a term expressing the closeness of any space distribution; as *electron density* (number of electrons per unit volume), etc. 3. (Phot.) A term used to specify the light-absorbing power of the silver image in photographic materials; defined as the negative common logarithm of the transmission factor. *Cf. current density, energy d., numerical d., line d., surface d.*, etc.

density-in-phase. The number of points, each of which corresponds to one of the particles of a system, per unit volume of the phase space used to represent the state of the system. (See Tolman, Statistical Mech., 1926, p. 33.)

deposition potential. The minimum p. d. between an electrode and the surrounding electrolyte required to deposit ions of a given kind. (See Newman, Electrolytic Conduction, 1931, p. 28.)

derivator. A device for measuring the slope of a curve at any point and hence, indirectly, the value of the derivative of the corresponding function. Syn. *tangent meter. Cf. integrator.*

Deslandres diagram. The frequency matrix of a spectral band system, *i.e.*, a table in which the frequencies are arranged according to ascending values of the quantum numbers n', n'' of the upper and lower energy states. All frequencies in a row have the same value of n', all in a column the same value of n''. (See Birge, *National Research Council Bull.* 2, 128, 1926; Gibson and Macfarlane, *Phys. Rev.* 46, 1062, 1934.)

Despretz law. States that the temperature of maximum density of water is lowered below 4°C. by the addition of a solute, by an amount proportional to the concentration of the solution. (See Gregg-Wilson and Wright, *J. Phys. Chem.* 35, 624, 1931.)

destruction limit. The limiting shearing stress at which a crystal begins to lose its lattice structure, as indicated by the change in the Laue x-ray pattern. (See Joffé, The Phys. of Crystals, 1928, chap. 4.)

detailed balancing. The process by which the energy of an ionized atom is imparted to a free electron or other particle when the atom is neutralized and the particle is sent off with additional velocity; the inverse of ionization by impact. *Cf. microscopic reversibility principle.* (See Loeb, Nature of a Gas, 1931, p. 117; Darrow, Electrical Phenomena in Gases, 1932, p. 72.)

detection coefficient. The approximately constant ratio of the intensity of a detector signal, *e.g.*, the increase of plate current from a triode detector, to the square of the impressed h.-f. e.m.f. causing it. (See Brown, Radio Frequency Elec. Meas., 1931, p. 236.)

detector. An apparatus which, acting as a rectifier or a relay, serves to detect or render audible radio-wave modulations or signals.

deuteron. The nucleus of the hydrogen isotope, deuterium, of atomic weight approximately 2. Many synonyms have been used: *deuton, demihelion, diplon, diproton, eta* (η) *particle, hemi-alpha particle* or *h.-a. group.* The term *deuteron* was suggested by Bohr and Heisenberg.

devitrification. Crystallization of a vitreous or amorphous substance upon subjection to a suitable temperature; sometimes accompanied by a considerable evolution of heat. (See Tamman and Mehl, States of Aggregation, 1925, p. 275.)

dew point. The temperature at which the condensation of the water vapor in the air begins for any given state of humidity, as the air is cooled. A *dew-point hygrometer* indicates the dew point, from which the relative humidity may be calculated.

Dewar flask. A flask surrounded by a vacuum space for the purpose of thermal insulation; a principle utilized in the thermos bottle.

dextrogyrate. Having the property of rotating the plane of polarization of a beam of transmitted, plane-polarized light in the right-handed or clockwise direction, as viewed by one looking in the direction in which the light travels. Syn. *dextrorotatory. Cf. levogyrate.*

diacaustic. A caustic produced by refraction.

diagram line. 1. An x-ray spectrum line which corresponds to one of the quantum transitions derivable from the energy-level diagram for the atom from which it comes; whether such transition is in accordance with the selection rules or not. (See Pauling and Goudsmit, Structure of Line Spectra, 1930, p. 176.) 2. An x-ray spectrum line which fits into the scheme graphically represented by the Moseley curves. (See Kaufman, *Phys. Rev.* 45, 385, 1934.)

dialysis. The separation of a colloid from a true solute by diffusion of the latter through a porous membrane, in a manner analogous

to osmosis. The apparatus is called a *dialyzer*.

diamagnetic. Having a negative magnetic susceptibility, *e.g.*, copper, silver, and bismuth.

diathermanous. Highly transparent to infrared; n., *diathermancy*.

dichroism. 1. Pleochroism in respect to two axes only. 2. The property, exhibited by certain colored, transparent bodies, of showing different colors of transmitted light, depending upon the thickness traversed or the concentration of the coloring matter; or of exhibiting one color by reflected and another by transmitted light. Syn. *dichromatism*. 3. (*Circular.*) The unequal absorption of the two circular components of plane-polarized light in an optically active (rotatory) medium, as in certain organic solutions. First observed by Cotton. (See Cotton, *Ann. de chim. et de phys.* 8(7), p. 347; McDowell, *Phys. Rev.* 20(1), 163, 1905.)

dichroscope. An instrument used in studying the dichroism (1) of crystals.

dielectric. A substance capable of sustaining an electric field and of undergoing electric polarization. All electric insulators are dielectrics.

dielectric absorption. *Cf. absorption* (3).

dielectric cohesion. The force with which the molecules of a dielectric oppose an electric field tending to ionize them; a term due to Bouty.

dielectric constant. 1. The ratio κ of the electric displacement (*cf. displacement* (3)) to the electric intensity in the same region. (See Page, Int. to Theoretical Phys., 1928, p. 331.) 2. It has also been defined as a quantity whose measure (in c.g.s. e.s.u.) is 8π times the electric energy density in the said region, divided by the square of the potential gradient in the direction of the displacement. (See A.I.E.E. Comm. Rep., 1932.) 3. Sometimes used for *specific inductive capacity*. Syn. *inductivity, permittivity*.

dielectric loss. Loss of power due to electric hysteresis.

dielectric polarization. *Cf. polarization* (2).

dielectric strength. Syn. *insulating strength*.

Dieterici equation. An empirical, characteristic gas equation:

$$p(v - b)e^{\frac{a}{RTv}} = RT;$$

in which a and b are the characteristic constants. *Cf. van der Waals equation.* (See Loeb, Kinetic Theory of Gases, 1927, p. 172.)

difference band. A spectral band arising in transition from an excited state, rather than from the ground state. (See Adel and Slipher, *Phys. Rev.* 47, 651, 1935.)

difference tone. A combination tone whose pitch corresponds to a frequency equal to the difference of the frequencies of the two components. *Cf. summation tone.* (See Richardson, Sound, 1929, p. 61.)

differential galvanometer. A galvanometer having two similar, opposed coils, the currents in which tend to neutralize each other's effect, and which gives a

zero reading when the currents are equal.

differential magnetic permeability. The derivative of the magnetic induction with respect to the magnetic intensity in the same region, *viz.*, dB/dH. Here both dB and dH are taken as positive; if reversed the ratio may be different, on account of hysteresis.

diffraction. A term applied to a variety of effects produced upon wave trains, such as light or x-rays, by the interposition of one or more obstacles, as a row of parallel bars in a grating or an array of atoms in a crystal; characterized by more or less systematic interference phenomena, *e.g.*, bands, halos, or spot patterns.

diffraction angle. The angle between the direction of an incident beam of light and any resulting diffracted beam.

diffraction evolute. A term referring to the law that when an object illuminated by a point source produces a diffraction pattern within its shadow, the predominant diffraction figure is the evolute of the boundary of the geometrical shadow. (See Becknell and Coulson, *Phys. Rev.* 20(2), 594 and 607, 1922.)

diffraction grating. *Cf. grating.*

diffuse reflection, d. refraction, or d. transmission. Reflection, refraction, or transmission in all directions, not in any sharply defined path. *Cf. scatter, regular reflection, etc.*

diffuse series. One of several spectral series in the characteristic spectrum of an element; so called because of the relatively large half-width of the lines. Syn. *first subordinate series.*

diffusion. 1. The permeation of any region by a fluid, due to the thermal agitation of its molecules. 2. Syn. *scattering. Cf. diffuse reflection, etc.*

diffusion coefficient, d. constant. The constant D in the Fick law of diffusion. Syn. *diffusivity.*

diffusion indicatrix. A graph, in polar co-ordinates, showing the candle power of a given element of an illuminated diffusing surface as viewed from various directions in a plane perpendicular to the element. (See Walsh, Photometry, 1926, p. 118.)

diffusion pump. A type of air pump which operates by virtue of the large momentum of mercury vapor or other heavy molecules, which, in a stream or jet, carry other gas molecules before them.

diffusivity. Syn. *diffusion coefficient. Cf. thermal diffusivity.*

dilatometer. 1. An instrument resembling a large-bulbed thermometer, used for measurements of the expansion of liquids. 2. Any device for the measurement of thermal expansion.

dimension formula. *In re* any physical magnitude: a symbolic representation of its definition in terms of fundamental magnitudes; *e.g.*, area $= L^2$, force $= MLT^{-2}$, etc.

dimensional analysis. An analysis of a relationship between concrete quantities with reference to their physical dimensions. It is always of a partial character, and in particular does not give numerical factors. Thus, the kinetic energy of a moving body

must be proportional to the *square* of the speed, because of the dimension formula ML^2T^{-2} for energy; but the factor ½ is not thereby revealed. *Cf. similitude.* (See Bridgman, Dimensional Analysis, 1922.)

dimensional constant. A factor, the numerical value of which depends upon the fundamental definitions and the size of the fundamental units, but not upon the particular physical system to which it is applied. *E.g.*, the gravitation constant G in the Newtonian formula Gm_1m_2/r^2 is dimensional; but in the formula for the circumference of a circle, $p = \pi d$, π is not dimensional, as it has the same value whatever the unit of length used for d and p. (See Bridgman, Dimensional Analysis, 1922, p. 14.)

dimensional homogeneity. Equality of physical dimensions in the terms of a formula or physical equation. *E.g.*, in the Einstein photoelectric equation

$$\tfrac{1}{2}mv^2 = h\nu - p,$$

each term represents energy and has the dimension formula ML^2T^{-2}.

dineric. A term descriptive of a solution in which there are two immiscible solvents with a single solute soluble in each. *Cf. distribution law* (1). (See Hand, *J. Phys. Chem.* 34, 1961, 1930.)

diode. A two-electrode vacuum tube.

diopter, dioptry. A unit of focal power, corresponding to a focal length of 1 m.

dip needle, dipping n. Syn. *inclinometer* (2).

diplon. Syn. *deuteron.* The term has been much used in Europe.

dipole. 1. A system composed of two equal electric charges of opposite sign, separated by a finite distance, *e.g.*, the nucleus and orbital electron of a hydrogen atom. 2. A similar system composed of two equal but opposite magnetic poles.

dipole moment. The electric or magnetic moment of a dipole.

dipole polarization. The type of electric polarization exhibited by homogeneous polar dielectrics, and ascribed to the orientation of the permanent molecular dipoles. *Cf. Maxwell-Wagner polarization.* (See Morgan, *Trans. Electrochem. Soc.* 65, 109, 1934.)

Dirac electron. The physical concept of the electron as expressed by Dirac in terms of relativistic wave mechanics. (See Laporte, *Phys. Rev.* 42, 340, 1932.)

Dirac equation. 1. A formula based upon relativity-quantum theory which gives the mass absorption coefficient of a substance for radiation quanta in terms of their energy and of the constants relating to the atoms of the substance. (See Dirac, *Proc. Roy. Soc.* A111, 423, 1926; Millikan and Cameron, *Phys. Rev.* 32(2), 541, 1928.) 2. One of a set of four similar differential equations involving the components ψ_1, ψ_2, ψ_3, ψ_4 of a four-dimensional vector. (See Dirac, *Zeits. f. Phys.* 63.9–10, 713, 1930.)

Dirac function. A function $\partial(x)$ arbitrarily defined by Dirac as having the property of being zero for all values of x other than zero, and also the property that its

definite integral from $-\infty$ to $+\infty$ is unity. The operative symbol appears in many equations relating to modern quantum mechanics. Syn. *delta function.* (See Condon and Morse, Quantum Mech., 1929, p. 194; Temple, *Proc. Roy. Soc.* 127, 339, 1930.)

direct-vision prism. *Cf. Amici prism.*

directional derivative. Of a scalar point function F with respect to any direction in space: the scalar (dot) product of the gradient of F by the unit vector in the given direction. (See Page, Int. to Theoretical Phys., 1928, p. 20.)

directional quantization. The application of quantum conditions to the orientation of a system in space traversed by a field of force; which limits, *e.g.*, the number of possible orientations of an atom in a magnetic field (*cf. Stern-Gerlach experiment*). Syn. *space quantization.* (See Gerlach, Matter, Electricity, and Energy, 1928, p. 139.)

Dirichlet principle. States that there is one and only one function F of the co-ordinate variables x, y, z which fulfills the following conditions: (1) that F and its derivatives are continuous and single valued throughout a given closed space S, (2) that F satisfies the Laplace equation throughout this region, and (3) that F may be made to assume any given set of boundary values all over the surface of S, provided these values are continuous over the surface. Important in the theory of potential. (See Peirce, Newtonian Potential Function, 1902, p. 105.)

discharge coefficient. The correction factor by which the theoretical rate of (volume) discharge through an orifice, $\pi r^2\sqrt{2gh}$, must be multiplied to give the actual rate as determined by experiment. *Cf. Torricelli law.* (See Bond, Int. to Fluid Motion, 1925, p. 19.)

discharge key. A device for suddenly switching the connections of a condenser from the charging circuit to a circuit through which it discharges.

discharge tube. Syn. *vacuum tube.*

disintegration. 1. The emission of an alpha or a beta particle by a radioactive atom. 2. The passage of a solid into a colloidal state. *Cf. also cathodic disintegration.*

disintegration constant. The decay coefficient for radioactive disintegration. Syn. *transformation constant, radioactive c.*

disintegration electron. An electron emitted from the nucleus of an atom upon radioactive disintegration, in that class of radioactive elements which emit beta rays. (See Rutherford, Chadwick, and Ellis, Radiations from Radioactive Substances, 1930, p. 398.)

dislocation. A disarrangement of the perfect configuration of the units of a crystal lattice, as evidenced by anomalous mechanical, optical, or magnetic properties. *Cf. mosaic structure.* (See McKeehan, *Phys. Rev.* 43, 924, 1933.)

disperse phase. That constituent of a disperse system which corresponds to the solute in a crystalloidal solution.

disperse system. Any colloidal solution having two phases separated by relatively large surfaces.

dispersion. 1. The process of separating or sorting an emission, in accordance with some characteristic such as frequency, wave length, or energy, into components which usually are given different directions; as a prism or a grating disperses white light, or a magnetic field sorts electrons of different speed. *Cf. rotatory dispersion.* 2. Quantitatively, a general measure for any such dispersion is the derivative of the deviation with respect to that variable (wave length, frequency, etc.) which is considered responsible for the separation; but some writers define refractive dispersion as the derivative of the refractive index with respect to wave length or frequency. *Cf. dispersive power.* (See Robertson, Int. to Phys. Optics, 1929, p. 246.) 3. The production of the disperse phase in a disperse system. (See Couch, Dict. of Chem. Terms, 1920.)

dispersion formula. One of a number of equations essaying to express the refractive index of a substance as a function of wave length or of frequency, *e.g.*, the Cauchy formula. Characteristic constants in such a formula are *dispersion constants* for the substance.

dispersional frequency. The frequency corresponding to the anomalous dispersion at an absorption discontinuity. (See Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 77.)

dispersive power. *In re* any refractive medium: the value of the ratio $\frac{n_1 - n_2}{n_m - 1}$, in which n_1 and n_2 are the refractive indices for the ends of the spectrum range considered, while n_m is that for some arbitrarily chosen wave length, often the mean of n_1 and n_2. Commonly n_1 and n_2 are taken for the *F* and *C* Fraunhofer lines, respectively, and n_m for the *D* (sodium) line. The reciprocal of the dispersive power is the *Abbe nu-value.* (See Preston, Theory of Light, 5th ed., p. 140; Southall, Mirrors, Prisms, and Lenses, 1923, p. 480.)

dispersoid. A highly disperse colloidal suspension, such as an emulsion. (See Couch, Dict. of Chem. Terms, 1920.)

displacement. 1. Any change in position. 2. The quantity of fluid, by weight or volume, displaced by a submerged body. 3 (*Electric.*) A vector quantity usually associated with the condition of a substance in an electric field. When a dielectric is placed in the field, the dielectric polarization and the electric intensity in the substance are both proportional to the displacement, their ratios to it depending upon the dielectric constant. *Cf.* also terms following.

displacement current. A term introduced by Maxwell to denote the effective current in a dielectric or a vacuum (as between the plates of a condenser) corresponding to the electron current in a metallic conductor (as in the wires leading to the condenser). Maxwell regarded the time rate of change of the electric intensity as equivalent to the value of an actual current. In modern usage, the displacement current density is defined as the time rate of the

electric displacement (*cf. displacement* (3)), *i.e.*, to $\frac{dE}{dt} + 4\pi\frac{dP}{dt}$; in which E is the intensity and P, the polarization.

displacement interferometer. An optical instrument consisting of an arrangement of mirrors, and used, in conjunction with a dispersive system such as a prism or a grating, for measuring small displacements. (See Bennett, *Phys. Rev.* 37, 263, 1931 and 45, 200, 1934.)

displacement law. 1. (Radiation.) The first of the Wien laws of thermal radiation (*q.v.*). 2. (Spect.) The second of the Kossel-Sommerfeld spectroscopic laws (*q.v.*). 3. (Radioact.) *Cf. Fajans and Soddy laws.* 4. (Chem.) A principle which recognizes the fact that an atom which has had one of its electrons removed behaves chemically like the one preceding it in the periodic table. (See Sidgwick, Electronic Theory of Valency, 1929, p. 66.)

dissipation (of energy). *Cf. degradation* (1).

dissipative system. A nonconservative system.

dissonance. 1. (Acous.) Musical discord. 2. (*Optical.*) The formation of maxima and minima by the superposition of two sets of interference fringes from light of two different wave lengths, *i.e.*, what may be called *stationary beats* or *secondary interference.* (See Ferguson, *J.O.S.A.* 24, 157, 1934.)

distortion. 1. A change in wave form in the transmission of a composite electric wave over a communication line, in which different component frequencies are transmitted with different speeds or with unequal attenuation. In a *distortionless* line, this effect is minimized by the use of certain devices. 2. An imperfection in an optical image, due to spherical aberration or similar defects of the optical system.

distributed capacitance. That part of the capacitance of an electric circuit which is due, not to the introduction of condensers, but to the insulation of the conducting wires from the ground, or esp. from a surrounding conducting conduit or sheath.

distribution. A statistical tabulation of one variable in terms of another which may be related to it through a *distribution function* (*q.v.*), *e.g.*, *frequency-energy distribution, velocity-angle d.*, etc. *Cf. distribution law* (2).

distribution coefficient, d. constant, d. ratio. The constant ratio of the concentrations of a solute dissolved in two immiscible solvents which are in contact in the same container. Syn. *partition coefficient. Cf. dineric, distribution law* (1). (See Couch, Dict. of Chem. Terms, 1920.)

distribution function. A mathematical expression indicating the relative frequency with which the value of a statistical variable may be expected to lie within any specified interval. *Cf. distribution law* (2). (See Rietz, Math. Statistics, 1927, pp. 11–14; Fry, Probability and Its Engineering Uses, 1928, pp. 93–97, 141–150.)

distribution law. 1. States that in a dineric solution, the ratio of the concentrations of the solute in the

two solvents is independent of the quantity of solute. Attributed to Nernst. Syn. *partition law. Cf. distribution coefficient.* (See Couch, Dict. of Chem. Terms, 1920.) 2. The mathematical statement of statistical frequency as expressed by a distribution function, *e.g.*, the Maxwell or the Gaussian distribution law.

distribution, modulus of. A term used by Gibbs to denote the quantity kT (Boltzmann constant $\times$ absolute temperature) as it occurs in the probability distribution function $e^{\frac{\psi-\epsilon}{kT}}$; in which ψ is the thermodynamic potential and ϵ is the energy. (See Gibbs, Statistical Mech., pp. 33 ff.; Haas, Int. to Theoretical Phys., 1925, v. 2, p. 210.)

divergence. A scalar differential operator, which, applied to a vector point function F, is denoted by the symbol $\nabla \cdot F$ and read "divergence of F" or "del dot F." If F_1, F_2, F_3 are the magnitudes of the three components of F, the divergence of F is expressed by the equation

$$\nabla \cdot F = \frac{\partial F_1}{\partial x} + \frac{\partial F_2}{\partial y} + \frac{\partial F_3}{\partial z}.$$

dividing machine, d. engine. A mechanism operated by a long micrometer screw, for marking the divisions on instrumental scales.

doma. A primitive crystalline form consisting of two plane surfaces forming a dihedral angle, which is bisected by a third plane surface. (See Rinne, Crystals and the Fine Structure of Matter, 1922, p. 29.)

domain. 1. One of the regions in a ferromagnetic substance in which the atomic magnetic moments are parallel. These regions apparently behave as units during change of magnetization. Attributed to Weiss. 2. *Cf. atomic domain.*

Doppler broadening. The broadening of a spectrum line due to the Doppler effect of the radial component of thermal motion in the emitting particles, which gives the line a width (*Doppler width*) superimposed upon that due to other causes. *Cf. Doppler-Fizeau principle.*

Doppler effects. The effects produced upon the frequency with which the waves of an undulatory emission reach the observer, by the motion of the source toward or away from the observer, or of the observer toward or away from the source, or both. Observed in the case of sound by Doppler in 1842. *Cf. Doppler-Fizeau principle.*

Doppler-Fizeau principle. The principle underlying the Doppler effects as applied by Fizeau to the shifting of spectrum lines.

Doppler shift. The displacement of spectral lines caused by the relative radial motion of source and observer. *Cf. Doppler-Fizeau principle.*

Dorn effect. Syn. *sedimentation potential.*

dosage. A measure of the time integral of irradiation, equal to the product of the intensity by the duration of exposure; a term used esp. in radiology. *Cf. roentgen.*

dot. 1. A notation, attributed to Newton, consisting of a dot placed over the symbol for a variable, and signifying the derivative of

that variable with respect to time. Such quantities as velocity and acceleration are frequently thus represented. 2. One of the symbols of vector multiplication; placed between the symbols for two vectors, it designates their scalar product.

double-image prism. An apparatus, one type of which, devised by Wollaston, consists of two wedges of doubly refracting crystal fitted together to form a rectangular block or prism, and with their axial directions at right angles. When a narrow beam of unpolarized light enters normally at one surface, it emerges from the other in two separate beams, plane-polarized at right angles to each other. (See Robertson, Int. to Phys. Optics, 1929, p. 276.)

double refraction. A phenomenon observed when light traverses certain types of crystal or other aeolotropic medium; manifested by the separation of the light into two components, polarized at right angles to each other, having different velocities within the medium, and, in general, taking different directions. These two components are termed the *ordinary* and the *extraordinary* rays. Syn. *birefringence*. *Cf. optic axis, forced double refraction, Kerr effect* (1), *Cotton-Mouton effect.*

doublet. 1. *Cf. multiplet.* 2. (*Electric.*) The ideal limiting case of an electric dipole consisting of two equal, opposite charges, $+q$, $-q$, when the distance d between the charges is diminished and the charges increased so as to keep the electric moment qd finite and constant; a concept useful in dielectric theory. 3. (*Magnetic.*) Definition similar to (2), but with opposite magnetic poles, $+p$, $-p$ substituted for the two charges.

drift speed. The mean speed with which electrons or ions progress through a medium where they are continually experiencing collisions. (See Darrow, Int. to Contemporary Phys., 1926, p. 418.)

drop-weight method. A method of investigating surface tension and cohesion in a liquid by weighing its drops which fall from a tube of specified dimensions. (See I.C.T., 1926, v. 4, p. 435.)

Duane-Hunt law, D.-H. relation. States that the maximum frequency in the beam of x-rays issuing from a tube, multiplied by the Planck constant, is equal to the energy acquired by one of the cathode electrons in traversing the tube. The law is expressed by the Planck-Einstein equation. (See Duane and Hunt, *Phys. Rev.* 6(2), 166, 1929; Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 400; Birge, *Rev. Mod. Phys.* 1, 51, 1929.)

Dubuat paradox. Refers to the fact that the forces exerted by a liquid flowing through a channel or conduit upon a body held at rest in it differ from those exerted when the liquid is at rest in the channel and the body is moved through it with the same relative velocity as before. This is due to the effect of the irregularities of the walls of the channel, and of wall friction, upon the motion of the liquid. (See De Villamil, Motion of Liquids, 1914, chaps.

5, 6; Gibson, Hydraulics and Its Applications, 1925, p. 385.)

ductility. A combination of properties in a metallic substance, including malleability and toughness, which makes it capable of being drawn into wires.

Dulong-Petit laws. At least two well-known laws are attributed to Dulong and Petit: 1. The specific heats of elements are inversely proportional to their atomic weights. *Cf. atomic heat.* 2. The rate at which the temperature of a body approaches that of its surroundings by radiation is proportional to the difference between two powers of the same constant whose exponents are, respectively, the absolute temperatures of the body and of its surroundings. The law is entirely empirical.

Dumas bulb. A form of apparatus, on the principle of the pycnometer, for measuring the densities of vapors, and hence, indirectly, their molecular weights.

dynamic equivalent. Syn. *mechanical equivalent.*

dynamical stability. A quantity whose measure is the torque, equal to the work necessary to produce a list or tipping of a floating body, divided by the angle through which it is tipped; a term applied especially to ships. (See Laws, Stability and Equilibrium of Floating Bodies, 1914, p. 149.)

dynamics. That branch of physics which treats of forces and their action upon material bodies. Adj. *dynamic, dynamical.*

dynamometer. 1. An instrument for measuring force, such as a spring balance. 2. Syn. *electrodynamometer.*

dynatron. A triode in which the grid and plate potentials are so chosen that the plate current decreases as the plate potential increases. This characteristic is due to secondary electron emission from the plate, and because of it a dynatron can be used as an oscillator. (See Hull, *Proc. I.R.E.* 6, 5, 1918.)

dyne. The absolute, c.g.s. unit of force, defined as that force which, acting upon a free mass of 1 gram, would impart to it an acceleration of 1 cm/sec^2.

dystectic. *In re* any mixture or solution: in such proportions as to have the maximum melting point of all mixtures of the same substances. *Cf. eutectic.* (See Couch, Dict. of Chem. Terms, 1920.)

E

(*Please note purpose of references as explained in preface.*)

Eagle mounting. A mounting for concave gratings, so arranged that the angles of incidence and diffraction are nearly equal.

Earnshaw theorem. States that an electric charge cannot be in stable equilibrium in an electric field unless acted upon by forces other than those due to the field. Analogous statements hold for magnetic and gravitational fields or combinations of them.

earth inductor. A coil, the sudden rotation of which in the earth's

magnetic field causes a surge of electricity and thus affords a means of measuring the intensity of the field. *Cf. flip coil.*

ebulliscope, ebullioscope. An instrument for determining the concentration of a solution by means of its boiling point.

ebullition. The familiar phenomenon of boiling, exhibited by a liquid at a temperature sufficiently high for the rapid formation and escape of bubbles of vapor.

echelette. A coarse diffraction grating ruled on metal to resemble a reflecting echelon of very small steps. Devised by R. W. Wood.

echelon. A type of diffraction grating capable of producing spectra of very high order and dispersion. The grating spaces are formed by building a miniature stairway out of glass plates of exactly equal thickness. Devised by Michelson.

eddy current. A transient and local electric current in a conductor, due to change in magnetic induction; *e.g.*, in the core of a generator armature. Syn. *Foucault current. Cf. laminate.*

eddy-current loss. The power loss due to eddy currents in a core, which has been expressed by the following empirical formula:

$$p_e = A(nfB_m l)^2,$$

in which n is the frequency, B_m the maximum induction during the cycle, l the thickness of the laminations, and f a form factor. A is the *eddy-current constant.* (See Williams, Magnetic Phenomena, 1930, p. 60; Wall, Applied Magnetism, 1927, p. 221.)

edge effect. An abnormality such as that exhibited by the electric field due to the charge on a conductor near where the latter terminates in a sharp edge. *Cf. end effect, guard ring.*

Edison effect. A thermionic current, discovered (1892) by Edison, who connected a galvanometer between a terminal of one of his incandescent lamp filaments and an auxiliary electrode placed in the bulb. (See Bloch, Thermionic Phenomena, 1927, p. 2.)

effective charge. An electric charge such that, if multiplied by the actual distance between the two atoms of a heteropolar, diatomic molecule, the result is equal to the actual dipole moment. (See Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 9.)

effective collision radius. *Cf. effective diameter.*

effective component. That vector component of a given force whose direction is that of the actual motion of the point of application of the force in question. *E.g.*, if a body slides down an inclined plane under the action of gravity, the effective component of its weight is parallel to the plane.

effective current. The value of that constant current which would have the same average power as an actual variable current in the same circuit. It is equal to the r.m.s. of the variable current.

effective diameter (or radius). *In re* molecules, atoms, ions, etc.: an average value of the diameters (or radii) of such particles, which, if they were of spherical shape,

would result in the production of such scattering effects, mean-free-path phenomena, etc., as are actually observed with the type of particle in question.

effective electromotive force. The value of that constant e.m.f. which would yield the same average power as an actual variable e.m.f. in the same non-inductive circuit. It is equal to the r.m.s. of the variable e.m.f.

effective interferometric wave length. That monochromatic wave length which, on being substituted for heterochromatic radiation, will give the same system of fringes in an interferometer. (See Buckley, *J.S.I.* 10, 351, 1933.)

effective ionic mass. A quantity used to represent the ionic mass in connection with a heteropolar molecule. If M_1 and M_2 are the masses of the two ions, the effective ionic mass is

$$M = \frac{(M_1 M_2)^{3/2}}{(M_1 + M_2)^2}.$$

effective molecular speed. That speed which each molecule of a pure gas would have, were their speeds all equal and the temperature unchanged. It is equal to the r.m.s. of the actual speeds, and is about 1.086 times the mean speed.

effective quantum number. A number appearing in spectral terms for non-hydrogen atoms, and analogous to the azimuthal quantum number for hydrogen. It is not, however, an integer, and is not properly a quantum number but merely a convenient measure of the inverse square root of the energy.

effective resistance. The resistance of a conductor to a periodic current, as measured by the ratio of rate of dissipation of energy to square of effective current. It differs from the true (steady-current) resistance because of skin effect. (See A.I.E.E. Comm. Rep., 1932; Page and Adams, Principles of Elec., 1931, p. 595.)

effective sound pressure. The r.m.s. value of the instantaneous sound pressure during a complete cycle, at any point of a medium traversed by sound waves. Sometimes abbreviated to *sound pressure.* (See Acous. Soc. Comm. Rep., 1934.)

effective temperature. Syn. *radiation temperature.*

effective wave length. *In re* a beam of nonhomogeneous radiation in a given medium: the wave length of a homogeneous beam having the same penetration in the same medium. *Cf. effective interferometric wave length.*

efficiency. The ratio of the useful energy derived from a dynamic system (as an engine or other machine) to the energy communicated to it during the same process or over a protracted period of operation. *Cf. luminous efficiency, light-source efficiency.*

efflux coefficient. A correction factor for the rate of efflux from an orifice, to allow for friction. *Cf. friction factor.*

effusion. The escape of a gas through a small opening. *Cf. thermal effusion.*

Ehrenfest formula. A modification of the Sackur equation for the entropy of a gas, in which allow-

ance is made for the molecular symmetry number. (See Giauque, Blue, and Overstreet, *Phys. Rev.* 38, 196, 1931.)

eigenenergy (Ger. *Eigenenergie*). A quantity of energy just corresponding to an actual atomic state. Used in quantum mechanics. Syn. *characteristic energy.*

eigenfunction (Ger. *Eigenfunktion*). A function which, among various possible forms, fulfills certain required conditions. Used in quantum mechanics. Syn. *characteristic function* (2).

eigenvalue (Ger. *Eigenwert*). A particular solution satisfying specified conditions. Used in quantum mechanics. Syn. *characteristic number, c. value.*

Einstein coefficients. Quantities which represent the probabilities of the emission or of the absorption of radiation quanta by an atom within a unit of time. (See Tolman, Theory of Relativity of Motion, 1917, p. 168.)

Einstein-deHaas effect. An angular momentum imparted to a free body by suddenly magnetizing it; the converse of the Barnett effect. (See Barnett, *Rev. Mod. Phys.* 7, 132, 1935.)

Einstein photoelectric equation. Expresses the kinetic energy of an escaped photoelectron as

$$E_K = h\nu - p,$$

in which $h\nu$ is the energy quantum of the incident radiation and p is the photoelectric work function for the metal concerned. (See Hughes and DuBridge, Photoelectric Phenomena, 1932, chap. 2.)

Einstein shift. A shift toward the red in the spectral lines of light which, according to the relativity theory, has its frequencies slightly reduced upon emerging from a strong gravitational field, such as that of a dense star. (See Einstein, Meaning of Relativity, 1923, p. 101; Jauncey, Modern Phys., 1932, p. 462.)

Einthoven galvanometer. *Cf. string galvanometer.*

elasmometer. An instrument for the study of Young's modulus and other elastic constants, esp. by optical methods. (See Tutton, Natural History of Crystals, 1924, p. 238.)

elastic aftereffect. The persistence of a strain, though gradually diminishing, after the stress has been removed from an elastic body. *Cf. afterflow.*

elastic collision, e. impact. An encounter between moving bodies or corpuscles, subject to the ideal condition that the total kinetic energy of translation is the same after the impact as it was before; *i.e.*, none of the energy is transformed into rotational or other forms.

elastic limit. The stress required to produce, in a given material, a permanent deformation of measurable amount, and at which the Hooke law ceases to hold. Syn. *proportional limit, P-limit, limiting stress.* (See Nádai, Plasticity, 1931, p. 55.)

elastic modulus. Syn. *modulus of stress;* but usually refers to the *Young modulus.*

elastic scattering. Scattering by elastic impact, *i.e.*, without loss of kinetic energy. *Cf. elastic col-*

lision. (See Jordan and Brode, *Phys. Rev.* 43, 112, 1933.)

elasticity. That property of a body or of a substance, by virtue of which it develops stresses when subjected to strain, and therefore tends to resume its original configuration. Kelvin defines a perfectly elastic body as one in which a given state of strain always corresponds to the same distribution of stress, however prolonged or however often repeated, provided the temperature remains unchanged.

electret. A dielectric which exhibits dielectric absorption, *i.e.*, still retains part of its electric polarization after the removal of the external field. *Cf. absorption* (3), *residual charge.*

electric absorption. Syn. *dielectric absorption* (*cf. absorption* (3)).

electric axis. Syn. *piezo-electric axis.*

electric breakdown. An electric discharge which takes place by reason of a transformation within the dielectric, rendering it, at least temporarily, a conductor; a disruptive discharge. *Cf. insulating strength.*

electric convection. An electric current consisting of electric charges carried by means of charged bodies of appreciable size, as by the "carriers" of a static machine or by electrified drops of liquid. (See Cremieu and Pender, *Phys. Rev.* 17(1), 385, 1903.)

electric density. The quantity of electricity per unit volume in any part of a space charge. *Cf. surface density.*

electric displacement. *Cf. displacement* (3).

electric double layer. Syn. *Helmholtz double layer.*

electric double refraction. *Cf. Kerr effect* (1).

electric flux. The surface integral, over any specified area, of the normal component of the electric displacement. *Cf. magnetic flux.*

electric force. Syn. *electric intensity.* (See A.I.E.E. Comm. Rep., 1932.)

electric image. A fictitious distribution of electricity, mathematically equivalent in its effect to an actual distribution induced on a conductor, and related to the inducing charge in a manner somewhat analogous to the relation of a virtual image to the source of light. *Cf. image force.*

electric induction. A redistribution of electricity which takes place in a conductor when placed in an electric field.

electric intensity. A vector quantity pertaining to the electric field, the measure of which, at any point in a vacuum, is the force per unit charge which would act upon a charged particle placed at that point. It is closely related to electric displacement. *Cf. displacement* (3), *dielectric constant.* (See A.I.E.E. Comm. Rep., 1932.)

electric moment. That vector, associated with a system having electric displacement, whose vector product by the electric intensity of the field in which the system is placed gives the resulting torque upon the same, the electric intensity considered being exclusive of any component contributed by the system itself. For a dipole with concentrated charges the electric moment is

approximately the product of the magnitude of either charge by the distance between them, and its direction is that of the line drawn from the negative to the positive charge. *Cf. magnetic moment.* (See A.I.E.E. Comm. Rep., 1932.)

electric oscillation. An a.c. having a natural frequency dependent upon the nature of the circuit, rather than upon the alternating character of the impressed e.m.f. Or, in general, any h.-f. a.c.

electric osmosis. The contact electrification of two dielectrics or of a dielectric and a conductor or semiconductor. *Cf. Coehn law.* Not to be confused with *electro-osmosis.* (See Coehn, *Wied. Ann.* 64, 217, 1898 and *Ann. d. Phys.* 43, 1048, 1914; Richards, *Phys. Rev.* 22(2), 122, 1923.)

electric polarization. 1. *Cf. polarize* (2). 2. Syn. *dielectric polarization.*

electric potential. 1. A scalar point function, the measure of which is the energy per unit charge involved in the transfer of an infinitesimal quantity of positive electricity from an infinite distance to the point in question. More briefly: the line integral of the electric intensity from the point to infinity. The potential is positive or negative according to whether work must be expended to bring the positive charge from infinity or to carry it to infinity from the given point. Any arbitrary zero, as the potential of the earth, may, however, be used. *Cf. Newtonian potential function.* 2. Sometimes loosely applied to p.d. or to e.m.f.

electric precipitation. The collection of dust or other finely divided matter by means of the inductive action of an electric field. (See Simon and Kron, *R.S.I.* 1, 527, 1930.)

electric screening. The device of completely surrounding any object or region by a closed metallic shell or casing, in order to exclude all extraneous electrostatic influence.

electric stress. The condition within a dielectric which is brought about by electric polarization, and under which the dielectric tends to recover its normal condition when the cause of the polarization is removed.

electric susceptibility. Syn. *dielectric susceptibility* (*cf. susceptibility* (2)).

electric vector. That component of the electromagnetic field associated with electromagnetic radiation which is of the nature of an electric field; supposed to coexist with, but to act at right angles to, the magnetic vector. *Cf. Poynting vector, Hertzian v.*

electric wave. 1. A wave of varying electric density and potential in a conductor, such as a telephone line. 2. Syn. *Hertzian wave* (*cf. H. radiation*).

electric wind. A current of air or other gas repelled from an electrified, pointed conductor, or carried along by streams of ions moving in the electric field. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 544.)

electrocapillarity. The effect of an electric current upon the equilibrium of the interface between two liquids in a capillary tube, consisting apparently in a modi-

fication of the surface tension. *Cf. capillary electrometer.* (See Butler and Ocrent, *J. Phys. Chem.* 34, 2286, 1930.)

electrochemical constant. Syn. *Faraday electrolytic constant.*

electrochemical equivalent. The mass of a substance liberated in electrolysis, per unit quantity (coulomb) of electricity passing through the electrolyte.

electrode. A surface of contact between a metallic and a non-metallic conductor (metallic includes such conductors as carbon).

electrodeless discharge. A luminous discharge in a gas confined in a closed tube without internal electrodes, due to subjecting the gas to a rapidly alternating electric field through the condenser action of the tube wall or to the inductive action of the current in a neighboring h.-f. circuit. (See Darrow, Electrical Phenomena in Gases, 1932, p. 446.)

electrodeposition. The depositing of a substance upon an electrode by electrolysis, as in electroplating.

electrodialysis. Dialysis under the influence of an electric potential gradient; analogous to electro-osmosis. (See Bradfield and Bradfield, *J. Phys. Chem.* 33, 1724, 1929.)

electrodynamics. That branch of physics which deals with the forces and energy transformations related to electric currents and the magnetic fields associated with them. Syn. *electromechanics* (2).

electrodynamometer. An instrument for measuring electric current by means of the interaction between parts of a single circuit carrying the current.

electro-endosmosis. Syn. *cataphoresis;* but used esp. when the liquid component of the suspension migrates, while the solid remains stationary. (See Couch, Dict. of Chem. Terms, 1920.)

electrographic. A term applied to the effect of cathode rays on a metal surface, in which the metal becomes less subject to the action of corrosive vapors, and which may be used to produce developable cathode-ray images. (See Wilcox and Carr, *Phys. Rev.* 45, 286, 1934.)

electrokinetic potential. The p.d. which exists across the Helmholtz double layer at the interface between a solid and a surrounding liquid; a term due to Freundlich. Syn. *zeta potential.*

electrokinetics. That branch of physics which deals with electricity in motion.

electrolysis. A chemical process which occurs at the interface between an electrode and an electrolyte when a unidirectional current passes from one to the other.

electrolyte. 1. A conducting medium in which the current consists of charges borne by carriers of atomic or molecular dimensions (ions). 2. A substance which conducts ionically either in the pure state or when dissolved in a suitable medium. Adj. *electrolytic.*

electrolytic capacitance. The capacitance of a cell acting as an electrolytic condenser. (See

Pierce, *Phys. Rev.* 31(2), 470, 1928.)

electrolytic condenser. A polarized electrolytic cell used as a condenser of large capacitance. *Cf. electrolytic capacitance.* (See Varley, *Phil. Trans.* 161, 129, 1872; Sheldon, Leitch, and Shaw, *Phys. Rev.* 2(1), 401, 1895.)

electrolytic valve. An electric current rectifier based on the nonsymmetrical resistance of certain electrolytic cells.

electromagnetic balance. An instrument which measures electromagnetic forces by balancing them against gravity, *e.g.*, the Kelvin balance. (See Ainslie, *R.S.I.* 4, 546, 1933.)

electromagnetic constant. A natural constant, having the dimensions of linear speed, which appears in the expressions for many relations between electric and magnetic quantities, and is commonly denoted by *c*. *E.g.*, the abcoulomb is equal to *c* times the e.s.u. charge. *c* plays its most familiar role as the speed of electromagnetic radiation in a vacuum. Its value is about 2.9977×10^{10} cm per second. (See Birge, *Nature* 134, 771, 1934.)

electromagnetic field. A region of space which is the seat of electromagnetic energy, by virtue of a rapidly moving electric field which sets up a coincident, moving magnetic field at right angles to the lines of electric force and to their direction of motion. This condition is believed to exist in the space traversed by electromagnetic radiation.

electromagnetic induction. Syn. *magnetoelectric induction.*

electromagnetic mass. The mass associated with a moving electric charge by reason of the fact that the energy of the magnetic field which it produces is proportional to the square of the speed. The mutual electromagnetic mass of two like charges moving side by side is greater than the sum of their separate electromagnetic masses. (See Haas, Int. to Theoretical Phys., 1925, pp. 244 ff.)

electromagnetic momentum. A momentum which, according to the theories of Maxwell and J. J. Thomson, exists in an electromagnetic field, and whose magnitude per unit volume is equal to the product of the electric and the magnetic field intensities divided by the electromagnetic constant *c*. (See Wilson, *Phys. Rev.* 16(2), 17, 1920.)

electromagnetic radiation. *Cf. radiation* (1).

electromagnetic unit. Any electric unit based primarily upon the magnetic effect of the electric current. The fundamental c.g.s. unit in the system is the abampere.

electromagnetic waves. Waves of electromagnetic radiation (*cf. radiation* (1)).

electromagnetics. That branch of physics which treats of the mutual relationships existing between electric currents and the attendant magnetic fields.

electromechanics. 1. A branch of electrical engineering which deals with machines producing or operated by electric currents, as generators and motors. 2. Syn. *electrodynamics.*

electrometer. An instrument for detecting or measuring p.d. by

means of electrostatic forces exerted between electrically charged bodies; a calibrated electroscope.

electromotive force. That which tends to alter the motion of electricity or to maintain its motion against resistance. Its measure is the energy per unit charge imparted to the electricity as it traverses the region in which the e.m.f. is operative; the units commonly employed being those of electric potential, *e.g.*, joules per coulomb (volts).

electromotive series. A series of different electrodes arranged in the order of their p.d.'s with normal solutions of their ions. There are two such series, one for positive and one for negative ions. (See Newman, Electrolytic Conduction, 1931, p. 208.)

electron. The negative elementary charge. (Most writers confine the term to this, though some refer to both negative and positive electrons.) The mass of an electron at rest is approximately 9×10^{-28} g. *Cf. positron.* (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

electron affinity. 1. The tendency of an atom or a molecule to attach free electrons and form negative ions. Its measure is the energy liberated upon the formation of the ion. 2. The p.d. corresponding to the energy necessary to separate an electron from a metal, as in photoelectric emission. *Cf. work function.* (See Smiths. P. T., 1929, p. 404; Oldenburg, *Phys. Rev.* 43, 534, 1933.)

electron band. A molecular spectrum band, usually in the visible or the ultraviolet, due to electron transitions within the molecule; as distinguished from rotational and vibrational transitions, which give bands in the infrared.

electron gas. An aggregation of electrons to which a kinetic theory may be applied, in some respects similar to the kinetic theory of gases.

electron gun. A device for projecting a narrow stream of electrons in any desired direction, *e.g.*, a slender tube closed at one end and with a thermionic filament at the bottom of the bore, the whole being negatively charged.

electron lens. An electric field, such as that about a circular opening in a charged metal plate, which acts upon an electron stream in a manner analogous to the action of a lens upon a beam of light. *Cf. electron optics.* (See Davisson and Calbick, *Phys. Rev.* 42, 580, 1932.)

electron microscope. A device for producing effects on streams of electrons, analogous to those produced on light rays in a microscope; a nonuniform magnetic or electric field being employed for the purpose. *Cf. electron optics.* (See Knoll, *Zeits. f. Phys.* 78, 318 and 340, 1932.)

electron optics. A system of controlling beams or rays of electrons by means of suitably adjusted electric or magnetic fields, the electron rays being thus made to imitate the rays of light in an optical instrument. *Cf. electron lens, electron microscope, electron telescope.* (See Zworykin, *J. Frank. Inst.* 215, 535, 1933; Zworykin and Morton, *J.O.S.A.* 26, 181, 1936.)

electron promotion. An increase in the principal quantum number of an electron, which may take place when the atom to which it belongs combines with another atom to form a diatomic molecule. Since it involves an increase in energy, such promotion renders the influence of the electron in question unfavorable to the union.

electron quantum number. One of a set of numbers which serve to describe the quantum states of electrons within atoms and molecules or the state of the electron system as a whole, and including a variety of special types.

electron specific heat. That part of the specific heat of a metal which is due to the free electrons; usually negligible compared with that due to the atomic lattice. It becomes significant at very low temperatures and, for ferromagnetic metals, near the Curie point. (See Slater, *Phys. Rev.* 50, 931, 1936.)

electron telescope. A device by means of which an infrared image of a distant object, focused upon a photosensitive cathode, gives rise to an enlarged electron image on a fluorescent screen. *Cf. electron optics.* (See Zworykin and Morton, *J.O.S.A.* 26, 181, 1936.)

electron tube. A vacuum tube in which the motion of electrons is especially important, *e.g.*, a thermionic, a photoelectric, or an x-ray tube.

electron-volt. A unit of energy, equal to about 1.591×10^{-12} erg, and defined as the change in energy experienced by 1 electronic charge on passing through a p.d. of 1 volt. Syn. *volt-electron, equivalent volt.* (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

electron wave. Syn. *de Broglie wave.*

electron wave length. The wave length associated with a moving electron. *Cf. de Broglie wave, de Broglie equation.*

electronic charge. Syn. *elementary charge.*

electronics. That branch of physical science which treats of electrons and of phenomena as explained in terms of them, *i.e.*, the electron theory; applied by some writers esp. to electronic vacuum-tube phenomena.

electronogen. A molecule or group of molecules which, according to the Kowalski theory of luminescence, emit electrons under the influence of light. *Cf. lumenophor.* (See Merritt, Nichols, and Child, Selected Topics in the Field of Luminescence (*National Research Council Bull.*), 1923, p. 12.)

electro-optical shutter. A device for controlling or cutting off a beam of light by means of the Kerr electro-optical effect. (See Abraham and Lemoine, *Compt. rend.* 129, 1899 and *J. de phys.* 9(3), 262, 1900; Beams, *R.S.I.* 1, 780, 1930.)

electro-osmosis, electrosmosis. The movement of liquids through membranes or capillary tubes under the influence of an e.m.f. Not to be confused with *electric osmosis.*

electrophoresis. The migration of particles or ions in a fluid under the influence of an electric field. *Cf. cataphoresis, photophoresis.*

electrophorus. An apparatus consisting of an electrified plate of some dielectric such as vulcanite, and, resting upon it, a metal disk provided with an insulating handle; used as a convenient means of generating, by induction, an indefinite succession of nearly equal electric charges. Devised by Volta (1816).

electrophotophoresis. *Cf. photophoresis.*

electroscope. Any one of several types of instrument for the detection of small charges of electricity. *Cf. electrometer.*

electrostatic analysis. 1. The separation of a stream of electrified particles by an electric field in accordance with their mass, their charge, or their speed, as in a mass spectrograph. The apparatus used for this purpose is called an *electrostatic analyzer. Cf. magnetic analysis.* (See Hughes and Rojansky, *Phys. Rev.* 34(2), 284, 1929; Smythe, *Phys. Rev.* 45, 299, 1934.) 2. In general, any process of separation or sorting by an electric field.

electrostatic generator. One of several recent designs of static machine, commonly employing endless belts of insulating material which discharge inside the hollow terminals. (See Van de Graaff, Compton, and Van Atta, *Phys. Rev.* 43, 149, 1933.)

electrostatic unit. Any electric unit based primarily upon the mutual dynamic interaction of electric charges. The fundamental c.g.s. unit in this system is the electrostatic unit charge which, if concentrated upon a small sphere, would repel a similar charge 1 cm distant in a vacuum with a force of 1 dyne.

electrostatics. That branch of physics which treats of the properties of electricity which do not depend upon its motion.

electrostriction. A deformation of a dielectric caused by subjecting it to an electric field.

elementary cell. Syn. *unit cell, unit crystal, lattice unit.* (See Davey, A Study of Crystal Structure and Its Applications, 1934, pp. 10 ff.)

elementary charge. The natural unit or quantum into which electric charges, positive or negative, appear to be subdivided. Its value has been found by electrical methods to be about 4.77×10^{-10} e.s.u.; x-ray and electron-wave data indicate a slightly higher value. Syn. *electronic charge. Cf. electron, positron, proton.*

elementary quantum of action. Syn. *Planck constant.*

elliptic polarization. Polarization in which the cycle is an ellipse. *Cf. polarization cycle.*

elongation. 1. Any increase in length. 2. The type of strain which accompanies tension, and which is measured by the ratio of the increase in length to the normal, unstressed length. 3. The radius vector of a body or a particle moving in an orbit.

emanation. A term applied by Rutherford to the gaseous radioactive products formed by the expulsion of an alpha particle from radium, from thorium X, or from actinium X; now inter-

nationally designated as *radon*, *thoron*, and *actinon*, respectively.

emission spectrum. The spectrum of a substance, as displaying the radiation which it emits; in contrast to the *absorption spectrum* (*q.v.*).

emissive power. The time rate of emission of radiant energy, in all directions, per unit surface area of a radiating body at a given temperature. The amount thus radiated within an infinitesimal wave-length range $d\lambda$ is $\epsilon_\lambda d\lambda$, in which ϵ_λ may be termed the *monochromatic emissive power*, as distinct from the *total emissive power* just defined. Syn. *intrinsic radiance*. *Cf. emissivity.* (See Richtmyer, Int. to Modern Phys., 1928, p. 179.)

emissivity. The ratio of the total emissive power of a surface to that of a black body at the same temperature. If confined to the radiation within an infinitesimal wave-length range, it may be called *monochromatic emissivity.* It varies somewhat with temperature. (See Richtmyer, Int. to Modern Phys., 1928, p. 186.)

emulsion. 1. The photographically sensitive coating which is applied to glass or celluloid in the preparation of photographic plates or films. 2. A colloidal solution, esp. one in which the suspended particles are an oily liquid.

enantiomorphic, enantiomorphous. *In re* two crystalline or molecular structures: having a bilateral symmetry with respect to each other, but incapable of being superposed; after the manner of a right and a left shoe.

enantiotropic. Occurring in two solid modifications, either of which is transformable into the other at a definite temperature. Syn. *monotropic.*

end correction. A modification of the computed frequency of an organ pipe or similar acoustic apparatus, necessary because of the effect of the open end.

end effect. A term similar in meaning to *edge effect*, except that it applies to an extremity or point instead of to an edge.

end product. The final, non-radioactive element of a radioactive series.

endosmosis. *Cf. osmosis.*

endothermic, endothermal. Involving the taking in of energy, esp. of heat energy, *e.g.*, the melting of ice.

energy. A physical entity, capable either of direct association with matter or (apparently) of independent existence. Energy is transferred from one body to another whenever the one does work on the other. This affords an expedient measure of energy, *viz.*, the quantity of work done in the process of transfer; work units are thus also commonly used as energy units. According to the relativity theory, matter and energy are interconvertible in the ratio c^2 absolute units of energy to 1 unit of mass (c being the electromagnetic constant).

energy band. *In re* a crystal: the set of energy values corresponding to the wave functions belonging to one or more of the Brillouin zones of the crystal. (See Slater, *Rev. Mod. Phys.* 6, 209, 1934;

Shockley, *Phys. Rev.* 51, 129, 1937.)

energy density. The quantity of energy per unit volume in a given region.

energy ellipsoid. An ellipsoid drawn with reference to a rigid body in free rotation (under no external torque) about a changing instantaneous axis, and used to illustrate the constancy of the rotational energy. Syn. *Poinsot ellipsoid.* (See Deimel, Mech. of the Gyroscope, 1929, p. 63; Brand, Vectorial Mech., 1930, p. 509.)

energy equation. 1. An equation which expresses the energy of a system in terms of variables defining its configuration. 2. An integral equation connecting the variables relating to the motion of a particle, which results from the solution of the differential equations expressing the components of force acting upon the particle. (See Prescott, Mech. of Particles and Rigid Bodies, 1929, p. 262.)

energy level. Syn. *quantum state.*

energy wall. Syn. *potential barrier.*

enhanced line. A spectral line, from a spark or other very hot source, whose intensity is out of proportion with that of other lines as compared with an arc or a flame spectrum. (See Allen, The Quantum and Its Interpretation, 1928, p. 82.)

ensemble. A group comprising a great number of independent systems, identical in nature but differing in their configuration and velocity, *e.g.*, the molecules of a pure gas.

enthalpy. A term applied by H. K. Onnes to the Gibbs function $\chi = u + pv$ and superseding *total heat, heat content,* and *heat of formation* (2). For a fluid system subject to no outside forces except a uniform, normal pressure, it is the thermodynamic potential for constant entropy and pressure. A process in which this quantity is constant is said to be *isenthalpic.* (See Eucken, Chemical Phys., German ed., 1930, p. 32; Roebuck, *Proc. Am. Acad. of Arts and Sci.* 64, 287, 1930.)

Entladungsstrahlen (Ger., "discharge rays"). A radiation from spark discharges, which produces marked ionizing and thermoluminescent effects and is absorbed by fluorite. When produced in air at atmospheric pressure, the wave-length range extends from 400 to 1000 Å, with shorter wave lengths at lower pressures. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 336; Laird, *Phys. Rev.* 33 (1), 512, 1911 and *J.O.S.A.* 13, 39, 1926.)

entrance-port. The image of the field stop of an optical system formed by the part of the system which is anterior to the field stop. If the field stop is in front of the system, it is identical with the entrance-port. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 406.)

entrance-pupil. A real or imaginary stop (usually circular) which controls the apertures of the bundles of incident rays in an optical instrument for a given position of the focal plane. The entrance-pupil of the eye is a little in front of the actual pupil.

entropy. A quantity introduced by Clausius. The entropy associated with an isolated physical system has the characteristic property that, as the system spontaneously settles into a final, steady state, the entropy approaches a maximum. It may be regarded as a measure of the degree in which the energy of the system is unavailable. *Cf. Boltzmann entropy hypothesis, available energy.*

entropy function. An expression for the entropy of a body as a function of the temperature. For a gas it takes the form of the Sackur equation (*q.v.*). (See Durand, *Phys. Rev.* 4(1), 343, 1897.)

Eötvös balance. A form of torsion balance especially designed for the detection and measurement of local irregularities in gravity.

Eötvös-Ramsey-Shields law. An empirical rule which states that the surface tension of a liquid is proportional to $T_c - T - 6°$, in which T is the absolute temperature of the liquid and T_c the absolute value of its critical temperature. (See Willows and Hatschek, Surface Tension and Surface Energy, 1923, p. 39.)

Epstein apparatus. A type of transformer used primarily for the measurement of core losses. Devised by J. Epstein (1911).

equally tempered scale. A musical scale having equal intervals, therefore with frequencies in geometrical progression. Introduced by Bach. Syn. *chromatic scale.*

equation of condition. An equation which must be rigorously fulfilled by a set of measured quantities, whatever other evidence may be available as to their values. *E.g.*, the sum of the three angles of a triangle is 180 deg, and any set of measurements upon them must be adjusted to meet that condition exactly. (See Weld, Theory of Errors and Least Squares, 1929, p. 91.)

equation of continuity. 1. An equation which, in physical analysis, expresses the fact that the rate at which the quantity of any conserved entity, *e.g.* matter, electricity, or energy, changes within any region is equal to the difference between the rates at which this entity enters and leaves that region. 2. An equation relating to the flow of a gaseous substance, which expresses the fact that the product of the cross section, the speed of flow, and the density remains constant. (See Page and Adams, Principles of Elec., 1931, p. 552; Mills, Int. to Thermodynamics, 1910, p. 105.)

equation of motion. An equation which gives information as to the motion of a body or of a point in space, in terms of suitable coordinates expressed as functions of the time.

equation of state. 1. An equation connecting the pressure p, the density ρ, and the temperature T of a fluid as any two or all of these quantities vary; *e.g.*, for an ideal gas it has the form

$$p/\rho T = \text{constant}.$$

2. In general, an equation connecting the variables chosen to specify the state of a substance.

equatorial quantum number. Syn. *magnetic quantum number.*

equilibrant. *In re* a system of forces: that single force, if such exists, which would, in co-opera-

tion with the given system, produce equilibrium. *Cf. resultant.*

equilibrium. 1. A condition of balance among the forces operating upon or within a physical system, such that no accelerated motions exist among the parts of the system. (But *cf. d' Alembert principle.*) The equilibrium is *stable* when a slight change in the configuration of the system gives rise to a condition tending to restore the original configuration (*cf. Le Chatelier principle, least-energy p.*); *unstable* when the change tends to increase; *neutral* when equilibrium persists regardless of the change. *Cf. stability.* 2. The mutual state of two or more simultaneous, continuous processes such that their net result is equivalent to a constant condition; *e.g.*, the evaporation and condensation at the surface between a liquid and its saturated vapor. *Cf. radioactive equilibrium, statistical e., thermal e., thermodynamic e., kinetic e.*

equilibrium curve. A graph representing the relation between values of two variables of state, as temperature and pressure, for which there is equilibrium between two states or phases. *E.g.*, the *fusion curve* follows the equilibrium between solid and liquid states; the *vaporization* or *saturation c.*, that between liquid and saturated vapor states; and the *sublimation c.*, that between solid and vapor states. Syn. *transformation c., phase diagram.*

equilibrium potential. The p. d. between an electrolyte and an electrode immersed in it, when they have come to equilibrium.

equimomental. *In re* two or more bodies: having equal mass and equal moments of inertia about corresponding axes. (See Prescott, Mech. of Particles and Rigid Bodies, 1929, p. 158.)

equipartition of energy. A principle, enumciated by Boltzmann, which states that the mean kinetic energy of the molecules of a gas is equally divided among the various degrees of freedom possessed by the molecules. The average molecular energy associated with any degree of freedom is one-half the product of the absolute temperature by the Boltzmann constant. Syn. *Maxwell-Boltzmann law.* (See Jauncey, Modern Phys., 1932, p. 468; Loeb, Kinetic Theory of Gases, 2d ed., pp. 83, 437.)

equipotential. Having the same value of the potential throughout. *E.g.*, a conductor in electrical equilibrium is electrically equipotential.

equivalence principle. 1. A principle of the general relativity theory which points out that phenomena ascribed to the existence of a gravitational field may with equal validity be attributed to the effect of acceleration; illustrated by the sensations which one experiences in an elevator. 2. *Equivalence principle of Pauli* is an obsolescent synonym for *exclusion principle.*

equivalent absorbing power. The thickness of any given absorbing material which will reduce the intensity of an emission in the same ratio as unit thickness of a standard substance (*e.g.*, air) under specified conditions. Not

to be confused with *equivalent absorption.* (See Hoag, Electron Phys., 1929, p. 107.)

equivalent absorption. *In re* any sound-absorbing object: the area of a surface of unit acoustic absorptivity which would absorb sound energy at the same rate as the given object under the same conditions. *Cf. sabin.* (See Acous. Soc. Comm. Rep., 1934.)

equivalent conductance. The ratio of the electric conductivity of an electrolytic solution to the concentration in mols per cm^3. (See Creighton and Fink, Prin. of Electrochem., 1928, p. 77.)

equivalent electrons. 1. (In atoms.) Electrons which have equal azimuthal quantum numbers and equal principal quantum numbers. 2. (In molecules.) Electrons which are identical in all orbital properties, except for a possible difference in sign of the orbital moment. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 322.)

equivalent paths. *Cf. optical path, o. length.*

equivalent weight. That weight or mass of an acid, base, or salt which equals 1 mol divided by the total number of valence bonds connecting the positive and the negative ions of the molecule. *E.g.*, for HCl the divisor is 1; for $Ca(OH)_2$ it is 2; for $Fe_2(SO_4)_3$ it is 6; etc.

erg. The absolute c.g.s. unit of energy and work, whose length and force factors are the centimeter and the dyne; *i.e.*, the *centimeter-dyne.*

erg-second. The c.g.s. absolute unit of action.

ergometer. An apparatus for measuring energy as it is transferred, *e.g.*, from one machine to another. It commonly takes the form of a friction brake and a speed indicator.

eriometer. An apparatus, due to Young, for measuring the diameters of very small objects by diffraction. (See Wood, Phys. Optics, 1929, p. 241.)

error equation. An equation expressing the probability of the occurrence of an error x:

$$p = \frac{h\Delta}{\sqrt{\pi}} e^{-h^2x^2}.$$

h is the precision index or measure of precision, Δ the error interval, *i.e.*, the smallest scale unit used in expressing the results of measurement and hence in expressing the errors. *Cf. Gaussian distribution.* (See Weld, Theory of Errors and Least Squares, 1929, p. 144.)

Esclangon effect. The deviation of a ray of reflected light, due to the motion of the mirror in a direction oblique to its surface. (See Carvallo, *Compt. rend.* 195, 769, 1932.)

étalon. A type of interferometer for producing interference effects by means of multiple reflection between fixed parallel, half-silvered glass plates. Devised by Fabry and Perot. (See Robertson, Int. to Phys. Optics, 1929, p. 194.)

ether, aether. A hypothetical medium, which has been supposed to pervade all space and all matter and assumed as the vehicle of propagation of light and other forms of radiation.

ether drift. A hypothetical relative motion of material bodies with

respect to the ether; much sought for but never detected with certainty. *Cf. Michelson-Morley experiment, Trouton-Noble e.*

Ettingshausen effect. A difference of temperature which develops between the two edges of a strip of metal, in which an electric current is flowing longitudinally, when the plane of the strip is set perpendicularly across a magnetic field. *Cf. Hall effect.* (See Campbell, Galvanomagnetic and Thermomagnetic Effects, 1923, chap. 9; Bridgman, Thermodynamics of Electrical Phenomena in Metals. 1934, chap. 7.)

Euler equations. Three differential equations of motion of a rigid body, referred to the principal axes through the c.m. as co-ordinate axes (X, Y, Z). They are:

$$I_x\frac{d\omega_x}{dt} - \omega_y\omega_z(I_y - I_z) = Q_x,$$

$$I_y\frac{d\omega_y}{dt} - \omega_z\omega_x(I_z - I_x) = Q_y,$$

$$I_z\frac{d\omega_z}{dt} - \omega_x\omega_y(I_x - I_y) = Q_z;$$

in which I is the moment of inertia, ω is the angular velocity component, and Q is the torque component, about the corresponding principal axis. (See Haas, Int. to Theoretical Phys., 1925, v. 1, p. 109.)

Euler formula. A formula for the load P which an elastic column of length l, sectional moment of inertia I, and Young modulus E, will sustain; *viz.*,

$$P = \frac{4\pi^2 EI}{l^2}.$$

(See Greene, Structural Mech., 1911, p. 142.)

eutectic. *In re* a mixture or a solution: in such proportions that all ingredients solidify or liquefy at the same temperature; which is also the minimum solidification temperature for all mixtures of these same substances. *Cf. dystectic, eutectoid.* (See Couch, Dict. of Chem. Terms, 1920.)

eutectoid. Similar to *eutectic*, except that it has reference to a solid solution, which resolves into separate components while in the solid state. Certain kinds of steel have this property.

Eve constant. The number of ions produced per cm^3 per sec in air at N.T.P., at a distance of 1 cm from a source of radium C in equilibrium with 1 curie of radon. Its value is approximately 3.56×10^9. (See Eve, *Phil. Mag.* 22(6), 551, 1911.)

even (or odd) term. A spectral term arising from one, two, three, . . . , nuclear electrons, the sum of whose respective azimuthal quantum numbers, l_1, l_2, l_3, . . . , is an even (or odd) number. (See White, Int. to Atomic Spectra, 1934, p. 187.)

exchange. 1. The equalization of temperature among neighboring bodies through mutual radiation, as first pointed out by Prevost (1792). 2. An interaction between electrons, protons, alpha particles, etc., in the same or in different atoms; hence the terms *exchange energy, e. force*, etc. *Cf. Majorana forces, Heisenberg f.*

excitation function. 1. The probability of excitation of a spectrum line due to electron impact, expressed as a function of the energy of the electron. 2. A function which expresses the cor-

rection necessary in comparing calculated and observed spectral line intensities, because of the unequal numbers of atoms or molecules in the different excited states. *Cf. Boltzmann factor.* 3. An expression for the probability that an atomic nucleus will be rendered radioactive by the impact of a rapidly moving particle, in terms of the particle energy or other factors.

excitation limit. The least value of the quantum energy of an incident, exciting electron which is capable of producing lines of a given spectral series.

excitation potential. The critical potential for the excitation of a given radiation, either a line or a group of lines.

excitation probability. *In re* the excitation of a gas by electronic impact: the number of excited atoms produced per unit electron current, per unit path length, per unit pressure at 0°C. (See Brode, *Rev. Mod. Phys.* 5, 257, 1933.)

excitation wave. A term used by Frenkel to characterize the process of absorption of radiation in a crystalline solid and its transformation into heat by the excitation of the atoms. (See Frenkel, *Phys. Rev.* 37, 17, 1931.)

excite. 1. To bring (an atom or a molecule) to a higher quantum state than its normal or ground state of lowest energy; as by heating, by radiation, or by electron impact. 2. To magnetize, as by a current.

exclusion principle. States that no two electrons in the same atomic or molecular system can have all their quantum numbers identical; discovered by Pauli. *Cf. equivalence principle* (2). (See Darwin, New Conceptions of Matter, 1932, p. 196; Condon and Mack, *Phys. Rev.* 35(2), 579, 1930.)

exhaustion. *In re* the potential energy of a material system: the quantity of work which would be required to effect the separation of the bodies or particles to infinite distances apart; a term due to Kelvin. (See MacMillan, Theory of the Potential, 1930, p. 136.)

exit-port. The image of the entrance-port of an optical system; or the image of the field stop as formed by the part of the system which is posterior to the field stop. If the field stop is behind the entire lens system, it is identical with the exit-port. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 409.)

exit-pupil. The image of the entrance-pupil of an optical instrument. It determines the apertures of the bundles of emergent rays. The exit-pupil of the eye is a little behind the actual pupil.

exosmosis. *Cf. osmosis.*

exothermic, exothermal. Involving the giving out of energy, esp. of heat energy; *e.g.*, the condensation of steam. *Cf. endothermic.*

expanding universe. Refers to the fact that the mean distance between the bodies of the universe is apparently increasing; the rate of recession of the more remote visible galaxies, as indicated by the red shift, being several thousand miles per second.

expansion chamber. Syn. *cloud chamber.*

expansion coefficient. A measure of the rate of expansion of a substance with temperature; usually defined as the ratio of the temperature rate of the change in length (or area, or volume) to the length (or area, or volume) at a chosen reference temperature or zero. Thus:

$$C = \frac{\Delta l}{\Delta t \cdot l_0}.$$

Linear, *superficial*, and *volume* or *cubical coefficients* are thus similarly defined. Syn. *expansivity.*

exploring coil. A small coil which may be moved about within a magnetic field in order to test the magnetic intensity at various points by electromagnetic induction. *Cf. flip coil.*

explosion spectrum. The spectrum of the light produced by an explosive reaction or by electrically "exploding" a metallic wire or filament by a heavy current.

exposure. A measure of photographic stimulus, defined as the product of the illumination by the exposure time; usually expressed in meter-candle-seconds.

extension-in-phase. Syn. *phase space.*

extensometer, extensimeter. An instrument for measuring small changes in length, such as those produced by tension or in magnetostriction. (See Williams, Magnetic Phenomena, 1930, p. 106.)

external resistance. The resistance of that part of a circuit in which no e.m.f. is operative, *e.g.*, the line connected between the terminals of a battery or other generator. *Cf. internal resistance.* (See A.I.E.E. Comm. Rep., 1932.)

external work. Work done by a system against external forces, or upon the system by external forces, *e.g.*, work done in compressing a gas, or by a gas during expansion against a piston. *Cf. internal work.*

extinction. 1. The decrease of intensity in radiation due to both absorption and scattering by the medium traversed. 2. Specifically, the shielding of inner layers of atoms in a crystal from incident x-rays by the outer layers. (See Wollan, *Rev. Mod. Phys.* 4, 208, 1932.)

extinction coefficient. *In re* any type of radiation traversing a material medium: the absorption coefficient plus the scattering coefficient. Syn. *total absorption coefficient.*

extinction photometer. A photometer in which the luminous intensity of a source of light is judged by the thickness of a given absorbing material necessary to render it invisible. (See Walsh, Photometry, 1926, p. 2.)

extraction energy. The energy corresponding to an ionizing potential. (See Darrow, Electrical Phenomena in Gases, 1932, p. 165.)

extraordinary. Pertaining to that plane-polarized component of a ray of light which, in traversing a doubly refracting crystal, has its electric vector in the principal plane. So named because this component has different speeds in different directions. *Cf. double refraction, ordinary.*

extraordinary index. The refractive index for the extraordinary ray in

a uniaxial crystal; defined as the ratio of the velocity of the light outside the crystal to that of the extraordinary component within the crystal in any direction perpendicular to the optic axis (in which its value differs most from the index for the ordinary component).

extrapolate. To estimate the value of a function for values of the variable lying outside the range in which values of the function are known; as by extending the graph of the function beyond the actually plotted points. *Cf. interpolate.*

eyepiece. That part of an optical instrument, as a telescope or a microscope, to which the eye is applied. Syn. *ocular.*

eyepiece micrometer. A finely divided scale ruled or photographed on a slip of transparent glass and placed in the focal plane of the eyepiece of a microscope, for the purpose of measuring the dimensions of objects viewed with the instrument.

F

(Please note purpose of references as explained in preface.)

f-electron. An orbital electron whose energy state is denoted by the azimuthal quantum number 3. *Cf. F-state.*

F-state, F-level. The state of an atom in which the azimuthal quantum number is 3. *Cf. S-, P-, D-states.*

f-value. The atom form factor, taken with reference to the center of the atom. *Cf. F-value.*

F-value. A symbol used by some writers for the atom form factor taken with reference to the lattice point corresponding to the atom, rather than to the center of the atom itself. *Cf. f-value.*

Fabry-Perot interferometer. A multiple-reflection instrument of very high resolving power, simpler than the Michelson type. It resembles an étalon, but with the distance between the plates variable by means of a micrometer screw.

face-centered. *In re* a unit cell of crystal structure: having an atom at the center of each face.

Fajans and Soddy laws. The radioactive "displacement laws," which state that, upon the disintegration of a radioactive atom, (1) the emission of an alpha particle results in a new radioactive element with atomic number 2 units less, and (2) the emission of a beta particle results in a new element with atomic number 1 unit more, than the disintegrating atom. (See Darrow, Int. to Contemporary Physics, 1926, p. 68.)

far point. That point on the axis of the eye which is at such distance as to be seen distinctly when the accommodation is completely relaxed, *i.e.*, when the focal power of the crystalline lens is least. *Cf. near point.* (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 434.)

farad. A unit of capacitance corresponding to 1 coulomb per volt and equal to 10^{-9} abf; named from Faraday. A more convenient unit is the *microfarad*, or 10^{-6} f.

farad bridge. A capacitance bridge arranged to read capacitances directly in microfarads.

faraday. Syn. *Faraday electrolytic constant.* Objectionable because of its resemblance to *farad.* (See I.C.T., 1926, v. 1, p. 36.)

Faraday constant. *Cf. Faraday electrolytic constant.*

Faraday cylinder, F. collector. A hollow, insulated metal cylinder, nearly closed, and placed so as to catch charged particles, the whole charge of which then appears upon its surface. *Cf. Faraday ice pail.*

Faraday dark space. The nonluminous region separating the negative glow from the positive column in a Crookes tube at moderate pressure. (See Darrow, Electrical Phenomena in Gases, 1932, p. 389.)

Faraday effect. A magneto-optical phenomenon, *viz.*, the rotation of the polarization plane of polarized light by an otherwise isotropic medium subjected to a magnetic field coincident in direction with the beam of light; discovered in 1845. Syn. *magnetic rotation, magneto-optical r. Cf. Verdet constant, Kundt c., magnetic rotation spectrum.* (See Wood, Phys. Optics, 1929, p. 696.)

Faraday electrolytic constant. The quantity of electricity which, in electrolysis, is required to liberate a gram atom of any univalent element; *viz.*, approximately 96,494 international coulombs per gram equivalent. Syn. *Faraday electrochemical constant.* (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

Faraday ice pail. A hollow, closed or nearly closed, insulated metal receptacle, used to demonstrate that when a charge is communicated to the inside of a hollow conductor it appears on the outside. (Faraday originally used a tin ice pail for this purpose.)

Faraday laws. Two laws of electrolysis, which state: 1. That the mass of any substance liberated by electrolytic action is in proportion to the quantity of electricity passing through the cell. 2. The masses of different substances liberated upon the electrolytic conduction of equal quantities of electricity are in proportion to the combining equivalents of those substances. Also: 3. The law of magnetoelectric induction, *viz.*, the e.m.f. induced in a circuit by the variation of the magnetic linkage with that circuit is proportional to the rate of variation of the linkage.

Faraday tube. Syn. *tube of force.*

fathometer. An instrument devised by H. G. Dorsey for supersonic ocean sounding. A neon tube, which rotates as an index around a circular dial, indicates the depth directly in fathoms by flashing upon the arrival of the echo.

fatigue. The gradual decrease of some characteristic property due to external causes; *e.g.*, of the photoelectric sensitivity of certain surfaces upon prolonged exposure to light.

fatigue strength, f. limit. The range of stress to which an elastic material may be subjected a

stated number of times in succession without fracture. (See I.C.T., 1926, v. 2, p. xii.)

fault. An interruption in the continuity or a defect in the insulation of an electrical conductor, such as a telephone line or a cable.

Fedorov co-ordinates. The distances, measured along the Cartesian co-ordinate axes (not necessarily rectangular) to the projections of the given point in space upon those axes. If the axes are rectangular, these co-ordinates are identical with the Cartesian co-ordinates, otherwise not. Used in crystallography. (See Wyckoff, Structure of Crystals, 1924, p. 53.)

feedback. An arrangement of a radio receiving apparatus in which the plate circuit of the detector tube is coupled to the grid circuit of the same tube, thus rendering it regenerative and very sensitive.

Fermat principle, F. law. A principle, announced by Fermat about 1665, which states that when light passes from a point A to another point B, the time required for its passage is either a maximum or a minimum with respect to other adjacent, arbitrary paths. For points in two homogeneous media separated by a plane surface, or for reflection in a single homogeneous medium by a plane surface, the time is a minimum, in which case the law is commonly known as the *principle of least time.* (See Wood, Phys. Optics, 1929, p. 72.)

Fermi-Dirac statistics. Differs from the Bose-Einstein statistics (*q.v.*) in that it imposes a specified upper limit to the number of molecules or quanta which may be contained in any one elementary compartment of the momentum space. (See Darrow, *Rev. Mod. Phys.* 1, 90, 1929.)

Fermi-Thomas distribution, F.-T. field. The approximate theoretical distribution of the electric potential within and about an atom, based upon certain physical and statistical assumptions. If the local density matrix is represented by plane waves, it is the closest approximation to this potential; otherwise Hartree's self-consistent field is closer. (See Fermi, *Zeits. f. Phys.* 49, 550, 1928.)

ferromagnetic. A term used to characterize substances which have, at ordinary temperatures, a combination of magnetic properties including the following: their susceptibility is positive as in paramagnetic substances; but they exhibit appreciable remanence and hysteresis; the magnetization has a measurable saturation limit, ordinarily far in excess of any magnetization attainable by paramagnetic substances; and even when unmagnetized they appear to have small regions (domains) throughout each of which there is definite magnetization. Iron, nickel, cobalt, gadolinium, and many alloys are ferromagnetic. *Cf. Heusler alloys.* (See Darrow, *Bell Syst. Tech. J.* 6, 295, 1927; 15, 224, 1936.)

Fick law. Expresses the rate of diffusion of a substance in solution as follows:

$$\frac{dm}{dt} = -Ds\frac{dC}{dx};$$

in which m is the mass diffused in

time t through cross section s normal to the direction x, C is the concentration, and D is the diffusion coefficient.

fictitious charge, fictive c. A term used to characterize the phenomena exhibited by a dielectric in an electric field, in contradistinction to the "true" induced charges on a conductor under the same conditions.

field. 1. A region under the influence of some physical agency, *e.g.*, gravitation, magnetism, etc. *Cf. wave field.* 2. Syn. *field intensity.* 3. The area or solid angle visible through an optical instrument.

field coil. One of the coils used to excite a field magnet.

field emission, f. current. The emission of electrons resulting from the application of intense electric fields. Syn. *autoelectronic emission, cold emission.* (See Koller, Phys. of Electron Tubes, 1934, p. 13.)

field equation. One of the equations which specify the properties of a field of force; *e.g.*, the Maxwell equations for the electromagnetic field.

field intensity. A vector denoting the magnitude and the direction, at any point, of an influence distributed through a field. *Cf. electric intensity, magnetici.* Often abbreviated to "field."

field lens. The anterior of the two lenses of the ocular of a telescope or a microscope, the effect of which is to enlarge the field of view. (See Edser, Light, 1928, p. 204.)

field magnet. A magnet used to produce a magnetic field in some selected region, as in a motor or a generator.

field stop. An opening, usually circular, in an opaque screen, which determines the field of view of an optical instrument. *Cf. entrance-port, exit-port.*

figure of merit. *In re* a galvanometer: that current which will produce a deflection of one scale division.

filar micrometer. A micrometer, the screw of which moves a fine wire or filament across the focal plane of a microscope or a telescope, and which can thus be used to measure the size of, or the angle subtended by, the object under examination.

filiation capacity. A quantity used by Fournier to define any given species of radioactive atom completely, and equal to three-fourths of the atomic weight minus the atomic number. Its value decreases by unity upon the emission of either an alpha or a beta particle. (See Fournier, *Compt. rend.* 188, 1553, 1929 and *J. de phys. et le radium* 7(1), 194, 1930.)

filter. 1. Any device which separates one or more of the ingredients of a mixture from the others. In particular: 2. (*Radiation.*) A selectively transparent body, which transmits only certain wave-length ranges. 3. (*Electric.*) A portion of a h.-f. circuit, which, by means of suitable inductances and capacitances, suppresses certain frequencies in a complex electric wave. 4. (*Acoustic.*) A device which acts on a sound in a manner analogous to

an electric wave filter, by cutting out certain frequencies.

fine quantum number. The quantum number associated with the quantization of the resultant of nuclear and extranuclear angular momenta. Its name arises from its relation to hyperfine structure. Syn. *hyperfine quantum number.* (See Pauling and Goudsmit, Structure of Line Spectra, 1930, p. 204.)

fine structure. Refers to the occurrence of spectral lines as doublets, triplets, etc. *Cf. multiplet, hyperfine structure.*

fine-structure constant. The quantity $2\pi e^2/ch$, in which e is the electronic charge, c the electromagnetic constant, h the Planck constant. The dimensions of these factors are such that the fine-structure constant is abstract. Its value is about 7.283×10^{-3} or $1/137$. It plays a fundamental role in quantum theory and spectroscopy. *Cf. Lewis-Adams relation.* (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

first (second, etc.) spark spectrum. The spectrum of a singly (doubly, etc.) ionized element.

fish tracks. Short cloud tracks terminating in a collection of droplets, attributed by Wilson to the scattering of x-ray quanta. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 229.)

Fitzgerald-Lorentz contraction. *Cf. Lorentz-Fitzgerald contraction.*

fixation. The act of orienting the eye so that a given point of the retinal image falls upon that point of the retina at which it may be most distinctly seen. The corresponding point of the actual object is the *fixation point.*

flaming arc, flame a. An electric arc produced between carbons which have been impregnated with chemical salts.

flashometer. An apparatus for studing the time-intensity distribution of flashes of light. (See Brachman and Kendall, *R.S.I.* 2, 111, 1931; Forsythe and Earley, *ibid.*, p. 638.)

Fleming-Kennelly law. States that the reluctivity of a ferromagnetic material is a linear function of the magnetic intensity, as magnetic saturation is approached. Equivalent to the relation expressed by the Frölich equation. (See Fleming, *Trans. A.I.E.E.* 3, 569, 1886; Kennelly, *ibid.*, 8, 485, 1891.)

flexural moment, f. torque. Syn. *bending moment.*

flexure. A strain in which particles or points, normally in a straight line, are displaced into a plane curve, called the *curve of flexure* or the *elastic line.*

flicker. The sensation produced by a fluctuation in brightness at a rate comparable to the reciprocal of the period of persistence of vision.

flicker effect. A variation in plate current in a radio tube, due to variations in the surface condition of the filament. *Cf. shot effect.* (See Hoag, Electron Phys., 1929, p. 19.)

flicker photometer. A photometer in which the matching of illuminations is determined by the absence of flicker when one is rapidly sub-

stituted for the other in the field of view.

flip coil. A coil which may be suddenly rotated through 180 deg in a magnetic field; the resulting current surge, measured by a ballistic galvanometer, indicates the intensity of the field. *Cf. earth inductor.* (See Smythe and Michels, Advanced Elec. Meas., 1932, p. 98.)

floating electromotive force. The e.m.f. supplied by a storage battery placed across a d.-c. power line usually near the far end, which automatically adjusts the voltage to a varying load. The battery discharges on heavy load and recharges when the load is light.

flotation plane. The plane of the level surface of the liquid in which a body floats.

fluidity coefficient. The reciprocal of the viscosity coefficient. (See I.C.T., 1926, v. 1, p. 36.)

fluorescence. A type of luminescence, characterized by the fact that it is observable only so long as the stimulus responsible for it is maintained.

fluorogen. A substance which promotes the fluorescence of another when mixed with it. Syn. *activator.* (See Couch, Dict. of Chem. Terms, 1920.)

fluorometer. 1. An instrument for the measurement of fluorescence. (See Duschinksy, *Zeits. f. Phys.* 81, 7, 1933.) 2. An apparatus for photometric measurements in the ultraviolet by means of the fluorescence produced by it; devised by Winther. (See Luckiesh, Ultraviolet Radiation, 1922, p. 188.)

fluoroscope. An instrument provided with a suitably mounted fluorescent screen, and used for detecting and studying x-rays or other emissions capable of exciting it.

flux. 1. A term used in connection with fields of force, the flow of fluids, various types of emission, etc., and designating in general the surface integral of normal field intensity, or the quantity of fluid or of emitted energy per unit time, over a specified area. *Cf. magnetic flux, electric f., luminous f., radiant f., sound-energy f.* 2. A substance used to facilitate the fusion of a metal and to protect it from oxidation while in the fused state.

flux density. 1. (*Magnetic.*) Syn. *magnetic induction.* 2. (*Electric.*) Syn. *electric intensity.* (See A.I.E.E. Comm. Rep., 1932.) 3. (Of an emission.) The flux through unit area of a surface normal to the direction of propagation; or, for a diffuse emission, the flux per unit solid angle per unit area normal to a specified direction. Syn. *intensity.*

flux refraction. A change in the direction of the magnetic induction at the interface between two media of different permeability, or of the electric displacement at the interface between two dielectrics of different dielectric constant. (See Karapetoff, The Electric Circuit, 1912, p. 29.)

fluxmeter. A ballistic galvanometer having negligible mechanical control of the position of the moving system; used primarily in conjunction with a suitable explor-

ing coil for the measurement of magnetic flux.

flux-turns. Syn. *linkage* (2), *turn-flux.*

focal collimator. A type of collimator consisting of an objective lens at one end of a tube and a pair of cross hairs placed accurately in its focal plane at the other end.

focal length. The distance of either of the two principal points of a symmetrical optical system from the corresponding focal point.

focal line. One of the two very short lines in the principal sections, *i.e.*, sections made by the principal planes, of a narrow astigmatic bundle of light rays; characterized by the fact that (according to Sturm) all of the rays intersect these two lines. Syn. *image-line.* (See Percival, Geometrical Optics, 1913, p. 31.)

focal plane. The plane passing through either focal point of an optical system, perpendicular to the axis of the system.

focal point. *In re* a symmetrical optical system: one of the two points on the axis which are conjugate to the axial points at infinity in opposite directions. An incident pencil of paraxial rays through the *first focal point* emerges as a cylindrical bundle, while an incident cylindrical bundle emerges as a pencil through the *second focal point.* These points may be real or virtual. Syn. *principal focus.*

focal power. *In re* a symmetrical optical system: a measure of the effect of the system upon the focus of a pencil of rays traversing it. If the rays are incident in air, the focal power is the reciprocal of the focal length for rays coming from the given direction; in general, it is the product of this reciprocal by the refractive index of the medium. *Cf. diopter.*

focal spot. The small area of an x-ray tube target upon which the cathode rays are concentrated and from which the x-rays proceed. Syn. *anode spot, cathode s.*

focometer. An instrument for measuring the focal length of a lens or of an optical system. (See Martin, Optical Meas. Instr., 1924, p. 188.)

fog chamber. Syn. *cloud chamber.*

foot-candle. A unit of illumination, equal to 1 lumen per ft^2; or, the illumination of a surface at a uniform distance of 1 ft from a symmetrical point source of 1 candle.

foot-lambert. A unit of brightness equal to the average brightness of any surface emitting or reflecting light at the rate of 1 lumen per ft^2, or the uniform brightness of a perfectly diffusing surface emitting or reflecting light at that rate. *Cf. lambert.*

foot-pound. A practical English unit of energy and work, whose length and force factors are the foot and the pound, respectively.

foot-poundal. A seldom-used absolute English unit of energy and work, whose length and force factors are the foot and the poundal, respectively.

forbidden. A term applied to certain intra-atomic phenomena which, while they might be looked for in accordance with the general rules, apparently never or very

rarely occur; *e.g.*, some electron transitions and corresponding spectral lines. *Cf. selection principle, quadrupole lines.*

force de cheval (Fr.). A metric gravitational unit of power, equal to 75 m-kg of work per second, and equivalent to about 736 watts or 0.9863 hp. Syn. *metric horsepower.*

force polygon. *Cf. vector polygon.*

forced double refraction. Double refraction produced in an otherwise isotropic medium as a result of strain. *Cf. photoelastic.* (See Herzfeld and Lee, *Phys. Rev.* 44, 625, 1933.)

forced vibration. A nonresonant vibration imposed upon a body or a system by some external agency, by which the frequency is also controlled. *Cf. covibration.*

fore pump. An auxiliary air pump, used to create a partial vacuum, preliminary to the operation of another, more effective air pump. Syn. *backing pump.*

form. A group of plane-families which, although represented by different permutations of the same Miller indices, are crystallographically indistinguishable. *E.g.*, in a cubic crystal, the [110] form is composed of the plane-families (110), (101), (011), $(\bar{1}10)$, $(1\bar{1}0)$, and $(0\bar{1}1)$.

form factor. 1. *In re* a periodic quantity, as an alternating e.m.f.: the ratio of the effective value to the average value during a half-cycle. For a pure harmonic the form factor is about 1.11, but it varies according to the wave form. (See A.I.E.E. Comm. Rep., 1932.) *Cf. atom form factor.* 2. *Cf. multiplicity factor.*

Fortrat diagram. A parabolic diagram by means of which the component lines of molecular bands may be represented graphically. (See Page, Int. to Theoretical Phys., 1928, p. 580.)

Foucault pendulum. A pendulum consisting of a very heavy mass suspended by a very long wire, the plane of vibration of which appears to change gradually owing to the rotation of the earth; as first demonstrated by Foucault in 1851 at Paris.

four-dimensional analysis. The space-time analysis of Minkowski.

Fourier integral. A double definite integral which constitutes a limiting case of the Fourier series, and the form of which is

$$f(x) = \frac{1}{\pi}\int_{-\infty}^{+\infty} f(r)dr \int_{0}^{+\infty} \cos s(r - x)ds.$$

(See Byerly, Fourier's Series and Spherical Harmonics.)

Fourier series. A series of the form

$$f(x) = a_0 + a_1 \sin\frac{2\pi x}{l} + a_2 \sin\frac{4\pi x}{l} + a_3 \sin\frac{6\pi x}{l} + \cdots + b_1 \cos\frac{2\pi x}{l} + b_2 \cos\frac{4\pi x}{l} + b_3 \cos\frac{6\pi x}{l} + \cdots;$$

in which the coefficients have the values

$$a_0 = \frac{1}{l}\int_0^l f(x)dx,$$

$$a_n = \frac{2}{l}\int_0^l f(x) \sin\frac{2\pi nx}{l}dx,$$

$$b_n = \frac{2}{l}\int_0^l f(x) \cos\frac{2\pi nx}{l}dx.$$

In series representing a physical function, these coefficients may

be obtained from the results of experiment. *Cf. Fourier integral.* (See Byerly, Fourier's Series and Spherical Harmonics.)

Fourier theorem. States that any finite, periodic motion may be analyzed into components, each of which is a simple harmonic motion of definite and determinate amplitude and phase.

fraction of saturation. The ratio of the actual pressure of a vapor to the maximum, or saturated, vapor pressure at the same temperature. *Cf. humidity.*

frame of reference. A set of points, lines, or planes used as a system of reference for defining space co-ordinates.

Franck-Condon principle. A theoretical interpretation of the relative intensity of spectral bands of a given system on the basis of electronic transitions within the molecule, and the vibrations which result from them. (See Condon, *Phys. Rev.* 28(2), 1182, 1926.)

Fraunhofer lines. The dark absorption lines of the solar spectrum, the more prominent of which were first studied by Fraunhofer in 1814 and designated by letters *A*, *B*, . . . , *H*. *Cf. D lines.*

free electron. An electron within a substance but not permanently attached to any one atom and not restricted by potential gradients within the substance.

free energy. 1. That part of the thermodynamic potential of a system which is internal, *i.e.*, the thermodynamic potential at constant volume. It is expressed by the Gibbs ψ function (*cf. Gibbs functions*). The term is due to Helmholtz. (See MacDougall, Thermodynamics and Chem., pp. 109 ff.) 2. Syn. *available energy.* (Rare.)

free magnetism. 1. The magnetic flux through an area of the surface of a body bounded by that closed line for which this flux is a maximum. On a magnet this line is the magnetic equator; in an electric circuit it is the outermost current streamline. 2. The pole strength corresponding to (1).

free-piston gauge. A gauge for high pressures, in which the unknown pressure is applied to a small piston, the resulting force being small enough to be conveniently measured. (See Bridgman, Phys. of High Pressure, 1931, pp. 61 ff.)

freezing-point law. States that the freezing point of any solvent is lowered below its normal value by an amount proportional to the quantity of solute present; and that the constant for any solvent is the same for all solutes, provided the concentration is expressed in mols per unit volume. Ascribed to Blagden (1788). *Cf. boiling-point law.*

frequency. 1. The number of occurrences of a periodic process per unit time. 2. The number of values of a statistical variable which lie within a specified range. *Cf. distribution function.*

frequency bridge. An arrangement resembling a Wheatstone bridge, and used for the measurement of a.-c. frequencies.

frequency condition. The condition upon which an atom or a molecule may emit radiation of given frequency; *viz.*, it must

undergo a change of energy equal to that frequency multiplied by the Planck constant h.

frequency distribution. *Cf. frequency* (2), *distribution function.*

frequency level. The logarithm to the base 2 of the tone interval between a given musical frequency and a specified keynote or reference frequency. For an interval of one octave, the frequency level is unity. (See Acous. Soc. Comm. Rep., 1934.)

frequency meter. Any instrument for measuring the frequency of an a.c. or of electric oscillations. *Cf. wave meter.*

frequency ratio. The ratio of the frequency impressed upon a vibrating system (as a circuit) to the natural or resonant frequency of the system. For perfect resonance, the ratio is unity.

fresnel. A unit of frequency, equal to 10^{12} cycles per second. (See Walsh, Photometry, 1926, p. 45.)

Fresnel coefficient of drag. The ratio, according to Fresnel, of the velocity of the ether in a moving transparent medium to the velocity of the medium itself; supposed to have the value $1 - \frac{1}{n^2}$, where n is the refractive index of the medium.

Fresnel formula. An expression for the loss of light perpendicularly incident at an interface between two transparent media. If the relative refractive index is n, the fractional loss is

$$\left(\frac{n-1}{n+1}\right)^2.$$

Fresnel mirrors. A pair of mirrors placed side by side at a very obtuse angle, so that they produce two adjacent images of a point or line source of light from which interference bands may be formed.

Fresnel rhomb. A rhombic glass prism, so shaped that a ray of plane-polarized light entering by one face emerges from the opposite face after two internal reflections, and is thereby elliptically polarized.

Fresnel zone. Syn. *half-period element.*

friction coefficient. The ratio of the tangential force of sliding friction between two surfaces to the force, normal to the surfaces, which presses them together. It depends upon the nature of the two surfaces, and is in general greater for static than for kinetic friction. *Cf. angle of friction.*

friction factor. A coefficient by which a dynamic quantity, calculated without reference to friction, must be multiplied in order to correct for friction.

fringe. A band or stripe of maximum or minimum illumination, due to interference or diffraction.

Frölich equation. An empirical formula for the magnetic induction in terms of magnetic intensity H:

$$B = \frac{H}{a + bH},$$

in which a and b are constants. Approximately valid as saturation is approached. *Cf. Fleming-Kennelly law.*

fugacity. A term employed in thermodynamics to denote quantitatively the tendency of a substance to escape or to disappear by some

chemical process from the phase in which it is. The ratio of the fugacities of a substance in two different phases may be measured by the excess of free energy per mol in the one phase over that in the other. (See Lewis, *Proc. Am. Acad.* 37, 49, 1901; Lewis and Randall, Thermodynamics, 1923, chap. 17.)

fugitive elasticity. Maxwell's conception of viscosity as the limiting case of elasticity, in substances just breaking down under shear and beginning to flow. (See Newman and Searle, General Properties of Matter, 1929, p. 200.)

Fulcher bands. The first known regularities in the spectrum of the hydrogen molecule, discovered by G. S. Fulcher in 1912. (See Fulcher, *Phys. Zeits.* 13, 1137, 1912; Dieke and Blue, *Phys. Rev.* 47, 261, 1935.)

fundamental. 1. (n.) The simple harmonic component of a composite vibration or musical tone which has the lowest frequency. *Cf. overtone.* 2. (adj.) Sometimes used in connection with three-phase equilibrium; *e.g., fundamental point,* syn. *triple point,* etc. (See Planck, Treatise on Thermodynamics, 1927, p. 161.) 3. *Cf. spectral series.*

funicular. Pertaining to, or made up of, rope or cord under tension; *e.g.,* a funicular polygon.

fusion curve. *Cf. equilibrium curve.*

G

(Please note purpose of references as explained in preface.)

g-factor, g-value. *Cf. interval rule.*

Galilean telescope. A form of telescope, devised originally by Lippershey (Holland) and improved by Galileo, which has a divergent lens for ocular and in which no real image is formed. Now used in the opera glass. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 456.)

Galitzin pendulum. A type of seismograph, the essential feature of which is a heavy pendulum with its axis of rotation almost vertical.

Galton pipe. A small whistle with an adjustable resonance chamber, for producing very high pitches of known frequency. (See I.C.T., 1926, v. 6, p. 456.)

galvanoluminescence. The property, exhibited by the anode in certain electrolytic cells, of emitting a feeble glow when the cell is in operation. (See Sullivan, *J.O.S.A.* 21, 513, 1931.)

galvanomagnetic. Pertaining to the influence of a magnetic field upon the movements of electricity within a conductor, *e.g.,* as in the Hall effect. *Cf. transverse effects.* (See Campbell, Galvanomagnetic and Thermomagnetic Effects, 1923.)

galvanometer. One of a variety of instruments, whose function is to indicate and measure relatively small electric currents, usually in terms of an arbitrary scale. *Cf. ammeter, milliammeter.*

gamma. A unit of magnetic intensity, *viz.,* 10^{-5} oersted; used for very weak fields, such as those

superposed on the terrestrial field by local or transient causes.

gamma rays. A component of the emission from radioactive substances, thought to be electromagnetic radiation of very short wave length (*viz.*, of the order of 10^{-8} mm) and of nuclear origin. A distinction is recognized between true gamma rays and the x-rays produced by the readjustments of extranuclear electrons disturbed by alpha, beta, and gamma rays from the nucleus.

gamma value. Syn. *interval factor.*

gas. Matter in which the cohesion is so negligibly small that it will diffuse throughout any enclosure in which it is placed; specifically, when the substance is at a temperature above its critical temperature. *Cf. vapor.*

gas constant. *Cf. ideal gas constant.*

gas thermometer. A thermometer the indications of which depend upon changes in the pressure or the volume of an enclosed gas.

gauss. 1. The practical c.g.s. electromagnetic unit of magnetic induction (by international agreement in 1932). 2. Prior to 1932, the practical c.g.s. electromagnetic unit of magnetic intensity, now called *oersted.* The term is still frequently used in this sense. If magnetic induction and magnetic intensity are taken as having the same dimensions, both are consistently expressed in gausses. If a linear conductor moves laterally with a speed of 1 cm/sec across a region in which the magnetic induction (or intensity) is 1 gauss, and at right angles to the direction of the induction (or intensity) vector, an e.m.f. of 1 abvolt is produced in each centimeter of length thereof. 3. The c.g.s. electromagnetic unit of magnetomotive force. (Rare.) *Cf. gilbert.*

Gauss theorem. States that the surface integral of the normal component of the gravitational field due to any distribution of matter, taken over any closed surface, is equal to $4\pi G$ times the mass of that portion of the distribution which lies within the closed surface, and is independent of that which lies without. G denotes the gravitation constant. Analogous propositions may be stated in reference to electrical and magnetic fields. (See Page, Int. to Theoretical Phys., 1928, p. 29.)

Gaussian distribution. A statistical distribution defined by the equation

$$p = ce^{-k^2x^2},$$

in which x is the statistical variable. It is a limiting form approached by many statistical phenomena under suitable extreme conditions; hence a valuable approximation. Accidental errors of measurement and similar phenomena theoretically follow this law. Syn. *normal distribution. Cf. error equation.*

Gaussian eyepiece. An eyepiece provided with a pair of cross hairs, illuminated by light from a side aperture reflected by a transparent glass plate extending obliquely across the axis of the instrument. The Huygens form of eyepiece is usually employed for this purpose. (See Martin, Optical Meas. Instr., 1924, p. 126.)

Gaussian unit. An absolute unit of force, such as the dyne or the poundal, defined in terms of its accelerating effect upon a given mass.

Gay Lussac law. Syn. *Charles law;* but stated independently by Gay Lussac in 1802.

Geiger counter. A type of counting tube, consisting of a highly charged needle inside a metallic cylinder. Devised by Geiger for detecting and counting ionizing particles in the air. *Cf. Geiger-Müller counter.* (See Rutherford, Chadwick, and Ellis, Radiations from Radioactive Substances, 1930, p. 52.)

Geiger-Müller counter. A metallic cylindrical sheath with a slender wire running axially through it, and used in a manner somewhat similar to the Geiger counter. (See Johnson, *J. Frank. Inst.* 214, 672, 1932.)

Geiger-Nuttall law. States that for different radioactive elements emitting alpha rays, the logarithm of the range of the alpha particles and the logarithm of the disintegration constant bear a linear relation to each other. (See Haas, Atomic Theory, 1927, p. 116.)

Geissler pump. A type of air pump utilizing the principle of the Torricellian vacuum. Also known as the *Toepler pump.*

Geissler tube. Any two-electrode discharge tube giving a glow discharge at low pressures. One useful form has a narrow constriction of straight tubing, in which the glow is concentrated and can thus be brought conveniently before the slit of a spectroscope.

gel. A jellylike substance formed by partial drying or by cooling certain colloidal solutions, such as those of soap or gelatin in hot water.

general radiation. Continuous radiation such as white light or the background of an x-ray spectrum.

generalized co-ordinates. *Cf. co-ordinate* (2).

generator (electric). A machine which utilizes mechanical energy to produce an electric current. *Cf. electrostatic generator.*

geomagnetic latitude. Syn. *magnetic latitude.* (See Compton, *Phys. Rev.* 43, 387, 1933.)

geometrical optics. *Cf. optics.*

geophysics. That branch of science which deals with physical phenomena related to the earth, esp. those aspects studied by strictly physical methods.

getter. A volatile metal, *e.g.*, magnesium, vaporized in and sublimated upon the walls of a discharge tube to remove traces of gas. *Cf. cleanup.* (See Hoag, Electron Phys., 1929, pp. 25, 158.)

ghost. A false line appearing in a grating spectrum, due to some defect of the grating.

Gibbs adsorption law. A law relating to systems of several (n) components, and expressed by the differential equation

$$\partial\gamma = -\sum_{1}^{n}(\Gamma\partial\mu);$$

in which γ is the interfacial free energy, the μ's are the partial free energies of the different components, and the Γ's are the masses

of those respective components which must be added, per unit increase of interface, to maintain the μ's constant. (See Bartell, Miller, and Almy, *J. Am. Chem. Soc.*, 55, 466, 1933.)

Gibbs functions. Three thermodynamic quantities, expressed as follows:

$$\psi = u - Ts \quad \text{(free energy)},$$
$$\chi = u + pv \quad \text{(enthalpy)},$$
$$\zeta = u - Ts + pv.$$

In these, u is internal energy, T is temperature, v is volume, p is pressure, s is entropy. The quantities usually pertain to unit mass of working substance. Syn. *heat functions*. (See Page, Int. to Theoretical Phys., 1928, pp. 264 ff.)

Gibbs-Helmholtz equation. An equation connecting the open-circuit e.m.f. of a reversible electrolytic cell with the heat of formation H of the compounds formed within it and with the absolute temperature T:

$$E = H + T\frac{\partial E}{\partial T}.$$

(See Newman, Electrolytic Conduction, 1931, p. 5; Page and Adams, Prin. of Electricity, 1931, p. 213.)

Gibbs (thermodynamic) surface. The (three-dimensional) graph of the equilibrium values of volume, energy, and entropy for a given pure substance. (See Gibbs, Collected Works, 1928, v. 1, p. 33.)

gilbert. The c.g.s. electromagnetic unit of magnetic potential or of magnetomotive force, equivalent to $5/2\pi$ amp-turns.

gilbert per centimeter. Syn. *oersted* (1), *gauss* (2); *i.e.*, the practical c.g.s. unit of magnetic intensity or magnetic potential gradient. It is sometimes used in analogy to the volt per centimeter for electric potential gradient, or to avoid the ambiguous term *oersted*.

Gladstone-Dale law. States that the refractivity of a medium is proportional to its density as the latter varies under changing conditions of pressure or temperature; *i.e.*, that the specific refractivity is constant. But *cf. Lorenz-Lorentz relation*.

Glan-Thompson prism. A form of polarizing prism of Iceland spar, resembling a Nicol prism but differing somewhat in design. The light enters and leaves this prism normal to the faces, and the parts are separated by a glycerine film. (See Weld, *J.O.S.A.* 6, 67, 1922.)

glancing angle. The complement of a very large incidence angle; *i.e.*, the very small angle between the incident emission and the surface upon which it is incident. *Cf. Bragg angle*.

glide plane. The common plane of the two axes of a twin crystal. *Cf. gliding*. Syn. *gliding plane* (2). (See Tamman, States of Aggregation, 1925, p. 192.)

gliding. The formation of twin crystals. *Cf. glide plane, gliding plane* (2). (See Davey, Study of Crystal Structure and Its Applications, 1934, pp. 213 ff.; Sauerwald and Sossinka, *Zeits. f. Phys.* 82, 634, 1933.)

gliding plane. 1. A plane within a crystal along which occurs a displacement of the crystal structure, *i.e.*, a slipping of one lattice layer

past the adjacent layer, when the crystal is subjected to shear. 2. Syn. *glide plane.*

globulite. A microscopic crystal of globular shape, without definite plane faces, due to strong surface-tension effects at the time of formation of the crystal. Syn. *spherolite.* (See Davey, Study of Crystal Structure and Its Applications, 1934, p. 376.)

glossimeter, glossmeter. An instrument for measuring the ratio of the light regularly or specularly reflected from a surface to the total light reflected. (See Walsh, Photometry, 1926, p. 381.)

glow, g. discharge. The most frequent form of initial electric discharge in a gas, often emitting a hissing sound but with no distinct sparks. It sometimes develops into a brush discharge. *Cf. corona.* (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 3, p. 533; Campbell and Ritchie, Photoelectric Cells, 1930, p. 61.)

glow potential. The voltage at which a glow discharge begins in a vacuum tube as the voltage is gradually increased.

gnomonic projection. A method of geometric projection used in the interpretation of Laue diffraction patterns. (See Clark, Applied X-Rays, 1927, pp. 123 ff.)

gold point. The melting point of gold, *viz.*, about 1064°C.; commonly used as a reference point in pyrometry. *Cf. international temperature scale.*

goniometer. An instrument for measuring the angles between the faces of crystals, prisms, etc., usually by utilizing beams of light reflected from those faces.

gradient. The vector which represents the linear derivative of a scalar point function S at any point, in a direction normal to the surface of equal values of S through this point; *e.g.*, of temperature in a direction normal to the isothermal surface. Denoted by grad S.

gradiometer. An instrument for measuring the gradient of the earth's gravity field in any locality. (See Lancaster and Jones, *J.S.I.* 9, 373, 1932.)

Graham law. States that the rates of efflux or of diffusion of different gases (volume per unit time) are, under similar conditions, inversely proportional to the square roots of the densities of the gases. (See Couch, Dict. of Chem. Terms, 1920.)

gram, gramme. A metric unit of mass, defined originally as the mass of 1 cm^3 of pure water at its maximum density (4°C.). But for practical purposes it is now defined as one-thousandth of the mass of the standard platinum kilogram at Sèvres; which is 1.000027 times the original, ideal value.

gram atom. That mass of an element which, in grams, is numerically equal to the atomic mass of the element. The gram atom of every element thus contains the same number of atoms, *viz.*, about 6.06×10^{23} (*Avogadro number*).

gram molecule. That mass of a pure substance which, in grams, is numerically equal to the molecular mass of the substance. The gram molecule of every pure substance thus contains the same

number of molecules, *viz.*, about 6.06×10^{23} (*Avogadro number*). Syn. *mol* or *mole.*

Gramme ring. A form of electromagnet in which the core is a continuous iron ring. Used in certain forms of generator armature.

graticule. A reticle composed of lines scratched upon a plate of glass, instead of the usual spider threads or wires. (See Martin, Optical Meas. Instr., 1924, p. 27.)

grating. A device for dispersing light or other wave emission by interference between wave trains issuing from fine, parallel slits in an opaque plate or from very narrow, parallel reflecting surfaces made by ruling grooves on polished metal. Often called *diffraction grating.*

grating constant, g. space. 1. The distance between successive rulings of a diffraction grating. 2. *In re* a crystal: syn. *lattice constant.*

gravitation constant. A constant G which appears in the expression for the Newtonian law of gravitational force between two concentrated masses m_1, m_2 separated by distance r:

$$f = G\frac{m_1 m_2}{r^2}.$$

Approximately equal to 6.664×10^{-8} cm^3 g^{-1} sec^{-2}. Syn. *Newtonian constant.* (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

gravitational potential. A point function analogous to electric potential, but always positive. Its value at any point is the line integral of the intensity of the gravitational field due to all matter, taken from that point to infinity. Syn. *Newtonian potential, mass p. Cf. Newtonian potential function.*

gravitational radius. A quantity, having the dimensions of a length, associated in the relativity theory of gravitation with any particle of matter, and equal to Gm/c^2; in which m is the mass of the particle, G the gravitation constant, and c the electromagnetic constant.

gravitational unit. A unit of force, pressure, work, power, or other magnitude, which involves in its measure the factor of terrestrial gravity; *e.g.*, the gram of force or the foot-pound.

gravity. 1. The resultant effect, upon any body of matter belonging to the earth or other planetary mass, of the gravitational field of the mass and the centrifugal force of the body due to the planetary rotation. 2. The intensity of the effect (1), as measured by the force per unit mass of the body, or by the resulting acceleration of the body if free to move; commonly denoted by g. Its standard terrestrial value is taken by international agreement as 980.665 cm/sec^2.

gravity cell. A primary cell in which the electrolyte is in two parts kept separate by their difference in specific gravity.

gray, grey. 1. An achromatic color. 2. The property of a radiating surface such that, while its radiation has the same spectral energy distribution, its emissive power is less at any temperature than that of a black body; and such that, while not black, its absorptivity is nonselective.

grid. 1. An electrode consisting of a wire mesh placed between the cathode and the anode in a thermionic tube so that the thermions must pass through it, and used as a control of the thermionic current by means of variations in the negative grid potential. 2. The metallic (commonly lead) part of either of the electrodes of a storage cell.

grid battery. A battery used to maintain a potential of the desired sign upon the grid of a vacuum tube. Syn. *C-battery.*

grid condenser. A small condenser interposed between the grid terminal of a thermionic vacuum tube and the source of grid potential control.

grid current. A current flowing to or from the grid of a vacuum tube. (See I.R.E. Comm. Rep., 1933.)

grid-glow tube. A thermionic relay similar to a thyratron.

grid leak. A very high resistance placed in parallel with a grid condenser to prevent an overaccumulation of negative charge upon the grid and thus to keep its mean negative potential approximately constant during operation.

gross structure. 1. The array of bands in a band spectrum, each represented by its head or by its zero line, without attention to the individual lines of which the bands are composed. 2. The general multiplet structure of an atomic spectrum. *Cf. hyperfine structure.*

Grotthus-Draper law. States that light is photochemically active only when it is absorbed by the material affected. (See Fajans, Radioelements and Isotopes, 1931, p. 108.)

ground form. The crystalline form of any crystal system which is bounded by natural faces, all of which intersect the crystal axes. *E.g.*, the ground form of the isometric system is the regular octahedron.

ground state. That configuration of an atom which corresponds to the lowest energy level and hence has greatest stability.

group phenomena. Properties of the crystalline state which apparently cannot be considered as properties of single atoms, but arise from the agglomeration of atoms into groups, each consisting of a definite number of atoms (10^7 to 10^9). The stability of the atoms thus arrayed is greater than that among the groups. (See Goetz, *Phys. Rev.* 45, 148 and 293, 1934.)

group velocity. The velocity of propagation of the resultant displacement maxima or minima constituting an interference wave form, in wave motion made up of two or more component wave trains of different frequency, *i.e.*, a wave group. If the components have different individual speeds, it may be quite different from the velocity of propagation of any one component.

guard ring. An outer region *A* surrounding any enclosure or area *B* in which it is desired to maintain uniform conditions throughout or to avoid edge effects; *B* being shielded from nonuniformity by creating in *A* approximately the same conditions as those required in *B*.

Gudden-Pohl law. States that the number of electrons liberated in

the photoconductive action of selenium is equal to the number of radiation quanta absorbed. (See Barnard, Selenium Cell, 1930, p. 175.)

Guillaume alloy, G. metal. An alloy of about 66 per cent Fe and 34 per cent Ni, which has the unusually low expansion coefficient 10^{-6} per °C. *Cf. invar.* (See Hill, *Phys. Rev.* 24(1), 322, 1907.)

gyro. The rotating part of any such device as a gyrostat, gyrocompass, etc.; or in general, any rotating rigid body. (See Deimel, Mechanics of the Gyroscope, 1929, p. 63.)

gyrodynamics. The dynamics of rotating bodies, esp. those affected by precession. (See Ferry, Applied Gyrodynamics, 1932.)

gyromagnetic. Pertaining to the magnetic properties of rotating electric charges, esp. of electrons moving within atoms.

gyromagnetic ratio. The ratio of the magnetic moment of a specimen of a substance to the angular momentum of its atoms. (See Frank, *Phys. Rev.* 39, 119, 1932.)

gyroscope. An instrument resembling a spinning top, used to demonstrate precession, etc. *Cf. gyrostat.*

gyrostat. Syn. *gyroscope*, but with emphasis upon the stabilizing effect of rotation.

gyrostatic compass, gyrocompass. One of several devices utilizing the tendency of a rapidly spinning gyro to maintain its axis of rotation as a nonmagnetic compass on shipboard. The arrangements for neutralizing various sources of error make the mechanism somewhat complicated. (See Ferry, Applied Gyrodynamics, 1932.)

H

(Please note purpose of references as explained in preface.)

H function. A function of the coordinates describing the motion of the molecules of a gas, which represents the cologarithm of the probability of a given thermodynamic state of the gas; a concept due to Boltzmann. *Cf. Boltzmann entropy hypothesis.* (See Loeb, Kinetic Theory of Gases, 1927, chap. 4.)

H-ray, H-particle. A positive hydrogen ion, or proton, which results from the bombardment of hydrogen or a hydrogen compound by alpha rays or by swiftly moving positive ions of any kind, or from the bombardment and disintegration of certain other elements, *e.g.* nitrogen, by alpha rays. First observed by Marsden in 1914. (See Univ. of Pittsburgh Staff, Outline of Atomic Phys., 1933, pp. 237 ff.)

H theorem. A theorem based upon the Maxwell-Boltzmann principle of equipartition of energy. States that if there are N_1 molecules in one state or phase, N_2 in another, etc., the quantity $H = \Sigma(N \log N)$ tends to a minimum and reaches its equilibrium value only when the condition of equipartition of energy is fulfilled. *Cf. H function.* (See Tolman, Statistical Mech., 1926, pp. 192, 196.)

half-cell. Consists of an electrode inserted into an electrolytic solution in order to set up a definite,

though not actually determinable, potential difference.

half-decay period. Syn. *half-value period.*

half-period element. One of the zone-like or annular areas, cut out from an advancing wave front by a succession of ideal, spherical surfaces concentric at any point of observation in the path of the oncoming wave and separated by radial distances each equal to one half-wave length; an analysis commonly employed in the theory of wave propagation and diffraction. Syn. *Huygens zone, Fresnel zone.*

half-quantum number. One of the values of the angular momentum assumed for an atom or a molecule, each equal to a whole multiple of $\frac{1}{2}(h/2\pi)$, in which h is the Planck constant. (See Darrow, Int. to Contemporary Phys., 1926, p. 379; Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 12.)

half-shade analyzer. A device used in polarimeters for determining the polarization plane. It may be a Jellet-Cornu prism, a Lippich prism, or an opening partly covered by a half-wave plate.

half-value layer. *In re* the absorption of radiation by any given substance: the thickness of that substance which will reduce the intensity to one-half its initial value. It is equal to 0.6931 divided by the (linear) absorption coefficient.

half-value period. The time required for any variable whose value undergoes decay in accordance with the exponential law to fall to one-half of its original value; equal numerically to 0.6931 divided by the decay coefficient. *Cf. transformation period, average life, relaxation time.*

half-wave plate. A plate of mica or other doubly refracting crystal, of such thickness as to introduce a phase difference of ½ cyc between the ordinary and the extraordinary components of the light traversing it. *Cf. quarter-wave plate.*

half-width (of spectrum line). *In re* any line in the spectrum of a gas or vapor: the wave length or wave number interval throughout which the intensity equals or exceeds one-half its maximum value (value at the line peak). Syn. *width-at-half-maximum.*

Hall coefficient. The transverse electric potential gradient produced in a conducting strip exhibiting the Hall effect, per unit current density per unit magnetic intensity. (See Bridgman, Thermodynamics of Electrical Phenomena in Metals, 1934, p. 132.)

Hall effect. A p.d. which develops between the two edges of a strip of metal, in which an electric current is flowing longitudinally, when the plane of the strip is set perpendicularly across a magnetic field. Discovered by Hall in 1879. *Cf. Nernst effect, Ettingshausen e., Righi-Leduc e.* (See Campbell, Galvanomagnetic and Thermomagnetic Effects, 1923, chaps. 1–7.)

Hallwachs effect. The discharge of a negatively charged body in a vacuum due to the incidence of ultraviolet; discovered by Hallwachs in 1888. It is a type of photoelectric effect.

halo. 1. One of several different atmospheric phenomena, manifested by the appearance of faintly colored rings surrounding the sun or the moon, and caused by refraction due to minute ice crystals suspended in the upper air. 2. (Phot.) A ring surrounding the photographic image of a bright source, due to one of several causes. 3. *Cf. powder pattern* (1).

Hamilton equations. A set of differential equations relating to a dynamic system, one pair for each of the n degrees of freedom corresponding to the generalized co-ordinates $q_1, q_2, \ldots, q_n$ and generalized momenta $p_1, p_2, \ldots, p_n$. If H denotes the Hamiltonian function, each pair of equations has the form

$$\frac{dq_r}{dt} = \frac{\partial H}{\partial p_r}, \quad \frac{dp_r}{dt} = -\frac{\partial H}{\partial q_r}.$$

($r = 1, 2, \ldots, n$.) They are equivalent to the Lagrange equations. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 110.)

Hamilton-Jacobi equation. A partial differential equation used in the dynamics of conservative systems, in the form of a Hamiltonian function:

$$H\left(\frac{\partial S_1}{\partial q_1} \cdots \frac{\partial S_f}{\partial q_f}, q_1 \cdots q_f\right) = E;$$

in which the q's are generalized co-ordinates, S's are actions, f is the number of degrees of freedom, and E is the constant total energy of the system. (See Page, Int. to Theoretical Phys., 1928, p. 176.)

Hamilton principle. A principle relating to any dynamic system, the total kinetic energy and potential energy of which are, respectively, E_k and E_p; expressed by the equation

$$\delta \int_{t_0}^{t_1} (E_k - E_p) dt = 0.$$

(See Haas, Int. to Theoretical Phys., 1925, v. 1, p. 76; Poor, Electricity and Magnetism, 1931, p. 104.)

Hamiltonian. The vector differential operator

$$i\frac{\partial}{\partial x} + j\frac{\partial}{\partial y} + k\frac{\partial}{\partial z};$$

sometimes abbreviated by ∇. (See Silberstein, Vectorial Mech., 1926, pp. 28 ff.)

Hamiltonian function. A function of the r generalized co-ordinates $q_1 \ldots q_r$ and generalized momenta $p_1 \ldots p_r$, defined by $H = \sum_1^r p\dot{q} - L$; in which L is the Lagrangian function. H satisfies the differential equations

$$\frac{\partial H}{\partial p} = \dot{q}, \quad \frac{\partial H}{\partial q} = -\dot{p}.$$

$\dot{q} = \frac{dq}{dt}$, $\dot{p} = \frac{dp}{dt}$. In many problems, H represents the energy of a conservative system expressed in terms of q's and p's. (See Haas, Int. to Theoretical Phys., 1925, v. 1, p. 83; Birtwistle, Quantum Theory of the Atom, 1929, pp. 48 ff.)

hammer, hammering. The sharp pounding of a liquid, such as water or mercury, often observed when the tube containing it is devoid of air, which would otherwise act as a cushion.

hardness. 1. Resistance to surface abrasion or indentation, as of steel or diamond. *Cf. Brinell hardness.* 2. *In re* x-rays or gamma rays, it denotes high penetration or low absorption coefficient, corresponding to short wave length and high quantum energy.

harmonic. 1. (n.) An overtone or partial bearing a simple frequency ratio to the fundamental. 2. (adj.) Capable of being expressed in terms of sine or cosine functions, and hence analogous to musical sound. *Cf.* terms following, and *spherical harmonic, zonal h.*

harmonic analysis. The expression of a function in terms of sine and cosine terms involving the variables, with such coefficients as to render the resulting series approximately equal to the given function for corresponding values of the variables. *Cf. Fourier series, harmonic analyzer.*

harmonic analyzer. An apparatus which mechanically, electrically, or otherwise, evaluates the coefficients of the Fourier series corresponding to any function subject to harmonic analysis.

harmonic band. Syn. *overtone band.*

harmonic echo. An echo in which there is a selective action on the frequencies of the incident sound, usually resulting in the suppression of the fundamental and other low-frequency components. (See Richardson, Sound, 1929, p. 13.)

harmonic motion. A vibration in which the acceleration is proportional to the displacement from the mean or zero position but with opposite sign, as the vibration of a string; or which is the resultant of any number of such motions. If there is but one component, the motion is termed *simple harmonic.*

harmonic oscillator. A particle, esp. an electric particle, oscillating with harmonic motion; a concept often used in radiation theory.

Hartley law. States that the separations of the components in any one series of doublet or of triplet spectral lines, expressed in frequencies or in wave numbers (not in wave lengths), are equal. (See Hartley, *J. Chem. Soc.* 43, 390, 1883; White, Int. to Atomic Spectra, 1934, p. 4.)

Hartmann test. A photographic method of testing large lenses for spherical aberration. (See Bell, The Telescope, 1922, p. 214.)

Hartree function. A wave function applying to a single electron in a central field, as developed by Hartree. (See Hartree, *Proc. Camb. Phil. Soc.* 24, 89, 1928.)

Hartree unit. A unit of wave length used in connection with the theory of diffraction of electrons by crystals, and equal to $h^2/4\pi^2me^2$, in which h is the Planck constant and m and e are the electronic mass and charge. Its value is about 5.3×10^{-19} cm. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 38.)

Haüy law. States that the parameters, and hence the Miller indices, of a crystal are always rational numbers. Syn. *rational index law.* (See Rinne, Crystals and the Fine Structure of Matter, 1922, p. 9; Davey, Study of Crystal Structure and Its Applications, 1934, p. 30.)

head. 1. A quantity used in relation to fluid motion, and having the

dimension of length, which is in proportion to the energy of the particles of fluid. Three component heads are distinguished, *viz.*, those corresponding to elevation, to pressure, and to speed of flow, respectively. *Cf. Bernoulli equation, thermal head.* 2. The edge of a spectral band or series. *Cf. band edge.*

heat capacity. Syn. *thermal capacity.*

heat content. *Cf. enthalpy.*

heat death. The final state of thermodynamic equilibrium which the material universe appears to be approaching, in accordance with the laws of dissipation of energy and increase of entropy.

heat function. 1. A quantity related to thermionic emission, and equal to the heat of emission per mol at constant pressure, minus $\frac{5}{2}RT$; in which R is the gas constant and T is temperature. The heat function h is related to the work function w by the equation

$$h = w - T\frac{dw}{dT}.$$

(See Becker and Brattain, *Phys. Rev.* 45, 694, 1934.) 2. Syn. any one of the Gibbs functions. (See Keys, *Proc. Nat. Acad. Sci.* 18, p. 328.)

heat of adsorption. Heat resulting from the transformation of energy which takes place during adsorption; expressed quantitatively in calories per gram or per mol, or, in the case of gases, sometimes in calories per cm^3.

heat of compression. The heat generated per unit mass per unit change of pressure or of volume, in the compression of a substance, such as a gas. Its value depends upon the circumstances of the compression.

heat of condensation. *Cf. heat of vaporization.*

heat of dilution. The quantity of heat absorbed or evolved per gram or per mol of a solute when a solution of given concentration containing it is infinitely diluted. It is a function of the initial concentration. *Cf. heat of solution.*

heat of dissociation. The quantity of heat evolved in the chemical dissociation of 1 g or 1 mol of an electrolyte. Syn. *heat of ionization. Cf. heat of linkage.*

heat of elastic extension. The heat generated per unit mass per unit change of tensile strain in the stretching of an elastic solid.

heat of emission. The additional heat energy that must be supplied to a surface which is emitting electrons, in order to maintain it at a constant temperature; analogous to heat of vaporization. *Cf. heat function, work function.* (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 1, p. 363.)

heat of formation. 1. The heat generated by the formation of a chemical compound, per gram or per mol. 2. *Cf. enthalpy.*

heat of fusion. The quantity of heat absorbed by a substance, per unit mass, upon passing from the solid to the liquid state, or released upon solidification; in either case without change of temperature.

heat of ionization. Syn. *heat of dissociation.*

heat of linkage. The energy required to break any chemical bond. It includes the heat of dissociation of a diatomic molecule as a special case. (See Ellis, *Phys. Rev.* 33(2), 27, 1929.)

heat of mixture. Heat evolved or absorbed upon the mixture of two liquids, not due to chemical reaction between them. *Cf. heat of dilution.* (See Clark, *Phys. Rev.* 24(1), 236, 1907.)

heat of radioactivity. The heat generated per unit time by the radioactive disintegration in unit mass of a radioactive substance.

heat of recalescence. Heat liberated per unit mass at certain temperatures by a cooling metal, due to the recalescence transformation.

heat of solution. The quantity of heat absorbed or evolved per gram or per mol of a solute when it is dissolved in so large a volume of solvent that further dilution causes no further absorption or evolution of heat. *Cf. heat of dilution.*

heat of sublimation. The heat liberated or absorbed, per unit mass, upon the sublimation of a substance.

heat of vaporization. The quantity of heat absorbed by a substance per unit mass, upon passing from the liquid to the vapor state, or released upon condensation; in either case without change of temperature. It is a function of the temperature at which the transformation takes place. Syn. *heat of evaporation, heat of condensation* (the latter if the vapor is condensing).

heat of wetting. The quantity of heat evolved per unit mass of dry material when thoroughly wet by immersion in a liquid. *Cf. heat of adsorption.* (See Sheppard and Newsome, *J. Phys. Chem.* 37, 389, 1933.)

Heaviside bridge. An arrangement somewhat resembling a Wheatstone bridge, but used for measuring mutual inductances.

Heaviside-Hertz equations. A set of electromagnetic field equations for a medium of dielectric constant κ, permeability μ, and electric conductivity γ, in which the magnetic intensity is H and the electric intensity E:

$$\text{curl } H = \frac{1}{c}\left(4\pi\gamma E + \kappa\frac{\partial E}{\partial t}\right),$$

$$\text{curl } E = -\frac{\mu}{c}\frac{\partial H}{\partial t},$$

$$\text{div } \mu H = 0, \quad \text{div } \kappa E = 0.$$

Cf. Maxwell equations. (See Poor, Electricity and Magnetism, 1931, p. 97.)

Heaviside layer. Syn. *ionosphere, Kennelly-Heaviside layer.*

Heaviside-Lorentz unit. One of a system of electric and magnetic units proposed by Heaviside and Lorentz for convenience in theoretical discussions. Syn. *rationalized unit.* (See Page, Int. to Theoretical Phys., 1928, p. 424.)

Hefner unit. A German unit of luminous intensity, defined as the light output of a standard Hefner amyl acetate lamp in a particular direction. It is equal to about 0.90 of the international candle. (See Smiths. P. T., 1929, p. 260.)

Heisenberg forces, H. interactions. Attractive forces between nuclear particles, due to the exchange energy of the type postulated by Heisenberg. This energy is now

regarded as a part of the Majorana exchange energy (*cf. Majorana forces*).

heliostat. An arrangement of mirrors driven by clockwork, used to reflect a beam of sunlight in a fixed direction as the sun moves across the sky.

helix. 1. A space curve which lies in the surface of a cylinder, and resembles a corkscrew. Adj. *helical.* 2. A coil of wire wound in the approximate form of a geometrical helix. *Cf. solenoid.*

Helmert formula. An empirical formula for the value of gravity at a given latitude l and altitude h (in meters), published by Helmert in 1901:

$$g = g_{45}(1 - 0.002644 \cos 2l + 0.000007 \cos^2 2l) - 0.0003086h;$$

in which g_{45} is the value of g at $l = 45$ deg and $h = 0$. (See Landolt and Börnstein, *Physikalisch-Chemische Tabellen*, 1923, p. 5.)

Helmholtz coils. Two equal circular coils placed coaxially at a distance apart equal to their radius, and traversed by the same current. The field near the axis between them is practically uniform.

Helmholtz double layer. A limited region which includes the surface of a metal in contact with an electrolytic medium, and contains a layer of positive metallic ions in the electrolytic medium and an adjacent layer of negatively charged metal. The term is due to Helmholtz. Syn. *electric double layer.* (See Robertson, *Phys. Rev.* 40, 583, 1932.)

Helmholtz equation. 1. (Dioptrics.) An equation of the form

$$n_1 y_1 \tan \alpha_1 = n_2 y_2 \tan \alpha_2,$$

expressing the relation between the linear and the angular magnification at a spherical refracting interface. y_1, y_2 are linear dimensions of object and image, α_1, α_2 the angles made by focal rays and axis at object- and image-points, and n_1, n_2 the refractive indices of the two media. Syn. *Lagrange-Helmholtz equation.* (See Helmholtz, Physiological Optics, English ed., 1924, v. 1, p. 74.) 2. Syn. *Gibbs-Helmholtz equation.*

Helmholtz pendulum. A device, due to Helmholtz, whereby it is possible to charge a condenser for a definite short time, varied at will, or to impart varying amounts of magnetization to a specimen of iron. (See Helmholtz, *Gesammelte Werke*, 1851, v. 1, p. 429.)

hemeraphotometer. A type of photometer used for measuring daylight factor. (See Walsh, Photometry, 1926, p. 368; Taylor, *J.S.I.* 1, 214, 1924.)

hemihedral. *In re* a crystal: having only one-half the number of faces necessary to complete a given type of symmetry. *Cf. holohedral.*

hemimorphic. *In re* a crystal: terminated at the two ends by dissimilar sets of faces. *Cf. holomorphic.* (See Tutton, Natural History of Crystals, 1924, p. 258.)

henry. The practical c.g.s. electromagnetic unit of inductance (or of mutual inductance), equal to 10^9 abhenrys; *viz.*, the inductance of a circuit in which the variation of current at the rate of 1 amp per second induces an e.m.f. of 1 volt.

The *millihenry* is usually more convenient. (See A.I.E.E. Comm. Rep., 1932.)

Henry law. States that, at constant temperature, the solubility of a gas in a liquid which does not act chemically upon it is proportional to the pressure. (See Couch, Dict. of Chem. Terms, 1920.)

herpolhode. The path traced by the point of contact of the energy ellipsoid of a rigid body with the fixed tangent plane on which it rolls. The term is due to Poinsot (1834). (See Deimel, Mech. of the Gyroscope, 1929, p. 64.)

Herschel effect. A decrease in developable density on a photographic plate produced by a second exposure to radiation of longer wave length. (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 339; Trivelli, *J. Frank. Inst.* 208, 483, 1929.)

Herschel-Quincke tube. A branched acoustic tube, resembling a divided or shunted electric conductor; used in studying acoustic interference phenomena. (See Stewart, *Phys. Rev.* 31(2), 696, 1928.)

hertz. A unit of frequency, equal to 1 cyc per second. (Rare in U. S.)

Hertz oscillator. An arrangement of conductors, electric oscillations in which are capable of emitting electromagnetic (Hertzian) radiations; a forerunner of the radio transmitting antenna circuit.

Hertzian radiation, H. waves. Electromagnetic radiation produced by the oscillations of electricity in a conductor; *e.g.*, radio waves. First demonstrated by Heinrich Hertz in 1888. Syn. *electric waves* (2).

Hertzian vector. A vector Π, pertaining to the electromagnetic field, in terms of which both the electric intensity E and the magnetic intensity H may be specified according to the equations

$$E = \nabla(\nabla \cdot \Pi) - \frac{1}{c^2}\frac{\partial^2 \Pi}{\partial t^2},$$

$$H = \frac{1}{c}\nabla \times \frac{\partial \Pi}{\partial t};$$

physically the equivalent of the vector of an oscillating dipole. *Cf. Poynting vector.*

heterochromatic. 1. Not monochromatic. 2. Not homochromatic.

heterodyne. A coupling of oscillatory circuits of such relative frequency that the beats between them come within the audible range.

heterodyne wave meter. A calibrated electrical oscillator of variable frequency, together with a device, employing the heterodyne principle, for indicating the setting at which the frequency of the oscillator bears a known relation to that of the circuit under test. *Cf. wave meter.*

heteromorphic. Occurring in two or more different crystalline forms. Syn. *polymorphic.*

heteropolar. Syn. *polar* (1). *Cf. homopolar.*

Heusler alloys. A series of alloys of nonferromagnetic substances, chiefly copper, manganese, and aluminum, which, however, exhibit ferromagnetic properties in a remarkable degree. Developed by F. Heusler and others about 1903.

hexagonal. *In re* crystal structure: having three equal axes at angles of 120 deg and a fourth at right angles to all three. *Cf. crystal system.*

Hibbert flux standard. A permanent magnet with an annular air gap through which a coil of wire is dropped to produce a known and invariable change in the magnetic flux linked with an electric circuit including the coil. Devised by W. Hibbert, 1892. (See Page and Adams, Prin. of Electricity, 1931, p. 409.)

Hicks formula. A modification of the Rydberg (spectral-series) formula, in which allowance is made for the variation of f with the number of the line in the series. It is somewhat similar to the Ritz formula. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 193.)

high-pass. *In re* a wave filter: having the property of transmitting all frequencies above a certain limit and suppressing those below it. *Cf. low-pass, band-pass.*

Hittorf dark space. Syn. *cathode dark space.*

Hittorf numbers. Syn. *transference numbers, transport n.*

hodograph. The locus of the terminal point of the vector which, drawn from a fixed origin, continuously represents the velocity of a point moving along any given path.

hodoscope. An apparatus for tracing the paths of cosmic rays by means of an array of small Geiger counters, each of which is connected with a neon lamp which flashes as the counter is set off by the cosmic particle. (See Johnson, *J. Frank. Inst.* 216, 329, 1933.)

Hohlraum (Ger., "empty space"). A black-body cavity. *Cf. black body.*

holohedral. *In re* a crystal: having the full number of faces corresponding to the development of the complete maximum symmetry possible to the crystal system in question. *Cf. hemihedral.* (See Tutton, Natural History of Crystals, 1924, p. 258.)

holomorphic. *In re* a crystal: having the two ends symmetrical with each other. *Cf. hemimorphic.*

holonomic, holonomous. *In re* a dynamic system: 1. having a number of degrees of freedom equal to the number of independent co-ordinates; 2. having integrable relations connecting the co-ordinate velocities. (See Poor, Electricity and Magnetism, 1931, p. 106; Seeger, *J. Wash. Acad. Sci.* 20, 481, 1930.)

Holtz tube. A vacuum tube across which are funnel-shaped constrictions pointing in one direction, and through which a h.-f. discharge passes much more readily one way than the other.

homocentric. *In re* a bundle of rays: passing through a common point, or traversing lines which, if produced, would pass through a common point. Syn. *stigmatic. Cf. pencil.* (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 25.)

homochromatic. *In re* different areas or different parts of the same area: having the same color,

or a uniformity of color. *Cf. heterochromatic* (2).

homogeneous strain. A strain such that all pairs of points in the strained body which were initially at equal distances in parallel directions are still at equal distances in parallel directions; though both the distances and the directions may have been altered. (See Kelvin and Tait, Natural Philosophy, 1901, v. 1, p. 116.)

homologous field. A field of force in which the lines of force in a given plane all pass through one point (*center of homology*), *e.g.*, the electric field between two coaxial charged cylinders. (See Whitehead, Dielectric Phenomena, 1927, p. 61.)

homologous temperatures. *In re* two or more substances, esp. metals: absolute temperatures which bear the same ratio to the absolute melting points of the respective substances; especially useful in discussing the properties of plastic solids. (See Nádai, Plasticity, 1931, p. 275.)

homopolar, homoeopolar. Electrically symmetrical, as a molecule which, like N_2, has no effective electric moment; not polar (1).

homotropic. Having similar crystalline structure.

Hooke law. An approximate empirical law of elasticity, which states that the ratio of the stress to the strain, in the case of elongation or rectilinear compression, is constant. First stated by Robert Hooke (1660).

horizontal. Perpendicular to the direction of gravity. *Cf. vertical.*

horizontal intensity. The intensity of the horizontal component of the earth's magnetic field at any point. *Cf. magnetic element* (3).

horopter. The locus of those points in the field of binocular vision which are seen single, *i.e.*, the images of which fall on corresponding retinal points. (See Helmholtz, Physiological Optics, Eng. ed., 1924, v. 3, p. 421; Ames, Ogle, and Glidden, *J.O.S.A.* 22, 539, 1932.)

horsepower. An English gravitational unit of power, based originally upon Watt's experiments with horses, and now standardized as work at the rate of 550 ft-lb per second. Equivalent to about 746 watts. *Cf. force de cheval.*

hot-wire ammeter (or voltmeter). An instrument for measuring current (or voltage) by the heating effect upon a filament.

hot-wire anemometer. An instrument for measuring the velocity of a current of gas by means of its cooling effect on an electrically heated wire. (See Bond, Int. to Fluid Motion, 1925, p. 12.)

hot-wire gauge. A pressure gauge which depends upon the cooling effect of the gas upon a hot filament. *Cf. Pirani gauge.* (See Knaur and Stern, *Zeits. f. Phys.* 53, 766, 1929.)

hue. That attribute of certain colors which permits them to be classed as reddish, yellowish, greenish, or bluish.

Hüfner rhomb. A rhombic glass prism used for the comparison of two illuminated surfaces in photometry. (See Walsh, Photometry, 1926, p. 160.)

Hull ring. Syn. *powder pattern, Debye-Scherrer ring.*

humidity. 1. (*Absolute.*) The percentage, by weight, of water vapor in the air. 2. (*Relative.*) The fraction of saturation of the water vapor in the air.

hunting. 1. The alternate lag and advance of a synchronous motor with respect to the current, or of one of two coupled alternators with respect to the other. 2. A condition of instability in a control device, such as a thermostat or an engine governor, resulting in large fluctuations in the quantity which the device is intended to keep constant.

Huygens eyepiece. A telescope eyepiece consisting of a plano-convex field lens and a plano-convex eye lens placed behind the field lens, with a stop halfway between them.

Huygens pendulum law. States that any two conjugate points of a gravity pendulum have the property that the period of oscillation is the same when the pendulum is suspended at either; and that this common period is equal to that of an ideal simple pendulum of length equal to the distance between the two points. *Cf. conjugate points* (2), *center of suspension, center of oscillation.*

Huygens principle. An important principle of wave propagation, the essential feature of which is the concept that every point on an advancing wave front acts as a source of disturbance and sends out waves, the resultant effect of which constitutes the propagation of the wave as a whole.

Huygens wave surface. The wave front of light traversing a doubly refracting medium. (See Wright and Garrett, *J.O.S.A.* 26, 360, 1936.)

Huygens zone. Syn. *half-period element, Fresnel zone.*

hydraulic grade line. An imaginary line so drawn, in reference to a conduit flowing full of liquid under pressure, that each point of the line lies vertically above or below the conduit, and at a distance from it equal to the pressure head at the corresponding point of the conduit. *Cf. hydraulic slope.* (See Daugherty, Hydraulics, 1937, p. 91.)

hydraulic gradient. The rate of fall of the pressure head along a conduit flowing full of liquid. *Cf. hydraulic slope.*

hydraulic mean depth. The quotient of the cross-sectional area of a stream flowing in a channel or a pipe, divided by the perimeter of the stream. Syn. *hydraulic radius.* (See Daugherty, Hydraulics, 1937, p. 269.)

hydraulic slope. The slope of the hydraulic grade line at any point; numerically equal to the hydraulic gradient.

hydraulics. The dynamics of liquids, esp. its technological applications.

hydrodynamics. The dynamics of liquids. *Cf. hydraulics.*

hydrofoil. A blade or vane set in such a way as to experience a lateral thrust as it moves through the water, *e.g.*, a rudder, or one of the blades of a screw propeller. *Cf. aerofoil.*

hydrogen scale. A temperature scale based upon the variation of pressure in hydrogen gas kept at constant volume.

hydrokinetics. That branch of physics which treats of the motion of liquids.

hydrometer. An instrument composed of a light float weighted at one end and bearing a vertical scale, which indicates the specific gravity of the liquid in which it is placed by the depth of its displacement when in equilibrium.

hydrostatics. That portion of hydrodynamics which does not involve effects of liquid motion. *Cf. hydrokinetics.*

hygrograph. A recording hygrometer. (See *U. S. Weather Bureau, Circ.* M, 1929.)

hygrometer. Any one of several instruments for measuring the humidity of the atmosphere.

hyperfine quantum number. Syn. *fine quantum number.*

hyperfine structure. The structure of a spectrum line which depends upon angular momentum in the atomic nucleus, each ordinary line being thereby rendered a multiplet. It is often superposed upon the isotope structure. *Cf. isotope effect.*

hypsometer. An instrument for measuring the boiling points of liquids, esp. for the purpose of estimating elevations above sea level.

hysteresigraph. An instrument which automatically traces hysteresis curves for specimens of magnetic material placed in it. (See Lehde, *R.S.I.* 2, 16, 1931.)

hysteresis. One of several effects resembling a kind of internal friction, accompanied by the generation of heat within the substance affected. *Magnetic h.* occurs when a ferromagnetic substance is subjected to a varying magnetic intensity; *electric h.*, when a dielectric is subjected to a varying electric intensity. *Elastic h.* is the internal friction in an elastic solid subjected to varying stress. Adj. *hysteretic.*

hysteresis curve, h. loop. The graph of the varying magnetic intensity H and the resulting magnetic induction B in a specimen of ferromagnetic material during a complete magnetization cycle.

hysteresis loss. A loss of power in the operation of electrical devices, due to magnetic hysteresis. *Cf. Steinmetz formula, dielectric loss.*

hysteresis meter. An instrument for testing magnetic hysteresis, usually depending upon the torque developed upon placing the specimen in a rotating magnetic field or rotating it in a stationary field. (See Spooner, Properties and Testing of Magnetic Materials, 1927, p. 329.)

hysteretic constant. Syn. *Steinmetz coefficient.* (*Cf. Steinmetz formula.*)

I

(Please note purpose of references as explained in preface.)

I value. The value of the quantum number I which determines the internal angular momentum of an atomic nucleus.

ice calorimeter. A calorimeter in which quantities of heat are measured by the quantity of ice melted. Developed by Black, Bunsen, and others.

ice point. The freezing point of water, *viz.*, 0°C. or 273.18°K. (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

ideal gas. A gas which obeys Boyle's law; not realized in physical fact. (But see Buckingham, *B.B.S.* 6, 409, 1909–1910; Webster and Romanoff, *Phys. Rev.* 29(1), 304, 1909; Bakker, *Phys. Rev.* 31(1), 589, **1910;** Farnau, *Phys. Rev.* 35 (1), 47, 1912.)

ideal gas constant. The constant R appearing in the equation representing the ideal gas law. Its value is about 8.3136×10^7 ergs/mol °C. *Cf. Boltzmann constant.* (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

ideal gas law. A law connecting the pressure p, molar volume v, and temperature T of an ideal gas; expressed by the equation $pv = RT$; in which R is the ideal gas constant.

ideal simple pendulum. A particle of finite mass but infinitesimal size, suspended as a gravity pendulum by a weightless thread; a convenient theoretical concept.

idiochromatic. *In re* a crystal: having photoelectric properties characteristic of the material of the pure crystal itself, and not due to foreign matter. *Cf. allochromatic.* (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 311; Nix, *Rev. Mod. Phys.* 4, 723, 1932.)

illumination. The ratio of the luminous flux incident upon an element of surface to the area of the element. *Cf. foot-candle, lux.*

illumination photometer, illuminometer. A portable photometer designed for the measurement of the illumination upon any surface, as a wall or a table. (See Walsh, Photometry, 1926, chap. 12.)

image. 1. A *real image* of an object-point is the point at which light, originating in the object-point, is finally converged after traversing an optical system. 2. A *virtual image* of an object-point is the point from which light, originating in the object-point, and having traversed an optical system, appears to be diverging. *Cf. conjugate points* (1). 3. The *image*, real or virtual, *of a finite object* is the aggregate of the images of its component points. 4. Also used by analogy *in re* the reflection of electric waves in conducting networks. *Cf. electric image, pinhole i.*

image force. The attraction between a charge concentrated upon a small body (esp. an electron) and its electric image in a neighboring conductor (as the metal plate from which the electron

has emerged); important in thermionic and photoelectric emission. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, pp. 494, 496; Langmuir, *Phys. Rev.* 43, 224, 1933.)

image-line. Syn. *focal line.*

image-point. *Cf. image* (1) and (2), *object-point.*

impact fluorescence. Fluorescence produced in atoms of one element by collisions (of the second kind) with excited atoms of another. Syn. *impact radiation.* (See Winans, *Phys. Rev.* 30(2), 1, 1927.)

impact parameter. The distance of the initial line of motion of a scattered particle from the center of the scattering field, *e.g.*, of the path of an incident electron from the nucleus of the scattering atom. (See Mott and Massey, Theory of Atomic Collisions, 1933, p. 25.)

impact polarization. Partial polarization detected in radiation excited by impact. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 477.)

impact radiation. Syn. *impact fluorescence.*

impedance. The ratio of the effective e.m.f. to the effective current in an a.-c. circuit. For a circuit of resistance R, inductance L, and (series) capacitance C, carrying a current of frequency n, its value is

$$\sqrt{R^2 + \left(2\pi nL - \frac{1}{2\pi nC}\right)^2}.$$

Cf. reactance, admittance, acoustic impedance.

impulse. The time integral of a force, esp. when applied for a short time; measured by the change in momentum which it would impart to a free mass if acting in a line through the c.m. *Cf. angular impulse.*

impulse radiation. Any radiation that may result from the impacts of rapidly moving particles upon a body of matter, *e.g.*, x-rays, produced by the impacts of electrons.

impulse ratio. The ratio of the potential difference required to initiate a spark between terminals, when the voltage is suddenly applied, to that required for the same spark gap with a steady field; a term due to Peek. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 523.)

incidence angle. The angle between the direction of an approaching emission and the normal to the surface upon which it is incident. *Cf. glancing angle.*

inclination. 1. The angle which a line, a surface, or any vector makes with the horizontal. 2. (Geom.) The angle which the direction of a vector or of a curve at any point makes with the axis of abscissas. 3. (*Magnetic.*) The angle which the magnetic field of the earth makes with the horizontal at any station. Syn. *magnetic dip. Cf. magnetic element.*

inclinometer. 1. Any instrument for measuring inclination, as of the surface of the land or of a rock stratum. 2. (*Magnetic.*) A magnetic needle poised in a vertical plane, used to indicate the magnetic inclination. Syn. *dip needle.*

indetermination principle, indeterminacy p. Syn. *uncertainty principle.*

index of refraction. Syn. *refractive index.*

indicator diagram. The graphical record made by a steam-engine indicator.

indicatrix. A vectorial ellipsoid, introduced by Fletcher to represent the relative refractive indices of a crystal in different directions. (See Tutton, Natural History of Crystals, 1924, pp. 256 ff.)

individual change. Any dynamic process in which the attention is fixed upon the behavior of a single particle, followed throughout all its course, changes in its motion being noted; in contradistinction to *local change, q.v.* (See Silberstein, Vectorial Mech., 1926, p. 124.)

induce. To bring about as the result of exposure to the influence or to the variation of a field of force; *e.g.*, an induced charge (*cf. electric induction*), or an induced current (*cf. magnetoelectric induction*), etc. Also *cf. induced radioactivity.*

induced radioactivity. 1. Radioactivity produced artificially, by corpuscular bombardment or otherwise. 2. Originally used by the Curies to denote *radioactive deposit.*

inductance. A (not necessarily constant) characteristic of an electric circuit, the measure of which is either the e.m.f. magnetoelectrically induced in the circuit by the variation at unit rate of the current flowing in it, or the magnetic linkage with the circuit produced by unit steady current flowing in it. The practical unit is the *henry* (for which the linkage per ampere is 10^8 maxwell-turns); *cf. abhenry.* Syn. *self-inductance, coefficient of self-induction. Cf. mutual inductance.*

inductance bridge. An arrangement resembling a Wheatstone bridge, and used for the comparison of inductances by a somewhat similar method.

induction. *Cf. induce, electric induction, magnetic i., magnetoelectric i., self-i., mutual i.*

induction coil. An apparatus consisting of two coupled circuits, interruptions of the current in one of which (the primary) induces an e.m.f., usually large, in another (the secondary). Used for ignition, for operating vacuum tubes, etc.

induction motor. An a.-c. motor, in which the torque on the rotating circuit, or rotor, is due to currents induced in it by a varying magnetic field excited by a. c.'s in the stationary circuit, or stator. Such motors are operated by single-phase, two-phase, three-phase, or polyphase currents.

inductivity. Syn. *dielectric constant.* (Rare.)

inductometer. A variable inductance, esp. one calibrated to indicate the inductance in henrys or millihenrys. *Cf. variometer* (1). (See Smythe and Michels, Advanced Elec. Meas., 1932, p. 86.)

inductor. A coil or electromagnet introduced into a circuit to provide inductance.

inertia. A property common to all forms of matter and exhibited also by electrons and apparently by energy (quanta); manifested

as a dynamic opposition to acceleration.

inertia ellipsoid. An ellipsoid so drawn, in reference to any point of a rigid body, that the radius vector from the center of the ellipsoid to any point on its surface represents the reciprocal square root of the moment of inertia of the body about that vector as an axis. The axes of the ellipsoid coincide with the principal axes of the body through the given point. (See Deimel, Mech. of the Gyroscope, 1929, p. 39; Silberstein, Vectorial Mech., 1926, p. 80.)

infrared. A wide range of invisible radiation frequencies adjoining the visible red and merging into Hertzian radiation.

infrasonic. Having a frequency below the audible range. *Cf. ultrasonic.*

initial magnetic permeability. The magnetic permeability corresponding to an infinitely small, normal magnetic induction.

initial stress. Syn. *residual stress.*

inner field, i. force. The electric field immediately surrounding any individual molecule in the interior of a polarized dielectric, or the magnetic field surrounding a molecule of a magnetized substance. Its intensity is a linear function of the electric polarization or of the magnetization. Syn. *intrinsic field.* (See Loeb, Kinetic Theory of Gases, 2d ed., pp. 486, 514 ff.)

inner field constant. The constant coefficient of the electric polarization or of the magnetization in the linear function representing the intensity of an inner field.

inner photoelectric effect, internal p.e. Syn. *photoconductivity.* (See Wilson, *Nature* 130, 913, 1932.)

inner quantum number. A quantum number J, associated with the quantization of the total angular momentum of the atom, exclusive of nuclear spin. It is analogous to the rotational quantum number J of a molecule (inclusive of electron spin); and the term is sometimes thus applied to the molecule. *Cf. J value.*

insolation. 1. Exposure to solar radiation. 2. The intensity of the solar radiation received at any point on the earth's surface. *Cf. solar constant.* (See *U. S. Weather Bureau, Circular* M, 1929.)

instantaneous axis. Syn. *axis of instantaneous rotation.*

instantaneous center. The point at which the instantaneous axis of a plane body moving in its own plane intersects that plane. (See Prescott, Mech. of Particles and Rigid Bodies, 1929, p. 110.)

instantaneous sound pressure. The actual pressure at any point of a medium traversed by sound waves, at any instant, minus the normal or *static* pressure. It may thus be either positive or negative. Syn. *excess sound pressure.* (See Acous. Soc. Comm. Rep., 1934.)

insulating strength. A measure of the ability of an electric insulator to withstand electric stress without breakdown; defined as the p.d. per unit thickness of the insulator necessary to initiate a disruptive discharge through it. Usually expressed in volts per

centimeter. Syn. *dielectric strength.*

integrating cube. *Cf. cube photometer.*

integrating meter. An instrument that sums up or integrates the electric energy used over a period of time, *e.g.*, the ordinary electric light meter.

integrating photometer. A photometer that sums or averages the intensity of a light source in all directions and thus gives the mean spherical candle power by a single observation.

integrating sphere. *Cf. sphere photometer.*

integrator. An instrument that performs definite integrations or summations mechanically.

intensifier. A device for stepping up a high pressure, by means of a double free piston with two unequal areas, the larger of which is exposed to the lower pressure. (See Bridgman, Physics of High Pressure, 1931, p. 56.)

intensifying screen. A fluorescent screen placed in close contact with a photographic plate used in radiographic work, the fluorescent light from which adds its effect to that of the invisible rays in producing the image on the plate.

intensity (of an emission). Syn. *flux density* (3). *Cf. luminous intensity, magnetic i., electric i.*

intensity level. A term used in acoustics to denote the relation of one sound intensity to another, as expressed in bels or decibels; it is the common logarithm of their ratio. (See Acous. Soc. Comm. Rep., 1934.)

intensity of magnetization. Syn. *magnetization* (1). Not to be confused with *magnetic intensity, q.v.*

intercombination line. A combination line between multiplet energy levels having different numbers of components, as between quintet and triplet levels. (See White, Int. to Atomic Spectra, 1934, p. 175.)

interelectrode capacitance. The capacitance of a vacuum-tube circuit due to the condenser action of two of the tube electrodes, as the filament and the plate.

interfacial angle. The dihedral angle between two adjacent faces of a crystal.

interfacial tension. The surface tension at the interface between two fluids, as water and oil. (See I.C.T., 1926, v. 4, p. 436.)

interference. A term applied to a variety of phenomena arising from the joint effects of two or more wave trains arriving at the same point simultaneously.

interference photometer. A photometer in which the balance is determined by the disappearance of superposed, complementary interference bands produced by the two sources in a thin film. (See Walsh, Photometry, 1926, p. 184.)

interferometer. An apparatus used to produce and exhibit interference between two or more coherent wave trains from the same large, luminous area, and often to compare wave lengths with observable displacements of reflectors or other parts. *Cf. Michelson interferometer, Fabry-Perot i., stellar i., beam i., Lummer-Gehrcke plate.*

intermittency effect. A difference between the photographic density produced by an exposure separated into short flashes and that due to a continuous exposure of the same illumination and total duration. (See Blair and Hylan, *Phys. Rev.* 44, 131, 1933.)

internal conversion. The effect upon an atom produced when a gamma-ray photon emerges from the nucleus and gives up its energy in an encounter with an extranuclear electron. *Cf. conversion coefficient.*

internal energy. That part of the energy of a system, any change in which is equal to the algebraic sum of the mechanical work and the heat received by the system; provided that the recognizable forms of bulk energy, such as the kinetic energy of motion of its parts, or its electrical and magnetic potential energy, remain constant throughout such change. The internal energy may be regarded as a scalar, reckoned from a zero taken at some arbitrarily chosen state. Syn. *intrinsic energy. Cf. Joule law* (2).

internal photoelectric effect. Syn. *volume photoelectric effect.*

internal potential. The average electric potential of the free electrons inside a metal. (See Debye, Interference of Electrons, 1931, p. 3; Morse, *Rev. Mod. Phys.* 3, 77, 1931.)

internal pressure. A pressure supposed to exist within a fluid because of its cohesion, and which co-operates with the external pressure to maintain equilibrium against the expansive effect of heat. Syn. *intrinsic pressure.* (See I.C.T., 1926, v. 4, p. 19.)

internal reflection. Reflection of light incident upon the surface of a body from the inside, or at an interface, the medium beyond which has a lower refractive index than that in which the reflection occurs. *Cf. total reflection.*

internal resistance. The resistance of the portion of a circuit occupied by sources of e.m.f. such as batteries or generators. *Cf. external resistance.* (See A.I.E.E. Comm. Rep., 1932.)

internal work. Work done by a system against forces operating within it or between its parts, or done upon the system by such forces; *e.g.*, when a body expands or when a liquid evaporates, work is done in general against the forces of cohesion between its molecules. *Cf. external work.*

international radium standard. A standard of radioactivity, consisting of 21.99 mg of pure radium chloride, prepared by Mme. Curie and preserved at the *Bureau International des Poids et Mesures* at Sèvres.

international temperature scale. A scale of temperature fixed by international agreement. Between −190 and +660°C., it is based upon the resistance of a standard platinum resistance thermometer in accordance with the following formulas for resistance at temperature t:
below 0°C.,

$$R_t = R_0[1 + At + Bt^2 + C(t - 100°)t^3],$$

above 0°C.,

$$R_t = R_0(1 + At + Bt^2);$$

where A, B, C are empirical constants. From +660°C. to the gold point it is based upon the platinum-platinrhodium thermel, and, beyond this, upon the optical pyrometer. (See Burgess, *B.S.J.R.* 1, 635, 1928.)

interpolate. To estimate the value of a function for values of the variable lying between those for which the function is known; either graphically, or by a proportion or other interpolation formula. *Cf. extrapolate.*

interrupter. A device for rapidly and periodically breaking and closing an electric circuit, as that of the primary of an induction coil. *Cf. Wehnelt interrupter.*

interval. The ratio of the higher of two musical frequencies to the lower; *e.g.*, the interval C sharp to C is 1.059.

interval factor. A quantity relating to the angular momentum levels in the Zeeman effect, introduced by Landé, and denoted by γ. Syn. *gamma value.*

interval rule (Landé). States that if the levels of a spectral multiplet are arranged in the order of their J values, the separations of the lines of successive pairs of adjacent components are proportional to the larger of the two J values for the respective pairs. The constant of proportionality is called the *Landé factor*, *splitting f.*, *separation f.*, *g-factor* or *g-value.* (See Bacher and Goudsmit, Atomic Energy States, 1932, pp. 7 ff.; Landé, *Zeits. f. Phys.* 15, 189, 1923.)

intrinsic contact potential difference. The true contact p.d. between two perfectly clean metals. Its value is given by Millikan as $h(\nu_1 - \nu_2)/e$, in which ν_1 and ν_2 are the threshold photoelectric emission frequencies for the two metals, h is the Planck constant, and e is the elementary charge. (See Millikan, *Phys. Rev.* 18(2), 236, 1921.)

intrinsic energy. Syn. *internal energy.*

intrinsic field. Syn. *inner field.*

intrinsic magnetic induction. That component of the magnetic induction which is proportional to the local magnetization.

intrinsic magnetic permeability. The magnetic permeability minus one. (See A.I.E.E. Comm. Rep., 1932.)

intrinsic potential. The constant amount by which, according to the theory of Frenkel, the potential in the interior of a body differs from that of its surroundings; closely associated with contact p.d. (See Frenkel, *Phil. Mag.* 33, 297, 1917.)

intrinsic pressure. Syn. *internal pressure.*

invar. An alloy of nickel and iron (about 36 per cent Ni) which has the remarkably small linear expansion coefficient 8×10^{-7} per °C. *Cf. Guillaume alloy.*

invariable plane. The plane through the c.m. of a body or system of bodies, perpendicular to the vector representing its angular momentum; invariable so long as the system is unaffected by external influences. *Cf. Poinsot theorem.* (See Haas, Int. to Theoretical Phys., 1925, v. 1, p. 58.)

invariant of magnetic rotation. The value of the expression

$$\frac{\Lambda n \rho}{(n^2 - 1)^2},$$

in which Λ is the Verdet constant, n the refractive index, and ρ the density, of a transparent substance; approximately the same for different substances. (See Mallemann, *J. de phys. et le radium* 7, 295, 1926; Salceanu, *Compt. Rend.* 193, 161, 1931.)

inverse photoelectric effect. The transformation of the kinetic energy of a moving electron into radiant energy, as in the recombination of an electron with an ion, or in the production of x-rays. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 63.)

inverse piezo-electric effect. The contraction or expansion of a piezo-electric crystal along an electric axis when subjected to an electric field in that direction. *Cf. electrostriction.* (See Jauncey, Modern Phys., 1932, p. 502.)

inverse voltage. The effective voltage attained in the non-current half of the cycle from an a.-c. source used with a valve rectifier, as in operating an x-ray tube with a transformer.

inversion. 1. A reversal of the usual direction of a process; *e.g.*, the change in density of water at 4°C. 2. The transformation of an optically active substance into one having the opposite rotatory effect, without change of chemical composition.

inverted term. A spectral term in which the fine-structure level having the largest inner quantum number lies farthest down on the energy-level diagram. *Cf. normal term.* (See White, Int. to Atomic Spectra, 1934, p. 256.)

inverter. A device for converting d.c. into a.c. *Cf. rectifier, relaxation inverter.* (See Reich, *R.S.I.* 4, 147, 1932 and *Elec. Eng.* 53, 817, 1933.)

ion. 1. One of two oppositely charged carriers which effect electric conduction in an electrolyte. 2. Any part of a molecule or of an atom, dislodged from the rest by a suitable application of energy. 3. Any electrically charged particle of molecular or atomic order of magnitude.

ion counter. A tubular ionization chamber designed by Ebert for measuring the ionization of the air. *Cf. Geiger counter, Geiger-Müller c.* (Mackell and Swann, *Phys. Rev.* 21(2), 436 and 449, 1923.)

ion lattice. The lattice of an ionic crystal.

ionic conductivity. The conductivity of a solution due to a given type of ions, corresponding to a given concentration of those ions in the solution. (See I.C.T., 1926, v. 6, p. 230.)

ionic crystal. A crystal having chemical ions, rather than neutral atoms or molecules, at its lattice points; *e.g.*, sodium chloride. *Cf. ion lattice.* (See Davey, Study of Crystal Structure and Its Applications, 1934, pp. 545 ff.)

ionicness. A condition defined as being present in a molecule, either heteropolar or homopolar, when, using atomic orbitals, the wave function contains terms corre-

sponding to opposite charges on the two atoms. (See Mulliken, *Phys. Rev.* 50, 1017, 1936.)

ionization chamber. An enclosure containing two oppositely charged electrodes in air or other gas, so arranged that when the gas is ionized, as by x-rays, the ions formed are drawn to the electrodes, thus establishing an ionization current.

ionization coefficient. The number of ions formed by the impacts of a rapidly moving corpuscle in a gas, per unit length of path. (See Whitehead, Dielectric Phenomena, 1927, p. 22.) *Relative ionization coefficients* are used to compare ionization produced by any ionizing agent in a given substance with that in a standard substance. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 243.)

ionization condenser. An apparatus consisting of two parallel metal plates, placed within an ionized gas and supplied with a h.-f., a.-c. voltage, for the purpose of testing the electrical properties of the ionized gas. (See Darrow, *Bell Syst. Tech. J.* 11, 576, 1932.)

ionization current. A current produced by an electric field in an ionized gas. *Cf. ionization chamber.*

ionization function. A coefficient proportional to the relative ionization produced in a given gas enclosed in a given ionization chamber by equal amounts of radiant energy of different wave length. (See Rutherford, Chadwick, and Ellis, Radiations from Radioactive Substances, 1930, p. 466.)

ionization gauge. A pressure gauge that depends upon the quantitative relation between pressure and ionization current in a vacuum tube. (See Fraser, Molecular Rays, 1931, p. 42.)

ionization potential. Syn. *ionizing potential.*

ionization pressure. An increase in the pressure within a gas-discharge tube, due to ionization of the gas. (See Crew and Hulbert, *Phys. Rev.* 30(2), 124, 1927.)

ionization probability. One of several arbitrarily chosen expressions involving factors relating to the ionization of a gas by a corpuscular emission, and used as measures of the likelihood or the relative frequency of the ionization of molecules. They are not *probabilities* in the usually accepted sense. (See Darrow, Electrical Phenomena in Gases, 1932, pp. 32 ff.; Brode, *Rev. Mod. Phys.* 5, 257, 1933.)

ionize. To separate into ions.

ionizing potential. The p.d., in volts, corresponding to the energy, in electron-volts, required to ionize an atom or a molecule, by the impact of an electron or otherwise. Syn. *ionization potential. Cf. critical potential.* (See Crowther, Ions, Electrons, and Ionizing Radiations, 1934, pp. 67 ff.)

ionometer. An ionization chamber used for measuring the intensity of an ionizing emission.

ionosphere. A stratum of the upper atmosphere which is believed to be more highly ionized than that at the earth's surface, and because of this, to be capable of reflecting radio waves and thus directing

their propagation, in a general way, parallel to the ground. Syn. *Kennelly-Heaviside layer, Heaviside layer.*

iontoquantimeter. A type of roentgenmeter, devised by Duane, and used for the measurement of x-ray intensities. (See Clark, Applied X-Rays, 1927, p. 88.)

irradiate. To subject to radiation of any kind.

irradiation. 1. The process of irradiating. 2. A quantity defined in the same manner as *illumination*, except that it refers to any kind of radiation; quantitatively expressed as the amount of radiant energy received per unit time per unit area of the irradiated surface. (See I.C.T., 1926, v. 1, p. 38.) 3. A visual illusion, which causes a bright object to appear larger than a dark one of the same dimensions.

irrational dispersion. An inequality in the deviation angle for the same wave length, produced by two prisms of the same total dispersion range but of different kinds of glass. (See Robertson, Int. to Phys. Optics, 1929, p. 125.)

irrotational. 1. Free from rotatory motion; esp. *in re* the motion of a fluid. 2. *In re* a vector: syn. *lamellar* (2), *noncircuital.*

isenthalpic. *Cf. enthalpy.*

isentropic. 1. (adj.) Taking place without change of entropy. 2. (n.) The graph representing the variables in a transformation during which the entropy remains constant.

isobar. 1. *Cf. isobaric* (3). 2. An isobaric line. *Cf. isobaric* (2).

isobaric. 1. Taking place without change of pressure. 2. Connecting points of equal pressure, as an isobaric line. 3. Having the same atomic weight but quite different chemical properties, *e.g.*, the elements uranium X_1 and uranium X_2; such elements are termed *isobars.*

isochor, isochore. The graph representing two variables involved in an isometric (constant-volume) thermodynamic change, *e.g.*, pressure-temperature, temperature-entropy, etc.

isochromat. A curve representing an isochromatic relation. *Cf. isochromatic* (2). (See Kirkpatrick and Ross, *Phys. Rev.* 45, 454, 1934.)

isochromatic. 1. (Phot.) Syn. *orthochromatic.* 2. Pertaining to any variation of factors in connection with radiation, in which the wave length or frequency is constant. (See Gerlach, Matter, Electricity, and Energy, 1928, p. 217.) 3. (n.) A line connecting points of constant shearing stress in an elastic body; so called because such lines correspond to lines of uniform color in the photoelastic test method. (See Nádai, Plasticity, 1931, chap. 37.)

isochronous. *In re* a vibration: having a period independent of the amplitude.

isoclinic, isoclinal. A term applied to points on the earth's surface at which the magnetic inclination is the same. An *isoclinic line* is a line connecting such points.

isocosm. A line of equal cosmic-ray intensity on the earth's surface. (See Compton, *R.S.I.* 7, 71, 1936.)

isodynamic. A term applied to points on the earth's surface at which the total magnetic intensity of the terrestrial field has the same magnitude. An *isodynamic line* is a line connecting such points.

isodynamostacy. A condition of kinetic equilibrium.

isoelectric point. That critical condition of a colloidal suspension in an electrolytic medium for which the cataphoresis of the suspended particles reduces to zero and reverses in sign as the activity of the electrolyte is increased. (See Burton, Phys. Properties of Colloidal Solutions, 1921, p. 164.)

isoelectronic. Having the same number of electrons outside the nucleus. *E.g.*, an atom may be made isoelectronic with the one below it in atomic number by removing one of its outer electrons. An *isoelectronic sequence* is a series of ions having the same number of extranuclear electrons, but successively increasing nuclear charge; *e.g.*, Li I, Be II, B III, etc. (See Gibbs and White, *Phys. Rev.* 29 (2), 426, 1927 and 33(2), 157, 1929.)

isoenergic. Taking place under the condition that the internal energy remains constant. (See Mills, Int. to Thermodynamics, 1910, p. 16.)

isogam. A line of equal acceleration of gravity on the earth's surface. (See Eve and Keys, Applied Geophysics, 1929, p. 170.)

isogonic. 1. Making, or pertaining to, a fixed angle. An *isogonic line* is a line on the earth's surface, at all points of which the magnetic declination has the same value. 2. *In re* two crystalline substances: having corresponding dihedral angles of one or more zones equal. (Rare. See Tutton, Natural History of Crystals, 1924, p. 260.)

isolux diagram. Syn. *isophote.*

isomer. One of two or more substances composed of molecules having the same kind of atoms and in the same proportions, but which, by reason of some difference in the number or arrangement of those atoms, have entirely different physical and chemical properties, *Cf. polymer* (1). (See Couch, Dict. of Chem. Terms, 1920.)

isometric. 1. *In re* crystal structure: having three equal and mutually perpendicular axes. Syn. *cubical* (1). *Cf. crystal system.* 2. Having the same volume, or involving the maintenance of a constant volume, *e.g.*, an isometric change in a gas. 3. Represented without perspective convergence, *i.e.*, as of the same size irrespective of distance.

isomorphism. The property, possessed by various groups of compounds, of being identical in crystalline form, and of having the same numbers of atoms, similarly arranged, within the molecule.

isophote. A curve or surface of equal light intensity. Syn. *isolux diagram.* (See Walsh, Photometry, 1926, p. 98.)

isoplanatic. *In re* an optical system: free from coma.

isosmotic. In equilibrium as regards osmotic pressure; applied to solutions on opposite sides of a porous

membrane when osmotic action ceases. (See Jones, Nature of Solutions, 1917, p. 69.)

isostatic. In static equilibrium; esp. applied to the hydrostatic equilibrium of the earth's crust in accordance with the theory of *isostasy*.

isotherm. An isothermal line.

isothermal. 1. (adj.) At the same temperature throughout. An *isothermal line* is a line on the earth's surface connecting points of equal temperature. 2. (n.) A graph representing the variables in a transformation during which the temperature remains constant.

isotope. One of two or more varieties of the same chemical element which, while they have the same atomic number, have different atomic masses. (See Aston, Isotopes.)

isotope effect, i. shift. A systematic difference in the positions of lines in the spectra of different isotopes of the same element or of molecules containing them. (See Hughes and Eckart, *Phys. Rev.* 36, 694, 1930; Almy and Hause, *Phys. Rev.* 42, 249, 1932.)

isotopic ratio. The ratio between the numbers of atoms of two isotopes of the same element in the natural mixture, as of O^{16} and O^{18} in ordinary oxygen. (See Smythe, *Phys. Rev.* 45, 299, 1934.)

isotropic. Having the same properties in all directions.

J

(Please note purpose of references as explained in preface.)

J value, j value. The value of the inner quantum number in atoms, or of the rotational quantum number in molecules. (See Mulliken, *Rev. Mod. Phys.* 2, 60, 1930.)

Jellet-Cornu prism. A type of half-shade analyzer in which two parts of a Nicol prism are ground to fit each other so that their transmission planes are not quite parallel. (See Martin, Optical Meas. Instr., 1924, p. 240.)

jet pump. A type of suction pump dependent upon the Bernoulli principle of reduced pressure at a narrow constriction in a current of air or liquid, or upon the imprisonment of bubbles in a turbulent stream through a narrow tube. Filter pumps and aspirators are commonly of this type.

Joly screen. A photometer screen devised by Joly, and apparently also in modified form by Elster, consisting of two slightly separated parallel plates of a translucent substance, *e.g.*, paraffin or opal glass. When the plates are equally illuminated, the interface disappears. (See Walsh, Photometry, 1926, p. 160.)

joule. A unit of energy or of work. The *absolute joule* is equal to 10^7 ergs. The *international joule* is defined, in electrical terms, as the work required to maintain a current of 1 international amp for 1 sec in a resistance of 1 international ohm. (See I.C.T., 1926, v. 1, p. 38.)

Joule effect. 1. (Magnetic.) Extension accompanying change of

magnetization. *Cf. magnetostriction, Villari reversal.* 2. Heating by mechanical means. 3. Generation of Joule heat.

Joule equivalent. Syn. *mechanical equivalent of heat.*

Joule heat. Heat generated by an electric current and dependent only upon the resistance and the current, *i.e.*, not including Peltier or Thomson effect. *Cf. Joule effect* (3), *Joule law* (1).

Joule law. 1. Expresses the quantity of heat (*Joule heat*) generated by an electric current I (amp) flowing for t (sec) in a conductor of resistance R (ohms) as $0.2388RI^2t$ (cal). Since the rate of heat generation is proportional to RI^2, energy lost in this way is sometimes called the RI^2 *loss.* 2. States that the internal energy of a perfect gas is a function of its temperature only, *i.e.*, does not depend upon its volume or pressure.

Joule-Thomson effect. An effect observed by Joule and Thomson (Kelvin) about 1852 upon the temperature of a gas escaping from a higher pressure into a lower pressure through a porous partition, the change being either a cooling or a heating (the so-called porous-plug experiment). This change indicates the presence of molecular interactions.

just scale. A musical scale in which the frequencies making up the chords have certain simple ratios. Syn. *diatonic scale.*

K

(Please note purpose of references as explained in preface.)

K series. A series of frequencies in the x-ray spectrum of an element, believed to arise from the transition of electrons from various higher quantum states to the state whose principal quantum number is 1.

kaleidophone. A device for producing the Lissajous curves, consisting of an elastic strip capable of two vibrations at right angles, and having a small mirror mounted across one end. Devised by Wheatstone. (See Richardson, Sound, 1929, p. 84.)

Kater pendulum. One of several types of rigid pendulum designed by Kater for relative or absolute gravity determinations. The most familiar is reversible, having two adjustable knife edges and depending upon the Huygens pendulum law.

Kauffman experiment. An experiment upon beta particles moving across magnetic and electric fields, which leads to the conclusion that the mass of an electron is entirely electromagnetic. (See Poor, Electricity and Magnetism, 1931, p. 173.)

Kelvin balance. An instrument for measuring an electric current by balancing, against the weight of a known mass, the electrodynamic force on two coils, one at each end of a balance beam; the force on each coil being produced by two fixed coils mounted one above, the other below, the moving coil.

Kelvin electrodynamic law. States that if a number of electric cir-

cuits carrying currents are displaced with reference to each other, the work thus done (whether positive or negative) appears as a change (positive or negative) in the total electromagnetic energy of the circuits. (See Page, Int. to Theoretical Phys., 1928, p. 401.)

Kelvin hydrodynamic theorem. States that the circulation around any closed fluid filament (stream line) is invariable in time, provided the impressed forces have a single-valued potential and the density is a function of the pressure alone. (See Silberstein, Vectorial Mech., 1926, p. 161.)

Kelvin scale. An ideal, absolute-temperature scale, proposed by Lord Kelvin (1848), the equal intervals on which correspond to equal quantities of work derived from a working substance performing in perfect Carnot cycles between the respective isothermals. It closely approximates the ordinary hydrogen-pressure absolute scale. Syn. *thermodynamic scale.* (See Poynting and Thomson, Heat, 1928, p. 9.)

Kelvin thermoelectric relations. Certain formulas derived by Lord Kelvin for the reversible heat development and the thermoelectromotive force in crystals. (See Uehling, *Phys. Rev.* 37, 821, 1932.)

Kennelly-Heaviside layer. Syn. *ionosphere, Heaviside layer.*

Kennelly law (of magnetization). States that the reluctivity in magnetizing a specimen of iron is a linear function of the magnetizing force. (See Spooner, Properties and Testing of Magnetic Materials, 1927, p. 12.)

Kepler laws. Three laws of satellite motion under a central inverse-square attraction, stated as follows: 1. The orbit is an ellipse with the attracting center at one focus. 2. The radius vector of the revolving satellite describes equal areas in equal times. 3. The squares of the periods of different satellites revolving about the same primary are proportional to the cubes of their mean radii vectors. First stated, empirically, by Kepler with reference to the planets; (1) and (2) in 1609, (3) in 1618.

Kepler telescope. A telescope in which the objective and the ocular are both convergent lenses, the objective forming a real image to be viewed by the ocular in whose first focal plane it lies.

kernel. 1. A line within a conductor carrying a current, along which the magnetic intensity due to the current is zero. (See Attwood, Electric and Magnetic Fields, 1932, p. 264.) 2. Syn. *Rumpf, core* (5). (Obsolescent. See Lewis, *J. Am. Chem. Soc.* 10, 1121, 1916.)

Kerr cell. An enclosure containing a small quantity of nitrobenzene or other transparent substance which exhibits electric double refraction, and used to demonstrate or utilize this effect. *Cf. Kerr effect* (1).

Kerr constants. The Kerr electro-optical constant (*cf. Kerr law*) and the Kerr magneto-optical constant (*cf. Kerr effect* (2)).

Kerr effect. 1. (Elec.) An electro-optical effect; *viz.*, certain

transparent, normally isotropic substances become doubly refracting when subjected to an electric field transverse to the beam of light. Syn. *electric double refraction. Cf. Kerr law, Cotton-Mouton effect.* (See Kingsbury, *R.S.I.* 1, 22, 1930; Beams, Rev. Mod. Phys. 4, 133, 1932.) 2. (Mag.) The conversion into elliptically polarized light of plane-polarized light when it is reflected, even in or perpendicular to the polarizing plane, from the polished pole-piece of a magnet (*polar reflection*). The rotation of the elliptic major axis is equal to the magnetization multiplied by the Kerr magneto-optical constant. (See Smiths. P. T., 1929, p. 383; Ingersoll, *Phys. Rev.* 35(1), 312, 1912.)

Kerr law. *In re* Kerr effect (1): if n_p and n_s are the refractive indices for light polarized in planes respectively parallel and perpendicular to the electric intensity E, then $n_p - n_s = B\lambda E^2$. Here B is constant for any fixed temperature and any fixed (air) wave length λ, and is called the *Kerr electro-optical constant* for the given substance, wave length and temperature. Also expressed in the form $\Delta = 2\pi BlE^2$, in which Δ is the phase difference (in radians) introduced by a thickness l of medium. (See Beams, *Rev. Mod. Phys.* 4, 133, 1932.)

Ketteler-Helmholtz dispersion formula. *Cf. Sellmeier dispersion formula.*

kilogram. The practical metric standard of mass and of weight; defined as the mass of a platinum cylinder, known as the *kilogramme des archives,* at Sèvres.

kilowatt-hour. A practical unit of electric energy, equal to 1,000 watt-hr.

kinematic viscosity coefficient. The ratio of the viscosity coefficient of a fluid to its density. (See I.C.T., 1926, v. 1, p. 38; Richardson, Sound, 1929, p. 142.)

kinematics. That branch of physics which deals with motion in the abstract, *i.e.*, of points or space figures, and apart from its dynamic aspects. *Cf. kinetics.*

kinetic energy. That part of the total energy of a body or system which is obviously associated with its motion or with the relative motions of its parts. Syn. *vis viva* (Lat.).

kinetic equilibrium. Equilibrium in which the system, or parts of it, are in motion; *e.g.*, a particle moving with uniform speed in a straight line is in this condition. Syn. *isodynamostacy. Cf. d'Alembert principle, kinetic stability.*

kinetic potential. 1. *In re* a particle of rest mass m_0 moving with speed u: A physical magnitude represented by the expression

$$-m_0c^2\sqrt{1-\frac{u^2}{c^2}},$$

c being the electromagnetic constant. The components of the momentum of the body are, in relativistic mechanics, the derivatives of this quantity with respect to the components of the velocity. 2. Syn. *Lagrangian function.*

kinetic reaction. The reaction of inertia in an accelerated body. If the mass is m and the acceleration is a, the kinetic reaction is $-ma$. (See Page, Int. to Theoretical Phys., 1928, p. 47.)

kinetic stability. The stability of a moving body or system, which has the property that when its motion is slightly altered, it oscillates and, if left to itself, returns to its former state of motion. Illustrated by touching a rapidly spinning top lightly with the finger. *Cf. kinetic equilibrium.* (See Ferry, Applied Gyrodynamics, 1932, p. 255.)

kinetic theory. A theory, relating to any group of phenomena, which explains them on the basis of motion, *e.g.*, the kinetic theory of gas dynamics.

kinetics. That branch of physics which deals with the motion of material bodies in relation to the forces acting upon them. *Cf. kinematics.*

Kirchhoff bridge. A type of resistance bridge described by Heaviside, in which the potential differences through the known and the unknown resistances in series are balanced in a differential galvanometer. (See Roller, Electric and Magnetic Meas., 1907, p. 115.)

Kirchhoff constant. The constant K in Kirchhoff's formula for the velocity of sound in air confined in a tube, which is

$$v = v_0\left[1 - \frac{K}{2r\sqrt{\pi n}}\right].$$

v_0 is the velocity in the open air, r the radius of the tube, n the frequency; K is dependent upon the properties of the gas. (See Wood, Textbook of Sound, 1930, p. 328; Buss, *Ann. d. Phys.* 7, 601, 1930.)

Kirchhoff laws. Several physical laws are attributed to Kirchhoff; the more important are: 1. The ratio of the emissive power of a surface to its absorptivity for the same radiation is the same for all surfaces at a given temperature and is equal to the emissive power of a black body at the same temperature. 2. Certain adaptations of Ohm's law to networks of conductors, treated in works on the mathematical theory of electricity. (See Loeb, Fund. of Electricity and Magnetism, 1931, pp. 112 ff.)

Kirchhoff potential. The retarded potential due to a moving charge or magnet. (See Poor, Electricity and Magnetism, 1931, p. 140.)

Klein-Nishina formula. A formula expressing the scattering coefficient μ of a substance for gamma radiation, assumed as due entirely to the Compton effect of the extranuclear electrons. Thus:

$$\mu = \frac{2\pi Ne^4}{m^2c^4}\left\{\frac{1+\alpha}{\alpha^2}\left[\frac{2(1+\alpha)}{1+2\alpha} - \frac{1}{\alpha}\log(1+2\alpha)\right] + \frac{1}{2\alpha}\log(1+2\alpha) - \frac{1+3\alpha}{(1+2\alpha)^2}\right\}.$$

N is the number of electrons per cm^3, m the electronic mass, e the electronic charge, c the electromagnetic constant, and

$$\alpha = \frac{h\nu}{mc^2},$$

where $h\nu$ is the radiation quantum energy (Planck constant $\times$ frequency). (Klein and Nishina, *Nature* 122, 399, 1928; Millikan and Cameron, *Phys. Rev.* 37, 235, 1931.)

knife-edge test. A method of testing large mirror objectives. (See

Bell, The Telescope, 1922, p. 212; Gaviola, *J.O.S.A.* 26, 163, 1936.)

Knudsen equation. A somewhat complicated equation for the flow of a rarefied gas through a cylindrical tube at very low pressures. (See Loeb, Kinetic Theory of Gases, 2d ed., pp. 290 ff.)

Knudsen gauge. A gauge for measuring extremely low gas pressures. It operates on the principle of unequal bombardment of a surface by molecules of different energies, which gives a measurable resultant force proportional to the pressure of the gas. Syn. *Knudsen absolute manometer.* (See Loeb, Kinetic Theory of Gases, 2d ed., p. 348; Hoag, Electron Phys., 1929, p. 162.)

Knudsen molecular scattering law. A law of the diffuse emission or reflection of molecules from a solid surface, analogous to the cosine emission law for radiation. It states that the fraction dn/n of all the n molecules emitted or reflected from the surface within solid angle $d\omega$ making an angle ϕ with the normal is equal to $\frac{1}{\pi} \cos \phi \, d\omega$. (See Fraser, Molecular Rays, 1931, p. 79.)

Knudsen-Weber law. An experimentally established law for the resistance to the motion of spheres in a viscous medium. It is an extension of the Stokes law and reduces to it under appropriate limits. (See Knudsen and Weber, *Ann. d. Phys.* 36, 981, 1911; Epstein, *Phys. Rev.* 23(2), 710, 1924.)

Koch resistance. A high resistance, consisting essentially of an illuminated photoelectric cell used at voltages low enough to insure that the resistance is independent of the voltage. (See Koch, *Ann. d. Phys.* 39, 705, 1912; Campbell and Ritchie, Photoelectric Cells, 1930, p. 128.)

Kohlrausch law. States that the two kinds of ions of an electrolyte in solution conduct the current independently of each other and in proportion to their transference numbers. (See Kraus, Properties of Electrically Conducting Systems, 1922, p. 33.)

Kossel-Sommerfeld laws. 1. States that the arc spectra of elements of even atomic number show odd multiplicity, and vice versa. Syn. *alternation law.* 2. States that the spectrum of a singly ionized element (first spark spectrum) resembles that of the next preceding element in the atomic-number table; the spectrum of a doubly ionized element (second spark spectrum), that of the next but one; etc. Syn. *displacement law* (2). (See Meggers, *Phys. Rev.* 9(2), 355, 1924.)

Kuhn-Reiche sum rule. *In re* the quantum theory of dispersion: states that the factors by which the classical terms corresponding to the several absorption frequencies in the dispersion formula of the atom are multiplied, and which are characteristic of the respective absorption lines, have unity as their sum. (See Breit, *Rev. Mod. Phys.* 4, 528, 1932.)

Kundt constant. The Verdet "constant" divided by the magnetic susceptibility. In the case of ferromagnetic substances, having variable susceptibility, the Verdet

factor is not constant but is proportional to the susceptibility; so that it must be divided by the latter to give a constant value. (See DuBois, *Wied. Ann.* 35, 137, 1888; Smiths. P. T., 1929, p. 382.)

Kundt tube. A long glass tube, like a horizontal organ pipe, inside which is sprinkled a quantity of fine powder, or which is provided with some other device to exhibit the acoustic nodes and antinodes when the tube is sounded.

L

(Please note purpose of references as explained in preface.)

L series. A series of frequencies in the x-ray spectrum of an element, believed to arise from the transition of electrons from various higher quantum states to the state whose principal quantum number is 2.

L-uncoupling. A change that may take place in the quantization of a rotating molecule as the angular speed increases; the change being from a quantization of the electronic angular momentum L to that of the angular momentum of the revolving nuclei.

lag. 1. A delay in the phase of current maxima behind the corresponding e.m.f. maxima in an inductive a.-c. circuit. *Cf. lead.* 2. In general, a delay in the action of any device, *e.g.* of a thermometer behind changes of temperature. *Cf. magnetic lag.*

Lagrange equations. A set of differential equations relating to a system of particles, one equation for each of the n degrees of freedom, corresponding to the generalized co-ordinates $q_1, q_2, \ldots, q_n$. If E_k denotes the kinetic energy of the system, the form of each equation is

$$\frac{d}{dt}\left(\frac{\partial E_k}{\partial \dot{q}_r}\right) - \frac{\partial E_k}{\partial q_r} = Q_r \qquad (r = 1, 2, \ldots, n);$$

in which $\dot{q}_r$ denotes dq_r/dt.

$$\sum_1^n Q_r \partial q_r$$

is the work done by the external forces in the arbitrary displacement $\partial q_1, \partial q_2, \ldots, \partial q_n$. (See Whittaker, Analytical Dynamics, 3d ed., pp. 37, 38; Page, Int. to Theoretical Phys., 1928, p. 170.)

Lagrangian function. An expression for the kinetic minus the potential energy in a conservative system. Syn. *kinetic potential* (2). (See Allen, The Quantum and Its Interpretation, 1928, p. 20; Whittaker, Analytical Dynamics, 3d ed., p. 39.)

Laguerre polynomial. A polynomial in x and e^x which occurs in the radial factor of the quantum-mechanical solution of the hydrogen atom. (See White, Int. to Atomic Spectra, 1934, p. 66.)

lambda value. The value of the orbital angular momentum of a molecule about its axis of figure, expressed as a multiple of the quantum number $h/2\pi$. *Cf. omega value, sigma value.* (See Mulliken, *Rev. Mod. Phys.* 2, 60, 1930.)

lambert. A unit of brightness, equal to that of a perfectly diffusing surface emitting or reflecting light

at the rate of 1 lumen per cm². Equivalent to $1/\pi$ candle/cm.²

Lambert law. Syn. *cosine emission law.*

lamellar. 1. Syn. *laminar.* 2. *In re* a vector point function: having a circuitation equal to zero. Syn. *irrotational, noncircuital.*

laminar. In the form of a thin layer or lamina. Syn. *lamellar* (1).

laminate. To divide into laminae; esp. the iron core of an electromagnet, to minimize the effect of eddy currents.

Lanchester rule. *In re* the precessional effect on a gyroscope: view the whirling gyro from a point in the plane of its rotation and apply a torque to the axis of rotation, the axis of the applied torque being coincident with the line of sight; the immediate result is a precessional tipping of the rotation axis toward or from the observer, such that the gyro now appears to rotate in the same direction as the applied torque. (See Newman and Searle, General Properties of Matter, 1929, p. 82.)

Landé factor. *Cf. interval rule.*

Landolt band. A dark band sometimes appearing in the field of crossed Nicols with an intense source, as the sun; due to the light being not strictly parallel, so that it is not all extinguished at once. (See Martin, Optical Meas. Instr., 1924, p. 211.)

Langevin function. A function of the form $L(x) = \cot x - \frac{1}{x}$; used in the kinetic theory of gases. (See Loeb, Kinetic Theory of Gases, 2d ed., pp. 491, 513, 518.)

Langevin ion. An electrified particle in a gas, resulting from the accumulation of gaseous ions upon dust particles or other nuclei.

Langevin law. Expresses the average magnetic moment of the molecules of a gas as $\mu^2 H/3kT$, in which μ is the magnetic permeability, H the magnetizing field, k the Boltzmann constant, and T the absolute temperature. (See Loeb, Kinetic Theory of Gases, 1927, p. 418.)

Langmuir dark space. A nonluminous region surrounding a negatively charged probe inserted into the positive column of a glow or arc discharge. (See Darrow, Electrical Phenomena in Gases, 1932, p. 359; Seeliger, *Phys. Zeits.* 30, 527, 1929.)

Laplace equation. A linear differential equation of the second order which occurs very frequently in mathematical physics. *E.g.*, for any point in an electric field at which there is no electricity, the potential V satisfies this equation, which in rectangular co-ordinates has the form

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = 0.$$

Cf. Laplace operator, Poisson equation.

Laplace law. *Cf. Ampère law.*

Laplace operator. The differential operator which occurs in the Laplace and the Poisson equations. In rectangular co-ordinates it is

$$\left[\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right],$$

and is often represented by the symbol ∇^2. Thus the Laplace

equation may be written $\nabla^2 V = 0$. Syn. *Laplacian.*

La Porte rule. States that in dipole radiation, even spectral terms combine only with odd, and vice versa. (See Pauling and Goudsmit, Structure of Line Spectra, 1930, p. 94.)

Larmor precession. *Cf. Larmor principle.*

Larmor principle. Sets forth the first-order effect of a magnetic field upon the electronic orbits in an atom, as a precessional motion of the orbit about an axis lying in the direction of the field, sometimes referred to as the *Larmor precession.* (See Allen, The Quantum and Its Interpretation, 1928, p. 206; White, Int. to Atomic Spectra, 1934, p. 51.)

lattice. An arrangement of points in space, representing the relative positions of corresponding atomic, molecular, or ionic centers in the elementary cells or structure units of a crystal. *Cf. surface lattice.*

lattice constant. The distance between successive planes of a specified plane-family in a crystal. For the (111) planes of calcite it is taken as 3.028×10^{-8} cm.

lattice energy. The energy which depends upon the configuration of the atoms in a crystal lattice, and which changes when any change is made in that configuration through mechanical stress, electric forces, or otherwise.

lattice unit. Syn. *unit cell, elementary cell.*

Laue equations. A set of three simultaneous equations which must be satisfied for any intensity maximum of radiation diffracted by a crystal. (See Compton and Allison, X-Rays in Theory and Experiment, 1935, p. 337.)

Laue pattern. The photographic record of the diffracted beams produced when heterogeneous x-rays from a pinhole or slit impinge upon a single crystal. *Cf. radiogram*(2). (See Davey, Study of Crystal Structure and Its Applications, 1934, pp. 56 ff.)

law of atmospheres. A law, first stated by Laplace, expressing the distribution of molecules in an ideal atmosphere subject only to gravity and thermal agitation. In one form, the number of molecules per unit volume at any altitude h is given by

$$N = N_0 e^{-\frac{3gh}{\overline{U^2}}},$$

where N_0 is the number at the arbitrary elevation zero. $\overline{U^2}$ is the mean square speed of molecular motion. It is a special case of the Boltzmann principle. (See Loeb, Kinetic Theory of Gases, 1927, p. 343.)

law of axes. States that the opposite ends of any one of the axes of a crystal are cut by the same number of similar faces similarly arranged. (See Butler, Manual of Geometrical Crystallography, 1918, p. 16.)

law of corresponding states. Expresses the approximate fact that if two of the three reduced variables of state are equal for two different bodies of gas, the third will also be equal for these bodies. Such gaseous bodies are said to be in *corresponding states.* (See Jeans, Dynamical Theory of Gases, 1916, p. 163.)

law of fall of potential. States that the difference in electric potential between points on a conductor is in proportion to the amount of electric energy transformed into other forms between the points in question. For simple ohmic resistance, it is proportional to the resistance between the points.

law of stages. The principle that in the process of crystallization from the liquid state, the atoms arrive at their final, permanent configuration through successive, temporary arrangements of varying stability. (See Tamman and Mehl, States of Aggregation, 1925, p. 236.)

lead (lēēd). 1. The opposite of *lag*. 2. A connecting wire to or from an electric device.

leak, leakage. 1. A ground or cross connection of very high resistance, *e.g.*, a grid leak. *Electric leakage* is the small current traversing such a leak. 2. *Magnetic leakage* is a straying of lines of magnetic induction from the prescribed magnetic circuit into the surrounding space.

least-action principle. States that if a dynamic system passes spontaneously and without change in total energy from one configuration to another, the action involved in the process is a minimum; or (an equivalent statement) that the line integral of the momentum of each particle is a minimum. Enunciated by Maupertuis. (See Haas, The World of Atoms, 1928, p. 117.)

least circle of aberration. The smallest cross section of a bundle of reflected or refracted rays forming a symmetrical caustic surface.

least-energy principle. States that a dynamic system is in stable equilibrium only for configurations in which the potential energy of the system as a whole has minimum values. *Cf. Le Chatelier principle.*

least-interval principle. A principle analogous to the principle of least time or the principle of least action, but which requires that any natural sequence of events take place in such a manner that the section of the world line connecting them in the space-time continuum shall be shorter than for any other, arbitrary sequence of events. (See Jeans, New Background of Science, 1933, p. 125.)

least-squares principle. A principle of the theory of errors, based upon the normal law of error, which states that the best estimate of an experimental quantity, deducible from a number of observations, is that for which the sum of the weighted squares of the residuals is least. (See Weld, Theory of Errors and Least Squares, 1929, arts. 29, 33, 52; Stewart, *Phil. Mag.* 40, 217, 1920; Uhler, *J.O.S.A.* 7, 1043, 1923.)

least-time principle. *Cf. Fermat principle.*

least-work principle. A special case of the principle of least energy which states, in reference to an elastic structure having redundant bars or members, that the stresses developed in the members by the application of loads are such as to render the total internal work throughout the structure a minimum. (See Church, Mech. of Internal Work, 1910, p. 31.)

Le Chatelier principle. A form of the least-energy principle, stating that when a dynamic system is in stable equilibrium, any change in its state brings about conditions opposed to further change in the same direction; equivalent to a definition of *stable equilibrium.* (See Willows and Hatschek, Surface Tension and Surface Energy, 1923, p. 5.)

Lecher oscillator. A device for producing a system of standing waves in two parallel wires, called *Lecher wires.*

Legendre equation. A differential equation of the form

$$\frac{d}{dx}\left\{(1 - x^2)\frac{dy}{dx}\right\} + ay = 0.$$

The solutions of this equation are *Legendre functions* or *Legendre polynomials.* (See Page and Adams, Prin. of Electricity, 1931, p. 88.)

Legendre polynomial. A cosine polynomial which occurs in the angular factor of the quantum-mechanical solution of the hydrogen atom. *Cf. Legendre equation.* (See White, Int. to Atomic Spectra, 1934, p. 60.)

Lenard rays. Cathode rays that have escaped from the vacuum tube through a "window" or thin metallic foil. Produced and studied by Lenard in 1894.

Lenard tube. A vacuum tube specially designed to exhibit Lenard rays; recently improved as the Coolidge cathode-ray tube.

lensometer. An instrument designed for the measurement of the optical characteristics of spectacle lenses. (See Sheard and Tillyer, *J.O.S.A.* 6, 1030, 1922.)

Lenz law. States that whenever an e.m.f. is induced in a conductor by the variation of a magnetic field or by the relative motion of the conductor and the field, the direction of that e.m.f. is such as to tend to produce a current whose reaction with the field opposes the variation or the motion.

levigation. The sorting of different-sized particles by virtue of the varying rate of fall in a fluid.

levogyrate, laevogyrate. The opposite of *dextrogyrate, i.e.,* producing a left-handed rotation in polarized light. Syn. *levorotatory.*

levorotatory. Syn. *levogyrate.*

Lewis-Adams relation. A hypothetical relationship involving the elementary charge e, the electromagnetic constant c, and the Planck constant h; *viz.,*

$$\frac{8\pi^3 e^2}{ch} = \left(\frac{15}{\pi^2}\right)^{1/3}.$$

Cf. fine-structure constant. (See Lewis and Adams, *Phys. Rev.* 3(2), 92, 1914.)

Lewis-Langmuir atom. A concept of the nuclear atom in which the extranuclear electrons are assumed to occupy fixed relative positions; in contrast to the orbital electronic atom of Rutherford and Bohr. Syn. *static atom.*

Lewis-Rayleigh glow. A yellow afterglow, most readily produced by condensed or electrodeless discharges in nitrogen. At ordinary temperatures, its spectrum consists of certain bands of the N_2 system. (See Jevons, Report on Band Spectra of Diatomic Molecules, pp. 6, 206 ff.; Kaplan,

Phys. Rev. 48, 800, 1935 and 51, 143, 1937.)

Leyden jar. The original form of electric condenser, in which the dielectric is a glass jar; credited to Muschenbroeck (Leyden, 1745).

Leyden temperature scale. A low-temperature range of the centigrade scale, based upon the boiling point of hydrogen as −252.74°C. and that of oxygen as −182.95°C.; from the work of Onnes at the Leyden laboratory. (See I.C.T., 1926, v. 1, p. 54.)

Lichtenberg figure. A pattern traced on a dielectric surface, which has been nonuniformly electrified, by sifting over it fine powders, such as a mixture of sulphur and red lead.

light-distribution curve. A graph showing the variations of luminous intensity with the direction of emission. If it is in polar co-ordinates, the curve is sometimes called a *polar candle-power diagram.* (See Walsh, Photometry, 1926, p. 88.)

light-negative. Having negative photoconductivity, *i.e.*, decreasing in conductivity under the action of light. Selenium sometimes exhibits this property. Syn. *photo-negative. Cf. light-positive.*

light-positive. Having positive photoconductivity, *i.e.*, increasing in conductivity under the action of light. Selenium ordinarily has this property. *Cf. light-negative.*

light pressure. *Cf. radiation pressure.*

light, quantity of. A measure of the time integral of luminous flux; commonly expressed in lumen-hours.

light-source efficiency. The ratio of the luminous flux from a source of light to the power required to maintain it; usually expressed in lumens per watt. *Cf. luminous efficiency.*

light valve. A device, either mechanical or electro-optical, for controlling the intensity of a beam of light, or for intermittently cutting it off, as a shutter.

light vector. The electric vector concerned in the propagation of electromagnetic radiation. *Cf. Poynting vector.*

light-year. A unit of interstellar distance, equal to the distance which light travels, in a vacuum, in 1 year; approximately equal to 9.45988×10^{17} cm or 5.87837×10^{12} mi.

limiting surface of stress. A surface, the rectangular co-ordinates of whose points represent the three principal stresses in an elastic substance when its elastic behavior reaches the stage of plasticity. (See Nádai, Plasticity, 1931, p. 55.)

line density. The mass per unit length, as of a wire or a slender rod.

line interval. The difference in frequency between two adjacent lines in a spectral series.

line of displacement. That which, in a polarized dielectric, corresponds to a line of electric force in a vacuum. The lines of displacement in a nonisotropic dielectric do not, however, necessarily coincide with the lines of force of the field in which it is placed. *Cf. line of induction.*

line of flow. The path followed by any one particle of a fluid when flowing. Syn. *streamline* (2).

line of force. 1. An imaginary line in a field of force which, at each of its points, coincides in direction with the field intensity; a concept due to Faraday. 2. A unit of flux (magnetic, electric), so defined that the number of lines intersecting any cross section, per unit area, is numerically equal to the component of field intensity normal to the section. *Cf. maxwell.*

line of induction. That which, in a magnetized body, corresponds to a line of magnetic force in a vacuum. The lines of induction do not, however, necessarily coincide with the lines of force of the field in which the body is placed. *Cf. line of displacement.*

line of separation. The line at which the two streams along the curved surface of a body advancing through a fluid, one from the front toward the rear, the other from the rear toward the front, meet upon the surface and at which they separate from it. *Cf. angle of separation.*

line of stress. An imaginary line extending through a stressed elastic substance in the direction of principal tension, compression, or shear. Syn. *principal stress trajectory.*

line spectrum. An atomic spectrum, characterized by distinct lines, rather than by bands as in molecular spectra.

line-turn. Syn. *maxwell-turn.*

linear oscillator. A system composed of two parts so connected that they are capable of oscillating with respect to each other along the line joining them, *e.g.*, two balls at the ends of a rubber cord, the two ions of a polar molecule, or the positive and negative electricity in a Hertz oscillator.

linkage. 1. A mechanical arrangement of solid pieces connected by movable joints, used for imparting motion of a desired character; *e.g.*, in the mechanism which controls the valves of a steam engine. 2. (*Magnetic.*) A measure of the interlocking of a magnetic flux with an electric circuit, *viz.*, the product of the flux by the number of turns of the circuit surrounding it, expressed in maxwell-turns. Syn. *turn-flux, flux-turns.* (See Zeleny, Elements of Elec., 1930, p. 157.) 3. A chemical bond between atoms in a molecule.

Liouville theorem. States that for a conservative system of particles, the number of particles per unit volume in any representative group of the particles remains unaltered as the particles move. (See Jeans, Dynamical Theory of Gases, 1916, p. 73; Swann, *Phys. Rev.* 44, 224, 1933.)

Lippich prism. A type of half-shade analyzer consisting of a small Nicol prism covering half the field of the polarimeter. (See Hardy and Perrin, Prin. of Optics, 1932, p. 611.)

Lippmann effect. The effect of a p.d. upon the mutual surface tension of two conducting, immiscible liquids, as mercury and an electrolytic solution. The surface tension is greatest when the p.d. is zero. *Cf. electrocapillarity.*

Lippmann fringes. Interference maxima which may be detected photographically, in parallel planes, in the space in front of a mercury surface from which light is normally reflected; due to the interference of the incident with the reflected light, forming stationary waves. (See Wood, Phys. Optics, 1929, p. 176.)

liquid crystal. A liquid that has optical anisotropy and other properties similar to those of a crystal, *e.g.*, para-azoxyanisole. Such a substance is said to be in a *liquocrystalline* or *mesomorphic* state. *Cf. cybotaxis.*

Lissajous curves. A family of plane curves described by a point having two simple harmonic motions at right angles; varying with the relations of amplitude, frequency, and phase.

liter, litre. Originally defined as 1,000 cm^3; but for practical purposes now defined as the volume of 1 kg of pure water at its maximum density (4°C.), and therefore equal to 1000.027 cm^3. (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

Lloyd mirror. A mirror used with very high incidence angle to produce by reflection two coherent light sources resulting in interference bands. (See Preston. Theory of Light, 3d ed., p. 148.)

load. 1. The power delivered by a generator to the line. 2. A resistance, inductance, or capacitance intentionally placed in a circuit, usually to increase or control the reactance. *Cf. loading coil.* 3. The force sustained by any structural member, as a beam or a column.

loading coil. A coil of adjusted inductance, introduced into certain complicated circuits to impart desired characteristics. *Cf. load* (2).

local action. A chemical reaction which takes place in an electrolyte on the surface of an electrode at points where particles of foreign matter serve to complete microscopic voltaic circuits, and which results in corrosion of the electrode even when the main circuit of the cell is open.

local change. Any dynamic process in which the attention is fixed upon a point of space, through which particles of a system pass in succession, differences in their motions being noted; in contradistinction to *individual change, q.v.* (See Silberstein, Vectorial Mech., 1926, p. 124.)

logarithmic decrement. The Napierian logarithm of a damping factor or oscillation decrement.

logarithmic potential. A potential associated with a field of force subject to the inverse-first-power law instead of to the Newtonian or inverse-square law; so called because its value involves the logarithm of the distance. (See MacMillan, Theory of the Potential, 1930, p. 35.)

logarithmic scale. A linear scale on which the actual distances of the points from the zero of the scale are proportional to the logarithms of the numbers with which these points are labeled.

long-wave limit. Syn. *photoelectric threshold.*

longitudinal mass. The ratio of force to acceleration, as given by

the special theory of relativity, in the case of a particle that is accelerated in the direction of its existing velocity; not a fundamental concept, since there is no law of conservation for this kind of mass. *Cf. transverse mass.*

looming. A type of mirage in which images of objects below the horizon appear in distorted form.

loop. 1. Syn. *antinode.* 2. A graph in the form of a cyclic closed curve, *e.g.*, a hysteresis loop.

Lorentz displacement. The difference in frequency between the undisplaced line and either of the two outer components of a Lorentz triplet in the normal Zeeman effect. *Cf. Lorentz unit.*

Lorentz double refraction. A group of optical phenomena in crystals, consisting of double refraction effects of the second order, not ordinarily observed and not included in the usual theories of crystal optics. *E.g.*, Lorentz showed that even certain cubic crystals are not optically isotropic.

Lorentz electromotive force. A force acting upon an electric particle by reason of its motion relative to a magnetic field. Syn. *Biot-Savart force.* (See Einstein, Meaning of Relativity, 1923, p. 46.)

Lorentz electron. A moving electron which, according to the theory of Lorentz, has had its dimension parallel to the direction of motion shortened in the ratio

$$\sqrt{1 - \frac{u^2}{c^2}} : 1;$$

in which u is the speed of the electron and c, the speed of light. (See Maizlish, *Phys. Rev.* 20(2), 34, 1922; Wang, *Phys. Rev.* 28 (2), 1309, 1926.)

Lorentz factor. 1. The ratio of the intensity of an x-ray crystal-diffraction beam of a given order to that of the zero order, or undeflected, beam. (See Terrill and Ulrey, X-ray Technology, 1930, p. 279.) 2. A factor expressing the dependence of the intensity upon the glancing angle, as the crystal is rotated. (See Blake, *Rev. Mod. Phys.* 5, 169, 1933.)

Lorentz-Fitzgerald contraction. A hypothetical shrinkage of all matter in the direction in which it moves through the ether, such that all dimensions in this direction are reduced in the ratio

$$\sqrt{1 - \frac{u^2}{c^2}} : 1;$$

where u is the speed of the motion and c, the speed of light. Syn. *relativity contraction. Cf. Lorentz electron.*

Lorentz invariance. An attribute of any fundamental equation of physics which exhibits its agreement with the requirements of the special theory of relativity by being invariant under the Lorentz transformation. (See Furry and Oppenheimer, *Phys. Rev.* 45, 251, 1934.)

Lorentz transformation, Lorentz-Einstein t. The process of transforming the mathematical expression corresponding to a given physical concept from the independent variables x, y, z, t, used by a given observer, to a new set x', y', z', t', used by a second observer in uniform motion relative to the first; making use of the

Lorentz equations for the transformation of space and time variables.

Lorentz triplet. A spectral triplet observed with light at right angles to the magnetic field, in the normal Zeeman effect. The center line is polarized with the electric vector parallel to the field, the others perpendicular to the field. *Cf. Lorentz displacement, L. unit.*

Lorentz unit. The difference in quantum energy corresponding to the Lorentz displacement in the normal Zeeman effect; expressed by the formula $heH/4\pi m_0 c$, in which h is the Planck constant, e the elementary charge (in e.m.u.), c the electromagnetic constant, m_0 the rest mass of the electron, and H the magnetic intensity responsible for the effect. (See Pauling and Goudsmit, Structure of Line Spectra, 1930, p. 70.)

Lorenz-Lorentz relation. A relation connecting the refractive index n of a dielectric with its density ρ:

$$\frac{n^2 - 1}{(n^2 + 2)\rho} = C;$$

in which C is a constant for the given dielectric, known as the *specific refractive power. Cf. atomic refraction, molar refraction, Clausius-Mosotti law.* (See Lorentz, Theory of Electrons, 2d ed., pp. 142 ff.)

Lorenz number. A constant which, according to Lorenz, represents the product of the mobility coefficient of an ion by its radius. Its value is about 9.37×10^{-7} cm/ohm. (See Taylor, Treatise on Phys. Chem., 2d ed., p. 567.)

Loschmidt number. The number of molecules per cm^3 of an ideal gas at N.T.P., equal to about 2.705×10^{19}. (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

low-pass. *In re* a wave filter: having the property of transmitting all frequencies below a certain limit and suppressing those above it. *Cf. high-pass, band-pass.*

lower state. That one of the two energy states or levels, before and after a quantum transition, in which the atom or the molecule has less electronic energy. *Cf. upper state.* (See Kaplan, *Phys. Rev.* 45, 675, 1934.)

Ludwig-Soret effect. The effect of temperature upon the concentration of one of the components of a mixed crystal. (See Wagner, *Ann. d. Phys.* 3, 629, 1929.)

lumen. A unit of luminous flux, equal to the flux through unit solid angle (spheradian) from a uniform point source of 1 candle. The total emission in all directions from such a source is 4π lumens.

lumen-hour. A unit quantity of luminous energy, equal to the emission of 1 lumen for 1 hr.

lumen meter. A device for measuring luminous flux; specifically, a photometer designed by Blondel for measuring mean spherical candle power. (See Walsh, Photometry, 1926, p. 204.)

lumenophor. A molecule or group of molecules which. according to the Kowalski theory of luminescence, is capable of emitting light when excited by absorbing the energy of an incident electron. *Cf. electronogen.* (See Merritt, Nichols, and Child, Selected

Topics in the Field of Luminescence (*National Research Council Bull.*, 1923, p. 12.)

lumeter. A type of illumination photometer, depending upon the comparison of the illuminated test area with an annular area illuminated by a lamp through a revolving adjustable diaphragm. (See Walsh, Photometry, 1926, pp. 353 ff.)

luminescence. 1. An emission of radiation, esp. visible light, by a substance as a result of the absorption of energy from some other emission, either radiant or corpuscular. *Cf. fluorescence, phosphorescence, thermoluminescence, Stokes law* (2). 2. In general, an emission of light by a substance from other causes than high temperature. *Cf. bioluminescence, chemiluminescence.*

luminosity curve. A distribution curve showing luminous flux per element of wave length as a function of wave length.

luminous center of gravity. Syn. *photometric center.*

luminous efficiency. The ratio of the luminous flux to the radiant flux for the complete range of an emission of radiant energy. *Cf. visibility factor, light-source efficiency.*

luminous flux, light flux. Rate of emission of visible radiation, esp. as judged by its visual effect. *Cf. lumen, visibility factor.* (See Smiths. P. T., 1929, p. 259.)

luminous intensity. *In re* a point source of light: the luminous flux emitted per unit solid angle (spheradian) in a specified direction. *Cf. candle, apparent candle power.*

Lummer-Brodhun photometer. A photometer in which the comparison of the illuminations on opposite sides of a white screen is made by a method depending upon the principle of total reflection. (See Walsh, Photometry, 1926, p. 155.)

Lummer-Gehrcke plate. A type of interferometer, based upon the interference effect of multiple reflections inside a glass plate with strictly plane and parallel faces, and capable of high resolving power.

lux. A practical metric unit of illumination, equal to 1 lumen per m^2; or, the illumination of a surface at a uniform distance of 1 m from a symmetrical point source of 1 candle. Syn. *metercandle. Cf. phot.*

luxmeter. A type of illuminometer that measures illumination in luxes. (See Fleury, *Compt. rend.* 192, 1715, 1931.)

luxometer. A portable form of cosine illumination photometer, depending upon the comparison of the illuminated test area with an area illuminated by a lamp at an adjustable angle of incidence. (See Walsh, Photometry, 1926, p. 351.)

Lyman bands. A group of spectral bands in the Schumann region of the hydrogen spectrum between 1450 Å and 1650 Å. The frequencies are multiples of

$$\left(\frac{1}{1^2} - \frac{1}{n^2}\right),$$

in which $n = 2, 3, 4, \ldots$.

(See Lyman, Spectroscopy of the Extreme Ultraviolet, 1914, chap. 3.)

Lyman continuum. A continuous spectrum in the ultraviolet, extending from the visible down to 300 Å or lower; produced by a heavy condenser discharge through a capillary. (See Collins and Price, *R.S.I.* 5, 423, 1934.)

M

(Please note purpose of references as explained in preface.)

M series. A series of frequencies in the x-ray spectrum of an element, believed to arise from the transition of electrons from various higher quantum states to the state whose principal quantum number is 3. Discovered by Siegbahn.

M value. Syn. *magnetic quantum number*.

Madelung constant. 1. A factor which occurs in the expression for the wave length of the residual radiation (*Reststrahlen*) selectively reflected by a given heteropolar crystal. 2. The constant k in the expression kE^2/r for the potential energy of separation of the two unlike ions in a heteropolar crystal, which have charges $\pm E$ and are at distance r apart. (See Sherman, *Phil. Mag.* 14, 745, 1932.)

magnalium. One of several alloys of aluminum and magnesium. That developed by Mach (69 per cent Al and 31 per cent Mg) has high reflectivity in the visible and the ultraviolet regions. (See Luckiesh, Ultraviolet Radiation, 1922, p. 95.)

magnetic analysis. 1. The separation of a stream of electrified particles by a magnetic field in accordance with their mass, their charge, or their speed. *Cf. electrostatic analysis, mass spectrograph.* 2. The study of the properties of iron or other magnetic bodies by magnetic methods. (See Brasefield, *Phys. Rev.* 31 (2), 215, 1928.)

magnetic axis. *In re* a magnet or an equivalent electric circuit: the vector direction of the magnetic moment. For a bipolar magnet with concentrated poles, it is approximately the direction of the line drawn from the south to the north pole.

magnetic circuit. *Cf. circuit* (2).

magnetic cycle. A cycle of changes in the magnetic induction or the magnetization of a ferromagnetic substance due to an alternating magnetic intensity. A symmetrical cycle may be represented by a hysteresis curve with its center at the origin.

magnetic damping. The damping of a mechanical motion by means of the reaction between a magnetic field and currents generated by the motion in accordance with the Lenz law.

magnetic double refraction. Syn. *Cotton-Mouton effect.*

magnetic element. 1. Syn. *Ampèrian current.* 2. Any group of Ampèrian currents, *e.g.*, a spinning electron, which conserves its magnetic moment throughout the

process considered. 3. Any one of the quantities customarily chosen to specify the earth's magnetic field at a given point; *viz.*, declination, inclination, total intensity, horizontal intensity, or vertical intensity.

magnetic equator. 1. A line around the earth, approximately a great circle midway between the magnetic poles, and coinciding with the line of zero magnetic inclination. 2. *Cf. free magnetism* (1).

magnetic field. A region in which there is a magnetic intensity, as indicated by the torque experienced by a bipolar magnet placed in it, due to the influence of magnets or electric currents.

magnetic flux. The surface integral, over any specified area, of the normal component of the magnetic induction; commonly expressed in maxwells or gauss-cm^2.

magnetic flux density. Syn. *magnetic induction.* (See A.I.E.E. Comm. Rep., 1932.)

magnetic inclination. *Cf. inclination* (3).

magnetic induction. A vector quantity, usually associated with the condition of a substance when placed in a magnetic field, having the same direction as the magnetizing force (provided the substance is isotropic), and having a magnitude dependent upon the magnetizing force and upon the nature of the substance. Its measure is the e.m.f. produced in an electric circuit linked with the induction at a definite time rate, in accordance with the Faraday law (3). The induction is *normal* if the substance is not already magnetized when placed in the magnetic field. Syn. *magnetic flux density. Cf. gauss, intrinsic magnetic induction.* (See A.I.E.E. Comm. Rep., 1932.)

magnetic intensity. A vector quantity pertaining to the magnetic field, the measure of which, at any point in a vacuum, is the force per unit pole experienced by a free magnetic pole placed at that point. It is closely related to magnetic induction; in a vacuum, proportional to it, and if in the same measure, even identifiable with it. *Cf. magnetizing force, oersted, permeability* (1).

magnetic lag. A delay, not due to eddy currents, in the establishment of the magnetic induction which finally corresponds to a given magnetic intensity in a given sequence of magnetic states. Syn. *magnetic aftereffect. Cf. magnetic viscosity.*

magnetic latitude. Latitude reckoned from the magnetic, instead of from the geographic, equator. Syn. *geomagnetic latitude.*

magnetic lens. An apparatus used to focus beams of rapidly moving electrons or ions by means of the effect of a nonuniform magnetic field. *Cf. electron lens.* (See Smythe, Rumbaugh, and West, *Phys. Rev.* 45, 724, 1934; Thibaud, *ibid.*, p. 781.

magnetic meridian. The horizontal line, through any point on the earth's surface, which coincides with the direction of the horizontal component of the earth's magnetic field at that point. *Cf. declination* (1).

magnetic moment. That vector, associated with a magnet or an

equivalent electric circuit, whose vector product by the magnetic intensity of the field, in which the magnet or the circuit is placed, gives the resulting torque upon the same; the magnetic intensity considered being exclusive of any component contributed by the magnetic body itself. For a bipolar magnet with concentrated poles, the magnetic moment is approximately the product of the pole strength by the distance between the poles, and its direction, that of the line drawn from the south to the north pole. *Cf. magnetic axis.*

magnetic pendulum. A bar magnet suspended so as to oscillate as a pendulum in a magnetic field.

magnetic pole. One of those regions of the surface of a magnet, just outside which the magnetic intensity arising therefrom is greatest. Unless this intensity is everywhere zero (as may happen), a magnet must have at least one pole of each sign. *Cf. point pole, unit p.*

magnetic pole strength. *Cf. unit pole.*

magnetic potential. A scalar point function analogous to electric potential. Its value at any point is the line integral of the magnetic intensity taken from that point to infinity. *Cf. Newtonian potential function, magnetomotive force, gilbert.* (See A.I.E.E. Comm. Rep., 1932.)

magnetic potentiometer. A slender solenoid, used to measure magnetomotive forces between points in a magnetic field. Its core may be of flexible, nonferromagnetic material, or of a highly permeable alloy. (See Chattock, *Phil. Mag.* 24, 94, 1887.)

magnetic quantum number. A quantum number related to the behavior of an atom or a molecule in a magnetic field, and equal to the component of the angular momentum of the system about the field direction as axis, expressed as a multiple of $h/2\pi$ (h is the Planck constant). Used in connection with magneto-optical phenomena, such as the Zeeman effect. Syn. *equatorial quantum number, axial quantum number, M value.*

magnetic rays. A term applied by Righi to certain phenomena in a discharge tube under the influence of a strong magnetic field. (See Ives, *Phys. Rev.* 7(2), 407, 1916.)

magnetic resonance accelerator. Syn. *cyclotron.*

magnetic rotation. Syn. *Faraday effect, magneto-optical rotation.*

magnetic rotation spectrum. The absorption spectrum of a substance under the influence of a magnetic field in the direction of the transmitted light, which is thus subjected to the Faraday effect. (See Wood, Phys. Optics, 1929, p. 542; Frederickson and Stannard, *Phys. Rev.* 44, 632, 1933.)

magnetic spectrograph. A magnetic mass or velocity spectrograph.

magnetic spectrum. The record of a magnetic spectrograph.

magnetic storm. A rapid and erratic disturbance of the terrestrial magnetic field, probably due to solar activity.

magnetic vector. That component of the electromagnetic field, asso-

ciated with electromagnetic radiation, which is of the nature of a magnetic field; supposed to coexist with, but to act at right angles to, the electric vector. *Cf. Poynting vector, Hertzian v.*

magnetic viscosity. A property sometimes ascribed to ferromagnetic substances to account for magnetic lag.

magnetics. That branch of physics which deals with the phenomena of magnetism.

magnetization. 1. A vector quantity associated with a substance under magnetic influence, *viz.*, the magnetic moment per unit volume. Divided by the density, it gives the *specific magnetization*, or magnetic moment per unit mass. Syn. *intensity of magnetization.* 2. The process of increasing the magnetic moment of a body.

magnetization curve. A graph on the magnetization-intensity (*I-H*) or the induction-intensity (*B-H*) diagram, representing successive states of a ferromagnetic substance. A *normal magnetization curve* is a portion of a symmetrical hysteresis loop. The *initial* or *virgin magnetization curve* is such a curve representing the first excursion from the origin, and is distinct from the subsequent cycles.

magnetizing force. The magnetic intensity brought to bear upon a substance and effective in producing its magnetization. It is in general less than the magnetic intensity of the field external to the substance. (See A.I.E.E. Comm. Rep., 1932.)

magneto compass. A device used as a compass on airplanes, utilizing the inductive effect of the earth's magnetic field to excite the field magnet of a small magneto or dynamo. When the instrument is properly oriented, the current generated reduces to zero. (See Ferry, Applied Gyrodynamics, 1932, p. 169.)

magnetocaloric effect. The reversible cooling of a ferromagnetic body, magnetized to saturation in a strong magnetic field, when the field is removed. Discovered by P. Weiss and R. Forrer in 1924. (See Bitter, *Phys. Rev.* 38, 528, 1931.)

magnetoelastic. Pertaining to magnetostriction effects associated with elastic vibration. (See Pennell and Lawther, *Bell Syst. Tech. J.* 15, 334, 1936.)

magnetoelectric induction. The production of an e.m.f. by the cutting of magnetic flux (whether the moving conductor cuts the flux or vice versa), *e.g.*, in an electric generator. First observed by Faraday in 1831. Syn. *electromagnetic induction. Cf. Faraday law* (3).

magnetogenerator. An a.-c. generator in which the field is maintained by a permanent magnet. Often abbreviated "magneto."

magnetometer. An instrument for the measurement of magnetic intensity, magnetic induction, or magnetic moment.

magnetomotive force. *In re* any closed path constituting a magnetic circuit: the line integral of the magnetizing force, or the change in magnetic potential, due to the magnetizing agency (as a coil) which acts upon the magnetic

circuit. If it is due to the current in a coil, it is proportional to the number of ampere-turns. *Cf. gilbert.*

magneton. 1. A unit of magnetic moment in terms of which molar magnetic moments are small integers (Weiss, 1911), or simple functions of small integers (Bohr, 1913). The empirical Weiss magneton is 1125.0 e.m.u., the theoretical Bohr magneton is 5557.7 e.m.u. 2. A unit of magnetic moment in terms of which the magnetic moments of magnetic elements (Ampèrian currents) are functions of small integers. The theoretical Bohr magneton in this sense is 9.158×10^{-21} c.g.s. e.m.u. *Cf. nuclear magneton.* (See Gerlach, Matter, Electricity, Energy, 1928, chap. 8.)

magneton number. An integral number by which, according to Sommerfeld, the Bohr magneton must be multiplied to give the magnetic moment of a given atom.

magneto-optical analysis. A method of chemical analysis based upon differences in the lag of the Faraday effect behind the magnetic intensity for different substances. (See Allison and Murphy, *J. Am. Chem. Soc.* 52, 3796, 1930.)

magneto-optical dispersion. Expresses the Faraday effect as the derivative, with respect to the wave length, of the product of the Verdet constant by the refractive index. (See Thomas and Evans, *Phil. Mag.* 11, 1220, 1931.)

magneto-optical parameter. A complex constant involved in the electron theory of the Faraday and the Kerr effect (2), and having a distinctive value for each metal. (See Snow, *Phys. Rev.* 2(2), 29, 1913.)

magneto-optical rotation. Syn. *Faraday effect, magnetic rotation.*

magnetophotophoresis. *Cf. photophoresis.*

magnetoresistance. An increase in electrical resistance of a conductor, associated with the application of a constant magnetic field; dependent upon the orientation of the conductor in the field. *Cf. bismuth spiral.* (See Heaps, *Phys. Rev.* 19(2), 7, 1922 and 45, 320, 1934.)

magnetostatic oscillator. Syn. *magnetostriction oscillator.*

magnetostrain. *Cf. magnetostriction.*

magnetostriction. A class of phenomena involving strains (*magnetostrains*) in a ferromagnetic body when placed in a magnetic field. *Cf. Joule effect* (1), *Wiedemann effect, Villari reversal.*

magnetostriction oscillator, magnetostrictive o. An electric oscillating system containing as one of its elements a magnetostriction resonator, by which the frequency is controlled. (See McKeehan, *Phys. Rev.* 39, 368, 1932.)

magnetostriction resonator. A magnetostrictive body, usually in the form of a rod, which may be excited magnetically into resonant vibration at one or more frequencies. Developed by G. W. Pierce. *Cf. m. oscillator.*

magnetostriction transceiver. A magnetostriction resonator applied to sending and receiving subaqueous signals of definite frequency, usually 17,000 cyc per sec or higher.

magnetron. 1. A type of thermionic vacuum tube in which the motion of the ions is controlled by the influence of a magnetic field perpendicular to the electric field propelling them. 2. A device for generating radio waves of very short wave length (from 75 to 150 cm). (See Page and Adams, Prin. of Electricity, 1931, p. 305.)

magnifying power. 1. Of a visual instrument (telescope, microscope, etc.): the ratio of the apparent diameter of the object as seen in the instrument to its apparent diameter as seen by the unaided eye at whatever distance it would be viewed without the instrument. (For a microscope, this distance is usually taken as 25 cm or 10 in.) 2. For a projection instrument, it is the ratio of any linear dimension of the projected image to the corresponding dimension of the object. Syn. *magnification.*

Magnus effect. A lateral thrust exerted by wind upon a rotating cylinder (*Magnus rotor*) whose axis is perpendicular to the wind direction. The effect has been utilized in ship propulsion and in other devices.

Majorana forces, M. interactions. Attractive forces between neutrons or between protons and neutrons within an atomic nucleus; supposed to offset the mutual repulsion of the nuclear protons and to produce saturation of bonds between nuclear particles. Of especial significance is the energy associated with these forces, which is supposed to owe its origin to the exchange of position of the two interacting particles. *Cf. exchange* (2). (See Majorana, *Zeits. f. Phys.* 82.3–4, 137, 1933.)

malleability. The plasticity of a metal, by virtue of which it may be rolled into sheets or otherwise worked into permanent shape when cold.

Malus law. 1. States that the intensity of a beam of light, after two reflections from nonmetallic surfaces at the polarizing angle, is proportional to the square of the cosine of the angle between the two planes of reflection. Discovered by Malus in 1808. A similar law applies to light passing through two Nicol prisms. 2. States that an orthotomic system of rays remains orthotomic after any number of reflections and refractions. (See Drude, Theory of Optics, 1913, p. 12.)

manganin. An alloy of copper (84 per cent), manganese (12 per cent), and nickel (4 per cent), used for resistance coils because of its very low temperature coefficient of resistance. *Cf. constantan.*

manocryometer. An instrument used for determining the variation of freezing point with pressure. Devised by de Visser. (See Couch, Dict. of Chem. Terms, 1920.)

manometer. A pressure gauge.

manometric balance. An apparatus for the comparison of the magnetic susceptibilities of liquids. (See Wills and Boeker, *Phys. Rev.* 42, 687, 1932.)

Mariotte bottle. A pneumatic device by which the rate of discharge of a liquid from an orifice may be maintained constant for some time, irrespective of the level

of its surface. (See Barton, Int. to the Mech. of Fluids, 1915, p. 124.)

Martens wedge. A type of quartz-wedge rotator for polarized light, used in some polarimeters to compensate and thus measure the optical rotation whose value is sought. (See Martin, Optical Meas. Instr., 1924, p. 249.)

Marx effect. The reduction in the energy of a photoelectric emission by the simultaneous incidence of radiation of lower frequency than that producing the emission. Observed by E. Marx in 1930, and called by him the *regressive effect.*

masking. A term used in acoustics to denote the shift of the audibility threshold of one sound, due to the presence of another. It may be expressed quantitatively in decibels. (See Acous. Soc. Comm. Rep., 1934.)

mass. A basic physical magnitude pertaining primarily to matter (though having an interpretation also, in modern physics, with reference to electricity and to energy); the measure of which is found in its relation to inertia. In accordance with Newton's second law, the masses of bodies are inversely proportional to the accelerations given them by the same force, as when two free bodies are drawn together by an elastic cord connecting them.

mass absorption coefficient. *Cf. absorption coefficient.*

mass defect. The amount by which the mass of an atom falls short of the sum of the masses of the particles of which it appears to be composed, as the latter are separately measured. *Cf. packing effect.* (See Loeb, Nature of a Gas, 1931, p. 14; Wigner, *Phys. Rev.* 43, 252, 1933; 44, 109, 1933.)

mass number. A type of atomic number which designates the number of protons in the nucleus of the atom, instead of the older, Moseley number. (See Sterne, *Phys. Rev.* 44, 238, 1933.)

mass spectrograph, m. spectrometer. An apparatus for separating an emission of electrically charged particles into distinct streams in accordance with their masses, by means of magnetic or electric deflection, and for ascertaining their masses in this way. The streams of particles are often made to strike a photographic plate and thus render their positions observable as "lines," like those of a spectrum. *Cf. magnetic spectrograph, velocity s.*

mass susceptibility. *Cf. susceptibility* (1).

Masson equation. An empirical formula for the apparent molar specific volume of a substance in solution, *viz.*,

$$\varphi = aC^{1/2} + b,$$

in which C is the molar concentration and a and b are empirical constants. *Cf. apparent volume in solution.* (See Scott, *J. Phys. Chem.* 35, 2315, 1931.)

matrix mechanics. The quantum mechanics of Heisenberg, expressed in the mathematical notation of matrices.

matter wave. Syn. *de Broglie wave.* (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 516.)

Matteucci effect. An e.m.f. developed between the ends of a twisted ferromagnetic wire upon change of its magnetization. Discovered by C. Matteucci, 1857. (See Ostermann and Schmoller, *Zeits. f. Phys.* 78, 690, 1932.)

Maupertuis principle. Syn. *least-action principle.*

maxwell. The practical, c.g.s. electromagnetic unit of magnetic flux, equal to 1 gauss-cm^2. Each maxwell may be represented by a "line" of (magnetic) force.

Maxwell-Ampère law. A modification of the Ampère law (2), made by Maxwell to allow for the displacement current in the dielectric as well as the current in the conductor. (See Page, Int. to Theoretical Phys., 1928, p. 434.)

Maxwell-Boltzmann law. The principle of equipartition of energy.

Maxwell bridge. 1. An arrangement resembling a Wheatstone bridge, but used for comparing an inductance with a capacitance. 2. An arrangement similarly used for comparing an inductance with a mutual inductance.

Maxwell demon. An imaginary intelligent being of molecular proportions, introduced by Maxwell into his arguments on the thermodynamics of gases. (See Maxwell, Theory of Heat, 1888, p. 728.)

Maxwell diagram. A diagram made up of the vector polygons of forces corresponding to the different members of a framed structure or truss, one polygon for each joint of the structure. *Cf. stress diagram.* (See Brand, Vectorial Mech., 1930, pp. 112 ff.)

Maxwell distribution law. An expression for the statistical distribution of speeds or energies among the molecules of a pure gas free from convection currents and at a uniform temperature. It takes various forms, of which the following is typical:

$$dN = Au^2e^{-B^2u^2}du;$$

expressing the number of molecules having speeds in the range $u - \frac{1}{2}du$ to $u + \frac{1}{2}du$. A and B are constants involving the temperature and pressure. (See Loeb, Kinetic Theory of Gases, 2d ed., pp. 81, 88, 93, 95.)

Maxwell electromagnetic equations. Four relations which, according to Maxwell's electromagnetic theory, describe the conditions at any point under the influence of varying electric and magnetic fields, in a region in which, in general, there are conductors, dielectrics, and paramagnetic or ferromagnetic bodies. They are most concisely expressed in vector notation, and appear in various forms, of which the following are typical:

$$\nabla \times H = \frac{1}{c}\frac{\partial D}{\partial t} + \frac{4\pi u}{c},$$
$$\nabla \cdot B = 0,$$
$$\nabla \times E = -\frac{1}{c}\frac{\partial B}{\partial t},$$
$$\nabla \cdot D = 4\pi\rho.$$

In these, H = magnetic intensity, B = magnetic induction, E = electric intensity, D = electric displacement, ρ = electric density, u = (conduction) current density, c is the electromagnetic constant. (See Slater and Frank, Int. to Theoretical Phys., 1933, p. 279.)

Maxwell series formula. A formula, derived by Maxwell, which expresses the mutual inductance of two coaxial circular coils as the difference of two complicated infinite series in terms of the radii of the two coils and their distance apart. (See Coffin, *Phys. Rev.* 2(2), 65, 1913.)

Maxwell thermodynamic relations. Four differential equations of thermodynamic change, which connect the temperature θ, the volume v, the pressure p, and the entropy ϕ, as follows:

$$\left(\frac{\partial\phi}{\partial p}\right)_v = -\left(\frac{\partial v}{\partial\theta}\right)_\phi, \quad \left(\frac{\partial\phi}{\partial v}\right)_\theta = \left(\frac{\partial p}{\partial\theta}\right)_v,$$

$$\left(\frac{\partial\phi}{\partial p}\right)_\theta = -\left(\frac{\partial v}{\partial\theta}\right)_p, \quad \left(\frac{\partial\phi}{\partial v}\right)_p = \left(\frac{\partial p}{\partial\theta}\right)_\phi.$$

The subscripts denote that the corresponding quantity is to be kept constant. The equations may take other forms, those here given being in terms of independent variables subject to experimental control. (See Page, Int. to Theoretical Phys., 1928, pp. 264 ff.)

Maxwell top. A gyroscope in the form of an adjustable top, whose point of support may be set below, at, or above the c.m. (See Ferry, Applied Gyrodynamics, 1932, p. 11.)

Maxwell triangle. A graphical device for representing the trichromatic coefficients of the components of a three-color mixture. (See Walsh, Photometry, 1920, p. 303.)

maxwell-turn. A unit of magnetic linkage, corresponding to one line of force surrounded by 1 turn of the circuit. Syn. *line-turn.*

Maxwell-Wagner polarization. A type of electric polarization exhibited by heterogeneous dielectrics, *e.g.*, colloidal suspensions, and ascribed to the accumulation of charges at the dielectric interfaces; in contrast to the *dipole polarization* of homogeneous polar dielectrics. (See Morgan, *Trans. Electrochem. Soc.* 65, 109, 1934.)

Maxwellian view. An optical arrangement in which a real image of a surface is formed by a lens at the pupil of the observer's eye, resulting in a field of uniform brightness more intense than that of the surface as viewed without the lens. (See Walsh, Photometry, 1926, p. 109.)

McCoy number. The ratio of the total alpha radiation from a radioactive substance to the alpha radiation per cm^2, in a direction perpendicular to the surface, of a layer of uranium oxide (U_3O_8) of indefinite thickness. (See I.C.T., 1926, v. 1, p. 368.)

McLeod gauge. A device for measuring the pressure of highly rarefied gases by first compressing a portion of the gas and observing the pressure thus "magnified"; from this the original pressure may be calculated.

mean center. *In re* a number of points in space: the point which corresponds to the centroid of a system of equal particles placed at the given points. (See Brand, Vectorial Mech., 1930, p. 22.)

mean free path. The average distance which the particles compos-

ing an ensemble, *e.g.*, molecules composing a gas, travel between successive encounters with other similar particles in the process of thermal agitation.

mean horizontal candle power. The average candle power of a light source, as viewed from all directions in the horizontal plane containing it. *Cf. mean spherical candle power.*

mean spherical candle power. The average candle power of a light source, as viewed from all directions. It equals the total luminous flux, in lumens, divided by 4π.

mechanical advantage. The (ideal) ratio of the force exerted *by* a machine to the force exerted *on* it by the operator. A more practical measure is the ratio of the linear displacement effected by the operator to the displacement produced by the machine, since this is independent of the influence of friction.

mechanical equivalent. The equivalent of a unit quantity of any form of energy in terms of the ordinary dynamic or work units. *E.g.*, the mechanical equivalent of heat is 4.1852×10^7 ergs/cal (see Birge, *Rev. Mod. Phys.* 1, 1, 1929); the mechanical equivalent of light is about 1.6×10^4 ergs/lumen-sec; etc. Syn. *dynamic equivalent.*

mechanics. Syn. *dynamics;* but often with special reference to machines or building construction. *Cf. quantum mechanics, matrix m., wave m.*, etc.

megohm sensitivity. The sensitivity of a galvanometer expressed as the resistance in megohms (millionths of an ohm) necessary to reduce the deflection to 1 scale division, when an e.m.f. of 1 volt is applied to the circuit. (See Smythe and Michels, Advanced Elec. Meas., 1932, p. 36.)

Meissner effect. The acquisition of nearly complete diamagnetism ($\mu = 0$) by certain metals when cooled below the superconductivity transition point. (See Smith and Wilhelm, *Rev. Mod. Phys.* 7, 244, 1936.)

Melde experiment. An experiment with a vibrating string, in which the nodes and antinodes are distinctly visible.

meniscus. The concave or convex free surface of a liquid in a tube, due to capillary action.

meniscus correction. A correction often necessary in taking readings on liquid columns, as in a barometer, because the end of the column is not a plane surface.

meniscus lens. A lens whose two surfaces have curvatures of the same sign, *i.e.*, which is either convexo-concave or concavo-convex. The former is called *convex-meniscus*, the latter *concave-meniscus.*

meridian. A line perpendicular to the axis of an optical system, *e.g.*, any diameter of a circular lens. *Cf. magnetic meridian.*

meridian ray. Any one of a narrow bundle of rays in a symmetrical optical instrument which lies in the meridian section of the bundle, made by the plane containing the chief ray and the optic axis of the instrument. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 311.)

Mersenne law. States that the frequency of a vibrating string varies inversely as the length, inversely as the square root of the line density, and directly as the square root of the tension. (See Lamb, Dynamical Theory of Sound, 1910, p. 70.)

meso form, m. phase. A form of a substance which fails to exhibit optical activity because of a structure in which the dextrogyrate and levogyrate effects are balanced against each other. (See Couch, Dict. of Chem. Terms, 1920.)

mesomorphic. In or pertaining to the liquid crystal state. Syn. *smectic. Cf. nematic.*

metacenter. That point, always above the c.m., of a rigid body floating in equilibrium, through which the buoyant force may be considered to act when the body is slightly tipped. In general its position depends upon the plane of tipping; a boat has a *transverse metacenter* (as it rolls) and a *longitudinal metacenter* (as it pitches). (See Laws, Stability and Equilibrium of Floating Bodies, 1914, p. 25.)

metacentric height. Height of the metacenter above the c.m.

metacrystalline state. An arrangement of molecules, due to strain or other influence, which, while it does not involve a true crystal structure, is capable of giving rise to x-ray diffraction patterns analogous to those produced by crystals. (See Clark, Applied X-Rays, 1927, p. 176.)

metamagnetic. Having the property of being either paramagnetic or diamagnetic, according to conditions such as the intensity or the direction of the applied field. (See Goetz and Focke, *Phys. Rev.* 38, 1569, 1931.)

metastable state. 1. A kind of equilibrium which is not attainable indifferently from different directions, *e.g.*, that of supercooled water, which may be reached by cooling liquid water but not by warming solid ice. 2. *In re* an atom: an excited state in which, however, the atom will not emit radiation unless further stimulated by some external influence or disturbance, such as a collision. (See Compton and Mohler, Critical Potentials, 1924, p. 61; Sommerfeld, Atomic Structure and Spectral Lines, 1922, p. 350.)

meteorograph. An apparatus which records conditions of atmospheric pressure, temperature, and humidity. *Cf. barograph, thermograph, hygrograph, radiometeorograph.*

meteorology. That branch of physical science which treats primarily of atmospheric phenomena.

meter. The basic unit of the metric system, originally defined as 0.0000001 of the earth's meridian quadrant at sea level. The actual metal standard meter bar at Sèvres is constructed to fulfill this ideal specification as accurately as possible. The ratio of the meter to the English yard is about 1.093611. (See Smiths. P. T., 1929, p. 6.)

meter-candle. Syn. *lux.*

meter-candle-second. A unit of photographic exposure, corre-

sponding to an illumination of 1 lux acting for 1 sec.

method of least squares. A systematic procedure for the adjustment of observations in accordance with the principle of least squares.

metric horsepower. Syn. *force de cheval.*

metrology. That branch of science which deals with systems of units and methods of measurement.

mho. A unit of electrical conductance, the reciprocal of the ohm. Thus a conductor having a resistance of 4 ohms has a conductance of 0.25 mho. Syn. *reciprocal ohm.*

micelle. An aggregate of colloidal particles, associated with water molecules. (See Couch, Dict. of Chem. Terms, 1920.)

Michelson interferometer. An interferometer, designed by A. A. Michelson, which is arranged to produce interference maxima and minima between two wave trains, as of light, separated from the same original train and reunited after reflection from two mirrors. The phase of the interference is varied by moving one of the mirrors forward or backward, and the wave length thereby compared with the mirror displacement.

Michelson-Morley experiment. A classic and crucial experiment, involving the transmission and reflection of light through the mirror system of an interferometer, which was intended to reveal the existence of an ether drift due to the earth's motion, and the negative result of which was the starting point of the theory of relativity. First performed by Michelson and Morley in 1881.

microbalance. 1. Any balance for weighing very small masses. 2. A very small differential buoyancy balance for measuring densities of gases. *Cf. dasymeter.*

microchronograph. A chronographic device for very small intervals of time, *e.g.*, the period of a sound vibration or the duration of an electric spark. *Cf. chronograph.*

microcinematograph. A moving-picture camera for microscopic objects, such as particles exhibiting the Brownian movement, growing microcrystals, etc.

microcrystal. One of the small crystals in a finely crystallized mass, *e.g.*, in cast iron.

microdensitometer. A microphotometer for the measurement of the density of photographic images.

micromanipulator. A device, controlled by compressed air or otherwise, for manipulating microscopic objects in any desired manner while under observation. (See Fonbrune, *Compt. rend.* 195, 603, 1932.)

micromanometer. An instrument for observing and measuring very small pressure differences or fluctuations.

micromechanics. The dynamics of very minute bodies, such as the component parts of an atom or of a molecule.

micrometer. 1. One of a class of measuring instruments in which linear displacements to be measured are made to correspond with the travel of a screw, of accurately adjusted pitch and provided with a large head graduated to indicate

small subdivisions of the pitch. *Cf. filar micrometer.* 2. Any very finely divided scale. *Cf. eyepiece micrometer.*

micron. A unit of length, equal to one-millionth of a meter, or 0.001 mm. Commonly designated by the symbol μ. The *millimicron*, or 0.001 micron, 0.000001 mm, is designated by $\mu\mu$ or mμ.

microphotometer. An instrument for the measurement or comparison of small luminous intensities.

micropyrometer. An apparatus, devised by Burgess, for measuring the melting points of small specimens of refractory substances.

microradiometer. An instrument for the measurement of very feeble radiation. *Cf. radiomicrometer, bolometer.*

microscopic reversibility principle. A principle of statistical equilibrium, formulated in various ways; by Richardson as follows: "Every isolatable process is exactly compensated in a state of statistical equilibrium by precisely the same process working backward." The process of detailed balancing in ionized gases is an example. (See Richardson, *Proc. Roy. Soc.* 36, 392, 1924; Tolman, Statistical Mech., 1926, p. 165.)

microvolt sensitivity. The sensitivity of a galvanometer as expressed in scale divisions per impressed microvolt. (See Smythe and Michels, Advanced Elec. Meas., 1932, p. 36.)

microwaves. Syn. *ultrashort waves.*

migration. The relatively slow movement of the ions in electrolysis, due to the applied electric field; or any similar movement of minute particles.

migration potential. A p.d. due to the settling or centrifuging of charged colloidal particles. It may be regarded as the reverse of electrophoresis.

Miller bridge. A type of bridge circuit devised by J. H. Miller for measuring the amplification factors of vacuum tubes. (See Smythe and Michels, Advanced Elec. Meas., 1932, p. 108.)

Miller index. One of the three numbers (h, k, l) used to designate any set of parallel planes of atoms in a crystal, *viz.*, the simplest integers proportional to the reciprocals of the intercepts of the planes on the crystal axes. *Cf. parameter* (3), *Bravais-Miller index.* (See Wyckoff, Structure of Crystals, 1924, p. 47.)

milliammeter. Any type of galvanometer which measures small electric currents directly in milliamperes, or thousandths of an ampere.

millivoltmeter. A voltmeter reading in millivolts, or thousandths of a volt.

Minkowski world. The totality of the four-dimensional continuum known as *space-time* and measured off in space-time co-ordinates.

mirage. An optical phenomenon produced by the presence of a stratum of heated air of varying density, across which the observer sees reflections, usually inverted and distorted, of distant objects.

missing line. Syn. *zero line.*

mix-crystal, mixed c. A crystal composed of two or more different

chemical substances, both of whose molecules or ions occupy positions in the same crystalline structure irrespective of the substance to which they belong. (See Davey, Study of Crystal Structure and Its Applications, 1934, pp. 536 ff.)

mixture method. A method of physical measurement in which two bodies are placed in communication until an equilibrium is obtained between them. Used esp. in calorimetry, in which case the quantity measured is heat and the equilibrium is one of temperature.

mobility. 1. Fluidity, low viscosity, *e.g.*, of a liquid, or of a plastic solid beyond its yield point. (See Bingham, *J. Rheol.* 1, 511, 1930.) 2. Syn. *mobility coefficient.*

mobility coefficient. 1. (*Electrolytic.*) The average speed per unit electric field with which ions of given sign move in the direction of the field. 2. (*Molecular.*) The average speed of diffusion, in the direction of the concentration gradient, of the molecules in a solution, at unit concentration and unit solution (osmotic) pressure gradient. Syn. *mobility* (2). (See Newman and Searle, General Properties of Matter, 1929, p. 296.)

mobilometer. Syn. *plastometer.* (See Bingham, *World Petroleum Congress Reprint* 95, 1933.)

mode. The most probable value of the variable in a statistical distribution. It corresponds to the abscissa of the highest point on the distribution curve. Adj. *modal.*

modified line. *Cf. Compton effect, Raman e.*

modulate. To vary, esp. the amplitude or the frequency of an oscillation or a wave train, in some characteristic manner, as in sending radio signals or in broadcasting.

mol, mole. Syn. *gram molecule.*

molar. 1. Pertaining to a mol, or measured in mols. Syn. *gram-molecular.* 2. Pertaining to masses of appreciable size; massive; bodily.

molar conductivity. The electrical conductivity of an electrolyte in solution (conductivity of solution minus that of the solvent) per unit concentration in mols per cm^2; usually as compared with some standard liquid, as mercury. (See Smiths. P. T., 1929, p. 346.)

molar free volume. The molar volume of a substance at any temperature in the liquid state, minus its molar volume at the freezing point. (See Bingham, Fluidity and Plasticity, 1922, p. 142.)

molar heat. The product of the molecular mass of a substance by its specific heat; or the thermal capacity of 1 mol of the substance.

molar polarization. A quantity P_m pertaining to the molecules of a pure dielectric, and connected with the polarizability α and the dielectric constant κ by the relation

$$P_m = \frac{4}{3}\pi N\alpha = \frac{\kappa - 1}{\kappa + 2}\frac{M}{\rho};$$

in which N is the Avogadro number, M the molecular weight, and ρ the density. It is also equal to the limiting value of the

molar refraction as the wave length increases. (See Debye, Polar Molecules, 1929, pp. 7 ff.)

molar refraction. The product of the molecular weight of a substance by its specific refractive power.

molar refractivity. The product of the specific refractivity by the molecular weight.

molar rotatory power, m. rotation. *Cf. rotatory power.*

molar susceptibility. The mass susceptibility of a pure substance multiplied by its molecular weight; or the mass expressed in terms of mols instead of grams. *Cf. susceptibility* (1). (See Smiths. P. T., 1929, p. 365; I.C.T., 1926, v. 6, p. 349.)

molar volume. The specific volume of a substance in cm^3 per mol; esp. in the liquid state at the boiling point (Nernst). Equal to the molecular mass divided by the density.

molecular crystal. *Cf. molecular lattice.*

molecular field. The electric field within a material body due to the presence of polar molecules.

molecular gauge. A pressure gauge for the measurement of very low gas pressures by means of the viscous friction exerted on a moving body, as a rotating disk. *Cf. decrement gauge, viscosity manometer.* (See Hoag, Electron Phys., 1929, p. 162; Newman and Searle, General Properties of Matter, 1929, p. 248.)

molecular lattice. A crystal lattice which may be regarded as built out of molecules as the units of structure. *Cf. ion lattice.* (See Davey, Study of Crystal Structure and Its Applications, 1934, pp. 543 ff.)

molecular moment. The electric moment of a polar molecule.

molecular pump. An air pump in which the molecules of the gas to be exhausted are carried away by the friction of a rapidly revolving disk or cylinder. (See Kaye, High Vacua, 1927.)

molecular ray, m. beam. A stream of molecules moving in nearly parallel directions, after emergence into a vacuum from a low-pressure reservoir through a succession of narrow apertures. (See Fraser, Molecular Rays; Rodenbush, *Rev. Mod. Phys.* 3, 392, 1931.)

molecular spectrum. A band spectrum composed of radiation frequencies due to energy changes within molecules. There are three types: vibration frequencies caused by changes in the vibration energy of the atoms; rotation frequencies, corresponding to changes in the rotation energy of the molecule; and electron frequencies, due to electronic transitions. Bands may also arise from combinations of these types. (See Kemble, Molecular Spectra in Gases (*National Research Council Bull.* 57), 1926; Kronig, Band Spectra and Molecular Structure, 1930.)

moment. 1. *Moment of a force* with respect to any axis: the product of the perpendicular distance r from the axis to the line of action of the force by that component of the force which is perpendicular to the axis and to the radius r. Syn. *torque.* 2.

Moment of a mass or a *volume* with respect to any plane (or axis): the volume integral of the products of the elements of mass or of volume by their distances from the plane (or axis). 3. *Moment of an area* with respect to an axis (or a point) in its plane: the surface integral of the products of the elements of area by their distances from the axis (or point). *Cf.* terms following and *magnetic moment, electric m., dipole m., molecular m.*

moment of inertia. Of a rigid body with respect to any axis: the volume integral of the product of the element of mass by the square of its distance from the given axis. It represents the torque required, per unit angular accceleration in radian measure, to change the speed of rotation of the body about that axis. Syn. *rotational inertia. Cf. areal moment of inertia.*

moment of momentum. Syn. *angular momentum* (*cf. momentum* (2)).

momentoid. A linear function of the momenta of the particles of a dynamic system. (See Jeans, Dynamical Theory of Gases, 1916, p. 97.)

momentum. 1. (Linear.) The product of the mass of a body by its linear velocity. 2. The *angular momentum* is the product of the moment of inertia of a rotating body, with respect to the (fixed) axis of rotation, by its angular velocity in radians per unit time; or, the volume integral of the products of the momenta of the elements of mass of the body by their distances from the axis of rotation. Syn. *moment of momentum.*

momentum ellipsoid. An ellipsoid drawn with reference to the principal axes of inertia of a rigid body in free rotation (under no external torque) about a changing instantaneous axis, and used to represent graphically the relation between the resultant angular velocity and the position of the instantaneous axis when the angular momentum is constant. (See Deimel, Mech. of the Gyroscope, 1929, p. 63; Silberstein, Vectorial Mech., 1926, p. 80.)

momentum space. A mathematical space in which the radius vector represents momentum and the co-ordinates x, y, z represent components of momentum. The momenta of the molecules of a gas, for example, then correspond to points of this space. *Cf. velocity space.* (See Darrow, *Rev. Mod. Phys.* 1, 90, 1929; Condon, *J. Frank. Inst.* 207, 467, 1929.)

monochord. *Cf. sonometer.*

monochromatic. *In re* any radiation, esp. light: composed of wave trains of a limited range of frequency. *Cf. spectral color, heterochromatic* (1).

monochromatic illuminator, monochromator. An instrument for producing and isolating a beam of monochromatic radiation.

monoclinic. *In re* crystal structure: having two of the three axes perpendicular to the third, but oblique to each other. *Cf. crystal system.*

monocrystal. A body of appreciable size composed of a crystalline substance and formed with

one continuous crystalline structure throughout, not as a mass of small crystals having various orientations. *Cf. polycrystal.*

monodisperse. A term used to characterize disperse systems whose particles are of sensibly uniform size. *Cf. polydisperse.* (See Freundlich, Colloid and Capillary Chem., 1926, p. 622.)

monomolecular layer, monolayer. An adsorbed film or layer having a thickness of one molecule of the substance composing it.

Morera theorem. Stated thus: "Any two systems, S_1, S_2, of forces acting on a system of particles with bonds independent of the time determine, starting from rest, displacements generable in the same infinitesimal interval of time, these displacements being such that the work computed as done by the forces S_1 through the displacements corresponding to the forces S_2 is equal to the work computed as done by the forces S_2 through the displacements corresponding to the forces S_1."

Morse-Allis-Lamar distribution function. A function representing the statistical distribution of the speeds of electrons in a gas. (See Morse, Allis, and Lamar, *Phys. Rev.* 48, 412, 1935.)

mosaic structure. The subdivision of a crystal into polyhedral blocks of macroscopic dimensions, with discontinuities in the lattice structure between them; apparently associated with the secondary structure. (See Davey, Study of Crystal Structure and Its Applications, 1934, chap. 12.)

Moseley curve, M. diagram. A curve which graphically exhibits the relationship between the atomic numbers of a sequence of elements and the wave lengths of their corresponding spectral lines. *Cf. Moseley law.*

Moseley law. States that all the heavier chemical elements may be arranged in a series, such that the square root of the frequency of a given line in the x-ray spectrum increases by a constant amount in passing from one element to the next. This sequence of elements is now recognized as that of their atomic (Moseley) numbers.

Moseley number. Syn. *atomic number. Cf. mass number.*

most probable value. A hypothetical value of a measured quantity, arrived at through calculations upon the tabulated results of several measurements upon it, in accordance with the theory of errors. (See Weld, Theory of Errors and Least Squares, 1929, p. 51.)

motivity. That part of the heat energy taken in during a thermodynamic cycle which is transformed into external work, *i.e.*, the available energy of the cycle. The term is attributed to Kelvin. (See Mills, Thermodynamics, 1910, p. 121.)

motor generator. A generator operated by a motor, esp. a d.-c. generator on the same shaft with an a.-c. motor, and used for obtaining d.-c. service from a.-c. mains. Syn. *motor transformer, rotary converter.*

Mott effect. The partial polarization of a beam of electrons, *i.e.*,

orientation of their spin axes in one direction, due to scattering by the atoms of a target. (See Mott, *Proc. Roy. Soc.* 124, 425, 1929.)

mu. A vernacular term used to designate: 1. The micron. 2. The amplification factor of a triode, esp. in such phrases as "high-mu tube," etc.; so called because of the common use of the symbol μ to represent this factor.

Mueller bridge. A five- or six-decade Wheatstone bridge for precise resistance thermometry, characterized by ratio arms of relatively high resistance, adjustable to equality, and a third arm variable in steps of 0.0001 ohm, with dial switches for the five lower decades. (See Mueller, *B.B.S.* 13, 547, 1916–1917.)

multiphase. Syn. *polyphase.*

multiple. Syn. *parallel* (in the electrical sense).

multiple ionization. The extraction of more than one electron from an atom, *e.g.*, by the impact of an electron of sufficient speed. (See Loeb, Nature of a Gas, 1931, p. 104.)

multiple (spectral) term. A group of nearly equal spectral terms corresponding to a set of closely adjacent quantum states or energy levels. *Cf. multiplicity.*

multiplet. A group of lines in an atomic spectrum, arising from transitions between the different components of two multiple spectral terms and hence exhibiting the characteristic frequency differences of these terms. The number may vary from 1 to 15 or 20. *Cf. singlet, doublet,* etc., *multiplicity.*

multiplicity. The largest number of components possessed by any multiple term in a given spectral system. Multiplicities as high as 9 are known, but not all the terms of a system have the maximum number of components. *Cf. multiplet.* (See Watson, *Phys. Rev.* 42, 509, 1932.)

multiplicity factor. A factor of the intensity of an x-ray beam reflected from a crystal, which depends upon the number of planes parallel to one face of the crystal form which are jointly responsible for the reflection, and hence upon the character of the form. Syn. *form factor* (2). (See Wyckoff, Structure of Crystals, 1924, p. 199; Blake, *Rev. Mod. Phys.* 5, 191, 1933.)

multiplier. A series resistance used in connection with a voltmeter so that it can be used to measure higher voltages than those indicated on the scale. *Cf.* also *voltage multiplier, Stern m.*

multivibrator. An electric oscillating system so designed that the energy is chiefly distributed among the harmonic partial frequencies rather than in the fundamental frequency. Devised by Abraham and Bloch. (See Brown, Radio Frequency Elec. Meas., 1931, p. 112.)

mutarotation. A change of optical rotatory power, or a reversal of its direction, *e.g.*, in a solution passing from levogyrate to dextrogyrate activity as it is diluted. (See Couch, Dict. of Chem. Terms, 1920.)

mutual conductance. *In re* a grid-controlled tube: the increment of plate current per unit change of

grid potential. Syn. *transconductance.* (See Hoag, Electron Phys., 1929, p. 59.)

mutual inductance. A (not necessarily constant) characteristic of a pair of coupled circuits, defined like inductance; except that the current, constant or variable, in one circuit (primary) and the linkage thereby produced, or the e.m.f. induced, in the other (secondary) are now referred to. Syn. *coefficient of mutual induction.*

mutual induction. The inducing of an e.m.f. in one circuit by the variation of the current in a neighboring circuit. *Cf. mutual inductance, coupling.*

mutual potential. A quantity of the nature of gravitational or electric potential, which is represented by the work expended upon two or more masses, or the work done by two or more electric charges, as they are displaced from their initial positions to an infinite distance apart. It is the negative of the potential energy of such masses or charges in any configuration, the zero of energy being that corresponding to an infinite separation.

N

(Please note purpose of references as explained in preface.)

N series. A series of frequencies in the x-ray spectrum of an element, considered as arising from the transition of electrons from various higher quantum states to the state whose principal quantum number is 4. First observed by Dolejsek.

Nagaoka formula. A formula for the inductance in microhenrys of any single layer of a cylindrical coil or solenoid:

$$L = K\frac{0.03948r^2N^2}{l};$$

in which r is the radius and l the length of the coil, in cm, N is the number of turns, and K a constant depending upon the ratio of r to l, tables of which have been published. (See *Bureau of Standards Circular* 74.)

near point. That point on the axis of the eye which is at such distance as to be seen distinctly with the utmost possible degree of accommodation, *i.e.*, when the focal power of the crystalline lens is greatest. *Cf. far point.* (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 434.)

negative crystal. A uniaxial, birefringent crystal in which the extraordinary wave has the greater velocity, *e.g.*, Iceland spar.

negative energy level. One of the negative values for the energy levels of an electron yielded by the Dirac equation, which has both positive and negative solutions. The positive values correspond to observation, but the physical significance of the negative values is not evident. (See Dirac, *Proc. Roy. Soc.* A133, 61, 1931; Uhlenbeck, *Phys. Rev.* 44, 510, 1933.)

negative energy spectrum. A set of transitions involving negative

energy levels. (See Beck, *Zeits. f. Phys.* 83, 498, 1933.)

negative glow. A luminous region in a Crookes tube at moderate pressure, lying between the Crookes dark space and the Faraday dark space.

negative impedance. A property possessed by certain electrical devices, such that when introduced into a circuit the current and the e.m.f. are in opposite directions. If there is no resultant inductance or capacitance effect, the property is termed *negative resistance.* (See Crisson, *Bell Syst. Tech. J.* 10, 485, 1931.)

negative pressure. 1. A pressure less than that of the atmosphere. 2. A condition of stress within a cohesive body which is subjected to equal tensions in all directions, and which is thus truly the opposite of pressure. (See Poynting and Thompson, Textbook of Phys. (Heat), 1929, chap. 11; Tamman and Mehl, States of Aggregation, 1925, p. 41.)

negative resistance. *Cf. negative impedance.*

nematic state. A stage preliminary to the mesomorphic state, in which the molecules may be regarded as having a common orientation, but not otherwise arranged. *Cf. liquid crystal, cybotaxis.* (See Clark, Applied X-Rays, 1927, p. 175.)

neper. A unit used, like the bel, to express the relationship between two amounts of power (acoustic, electric, etc.) as an interval on a logarithmic scale. The number of nepers in such an interval is the Napierian logarithm of the square root of the ratio of the two powers compared; therefore 1 neper is the value of that interval for which the ratio is $e^2 = 7.389$. The neper is equal to 0.8686 bel or 8.686 decibels. (See Acous. Soc. Comm. Rep., 1934.)

nephelometer. A type of photometer used for the measurement of light transmitted or of light scattered by translucent substances, or of the turbidity of liquids, and for determining therefrom the quantity of suspended matter present. *Cf. turbidimeter.* (See Walsh, Photometry, 1926, p. 385; Sosman, *R.S.I.* 4, 33, 1933.)

Nernst bridge. A four-arm bridge containing condensers instead of resistances, and used for the measurement of capacitances at high frequencies. (See Glazebrook, Dict. of Applied Phys., v. 2, 1923, p. 132.)

Nernst effect. A p.d. which develops between the two edges of a strip of metal, in which heat is flowing longitudinally, when the plane of the strip is placed perpendicularly across a magnetic field. Discovered by Ettingshausen and Nernst in 1886. *Cf. Hall effect.* (See Campbell, Galvanomagnetic and Thermomagnetic Effects, 1923, chap. 12.)

Nernst heat theorem. States that in the neighborhood of absolute zero, all physical and chemical processes are isentropic. *Cf. thermodynamic laws* (3). (See Nernst, The New Heat Theorem, 1926.)

Nernst lamp. An electric lamp whose luminosity proceeds from a short, slender rod of zirconium oxide (*Nernst glower*) heated to

brilliant white incandescence by the current.

Neumann triangle. The triangle which graphically represents the equilibrium of the three surface tensions at a point where two immiscible liquids come in contact in the air, as when a drop of one liquid rests on the surface of the other. (Newman and Searle, General Properties of Matter, 1929, p. 195.)

neutral axis. The line of intersection of any cross section of a rod or beam with the neutral layer.

neutral curve. A graph between pressure and temperature, at all points of which the specific volumes of the solid and the liquid phases are equal. For points on one side of the curve the solid specific volume exceeds that of the liquid, while the reverse is true for points on the other side. (See Tamman and Mehl, States of Aggregation, 1925, p. 28.)

neutral layer. That longitudinal layer of material in a rod or beam, perpendicular to the plane of flexure, which is neither lengthened nor shortened when the rod is bent. *Cf. neutral axis.*

neutret. A name suggested by Langer for a type of neutron having electronic mass or smaller. The existence of such a particle was suggested by Bragg. Syn. *neutrino.* (See Langer, *Phys. Rev.* 45, 495, 1934.)

neutrino. Syn. *neutret.*

neutrodyne. An amplifier circuit containing a capacitance for neutralizing the tendency to regenerate due to the internal capacitance between plate and grid of the amplifier tube.

neutron. An apparently stable particle, having a mass at least approximately equal to that of the proton, but electrically neutral. Its existence was first demonstrated by Chadwick in 1932. *Cf. neutret.* (See Jauncey, Modern Phys., 1932, pp. 233, 382.)

Newton law of cooling. States that the rate of cooling of a heated body by radiation and convection varies directly as the excess of its temperature above that of its surroundings. It is approximately applicable only to small ranges of temperature. *Cf. Dulong and Petit laws* (2), *Stefan-Boltzmann law.*

Newton laws of dynamics. Three dynamic principles which underlie the structure of the Newtonian mechanics. They may be stated as follows: 1. Every body remains in its state of rest or of uniform motion in a straight line, except as it may be caused to alter that state by the application of external forces. 2. Any change of momentum takes place in the direction of the force producing it, and at a rate proportional to the magnitude of the force. 3. To every force there is opposed an equal, reactive force in the same straight line. *Cf. d'Alembert principle.*

Newton rings. The circular interference bands formed by light reflected from the glass-air interfaces between a convex glass surface and a plane glass surface in contact with it. The center of the ring system is the point of contact.

Newton theorem of orbital motion. States that the velocity of a body moving in a central orbit is inversely proportional to the normal from the center of attraction to the tangent to the orbit at the point occupied by the body. (See Silberstein, Vectorial Mech., 1926, pp. 67 ff.)

Newtonian force. One of several types of mutual interaction which obey the inverse-square law, *e.g.*, gravitation, electric force, magnetic force, etc.

Newtonian mechanics. The classical mechanics based upon the Newton laws of dynamics, as distinct from quantum mechanics, wave mechanics, or relativity.

Newtonian potential. Syn. *gravitational potential, mass p.*

Newtonian potential function. An expression common to all potentials associated with inverse-square forces, *viz.*,

$$V = \int \frac{dm}{r},$$

in which m is mass (or electric charge, or magnetic pole strength) and r is distance from the element dm. The gravitational, the electric, and the magnetic potentials each contain a factor of this form.

Nichols radiometer. An instrument devised by Nichols to demonstrate the pressure of light, and used to measure the intensity of radiation in the visible and infrared. *Cf. radiation pressure.*

Nicol prism, Nicol, nicol. A well-known device for producing plane-polarized from unpolarized light, by means of two prismatic segments of Iceland spar cemented by a thin layer of Canada balsam interposed at such an angle that the ordinary component of the original light is entirely eliminated by total reflection at the cementing layer, while the extraordinary component passes through.

nodal points. *In re* a symmetrical optical system: two conjugate points on the axis, such that any paraxial ray which, before entering the system, intersects the axis at the *first nodal point*, will emerge from the system in a parallel direction and intersect the axis at the *second nodal point*. If the system is surrounded by the same medium on both sides, the nodal points are identical with the principal points, *q.v.*

node. 1. A point, line, or surface in a vibrating medium at which the amplitude of the vibration is reduced to zero by the interference of oppositely directed wave trains, forming stationary waves; *e.g.*, one of the stationary points on a vibrating string. 2. *In re* a wave function: A point at which the real part of the wave variable changes sign.

nonvariant. Having no degrees of freedom, *i.e.*, zero variance. (See Planck, Treatise on Thermodynamics, 1927, p. 185.)

normal cathode potential drop. The constant value of the p.d. between the cathode and the negative glow in a discharge tube in which the cathode is not entirely covered by the cathode glow. *Cf. normal current density.* (See Hoag, Electron Phys., 1929, p. 75; Darrow. Electrical Phenomena in Gases, 1932, p. 406.)

normal current density. The constant value of the current density over that part of the cathode in a discharge tube which is covered with the cathode glow, when this does not entirely cover the cathode. *Cf. normal cathode potential drop.* (See Hoag, Electron Phys., 1929, p. 75; Darrow, Electrical Phenomena in Gases, 1932, p. 398.)

normal electrode. A metal electrode immersed in a normal solution of an electrolyte having that metal as one of its ions. (Smythe and Michels, Advanced Elec. Meas., 1932, p. 231.)

normal equation. One of a set of simultaneous equations involving a set of experimental unknowns, which occurs in the course of the least-square adjustment of a larger number of observation equations. (See Weld, Theory of Errors and Least Squares, 1929, p. 69.)

normal (magnetic) induction. *Cf. magnetic induction.*

normal liquid, vapor, or gas. A liquid, vapor, or gas whose molecules are all of one kind, and not polymerized. (See Tamman and Mehl, States of Aggregation, 1925, p. 147.)

normal solution. A solution in which the solute has a concentration of 1 equivalent weight per liter of solution.

normal temperature and pressure (N.T.P.). The temperature 0°C. and pressure 1 atm. Syn. *standard conditions.*

normal term. A spectral term in which the fine-structure level having the smallest inner quantum number lies farthest down on the energy-level diagram. *Cf. inverted term.* (See White, Int. to Atomic Spectra, 1934, p. 256.)

normalization. The operation of multiplying a given characteristic wave function (eigenfunction) ψ_m by a constant, called a *normalization constant*, in order that when so modified, the wave function will fulfill the condition that the volume integral $\int|\psi_m|^2 dv = 1$. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 538.)

nuclear magneton. A unit of magnetic moment, in terms of which those parts of atomic magnetic moments attributed to the atomic nuclei are simple functions of small integers.

nuclear moment. The electric or the magnetic moment, or the moment of momentum, of an atomic nucleus; the last, called the *nuclear mechanical moment*, being usually expressed in units equal to $h/2\pi$. (See Goudsmit, *Phys. Rev.* 37, 663, 1931; Grace, *Phys. Rev.* 44, 361, 1933.)

nucleation. The action of ions or other particles as centers of condensation. (See Barus, *Phys. Rev.* 16(1), 247 and 287, 1903.)

nucleus. That part of an atom which is supposed to be the seat of its effective mass and to control the motions of its orbital electrons. Current atomic theory assigns to the nucleus a structure which involves an excess positive charge.

null method. Syn. *balance method.*

numerical aperture. *In re* an objective, esp. of a microscope: 1. The

product of the refractive index of the medium in front of the objective by the sine of half the angle of the cone of rays which enters the objective and which thus defines the field of view. 2. The ratio of the diameter of the aperture of the objective to the focal length. (See Johnson, Practical Optics, 1922, p. 118.)

numerical density. The number of particles or points per unit of space (area or volume) in any region.

O

(Please note purpose of references as explained in preface.)

O series. A series of frequencies believed to exist in the x-ray spectrum of an element and to arise from the transition of electrons from various higher quantum states to the state whose principal quantum number is 5. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 240.)

object-point. The real or virtual point of intersection of a pencil of rays incident upon an optical system. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 25.)

objective. That lens, lens combination, or mirror which, in an optical instrument, first receives the light coming from the object and gives the rays their first change of focus, as in the formation of a real image by the objective of a telescope. Syn. *object glass.*

objective prism. A large prism placed before the objective of a telescope in order to produce spectral images of stars on a photographic plate in its focal plane.

oblateness. *In re* a spheroid, like the earth: the fraction $(E - P)/E$, in which E and P are respectively the equatorial and the polar diameters. Value for the earth, about $\frac{1}{297}$.

observation equation. An equation, admittedly only approximately true, which connects one or more quantities, to be experimentally determined, with the results of an observation upon some function of them. (See Weld, Theory of Errors and Least Squares, 1929, p. 67.)

occlude. To absorb, as some metals take up certain gases and apparently incorporate them into the metallic structure.

octave. 1. A musical interval of numerical value 2; *i.e.*, a range of pitches, the highest of which has double the frequency of the lowest. 2. Hence, a ratio of 2:1 between frequencies of any type of vibration or wave emission.

octet. A group of eight electrons collectively related in a special manner to the outer structure of an atom. (See Loeb, Nature of a Gas, 1931, p. 38.)

octupole. A system consisting of two equal quadrupoles in parallel planes, but with their corresponding charges reversed.

ocular. 1. (adj.) Pertaining to the eye, or to vision. 2. (n.) Syn. *eyepiece.*

ocular micrometer. 1. A micrometer mounted in an eyepiece or ocular. 2. A microscopic scale mounted in the focal plane of a microscope or telescope ocular.

odd molecule. One of the very rare molecules having in its neutral state an odd number of extranuclear electrons. (See Lewis, Valence and the Structure of Atoms and Molecules, 1923, p. 80; Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 290.)

odd term. *Cf. even term.*

oersted. 1. Substituted by international agreement in 1932 for the term *gauss* to designate the practical, c.g.s., electromagnetic unit of magnetic intensity; *cf. gauss* (2). A unit magnetic pole, placed in a vacuum in which the magnetic intensity is 1 oersted, is acted upon by a force of 1 dyne in the direction of the intensity vector. 2. Prior to 1932, the practical, c.g.s. electromagnetic unit of magnetic reluctance.

Oersted experiment. A classic experiment with a wire and a compass needle, which revealed the presence of a magnetic field surrounding an electric current. (Copenhagen, 1820.)

ohm. The practical unit of electrical resistance. The *absolute ohm* is that resistance in which an e.m.f. of 1 abvolt will maintain a constant current of 1 abamp. The *international ohm* is the resistance of a column of mercury of uniform cross section, having a mass of 14.4521 g and 106.3 cm in length, at 0°C. (The cross section is 1 mm^2.) The ratio of the international to the absolute ohm is about 1.0005. (See A.I.E.E. Comm. Rep., 1932; Birge, *Nature* 134, 771, 1934.) *Cf.* also *acoustic ohm.*

Ohm acoustic law. States that all musical tones are either simple harmonic or capable of analysis into simple harmonics; and that the ear is able to distinguish the several components as distinct, pure tones. (See Miller, Science of Musical Sounds, 1916, p. 62; Richardson, Sound, 1929, p. 232.)

ohm-centimeter. A unit of electric resistivity, *viz.*, the resistivity of a substance of which a uniform rod of 1 cm^2 cross section has a resistance of 1 ohm per cm length.

Ohm law (of electric currents). A law which connects the e.m.f., the resistance (or conductance), and the current in a conductor or a circuit, and which takes different forms according to the circumstances in which it is applied. The usual, elementary statement is: The steady current in a circuit is equal to the e.m.f. divided by the resistance of the circuit. It does not apply to all circuits. *Cf. Ohm acoustic law.*

Ohmic resistance. Syn. *resistance.* The term is used to distinguish the true resistance from the types of impedance which do not contribute to the heating of the circuit.

ohmmeter. An instrument for measuring resistance directly in ohms.

oleorefractometer. An instrument for comparing the refractive indices of liquids, such as oils, with that of a standard liquid. Devised by Amagat and Jean. (See

Ferry, Handbook of Phys. Meas., 1918, v. 1, p. 136.)

omega value. The value of the quantum number which refers to the combined spin and orbital angular momentum of a molecule, expressed as a multiple of $h/2\pi$. *Cf. lambda value, sigma v.* (See Mulliken, *Rev. Mod. Phys.* 2, 60, 1930.)

onde de choc (Fr. "impact wave"). The "bow wave" in the air in front of a projectile which moves with a speed greater than that of sound. (See Richardson, Sound, 1929, p. 26.)

opacimeter. Syn. *turbidimeter.*

opposition. A phase difference of one-half cycle.

optic axis. A direction through a doubly refracting crystal in which light traversing the crystal suffers no double refraction. Syn. *axial direction. Cf. uniaxial, biaxial.*

optical analysis. The investigation of problems concerning stresses in materials by photoelastic methods.

optical bench. A horizontal track with a graduated scale upon which lenses or other optical pieces may be mounted for experiments in image formation, interference, etc.

optical center. A point so located on the axis of a lens that any ray, which in its passage through the lens traverses a line passing through this point, has its incident and emergent parts parallel.

optical constants. A set of quantities used to specify the optical properties of a substance; such as the refractive index, the reflectivity, and the absorption coefficient.

optical length. The vacuum equivalent of an optical path. For any one medium, it is equal to the geometrical length of the path multiplied by the refractive index of the medium. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 90.)

optical lever. A laboratory device for measuring angles of deflection by means of a long beam of light reflected from a small mirror. Syn. *mirror and scale.*

optical path. The path followed by luminous energy through an optical system. Optical paths are *equivalent* if they require the same time when traversed by light of the same frequency. *Cf. path difference, optical length.*

optical pyrometer. A pyrometer in which the temperature of a body is indicated by the total brightness of its incandescence, or by the ratio of the brightness at two different wave lengths.

optical rotation. The effect which some transparent media, such as sugar solutions and quartz (parallel to its axis), exhibit in rotating the polarization cycle, whether linear or elliptical, of light traversing them, by a definite amount for each unit of thickness. Syn. *rotatory polarization. Cf. rotatory power, activity* (4).

optically plane, o. flat. Departing from a true plane only by distances small compared with the wave lengths of light.

optics. That branch of physical science which treats of the phenomena of light and of vision. *Physical optics* deals with the theories of the mechanism of light

and its propagation. *Geometrical optics* regards light simply as an emission traveling in straight lines and traces its course in "rays" through reflecting and refracting systems. *Physiological optics* deals with the eye and vision. *Cf. optometry.*

optometry. A branch of optics dealing with the optical performance of the individual eye and with measurements upon it.

orbit. 1. The path described by a particle, or by the centroid of a body, under the influence of a gravitational or other force field. *Cf. central orbit.* 2. The hypothetical locus of one of the nonnuclear electrons within an atom.

orbital. 1. (adj.) Pertaining to an orbit or to motion in an orbit. 2. (n.) An orbital wave function pertaining to a single electron; a characteristic solution of the Schroedinger equation for a one-electron problem, excluding spin. (See Mulliken, *Phys. Rev.* 50, 1017, 1936.)

orbital electron. One of those electrons of an atom or a molecule which are often visualized as moving in orbits around the nucleus or nuclei.

orbital moment. The moment of momentum of an atomic electron due to its orbital motion. (See Bacher and Goudsmit, Atomic Energy States, 1932, p. 6.)

orbital valence. An interaction between atoms in a molecule, ascribed to a coupling between orbital motions of electrons; a term introduced by Heitler. (See Bartlett, *Phys. Rev.* 37, 507, 1931.)

order. The integral number of wave lengths or cycles in the phase difference between two mutually amplifying wave trains, as in the production of interference bands or diffraction spectra. Successive bands or grating spectra are of the first, second, . . . , *n*th order.

ordinal number. 1. The number of a line in a rotation-vibration spectral band, counting either way from the zero line. In the *R* branch the numbers are +, in the *P* branch they are −. (See Adel and Dennison, *Phys. Rev.* 44, 99, 1933.) 2. An integer denoting the position of a term in a spectral series, the value for the lowest term being fixed by arbitrary convention. 3. Syn. *atomic number.* (Rare.)

ordinary. Pertaining to that plane-polarized component of a ray of light which, in traversing a uniaxial crystal, has its electric vector at right angles to the principal plane. It obeys the Snell law of refraction. *Cf. double refraction, extraordinary.*

orientation. The assignment or imposition of a definite direction in space.

origin. The zero line in a band spectrum.

orthobaric. A term used to characterize the densities or specific volumes of the phases which are in thermodynamic equilibrium in any closed system; most commonly applied to the coexistent liquid and vapor phases of a one-component system. (See I.C.T., 1926, v. 3, pp. 202, 203.)

orthochromatic. A term which, in reference to photographic materials, implies equal sensitivity to all colors; a condition which is by no means fulfilled in fact. The term really indicates that the material is sensitive to green as well as to shorter wave lengths. Syn. *isochromatic* (1). *Cf. panchromatic.*

orthorhombic. *In re* crystal structure: having three mutually rectangular axes, no two of which are equal. *Cf. crystal system.*

orthoscopic. Free from optical distortion (*cf. distortion* (2)). (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 543.)

orthotomic. *In re* a system of light rays: so disposed that they may all be cut at right angles by a suitably chosen surface. (See Drude, Theory of Optics, 1913, p. 11.)

Osborne-Reynolds streaming. The movement of a gas from cold to hot along a surface having a temperature gradient of suitable magnitude. It is prominent in thermal transpiration, and also appears to be responsible for at least a part of the radiometric forces in gases at intermediate pressures. (See Loeb, Kinetic Theory of Gases, 2d ed., pp. 353 ff.)

oscillation transformer. *Cf. Tesla coil.*

oscillograph. An instrument which renders visible, or automatically traces, a curve representing the time variations of electric phenomena. The recorded trace is an *oscillogram.* Developed largely by Duddell and Braun. (See Irwin, Oscillographs, 1935; Brown, Radio Frequency Elec. Meas., 1931, p. 129.)

oscilloscope. An instrument similar to an oscillograph, and with which oscillatory phenomena are observed visually.

osmometer. An apparatus for measuring the rate of osmosis.

osmosis. The unidirectional diffusion of fluids through membranes or porous partitions, which results in *osmotic pressure.* The phenomenon is termed *endosmosis* when the diffusion is inward, toward the interior of the osmotic cell; *exosmosis,* when it is outward. *Cf. electric osmosis.*

osmotic pressure. *Cf. osmosis.*

Otto cycle. Syn. *Beau de Rochas cycle.*

outgas. To free from occluded or adsorbed gases by the application of heat. Syn. *degas.*

overlapping. The coincidence of the long-wave end of a diffraction or interference spectrum with the short-wave end of the spectrum of the next higher order; which may give rise to confusion in spectroscopy.

overpotential. An excess of potential, or p.d.; esp. the p.d. required to effect the electrolysis of an electrolyte, minus that of the electrodes with the products deposited upon them after the separation has taken place. Syn. *overvoltage, excess v.*

overtone. 1. One of the frequencies with which a vibrating body or system can freely oscillate, in addition to the lowest frequency. 2. A musical sound produced by a

sonorous body vibrating with one of its higher possible frequencies. *Cf. fundamental.*

overtone band. A spectral frequency which bears a relation to a given spectral frequency analogous to that of an acoustic overtone to its fundamental. Syn. *harmonic band.* (See Dunham, *Phys. Rev.* 34(2), 438, 1929; Shearin, *Phys. Rev.* 35(2), 973, 1930.)

oxygen point. The equilibrium temperature between liquid and gaseous oxygen at 760 mm pressure; a standard temperature point, taken as −182.97°C. (See Burgess, *B.S.J.R.* 1, 635, 1928.)

P

(Please note purpose of references as explained in preface.)

P branch. A set of molecular spectrum lines corresponding to unit increases in rotational quantum number. *Cf. R branch.* (See Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 11.)

p-electron. An orbital electron whose azimuthal quantum number is 1. *Cf. P-state.*

P series. A series of frequencies believed to exist in the x-ray spectrum of an element and to arise from the transition of electrons from various higher quantum states to the state whose principal quantum number is 6. Not to be confused with *p-series*, sometimes used as an abbreviation for *principal series.* (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 240.)

P-state, P-level. The state of an atom in which the azimuthal quantum number is unity. *Cf. S-, D-, F-states.*

pachimeter. An instrument for measuring the elastic shear limit of a solid material. (See Blair and Schofield, *J. Rheol.* 3, 318, 1932.)

packing effect. The existence of a mass defect in the nucleus of an atom, attributed by some to an emission of energy upon the building together of the component parts of the nucleus. *Cf. binding energy.*

packing fraction. The ratio of the amount, by which the atomic weight of an isotope differs from the nearest integral value, to that atomic weight; expressed in tenthousandths of a unit. *E.g.*, for beryllium, of atomic weight 9.02, the packing fraction is

$$0.02/9.02 = 22.17 \times 10^{-4}.$$

(See Thomson, Cond. of Elec. through Gases, 3d ed., v. 1, p. 284; Hoag, Electron Phys., 1929, p. 83.)

panchromatic. A term applied to photographic materials which are sensitive to all wave lengths within the visible spectrum (though not uniformly so; different panchromatic materials vary considerably in the wave-length distribution of their sensitivity). *Cf. orthochromatic.*

parabolic velocity, p. speed. The speed with which a particle at any

point in the field of a gravitational attracting center must be endowed in order that its orbit shall be a parabola. If the point is at the surface of the gravitating mass (as a planet), this speed is the same as the *velocity of escape.* Syn. *critical speed.*

parachor. A term due to Sugden, pertaining to a liquid and its saturated vapor, and denoting the (constant) value of the expression

$$\frac{m\tau^{1/4}}{\rho - \delta}.$$

m is the molecular weight, τ the surface tension, and ρ and δ the densities of liquid and vapor, respectively. (See Sidgwick, Electronic Theory of Valency, 1929, p. 125.)

paracrystalline state. An incipient crystallization, *i.e.*, the arrangement or arraying of the molecules of a substance as it approaches the crystallization point. *Cf. nematic state, liquid crystal.*

parallax. The change in the apparent position of an object, or in its direction from the observer, due to a movement of the observer.

parallel. Electrically connected between the same terminals, as two or more conductors or condensers. Syn. *multiple.*

paramagnetic. Having a magnetic permeability greater than unity, and susceptibility therefore positive; yet not ferromagnetic. *Cf. diamagnetic.*

parameter. 1. One of the constants entering into a functional equation and corresponding to some characteristic property, dimension, or degree of freedom. 2. The ratio of the displacement of an atom from its normal position within a crystal to the lattice constant in the direction of displacement. (See Goetz and Hergenrother, *Phys. Rev.* 40, 147, 1932.) 3. The distance from the origin of the axes of a crystal to the intersection of any axis with a face, or a face produced, in terms of the arbitrary unit selected for measurement along that axis. *Cf. Miller index, Haüy law.* (See Davey, Study of Crystal Structure and Its Applications, 1934, pp. 153, 156 ff.)

parametral plane. A crystal plane whose parameters are all unity (*cf. parameter* (3)), and whose Miller indices are therefore (111).

parasite. A current in a circuit, due to some unintentional cause, such as inequalities of temperature or of composition; particularly troublesome in electrical measurements. (See Ferry, Practical Pyrometry, 1917, p. 27.)

paraxial. *In re* light rays traversing an optical system: close to and making only small angles with the axis.

parent. 1. The first or primordial element of a radioactive series. 2. *In re* any radioactive product: that element from whose disintegration it is immediately derived. *E.g.*, the parent of radon is radium, while that of the whole series is uranium. 3. A spectrum line which represents a normal quantum process, unaffected by such influences as are responsible for satellite lines, as in the Zeeman effect.

parhelion. One of the bright, spectrally colored spots, commonly called "sun dogs," which appear

at times in cold weather on either side of and above and below the sun, at a distance of about 22 deg from it. They are due to the refraction of the sunlight by minute crystals of ice suspended in the air.

partial. Syn. *overtone.*

partial node. A region in a stationary wave system similar to a node, but at which the amplitude is a minimum without being reduced to zero. (See Acous. Soc. Comm. Rep., 1934.)

partition coefficient. Syn. *distribution coefficient.*

partition law. Syn. *distribution law* (1).

Pascal law. States that such part of the pressure in a fluid as is due to externally applied forces (not to gravity, inertia, electrical potential, etc.) has the same value throughout the body of fluid when the latter is in equilibrium.

Paschen-Back effect. A magneto-optical phenomenon, related to the Zeeman effect, but produced only in the most intense magnetic fields. Discovered by Paschen and Back in 1921. (See Pauling and Goudsmit, Structure of Line Spectra, 1930, pp. 73, 118; Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 321.)

Paschen law. States that the sparking potential between two given terminals in a given gas is a function of the product of the pressure by the spark length. It follows that for a given p.d., the spark length is inversely proportional to the pressure. (See Thomson, Cond. of Elec. through Gases, 3d ed., v. 2, p. 486.)

Paschen series. A series of infrared spectral lines of the hydrogen spectrum, whose frequencies are multiples of $\left(\frac{1}{3^2} - \frac{1}{n^2}\right)$, in which $n = 4, 5, 6, \ldots$. *Cf. Brackett series.* (See Clark, Applied X-Rays, 1927, p. 51.)

passive resistance. A condition within a system in unstable equilibrium which keeps it from releasing energy and becoming stable until slightly disturbed, *e.g.*, a cocked gun or a supercooled liquid. *Cf. metastable state.* (See Planck, Treatise on Thermodynamics, 1927, p. 119.)

path difference. The difference between the distances traversed by two co-initial wave trains between the point of separation and the point of subsequent reunion, as in an interferometer; or, if in different media, the difference between their equivalent paths in a vacuum or in air. *Cf. optical path.*

path-reversal principle. The fact that if light follows a given course through any optical system, it will, if reversed, traverse the same course in the opposite direction, so that a point and its real image are interchangeable.

Pauli principle. *Cf. exclusion principle.*

Peltier coefficient. The quantity of heat (*Peltier heat*) developed or absorbed per second per ampere of current at a given thermojunction in the Peltier effect. (See I.C.T., 1926, v. 6, p. 213.)

Peltier effect. The heating or cooling effect produced at the junction between two metals by a current sent across the junction (exclusive

of the Joule heat due to resistance); depending upon the direction of flow. Discovered by Peltier in 1834. Heat so evolved or absorbed is called the *Peltier heat. Cf. Peltier coefficient.*

Peltier electromotive force. That component of the e.m.f. of a thermocouple which corresponds to the local Peltier heats at the junctions between the different metals, and is added to the Thomson e.m.f. to make up the total (Seebeck) thermoelectromotive force. (See Loeb, Fundamentals of Electricity and Magnetism, 1931, p. 167.)

Peltier heat. *Cf. Peltier effect.*

pencil. A homocentric bundle of rays, corresponding to a train of concentric waves.

penetrance coefficient. A quantity which measures the tendency of a liquid to penetrate a given material which it wets; defined as half the product of the surface tension by the fluidity coefficient. (See Bingham, Fluidity and Plasticity, 1922, p. 259.)

penetrating orbit. An outer or valence electron orbit which passes inside the atomic *Rumpf.* (See White, Int. to Atomic Spectra, 1934, p. 103.)

penetrating radiation. Syn. *cosmic radiation.*

penetration tension. *In re* a liquid in a capillary tube: the product of the surface tension of the liquid by the cosine of the angle of contact. (See Peek and McLean, *Industrial and Eng. Chem.* 6, 85, 1934.)

penetrometer. 1. An instrument for testing the hardness of more or less plastic solids. (See Wolf, *J.S.I.* 9, 22, 1932.) 2. An instrument for indicating the quality or "hardness" of x-rays.

penta prism. A five-sided optical prism, of which one angle is 90 deg and the other four are 112 deg 30 min each. A ray entering at one of the faces adjacent to the 90-deg edge emerges from the other, after two internal reflections, at right angles to its original direction. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 588.)

pentane candle. A unit of intensity of a light source, equal to one-tenth of the intensity of the standard pentane lamp. Its value is approximately equal to the international standard candle. (See Smiths. P. T., 1929, p. 260.)

pentode. A type of vacuum tube having five elements, *viz.*, the filament, the plate, and three grids. (See Moyer and Wostrel, Radio Handbook, 1931, p. 308.)

penumbra. That part of a shadow from which the light from only a portion of the source is excluded by the opaque obstacle. *Cf. umbra.*

percentage bridge. A type of slide-wire bridge, so adjusted that a change of 0.01 per cent in the ratio of the two resistances compared requires, for balancing, a change of one division on the slide scale. Devised by H. C. Parker. (See Longden, *Phys. Rev.* 24(1), 349, 1907.)

perfect crystal, ideal c. A crystal having no mosaic structure and capable of x-ray reflection in accordance with the Darwin-Ewald-Prins law. (See Compton

and Allison, X-Rays in Theory and Experiment, 1935, p. 366; Bozorth and Haworth, *Phys. Rev.* 45, 821, 1934.)

perfect fluid. An ideal fluid possessing no viscosity; a concept useful in theoretical discussions.

perfect gas. Syn. *ideal gas.*

perfect radiator, ideal r. Syn. *black body.*

periodic law. The principle that certain properties of the elements recur in regular cycles when the elements are arranged in the order of their atomic weights (as discovered by Mendelejeff), or, more accurately, when arranged in the order of their atomic numbers (as pointed out by Moseley). An arrangement of the elements to exhibit this principle is called the *periodic table* or the *periodic system.*

periodicity, modulus of. The change which takes place in the action during one complete cycle of a periodic process.

periodogram. A curve or graph representing a periodic variation, such as the wave form of a complex musical sound.

periodometer. A type of harmonic analyzer developed by C. G. Abbot for the study of solar radiation and meteorological data.

peripheral electron. One of the outer electrons of an atom, to whose activity the spectral lines of visible light and thermal radiation are attributed, and which are supposed to be responsible for chemical combination. Syn. *valence electron.*

permalloy. One of a series of alloys of nickel, iron, and sometimes small quantities of other metals, as chromium or molybdenum, having abnormally high magnetic permeability. A typical permalloy is composed of 78.5 per cent Ni and 21.5 per cent Fe.

permanence principle. Either of two "sum rules" relating, respectively, to the sums of the Landé factors and interval factors of the components in the Zeeman effect; which state that the sum of the values of the factor in question for all the J values, other quantum numbers remaining constant, is independent of the magnetic intensity. Syn. *sum rule.*

permanent axis. An axis about which a free rigid body, when once set rotating, will continue to rotate in stable equilibrium. It is in general the principal axis of greatest moment of inertia through the c.m.

permanent gas. A gas, such as hydrogen or nitrogen, whose critical temperature is far below normal atmospheric temperatures, and which therefore retains its gaseous state at all pressures.

permanent set. A deformation which persists after release from stress. (See Prescott, Mech. of Particles and Rigid Bodies, 1929, p. 165.)

permeability. 1. (*Magnetic.*) The ratio of the magnetic induction to the magnetic intensity in the same region. In paramagnetic matter the permeability is nearly independent of the magnetic intensity; in a vacuum it is strictly so. But in ferromagnetic matter the relationship is definite only under fully specified conditions. *Cf. initial magnetic permeability,*

differential m.p., intrinsic m.p., reluctivity. 2. (*Porous.*) The volume of a fluid of unit viscosity which, in unit time, passes through unit cross section of a porous medium under unit pressure gradient. *Cf. Darcy law.* (See Wyckoff, Botset, Muskat, and Reed, *R.S.I.* 4, 394, 1933.)

permeameter. An instrument for measuring the average magnetic permeability of a ferromagnetic sample.

permeance. The reciprocal of the magnetic reluctance. (See A.I.E.E. Comm. Rep., 1932.)

perminvar. One of a series of alloys of iron, nickel, and cobalt, whose magnetic permeability is constant at different magnetic intensities, *i.e.*, for which the induction is proportional to the magnetizing field.

permittivity. Syn. *dielectric constant.* (See A.I.E.E. Comm. Rep., 1932.)

persistent spectrum. The spectrum of a substance which results from only the most moderate excitation. The most persistent lines, which remain when all others have subsided or when the quantity of the substance is diminished to a trace (but which are not always the brightest in the complete spectrum), are called the *raies ultimes*, a term due to de Gramont. (See I.C.T., 1926, v. 5, p. 322.)

perturbation. 1. (Spect.) An irregularity in the spacing of the lines of a band spectrum. 2. A deviation of the values of terms in a spectral series from the appropriate series formula. 3. (Cryst.) The influence of thermal agitation on the relations between atoms in a crystal or in a molecule. (See Epstein, *Phys. Rev.* 19(2), 578, 1922; Dieke, *Phys. Rev.* 38, 646, 1931.) 4. (Astron.) A deviation of a celestial body from the ideal orbital motion, due to some disturbing force.

Petzval condition. A criterion stated by Petzval for the flatness of an image formed by a refracting optical system of S surfaces. If the radius of curvature of the sth refracting surface through which the light passes is r_s and its refractive index is n_s, the condition is expressed by the summation

$$\sum_{s=1}^{s=S} \frac{1}{r_s}\left[\frac{1}{n_s} - \frac{1}{n_{s-1}}\right] = 0.$$

(See Whittaker, Theory of Optical Instr., 1907, p. 39.)

Pfund series. A series believed to exist in the far infrared spectrum of hydrogen, in which the frequencies are characterized by the factor

$$\left(\frac{1}{5^2} - \frac{1}{n^2}\right), \quad n = 6, 7, 8, \ldots .$$

Cf. Brackett series, Paschen series (See Pfund, *J.O.S.A.* 9, 193, 1924.)

phase. 1. A quantity which denotes the stage of progress of any cyclic operation, as a vibration; often expressed as an angle, by analogy with rotation. Thus if the cycle is one-third completed, the phase is $2\pi/3$ or 120 deg; etc. 2. One of two or more dissimilar components of a body of matter, segregated from each other by interfaces dependent on their dissimilarity; *e.g.*, two immiscible liquids in contact, or the solid, liquid, and

vapor phases of one substance in three-phase equilibrium.

phase angle. The phase difference between the impressed e.m.f. and the current in an a.-c. circuit, expressed as an angle. *Cf. lag, lead.*

phase constant. *In re* a harmonic, cyclic process: the constant term in that linear function of the time which appears as the argument of the sine or cosine factor in the expression for the cyclic variable. *E.g.*, for an a.c.

$$I = I_0 \cos (2\pi nt + \Delta),$$

Δ is the phase constant. (See Haas, Int. to Theoretical Phys., 1925, v. 1, p. 134.)

phase diagram. Syn. *equilibrium curve.*

phase equilibrium. An equilibrium between two or more interconvertible phases of a substance, as between ice, water, and water vapor, or between a solute and its saturated solution. *Cf. phase diagram.*

phase meter. An apparatus for measuring phase differences between a.c.'s or electric oscillations. (See Law, *R.S.I.* 4, 537, 1933.)

phase reversal. A change of phase equal to one-half cycle, such as may be experienced by light waves upon reflection under certain conditions. *Cf. opposition.*

phase rule. A law of equilibrium between phases of a chemically homogeneous mixture (as a solution) or of a pure substance; stated as follows: The number of degrees of freedom, or the *variance*, of the system is equal to the number of components in the mixture, minus the number of phases involved, plus 2. *E.g.*, if the substance is pure and we include all three possible phases, there is no degree of freedom, three-phase equilibrium existing only at the triple point; but if we consider only the liquid and the vapor states, a pure substance has one degree of freedom, *i.e.*, along the vaporization curve. First stated in general form by J. W. Gibbs.

phase space. An ideal, multidimensional space in which the co-ordinates represent the variables required to specify the state of a substance or of a system. Syn. *extension-in-phase.* (See Page, Int. to Theoretical Phys., 1928, p. 280.)

phase velocity. A vector whose direction is normal to the wave front and whose magnitude is the speed of propagation of a plane-wave disturbance. Syn. *wave velocity.*

phase wave. Syn. *de Broglie wave.* (See Condon and Morse, Quantum Mech., 1929, p. 11.)

phonautograph. An early device for recording the wave form of sounds; designed by Koenig and Scott. *Cf. phonodeik.* (See Miller, Science of Musical Sounds, 1916, p. 71.)

phonetics. That branch of acoustics which deals with the study of the production and the constitution of vocal sounds.

phonic wheel. A type of synchronous motor geared to a revolution counter, which can be used to measure the frequency of the alternating or interrupted current

driving it. The modern synchronous electric clock operates on a similar principle. Devised by La Cour. (See Ferry, Handbook of Phys. Meas., 1918, v. 2. p. 56.)

phonodeik. An apparatus which photographically records the wave form of any sound on a moving film, so that it may be studied and analyzed. Devised by D. C. Miller. (See Miller, Science of Musical Sounds, 1926, p. 78.)

phonometer. An instrument for the measurement of the intensity of sounds. (Knauss and Hale, *R.S.I.* 4, 447, 1933.)

phosphor. Any substance which is phosphorescent; esp. a synthetic material.

phosphorescence. A form of luminescence in which the emission of light continues for a time after the exciting stimulus has ceased.

phosphorogen. A substance which promotes phosphorescence in another, as manganese does in zinc sulphide. (See Coustal and Prevet, *Compt. rend.* 190, 485, 1930.)

phosphoroscope. An apparatus for observing and measuring the decay of phosphorescence. (See Samson, *Phys. Rev.* 40, 940, 1932.)

phot. A unit of illumination, equal to 1 lumen per cm^2, or 10,000 luxes. (See Smiths. P. T., 1929, p. 259.)

photoactivity. Syn. *photoconductivity.*

photo-anisotropy. The property of having different optical constants in different directions, possessed by many crystals, and by other substances under special anisotropic conditions.

photocathode. The illuminated electrode, at a negative potential, in a photoelectric cell.

photocell. Syn. *photoelectric cell.*

photochemical. Pertaining to the chemical activity of molecules, ions, and atoms brought about by the absorption of radiant energy.

photochemical equivalence. The principle, enunciated by Einstein, that in photochemical action each effective light quantum is transformed entire into chemical energy. (See Kistiakowsky, Photochemical Processes, 1928, pp. 17, 45.)

photoconductivity. Electrical conductivity due to photo-ionization, *e.g.*, in gases or in many nonmetallic crystals. Syn. *photoactivity, photosensitivity. Cf. volume photoelectric effect, internal photoelectric effect.* (See Hughes and DuBridge, Photoelectric Phenomena, 1932, chap. 8.)

photocurrent. A photoelectric or a photovoltaic current.

photocurrent coefficient. The change in the photocurrent generated by a photoelectric or a photovoltaic cell, per unit change in radiant flux producing it. (See I.R.E. Comm. Rep., 1933.)

photodensitometer. Syn. *densitometer.* (See Harrington, *J.O.S.A.* 16, 211, 1928.)

photodisintegration. The disintegration of an atomic nucleus by the action of radiant energy. (See Mitchell and others, *Phys. Rev.* 50, 189, 1936.)

photodissociation. 1. The dissociation of a chemical compound by the action of radiant energy. 2. Syn. *photodisintegration.* (See

Breit and Condon, *Phys. Rev.* 49, 904, 1936.)

photoeffect. Syn. *photoelectric effect* (*cf. photoelectric*).

photoelastic. Pertaining to the study of elastic phenomena in transparent solids by means of their effects on transmitted polarized light; esp. that of forced double refraction. *Cf. optical analysis.* (See Baud and Wright, *J.O.S.A.* 20, 381, 1930.)

photoelectric. Pertaining to the electric effects of light or other radiation; esp. to the phenomenon (*photoelectric emission*), manifested by certain metals, of giving off electrons (*photoelectrons*) when subjected to suitable radiation. The movement of these electrons in an electric field imposed for the purpose is a *photoelectric current. Cf. Hallwachs effect, photovoltaic, photoconductivity.* (See Hughes and DuBridge, Photoelectric Phenomena, 1932.)

photoelectric absorption. The conversion of radiant energy into the energy of photoelectric emission.

photoelectric cell. A compact arrangement of metallic electrodes to obtain a photoelectric current (*cf. photoelectric*).

photoelectric constant. A quantity which, multiplied by the frequency of any radiation exciting photoemission, gives in c.g.s. units the p.d. corresponding to the quantum energy absorbed by the escaping photoelectron. Equal to h/e, where h is the Planck constant and e the electronic charge. (See I.C.T., 1926, v. 1, p. 40.)

photoelectric current. *Cf. photoelectric.*

photoelectric emission. *Cf. photoelectric.*

photoelectric emissivity. Syn. *photoelectric yield.* (See Brewer, *Phys. Rev.* 44, 1016, 1933.)

photoelectric limiting potential. The stopping potential for the fastest electrons in a given photoelectric emission.

photoelectric sensitivity. Syn. *photoelectric yield.*

photoelectric threshold. The quantum energy just sufficient to release photoelectrons from a given surface. The corresponding frequency is the *threshold frequency.*

photoelectric work function. The work function for the emergence of photoelectrons from a given metal. *Cf. Einstein photoelectric equation.*

photoelectric yield. The rate of photoelectric emission from a metal per unit radiant flux of any given frequency. Syn. *photoelectric emissivity, p. sensitivity, spectral sensitivity. Cf. quantum efficiency.* (See Hughes and Du Bridge, Photoelectric Phenomena. 1932, p. 39.)

photoelectromotive force. An e.m.f. due to photovoltaic action.

photoelectron. *Cf. photoelectric.*

photoemission. Syn. *photoelectric emission* (*cf. photoelectric*).

photogen. A substance which emits light by luminescence.

photogoniometer. An apparatus for studying various aspects of crystal x-ray diffraction and x-ray spectra. May be used as an x-ray spectrograph or as a goniometer. (See Klug, *R.S.I.* 3, 439, 1932.)

photo-impact. The impact of a photon or light quantum, as in such processes as photo-ionization or photoelectric emission.

photo-ionization. Ionization in a gas which results from the action of radiation quanta, esp. those of visible light or ultraviolet.

photoluminescence. Luminescence of which the stimulating cause is visible light or ultraviolet.

photomagnetic effect. The direct effect of light upon the magnetic susceptibility of certain substances. (See Garrison, *J. Am. Chem. Soc.* 47, 622, 1925.)

photometer. An apparatus for measuring the intensity of a light source. *Cf. spectrophotometer, microphotometer.*

photometer head. That part of a photometer which comprises the screen, the means of viewing it, and the accessories used in judging the equality of illumination. (See Walsh, Photometry, 1926, p. 151.)

photometric center, p. centroid. That point of a luminous or of an illuminated surface which bears the same relation to the distribution of brightness or of illumination that the centroid of a thin plate bears to the distribution of its mass per unit area. *Syn. luminous center of gravity.* (See Walsh, Photometry, 1926, p. 224.)

photon. An energy quantum of visible light; or in general, of any electromagnetic radiation.

photo-neutron. A neutron emitted as the result of photodisintegration. (See Mitchell and others, *Phys. Rev.* 50, 189, 1936.)

photophoresis. A propulsive effect of an intense beam of light upon very small particles (of the order of 1 micron in diameter) in suspension in the air; the particles moving either toward or away from the light source. The effect becomes less as the pressure increases. In *electrophotophoresis* (photophoresis in an electric field) and in *magnetophotophoresis* (photophoresis in a magnetic field), the particles have a component of motion in the direction of the field. (See Ehrenhaft, Reiss, and Wasser, *Zeits. f. Phys.* 67, 7–8, 519, 1931.)

photosensitivity. The property of exhibiting any kind of photoelectric effect when irradiated, *e.g.*, photoelectric emission, photoconductivity, or photovoltaic action.

photovoltaic. Capable of acting as a source of e.m.f. under the influence of light. *Cf. Becquerel effect, blocking layer, photronic cell.* (See Hughes and DuBridge, Photoelectric Phenomena, 1932, chap. 9.)

photronic cell. A type of photovoltaic cell using cuprous oxide. *Cf. blocking layer.*

physical equation. An equation, each term of which represents a concrete physical quantity, or which contains symbols representing such quantities.

pi-planes. Atomic planes bounding crevices in the mosaic structure of a crystal. Sometimes called *Zwicky pi-planes.*

piezo-dielectric. Pertaining to changes in dielectric constants resulting from mechanical stress.

(See Osterberg and Cookson, *Phys. Rev.* 51, 1096, 1937.)

piezo-electric. Characterized by the property, exhibited by certain crystals, of becoming electrically polarized and of developing charges of "piezo-electricity" when subjected to strain. *Cf. pyro-electric.*

piezo-electric axis. One of the directions in a crystal in which either tension or compression will cause it to develop piezo-electric charges. Syn. *electric axis.* (See Jauncey, Modern Phys., 1932, p. 502.)

piezo-electric constants. The constants in the linear equations expressing the electric polarization developed in a deformed crystal in terms of the components of strain and the components of stress. (See I.C.T., 1926, v. 6, p. 208; Van Dyke, *Phys. Rev.* 42, 587, 1932.)

piezo-electric oscillator, p.-e. generator. An electric oscillating system containing as one of its elements a piezo-electric resonator by which the frequency is controlled. Syn. *piezo-oscillator.*

piezo-electric resonator. A plate or rod of piezo-electric crystal which may be excited electrically into resonant vibration at one or more frequencies. The term is commonly applied to the combination of the piezo-electric body with electrodes in a suitable mounting. Developed by W. G. Cady.

piezoluminescence. Syn. **triboluminescence.**

piezometer. 1. A glass bulb, the stem of which is closed by a plug of mercury, and in which liquids may be placed for the purpose of studying their behavior under great pressure. 2. A simple liquid manometer.

pilot balloon. A small balloon released for the purpose of studying the movements of the air. *Cf. sounding balloon.*

pilot spark. A feeble disruptive discharge sometimes released between close spark terminals in order to promote a more violent spark in an adjacent, wider gap. The whole arrangement is called a *three-point gap. Cf. Entladungsstrahlen.*

pinhole image. The inverted picture formed by light passing from the source directly through a small opening and falling on a screen.

Pirani gauge. A type of hot-wire gauge which, as improved by Hale, has a filament resembling that in an incandescent lamp. The filament temperature is deduced from its resistance. (See Dunoyer, Vacuum Practice, 1926, p. 94.)

pitch. 1. That characteristic of a musical sound which is determined by the position to which the normal ear assigns it in the musical scale. 2. The distance between the successive threads of a screw.

pitometer. An instrument, utilizing the principle of the Pitot tube, which makes a continuous record of the variations in velocity of a liquid stream. Devised by Cole. (See Russell, Textbook on Hydraulics, 3d ed., p. 212.)

Pitot tube. A narrow tube inserted in a fluid stream with its open end facing the current, and communicating at the other end with

a manometer; used for measuring the speed of flow. (See Bond, Int. to Fluid Motion, 1925, p. 23.)

Planck constant. A constant h having the dimensions of action (energy $\times$ time) and appearing in many physical formulas; approximate value, 6.547×10^{-27} erg-sec. In particular it represents the ratio of the energy of any radiation quantum to its frequency. First recognized by Planck in 1900. *Cf. Planck law.* Syn. *elementary quantum of action.* (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

Planck-Einstein equation. The equation

$$h\nu_{max} = Ve,$$

which is the mathematical expression corresponding to the Duane-Hunt law for the conversion of electron energy into x-ray quanta. ν_{max} is the maximum x-ray frequency evoked by an electron e which has acquired its energy from a potential increment V; h is the Planck constant. An equivalent form of the relation is $\lambda V = 1.234 \times 10^{-4}$ cm-volt, in which λ is the x-ray wave length. (See Clark, Applied X-Rays, 1927, p. 30.)

Planck equation. A formula expressing the spectral energy distribution of black-body radiation at a given absolute temperature T in terms of wave length λ. The emissive power of the black body within the wave-length range $d\lambda$ is given as

$$dE_\lambda = 2\pi c^2 h\lambda^{-5}\left[e^{\frac{ch}{k\lambda T}} - 1\right]^{-1} d\lambda,$$

in which c is the electromagnetic constant, h the Planck constant, and k the Boltzmann constant. An alternative form gives the radiant energy density within the black-body cavity as

$$8\pi ch\lambda^{-5}\left[e^{\frac{ch}{k\lambda T}} - 1\right]^{-1} d\lambda.$$

Cf. Wien laws (3), *Rayleigh-Jeans Law.* (See Richtmyer, Int. to Modern Phys., 1928, pp. 229 ff.)

Planck law. 1. The statement that the value of the quanta of radiation of any frequency is proportional to the frequency, as expressed by the equation

$$q = h\nu,$$

in which ν is the frequency and h the Planck constant. First enunciated by M. Planck in 1900. 2. *Cf. Planck equation.*

Planckian color. The color or the wave-length-intensity distribution of the light emitted by a black body at a given temperature. *Cf. color temperature, Planckian distribution.* (Judd, *B.S J.R.* 4, 538, 1930; Davis, *B.S.J.R.* 7, 659, 1931.)

Planckian distribution. *Cf. Planck equation.*

Planckian radiator. An ideal black body.

plane-family. The totality of all planes of atoms in a crystal which are parallel to each other. *E.g.*, any (101) plane of a cubic crystal belongs to the (101) plane-family. *Cf. form.* (See Davey, Study of Crystal Structure and Its Applications, 1934, pp. 29 ff.)

plane motion. Motion of a body or a figure, such that all points of it move in paths which are parallel to the same fixed plane.

plane of union. The plane upon which the two components of a twin crystal are united. It always coincides with a possible crystal face.

plane polarization. Polarization in which the cycle is a straight line, corresponding to a rectilinear vibration. *Cf. polarization cycle.*

planimeter. An instrument used to measure the area of any closed, plane figure traced on paper. A well-known type which makes use of polar co-ordinates about a fixed pivotal point is called a *polar planimeter.*

plano-concave. Having two surfaces, one of which is plane and the other concave; applied esp. to lenses.

plano-convex. Having two surfaces, one of which is plane and the other convex; applied esp. to lenses.

plasma. That part of an electric discharge in a rarefied gas which contains electrons and positive ions in such relative numbers that their charges nearly neutralize one another. *Cf. sheath.* (See Tonks and Langmuir, *Phys. Rev.* 34(2), 876, 1929; Wood, *Phys. Rev.* 35(2), 673, 1930; Tonks, *Phys. Rev.* 38, 1219, 1931.)

plasmoid. One of a class of luminous bodies of various shapes which appear in highly exhausted tubes under excitation of very high frequency, and which are not as yet well understood. (See Wood, *Phys. Rev.* 35(2), 673, 1930.)

plasticity. A property of some solids, by virtue of which they begin to exhibit continuous shear, or to flow, when subjected to shearing stress of sufficient magnitude. (See Bingham, Fluidity and Plasticity, 1922.)

plastometer. An apparatus for measuring the plasticity of a substance.

plate. 1. The positive electrode of a thermionic vacuum tube. 2. Any flat electrode, as of a storage cell or a condenser.

plate current. A current flowing to or from the anode or "plate" of a vacuum tube. (See I.R.E. Comm. Rep., 1933.)

platinite. An alloy of nickel and iron (about 46 per cent Ni), whose expansion coefficient is nearly equal to that of platinum, and which may therefore be used to replace that metal for lead wires in vacuum tubes. (See *Bureau of Standards Circular* 100.)

platinrhodium. An alloy of platinum and rhodium, commonly used in thermocouples.

platinum standard (photometric). A unit of luminous intensity proposed by J. Violle, *viz.*, that of 1 cm^2 of the surface of molten platinum at its melting point. Syn. *Violle standard. Cf. Waidner-Burgess standard.* (See Walsh, Photometry, 1926, pp. 130 ff.)

pleochroism. The property, possessed by certain crystals, of exhibiting different absorption colors as viewed in the direction of the different crystal axes; *e.g.*, iolite, which appears dark blue, light blue, and yellow with light transmitted along the respective axes. Syn. *polychroism. Cf. dichroism* (1).

pneumatics. That branch of physics which deals with the dynamic properties of gases.

Poinsot motion. The motion of a rigid body having one point fixed, the resultant of all forces acting upon which is zero. (See Brand, Vectorial Mech., 1930, p. 509; Silberstein, Vectorial Mech., 1926, p. 78.)

Poinsot precession. The precessional rotation of a nonsymmetrical body, *i.e.*, one which has three principal axes with different moments of inertia; as distinguished from regular precession.

Poinsot theorem. States that when a rigid body moves about its fixed c.m. under no forces, the energy ellipsoid, fixed in the body, rolls without slipping on a plane fixed in space (the *invariable plane*); and the vector from the fixed point to the point of contact represents the instantaneous angular velocity of the body in direction and magnitude. (See Brand, *Vectorial Mech.*, 1930, p. 510.)

point function. A variable quantity which is a function of the position of a point in space. *E.g.*, the electric potential, the temperature, the value of g, etc., are point functions.

point group. Syn. *space group.* (See Clark, Applied X-Rays, 1927, p. 103.)

point pole. A sharply defined magnetic pole, from which the field radiates almost as if from a point. Syn. *magnetic charge.*

point symmetry. *Cf. symmetry.*

poise. A unit of viscosity, for which the viscosity coefficient is equal to 1 dyne-sec/cm^2. Named from Poiseuille. The practical unit for solutions, etc., is the centipoise, or 0.01 poise. (See Smiths. P. T., 1929, p. 155.)

Poiseuille law. Expresses the (volume) rate of flow through a capillary as follows:

$$\frac{dV}{dt} = \frac{\pi r^4 \Delta p}{8\eta l}.$$

Δp = pressure difference, r = radius, l = length of capillary, η = viscosity coefficient of fluid. *Cf. Knudsen equation.*

poison. A substance whose effect on a luminescent material is the opposite of that produced by a phosphorogen. *E.g.*, iron is a poison to certain phosphorescent materials prepared from zinc sulphide.

Poisson bracket. An abbreviated notation used in mechanics. The Poisson bracket of F_r and F_s with respect to the variables $p_1, p_2, \ldots, p_n, q_1, q_2, \ldots, q_n$ is defined as

$$\left[F_r F_s\right] = \sum_{k=1}^{k=n} \left(\frac{\partial F_r}{\partial q_k} \frac{\partial F_s}{\partial p_k} - \frac{\partial F_s}{\partial q_k} \frac{\partial F_r}{\partial p_k} \right).$$

(See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 614.)

Poisson distribution. A statistical distribution defined by the equation

$$p = \frac{a^x e^{-a}}{x!}.$$

It is approximated by the Gaussian distribution when a is large. (See Fry, Probability and Its Engineering Uses, 1928, pp. 220 ff.)

Poisson equation. A differential equation relating the potential function to the density at any point. For the gravitational potential function V it is

$$\nabla^2 V = -4\pi\rho,$$

where ρ is the (mass) density. *Cf. Laplace operator.* In a vacuum it degenerates into the Laplace equation.

Poisson ratio. The ratio of the fractional transverse contraction to the fractional longitudinal extension of a body under tensile stress. Syn. *rho* (ρ) *ratio.* (Smiths. P. T., 1929, p. 101.)

polar. 1. Electrically nonsymmetrical, as a molecule which, like HCl, has an effective electric moment. Syn. *heteropolar. Cf. homopolar.* 2. *In re* a crystal structure: having an asymmetry in the location of certain sets of atoms. 3. Pertaining to or measured from a pole.

polar candle-power diagram. *Cf. light-distribution curve.*

polar moment of inertia. An areal moment of inertia of a plane figure, but with respect to a line perpendicular to the plane instead of to a line lying in the plane.

polarimeter. A polariscope provided with circles or other equipment for making quantitative observations upon the state of polarization.

polariscope. An instrument for examining the state of polarization of light or other radiation, or for studying the polarizing properties of bodies.

polarity. 1. The electrically positive or negative condition of a battery or generator terminal. 2. The magnetically positive (north) or negative (south) character of a magnetic pole. 3. The degree in which a molecule is polar. (See Mulliken, *Phys. Rev.* 50, 1017, 1936.)

polarity effect. An asymmetry or inequality in the current through a series of partial conductors, such as metallic sulphides or oxides, according to which way it is caused to flow; illustrated by crystal detectors.

polarizability. A quantity α pertaining to the molecules of a dielectric and defined as the molecular electric dipole moment per unit electric intensity. It is connected with the dielectric constant κ through the relation

$$\alpha = \frac{3M}{4\pi N}\frac{\kappa - 1}{(\kappa + 2)\rho},$$

in which M is the molecular weight, N the Avogadro number, and ρ the density. *Cf. molar polarization, Clausius-Mosotti law.* (See Loeb, Kinetic Theory of Gases, 2d ed., p. 479.)

polarization. 1. *Cf. polarize.* 2. (*Dielectric.*) *In re* a polarized dielectric: the electric moment per unit volume. 3. (*Electrolytic.*) An alteration of the p.d. in an electrolytic cell by reason of a poorly conducting electrolytic deposit. 4. (*Magnetic.*) Syn. *magnetization.* (Rare.) *Cf. displacement* (3), *molar polarization.* (See Page and Adams, Prin. of Electricity, 1931, p. 38; A.I.E.E. Comm. Rep., 1932.)

polarization capacitance. The capacitance of the condenser formed

by the two electrodes of a cell. (See I.C.T., 1926, v. 1, p. 35.)

polarization cycle. A closed figure formed by the terminus of the vector representing the vibrations in a beam of radiation polarized in any given manner. For plane-polarized light, it is a straight line; for elliptically polarized light, it is an ellipse; etc. *Cf. polarize* (3).

polarization photometer. A photometer in which the intensity of the light from one or both sources is varied by the use of polarizing apparatus. *Cf. Malus law.* (See Walsh, Photometry, 1926, p. 3.)

polarization plane. A plane associated with a ray of plane-polarized radiation, believed to correspond to the vibrations of the magnetic vector as the wave progresses. If the polarization is produced by reflection, it coincides with the plane of that reflection.

polarization tint. A coloration of the field of a polariscope analyzer when using a white-light source, due to the emergence of the different wave lengths from the analyzer with altered relative intensities.

polarize. 1. To endow with poles, as a magnet. 2. To produce an electrical separation or orientation, esp. in the molecules of a dielectric. 3. To impress some spatial characteristic, as upon the vibrations identified with radiation; e.g., in elliptically polarized light. *Cf. polarization.*

polarizer. A Nicol prism or other device for polarizing light, esp. one introduced into a polariscope to receive the light as it enters. *Cf. analyzer.*

polarizing angle. The angle at which light must be incident upon the surface of a dielectric reflector in order to experience maximum plane-polarization. Syn. *Brewster angle. Cf. Brewster law.*

pole effect. A discrepancy observed in the wave lengths of spectral lines when the light comes from the vicinity of the electrodes in an arc. (See I.C.T., 1926, v. 5, p. 432; Babcock and St. John. *Phys. Rev.* 9(2), 577, 1917.)

polhode. The curve which marks the intersection of the energy ellipsoid and the momentum ellipsoid of a free rigid body. The term is due to Poinsot (1834). (See Deimel, Mech. of the Gyroscope, 1929, p. 65.)

polychroism. Syn. *pleochroism.*

polycrystal. A body made up of a number of small crystals in a mass. *Cf. monocrystal.*

polydisperse. *In re* a disperse system: having particles of different sizes. *Cf. monodisperse.* (See Freundlich, Colloid and Capillary Chem., 1926, p. 622.)

polymer. 1. One of two or more isomers having different molecular weights, *e.g.*, C_2H_2 (acetylene) and C_6H_6 (benzene). 2. A complex molecule, or molecular aggregate, which may be considered as a multiple of some simpler molecule, *e.g.*, $H_4O_2 = 2H_2O$.

polymorphism. Syn. *allotropy, allotropism;* but with especial reference to differences in the crystal structure. *Cf. dimorphism.*

polyphase. Having or utilizing several phases; *e.g.*, a polyphase current or motor. Syn. *multiphase. Cf. two-phase current, three-phase c.*

polytropic. Pertaining to a change during which the pressure and the volume vary in accordance with the relation pv^n = constant (the *polytropic equation*), in which n has special constant values in different cases. *E.g.*, for the Boyle law, $n = 1$. (See Goodenough, Prin. of Thermodynamics, 1920, p. 43.)

porous-plug experiment. *Cf. Joule-Thomson effect.*

Porro prism. A triangular optical prism having one 90- and two 45-deg angles. Light entering perpendicular to the hypothenuse face emerges from the same face after two internal reflections. Two of these are used in each telescope of the prism binocular. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 588.)

positive column. A striated, luminous region adjacent to the anode in a Crookes tube at moderate pressure. (See Darrow, Electrical Phenomena in Gases, 1932, p. 390.)

positive crystal. A uniaxial, birefringent crystal in which the extraordinary wave has the less velocity, *e.g.*, quartz.

positive electron. Syn. *positron.*

positive-ion emission. Thermionic emission of positive particles; ions either of the metal itself or, commonly, due to some impurity.

positive-ray analysis. The separation and measurement of the masses of atoms by subjecting their positive ions to deflection by electric or magnetic fields.

positive rays. A stream of positively charged atoms or molecules, produced by a suitable combination of ionizing agents, accelerating fields, and limiting apertures.

positron. A positive charge having a mass equal to that of the electron, and electrically its counterpart. Its existence was first announced by Carl Anderson. Syn. *positive electron, antielectron.* (See Anderson, *Phys. Rev.* 44, 406, 1933.)

potential. A term applied to several different scalar quantities, the measure of each of which involves energy as a function of position or of condition (potential energy). *Cf. gravitational potential, electric p., magnetic p., logarithmic p., thermodynamic p., potential function;* also *kinetic p., velocity p.* (which do not come under the above definition).

potential barrier. A region in which the electric potential is such that moving electric charges attempting to traverse it encounter opposition and may be turned back. *Cf. stopping potential, work function.*

potential energy. Any form of energy which is not demonstrably kinetic.

potential function. A function which constitutes the variable factor in the expression for any physical potential. *Cf. Newtonian potential function, vector p. f.*

potential galvanometer. An instrument of the galvanometer type, having such high resistance as to take practically no current, so that the readings can be taken to indicate the p.d. between its terminals. *Cf. voltmeter resistor.*

potential hole, p. well. A region toward which the electric poten-

tial drops abruptly and throughout which its value is distinctly lower than on either side; a term common in nuclear physics.

potential streaming. Fluid motion in which the velocity is the negative of a velocity potential gradient, so that the flow is irrotational. If the fluid is incompressible, the lines of flow coincide with the lines of a possible electric field in empty space. (See Lamb, Hydrodynamics, 5th ed., sec. 17 and chap. 2.)

poundal. The absolute English (foot-pound-second) unit of force which, acting upon a free mass of 1 lb, would impart to it an acceleration of 1 ft/sec^2.

powder method. A method of crystal analysis, devised independently by Hull and by Debye and Scherrer, in which the varied orientation of the particles of the finely pulverized substance produces the same diffraction-ring pattern as would result from giving a single crystal all possible orientations. (See Hull, *Phys. Rev.* 10(2), 661, 1917.)

powder pattern. 1. *Cf. powder method.* Syn. *Hull ring, Debye r., Debye-Scherrer r.;* sometimes called *halo*, esp. in connection with diffraction effects from amorphous materials. 2. A pattern of parallel lines or bands of ferromagnetic powder deposited on the surface of a magnetized crystal. Syn. *Bitter pattern.* (See Bitter, *Phys. Rev.* 41, 507, 1932; Sixtus, *Phys. Rev.* 51, 870, 1937.)

Powell bands. Interference bands produced by the insertion of a transparent plate into a hollow prism which contains a liquid and is used to produce a spectrum, when the plate, with its edge parallel to the prism edge, covers only one half of the field. *Cf. Talbot bands.* (See Powell, *Phil. Trans.*, 1848, II, p. 213.)

power. The time rate of the doing of work; or energy transferred per unit time. *Cf. watt, horsepower;* also *magnifying power, thermoelectric p., resolving p., focal p., emissive p.*, etc.

power factor. The ratio of the mean power to the apparent power in an a.-c. circuit. If the e.m.f. and current are sinusoidal, the power factor is equal to the cosine of the phase angle.

Poynting theorem. States that the transmission of energy in an electromagnetic field takes place in a direction perpendicular to both electric and magnetic components, and that the rate of energy transfer is proportional to the vector product of those components (electric and magnetic intensities), called the *Poynting vector* or *vector radiant.* (See Poor, Electricity and Magnetism, 1931, p. 126; Douglas, *Phys. Rev.* 33(1), 322, 1911.)

Poynting vector. *Cf. Poynting theorem.*

precession. A motion of the axis of a symmetrical rotating body, which slowly describes a cone with the centroid as vertex, due to the action of a small torque tending to change the direction of the axis; illustrated by a spinning top or gyroscope. The axis of the cone is the *precession axis. Cf. Poinsot precession, Lanchester rule.*

precision. That kind of refinement in physical measurement which is attested by the close agreement of different results. It is not, however, a guarantee of *accuracy* (negligible error), because of the possibility of large, constant sources of error affecting all the results alike. *Cf. consistency* (1).

precision index. *Cf. error equation.*

predissociation. 1. A state that exists in a diatomic or polyatomic molecule which, usually after the absorption of light, has a tendency to dissociate spontaneously, usually into two uncharged parts. The resulting absorption bands are diffuse, lacking the usual rotational fine structure. 2. The process of decomposition from the state described under (1).

pressure broadening. An increase in the half-width of a line in the spectrum of a gas, when the source is under high pressure. It is often asymmetrical, the asymmetry being associated with a pressure shift. (See Margenau, *Phys. Rev.* 44, 931, 1933.)

pressure coefficient. 1. The ratio of the change in pressure per degree of temperature, in a gas kept at constant volume, to the pressure at the scale zero of temperature. It is very nearly equal to the (volume) expansion coefficient. 2. The increment of any quantity, which is a function of the pressure, due to unit change of pressure. *Cf. temperature coefficient.*

pressure shift. A change in the wave length of the lines of a spectrum, when the source is under high pressure. *Cf. pressure broadening.*

Preston law. *In re* the Zeeman effect: states that all of the lines belonging to any given series of the spectrum of an element undergo the same resolution in frequency when the element is subjected to a magnetic field. (See Zeeman, Researches in Magneto-Optics, 1913, p. 65; Allen, The Quantum and Its Interpretation, 1928, p. 211.)

primary bow. The inner and brighter of the two rainbows sometimes visible.

primary cell. A battery cell whose energy is intrinsic in the substances originally composing it, and not derived from charging as in a storage (secondary) cell.

primary circuit. A circuit, the variation of the current in which induces an e.m.f. in a coupled, secondary circuit as in a transformer. Often abbreviated to *primary.*

primary colors. *Additive primaries* are three colors which, added in proper proportions, produce a sensation of white; those usually chosen are red, green, and blue. Their complementaries (*cf. complementary colors*), blue-green, purple, and yellow, respectively, are *subtractive primaries;* if white light is passed in succession through transparent screens of these colors, it is completely absorbed. (See Luckiesh, Color and Its Applications, 1915, chap. 3.)

primary dark space. A narrow, nonluminous region which appears between the cathode and the cathode glow in certain gases. (See Darrow, Electrical Phenomena in Gases, 1932, p. 424.)

primary electron. 1. An electron belonging to a primary emission. 2. That electron which, after a collision of two electrons, has the greater energy. *Cf. secondary electron.* (See Neher, *Phys. Rev.* 38, 1321, 1931.)

primary emission. Incident emission, which may excite secondary emission from the irradiated matter. If it is of the nature of radiation (ultraviolet, x-rays, etc.), it is usually called *primary radiation.*

primary standard. A unit directly and originally defined and established by some authority, *e.g.*, the standard meter at Sèvres. *Cf. prototype, secondary standard.*

primary structure. *Cf. secondary structure.*

priming illumination. A small, steady illumination applied to a photoelectric cell to render it more sensitive to the (superposed) variations in illumination which the cell is being used to measure or record. (See Campbell and Ritchie, Photoelectric Cells, 1930, p. 162.)

principal angle of incidence. The angle at which a ray of plane-polarized light must be incident upon a reflecting metallic surface in order that the components of the elliptically polarized reflected ray, parallel and perpendicular to the plane of reflection, shall differ in phase by one-quarter cycle. (See Haas, Int. to Theoretical Phys., 1925, v. 1, p. 294.)

principal axis. A line so chosen with reference to a rigid body, that the body may rotate about it without developing a centrifugal torque in any plane containing that line. Through any point there are in general three such lines, which are axes of maximum or minimum moment of inertia. *Cf. permanent axis.*

principal azimuth. The azimuth of the elliptically polarized beam produced when plane-polarized light, with an azimuth of 45 deg with the plane of incidence, is reflected at the principal angle of incidence from a metallic surface. (See Haas, Int. to Theoretical Phys., 1925, v. 1, p. 294.)

principal focus. Syn. *focal point.*

principal line. The first and strongest line of a spectral series.

principal magnetic susceptibility. The mangetic susceptibility of a nonferromagnetic crystal for one of the three or more directions along which the magnetization is parallel to the magnetic intensity. (See Jackson, *Proc. Roy. Soc.* 140, 695, 1933.)

principal moment of inertia. The moment of inertia of a body with respect to one of its principal axes.

principal plane. 1. *In re* a ray of light traversing a doubly refracting crystal: the plane determined by the direction of the ray and the axial direction of the crystal. 2. *In re* a symmetrical optical system: one of two planes perpendicular to the axis, such that any incident paraxial ray meets the first, and the same ray upon emergence meets the second, in points on a line parallel to the axis. The magnification ratio for these two planes being +1, they are sometimes called the *unit planes. Cf. principal points.*

principal points. Two points at which the principal planes of a symmetrical optical system intersect the axis. Syn. *unit points. Cf. nodal points.*

principal quantum number. The sum $l + l'$ of the azimuthal and the radial quantum number in the Bohr theory, or $l + l' + 1$ in the new quantum mechanics (since in the latter l is one less). So called because the energy of a quantum state depends primarily upon it. The principal quantum number is usually denoted by n. Syn. *total quantum number.*

principal series. A spectral series corresponding to transitions from a low S-state to higher P-states. This gives the strong, persistent lines of the alkalis and alkaline earths but not, in general, of other elements.

principal strains and p. stresses. The components of strain, and the corresponding components of stress, in the directions of the strain axes at any point of an elastic solid under deformation. (See Newman and Searle, General Properties of Matter, 1929, p. 139.)

principal velocity. One of the three velocities which, taken by twos, correspond to the velocities of propagation of the two plane-polarized light waves traveling outward from a point source within a birefringent crystal in directions parallel to the three axes of dielectric symmetry. In a uniaxial crystal, two of the three principal velocities are equal, *viz.*, in the direction of the optic axis.

prism binocular. A type of binocular field glass, each telescope of which contains two right-angled prisms (Porro prisms) so placed as to secure at the same time the erection of the image, a shorter tube, and greater stereo power than an ordinary binocular.

probability amplitude. A wave function, commonly denoted by Ψ, which satisfies the Schroedinger wave equation or other similar equations of wave mechanics, and corresponds to a quantum condition actually fulfilled in nature. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 623.)

probable error. The magnitude of an error that is as likely as not to be exceeded by a single observation, or by the mean or the adjusted result from a certain number of observations. It is selected with reference to the true but unknown mean which would theoretically be obtained from an indefinitely large number of observations, and is a statistical measure of precision. (See Weld, Theory of Errors and Least Squares, 1929, chap. 8; Deming and Birge, *Rev. Mod. Phys.* 6, 119, 1934.)

product of inertia. *In re* any body, with respect to any pair of rectangular axes X and Y: the value of the volume integral $\int\int\int xydxdydz$ taken throughout the volume of the body.

production coefficient. The rate at which primary radiation produces secondary radiations with respect to the thickness of medium traversed. If dI_2 is the intensity of secondaries produced in thick-

ness dx by primary radiation of intensity I_1, the coefficient is

$$\beta = \frac{dI_2/dx}{I_1}.$$

Cf. absorption coefficient. (See Johnson, *Phys. Rev.* 41, 545, 1932.)

progression. A set of spectral bands having a common upper (or lower) rotational state, but differing by steps of unity in the vibrational quantum number of the lower (or upper) state. (See Darbyshire, *Phys. Rev.* 40, 366, 1932.)

prometacenter. The center of curvature of a curve of buoyancy at any point.

propagation constant. *In re* the steady transmission of sound through any enclosure: the Napierian logarithm of the ratio of the volume velocity at entrance to that at exit of the wave train from the enclosure. (See Acous. Soc. Comm. Rep., 1934.)

proper energy. The energy which, according to relativity theory, is equivalent to a given mass m, and is equal to mc^2, where c is the electromagnetic constant. Syn. *characteristic energy.* (See Haas, Int. to Theoretical Phys., 1925, v. 2, p. 327.)

proton. An elementary particle, of mass about 1.66×10^{-24} g (1845 times that of the electron) and with a positive charge equal to that of the electron (4.77×10^{-10} e.s.u.). The nucleus of the ordinary hydrogen atom is thought to be a single proton. *Cf. positron.* (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

prototype. An accurate copy of a primary standard unit. Syn. *secondary standard* (2).

proximity effect. One of the results of winding a wire in a coil with closely adjacent turns, *e.g.*, self-capacitance, the increase in effective resistance for h.-f. currents, etc.

pseudomorphic. Having a definite geometrical form for the external surface, but made up structurally of smaller crystals of a form quite different.

psychrometer. Syn. *wet-and-dry-bulb thermometer.*

pulse. A single disturbance propagated as a wave, but not having the cyclic characteristic of a wave train; *e.g.*, the sound of an electric spark.

pure spectrum. A spectrum of which each point corresponds to one and only one wave length or frequency of the dispersed radiation.

push-pull amplifier. A combination of two vacuum-tube circuits so related that they are in phase for those frequencies which it is desired to amplify and out of phase for those which are to be eliminated.

pycnometer, pyknometer. Any container used in the manner of a specific-gravity bottle for measuring the densities of liquids.

pyranometer. An instrument which measures the intensity of the radiation received from any portion of the sky. (Kalitin, *Monthly Weather Rev.* 58, 59, 1930.)

pyrheliometer, pyroheliometer. An instrument for measuring the total intensity of solar radiation, both direct and scattered by the surrounding atmosphere. Syn. *solarimeter.*

pyro-electric. Characterized by the property, exhibited by certain asymmetric crystals, of becoming electrically polarized and of developing charges of "pyro-electricity" upon change of temperature. The true pyro-electric effect results directly from the temperature change; there is a pseudo-pyro-electric effect which arises from strains due to alteration of temperature and which is therefore an indirect piezo-electric effect.

pyro-electric constant. Change in the electric polarization of a pyro-electric crystal per unit change in temperature. (See I.C.T., 1926, v. 6, p. 209.)

pyrometer. Any instrument for the measurement of high temperatures. *Cf. optical pyrometer, radiation p.*

pyroscope. A form of optical pyrometer, devised by Shore. (See Ferry, Practical Pyrometry, 1917, p. 103.)

Q

(*Please note purpose of references as explained in preface.*)

Q branch. A set of molecular spectrum lines corresponding to changes in vibrational energy with none in rotational energy. *Cf. P branch, R branch.* (See Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 11.)

quadrant electrometer. An electrometer consisting of a light, elongated metallic plate suspended horizontally within a flat metallic cylinder divided into quadrants. The electric reaction between the charged plate and the charged quadrants causes the former to turn against the torsion of the suspending wire.

quadrature. A phase difference of one-quarter cycle.

quadruplet. *Cf. multiplet.*

quadrupole, quadripole. A system consisting of two equal dipoles parallel to each other, but with their corresponding charges reversed.

quadrupole lines. A type of "forbidden" spectral lines, whose infrequency of occurrence is interpreted as due to the action of the atom as an electric quadrupole instead of as the more usual dipole. Such lines exist, however, in the spectra of nebulae and the aurora.

quality. 1. That characteristic of a musical sound which is dependent upon the wave form and hence upon the harmonic components and their relative intensities. Syn. *timbre, tone color.* 2. *In re* a system composed of the liquid and the vapor states of a pure substance: the ratio of the mass of the vapor to the total mass of both phases. Syn. *dryness.*

quantity of light. *Cf. light, quantity of.*

quantized. 1. Composed of, or associated with, quanta of energy; *e.g.*, quantized radiation. 2. Expressed in terms of the general quantum theory.

quantum, quant. 1. A discrete portion of energy, of definite amount,

first associated with intra-atomic or intramolecular processes involving changes among the electrons and with the corresponding radiation. 2. Any supposed smallest portion of a magnitude; *e.g.*, the electronic charge is sometimes called a quantum of electricity. *Cf. Planck law, Planck constant.*

quantum condition. The mathematical condition which must be satisfied for any given quantum state of an atom or other system to be possible.

quantum correction. A correction required by any classical law or formula to bring it into harmony with the quantum theory.

quantum defect. The principal quantum number for the electron responsible for a spectral series, minus the square root of the Rydberg denominator for any actual spectral term of the series. It is usually, but not always, positive.

quantum efficiency. The number of photoelectrons emitted from a metal per quantum of incident radiation. Syn. *quantum yield. Cf. photoelectric yield.*

quantum equivalence principle. The principle that when, in a photoelectric or photovoltaic process of any kind, a quantum of radiation is "absorbed," its entire energy reappears in some other definite form, such as the kinetic energy of a released photoelectron, or the energy of an ionized atom. (See Hughes and DuBridge, Photoelectric Phenomena, 1932, pp. 199, 301.)

quantum mechanics. 1. A general physical theory which seeks to deal with atomic structure and related problems in terms of only those quantities which can be actually measured, and excluding such purely inferential concepts as the position or the velocity of an electron in a supposed orbit. It embraces the matrix mechanics of Heisenberg, the wave mechanics of Schroedinger, and the transformation theory of Jordan and Dirac. 2. The mechanics of phenomena which are subject to quantum conditions, such as the processes going on within and among atoms and molecules.

quantum number. An integral number which is characteristic of the statement of a quantum condition. *E.g.*, for a hydrogen atom (disregarding relativity and spin corrections) the energy corresponding to any quantum state is inversely proportional to the square of the (principal) quantum number. *Cf. electron, principal, azimuthal, radial, inner, magnetic, vibrational, rotational,* and *effective quantum numbers.* (See Pauling and Goudsmit, Structure of Line Spectra, 1930, p. 17.)

quantum of action. *Cf. Planck constant.*

quantum state. One of the several discrete states in which an atom or a molecule may exist, permanently or momentarily, transitions between which are thought to cause the emission of distinct radiation frequencies and quanta, corresponding to lines of the spectrum. Syn. *energy level.*

quantum transition. An abrupt readjustment which is accompanied by the emission or the absorption

of a quantum of radiant energy. Syn. *quantum jump.*

quantum weight. Syn. *statistical weight.*

quarter-wave plate. A plate of mica or other doubly refracting crystal of such thickness as to introduce a phase difference of one-fourth cycle between the ordinary and the extraordinary components of the light traversing it. *Cf. half-wave plate.*

quartz-fiber manometer. A type of manometer in which the pressure of a gas is measured by the damping which it offers to the vibrations of a quartz fiber. Devised by Haber and Kerschbaum. (See Newman, Production and Measurement of Low Pressures, 1925, p. 146.)

quench. 1. To extinguish, as a glowing solid or a spark, by immersion in a liquid. 2. To suppress or reduce the fluorescence or phosphorescence of a substance by the admixture of some other substance, or by the action of some agency such as radiation.

Quincke tube. An acoustic wave filter consisting of a short tube with a semicircular side branch. (See Stewart and Lindsay, Acoustics, 1930, p. 90.)

R

(Please note purpose of references as explained in preface.)

R branch. A set of molecular spectrum lines corresponding to unit decreases in rotational quantum number. *Cf. P branch.* (See Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 11.)

r unit. Syn. *roentgen.*

Rabi field. A magnetic field used to deflect particles having an intrinsic magnetic moment. It is a nonuniform field, the portion used being that in the plane midway between parallel, flat, rectangular pole pieces. (See Fraser, Molecular Rays, 1931, p. 117.)

racemic. Not optically active; *e.g.* racemic quartz, in which the two kinds are twinned so as to compensate each other. A substance having this characteristic is called a *racemate*, and the acquisition of the property is *racemization.*

radial quantum number. A quantum number associated with radial motion, which must be an integer for any allowed stationary state of a particle moving subject to a central field.

radial velocity. The component of linear velocity in line with the observer.

radiant energy. Energy transmitted through the agency of electromagnetic radiation.

radiant flux, r. power. Rate of emission of energy in the form of radiation, expressed in watts or other power units. *Cf. luminous flux, visibility factor.* (See Smiths. P. T., 1929, p. 259.)

radiant intensity. *In re* a point source of radiation: the radiant flux emitted per unit solid angle (spheradian) in a specified direction. *Cf. luminous intensity.*

radiating power. Syn. *emissive power.*

radiation. 1. The propagation of energy through space or through material media in the form of electromagnetic waves, but subdivided in some manner into discrete portions or *quanta*. Commonly classified, according to frequency, as *Hertzian radiation, infrared,* (visible) *light, ultraviolet, x-rays, gamma rays,* etc. *Cf. thermal radiation.* 2. Sometimes extended to include corpuscular emissions, as alpha and beta "radiation," or emissions of mixed or unknown type, as cosmic "radiation."

radiation damping. A decrease in the amplitude of an electric oscillation due to the emission of energy by radiation; distinct from that due to ohmic resistance.

radiation potential. The p.d., in volts, corresponding to the energy, in electron-volts, required to excite an atom or a molecule to emit one of its characteristic radiation frequencies. The *first r.p.* excites the lowest frequency, etc. Syn. *resonance potential. Cf. critical potential.* (See Crowther, Ions, Electrons, and Ionizing Radiations, 1934, pp. 67 ff.)

radiation potentiometer. An apparatus for studying the spectral energy distribution of thermal radiation, by the potentiometer comparison of the thermoelectric effects of radiation from limited spectral ranges with that of the total radiation. (See Stockbarger, *J.O.S.A.* 12, 349, 1926.)

radiation pressure. A pressure exerted upon a surface exposed to light or other electromagnetic radiation, the value of which is proportional to the radiant energy density in the space to which the surface is exposed. *Cf. Nichols radiometer.*

radiation pyrometer. A pyrometer which gives the temperature of the heated body by measuring the total intensity or the spectral energy distribution of the thermal radiation emitted by it.

radiation reaction. A force acting upon a body by reason of its emission of radiation, the direction of the force being opposite to that in which the radiation is emitted. It is the counterpart of force involved in radiation pressure.

radiation resistance. That part of the apparent or measured resistance of an oscillating circuit which is due to the loss of energy through Hertzian radiation.

radiation temperature. *In re* a source of thermal radiation: the temperature to which an ideal black body must be heated in order to give it the same emissive power as the source in question. Syn. *effective temperature. Cf. brightness temperature, color t.* (See I.C.T., 1926, v. 5, p. 245.)

radiative equilibrium. The maintenance of a constant temperature by the absorption and emission of radiant energy at the same rate.

radio frequency. Any frequency, usually above the audible range, suitable for the transmission of radio signals.

radioactive deposit. A film of radioactive matter formed from the disintegration of a radioactive emanation (radon, thoron, actinon) and of the subsequent products. Such films may be found upon solid objects which have been

in contact with any one of these emanations. *Cf. induced radioactivity* (2).

radioactive equilibrium. A relationship between a radioactive substance and its parent substance, in which at any instant the rate of disintegration of the former is equal to its rate of formation from the latter. The equilibrium is "transient" if the balanced rates change rapidly, "secular" if the parent substance has a very long period.

radioactive product. A substance which results from the radioactive disintegration of another (parent) substance.

radioactive series. A succession of radioactive elements, each of which is derived from the disintegration of the one preceding. *Cf. actinium series, thorium s., uranium s.*

radioactivity. A property of certain elements, which involves the spontaneous emission of alpha particles or of beta particles from the nucleus of the atom. Gamma rays, also of nuclear origin, may accompany or immediately follow the disintegration, but are a by-product of that process. *Cf. induced radioactivity.*

radioelement. A radioactive element.

radiogenic. Produced as a product of radioactivity; *e.g.*, radiogenic lead. (See Rose and Stranathan, *Phys. Rev.* 50, 792, 1936.)

radiogram. 1. Syn. *radiograph.* 2. An x-ray pattern produced by crystal diffraction. *Cf. Laue pattern.* 3. A wireless telegraph message.

radiograph. An x-ray or radium photograph, showing the non-uniform density of the structure through which the rays pass.

radiology. 1. That branch of physics which deals with x-rays, radioactivity, and other h.-f. radiation. 2. The art of diagnosis and treatment of diseases by means of x-rays, radium, or ultraviolet radiation.

radioluminescence. Luminescence stimulated by radioactive emission or by x-rays.

radiometeorograph. A meteorograph which, when sent up in a balloon, automatically reports atmospheric conditions by radio to receiving apparatus at the ground station.

radiometer. An instrument for measuring the intensity of thermal radiation. *Cf. Crookes radiometer, Nichols r., microradiometer.*

radiometric gauge. Any low-pressure gas manometer dependent upon the inequality of pressure due to molecular bombardment on opposite sides of a suspended vane; *e.g.*, the *Knudsen gauge.* (See Dunoyer, Vacuum Practice, 1926, p. 74.)

radiomicrometer. An instrument, devised by Boys, consisting of a short-circuited thermocouple suspended in a strong magnetic field, and sensitive to very feeble thermal radiation. *Cf. microradiometer.*

radio-photoluminescence. Luminescence exhibited by certain minerals, as kunzite and fluorite, as a result, first of irradiation with beta and gamma rays, followed by exposure to light; first observed

by K. Przibram. (See Kovarik and McKeehan, *National Research Council Bull.* 10, 164, 1925.)

radio-thermoluminescence. Luminescence exhibited by certain vitreous and crystalline substances as a result, first of irradiation with beta and gamma rays, or by *Entladungsstrahlen*, followed by heating; first observed by E. Wiedemann. (See Kovarik and McKeehan, *National Research Council Bull.* 10, 163, 1925.)

radius of gyration. Of a rigid body with respect to a given axis: a distance such that, if all the particles of the body were at that distance from the given axis, its moment of inertia with respect to that axis would be unchanged. Syn. *swing radius.*

raies ultimes (Fr.). *Cf. persistent spectrum.*

Raman effect. The presence, in scattered light, of frequencies differing from that of the incident light by various values characteristic of the scattering substance but independent of the incident frequency. Discovered by C. V. Raman in 1928. The scattered or "modified" lines constitute the *Raman spectrum* of the scatterer. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 360.)

Raman viscosity formula. Expresses the viscosity coefficient η of a liquid in terms of the absolute temperature T, as follows:

$$\eta = Ae^{\frac{B}{T}},$$

in which A and B are constants.

Ramsauer effect. 1. The absorption of slow-moving electrons by intervening matter, somewhat as alpha particles are absorbed by gases. (See Hoag, Electron Phys., 1929, p. 45.) 2. The abnormally low collision probability of slow-moving electrons traversing inert gases. (See Brode, *Rev. Mod. Phys.* 5, 257, 1933.)

Ramsden eyepiece. An eyepiece for optical instruments, consisting of two similar plano-convex lenses with their convex faces facing each other and at a distance equal to two-thirds the focal length of either.

range. 1. The distance to which a corpuscular emission, as alpha rays, will penetrate a given substance before all its energy is absorbed. 2. The distance from its starting point, on a horizontal plane, at which a projectile again reaches the plane.

range of stability. The angle through which a floating body may be rotated from its equilibrium position without capsizing, *i.e.*, before the restoring torque becomes zero. (See Laws, Stability and Equilibrium of Floating Bodies, 1914, p. 60.)

Rankine cycle. A type of thermodynamic engine cycle in which the isothermal compression is continued until the original volume is attained, and the cycle is then completed by an increase of pressure at that volume. The ordinary steam engine approximates this cycle.

Raoult law. A more specific form of the *van't Hoff law; viz.:* The fractional lowering of the vapor pressure of a solvent by a non-volatile solute is equal to the ratio of the number of molecules

of the solute to the total number of molecules of both solute and solvent.

rational index law. Syn. *Haüy law.*

rationalized unit. Syn. *Heaviside-Lorentz unit.*

Rayleigh disk. A light disk which, placed in a sound field, tends to set itself at right angles to the direction of motion of the particles of the medium.

Rayleigh-Jeans law. A law intended to express the spectral energy distribution of black-body radiation at a given absolute temperature T in terms of wave length λ. The emissive power of the black body within the wavelength range is given as

$$dE_\lambda = 2\pi ckT\lambda^{-4}d\lambda;$$

in which c is the electromagnetic constant and k, the Boltzmann constant. The law fails to meet the experimental facts except at long wave lengths. *Cf. Wien laws* (3), *Planck equation.* (See Richtmyer, Int. of Modern Phys., 1928, pp. 221 ff.)

Rayleigh law. States that at very low values of the maximum magnetic induction, the hysteresis loss in a magnetic cycle is proportional to the cube of that induction.

Rayleigh line. That component of a spectrum line in scattered radiation which has the same frequency as the corresponding incident radiation, arising simply from ordinary or Rayleigh scattering, not from the Compton or the Raman effect. (See Sommerfeld, *Phys. Rev.* 50, 38, 1936.)

Rayleigh scattering. The selective scattering of light by very small particles suspended in the air, such as dust or even the molecules of the air itself.

reactance. 1. (*Inductive.*) That component of the impedance of a circuit which is due to inductance; expressed by $2\pi nL$. 2. (*Capacitive.*) That component which is due to capacitance; expressed by $1/2\pi nC$. Both are measurable in ohms. *Cf. acoustic impedance.*

real image. *Cf. image.*

Réaumur scale. A thermometric scale on which the freezing point of water is 0° and the boiling point 80°. Introduced by René de Réaumur about 1730, and still largely used in Central Europe.

recalescence. The sudden evolution of heat by solid iron and some other ferromagnetic metals at certain high temperatures as the metal cools; probably due to some exothermic structural transition. *Cf. decalescence.*

reciprocal-energy theorem. A theorem due to Rayleigh; as follows: Let an e.m.f., E_1, inserted in any branch, designated as No. 1, of a transducer produce a current I_2 in any other branch No. 2; correspondingly, let an e.m.f., E_2, inserted in branch No. 2, produce a current I_1 in branch No. 1; then, if Ohm's law holds,

$$I_1E_1 = I_2E_2.$$

Closely related to the *reciprocity theorem* (1). (See Carson, *Bell Syst. Tech. J.* 9, 325, 1930.)

reciprocity law (photographic). States that the time of exposure

and the illumination required to produce a given photographic effect on a plate or film are in reciprocal relation to each other; so that exposures having the same value of the product It will, after the same development, result in the same density of image. The law is not strictly true. (See Webb, *J.O.S.A.* 23, 158, 1933.)

reciprocity theorem. One of several analogous theorems, *e.g.:* 1. A principle of electric networks, in accordance with which the current in any branch A due to an e.m.f. in any other branch B is equal to the current in B due to an equal e.m.f. in A. *Cf. reciprocal-energy theorem.* (See Shea, Transmission Networks and Wave Filters, 1930, p. 52.) 2. *In re* a vibrating string: the amplitude of vibration at a point A due to a periodic force applied at another point B is equal to the amplitude produced at B by an equal periodic force of the same frequency applied at A. (See Lamb, Dynamic Theory of Sound, 1920, p. 81.) Also *cf. reciprocity law (photographic).*

recoil. The motion of an atom because of the emission of an alpha particle, a beta particle, a neutron, or (possibly) a quantum of radiation; or the motion of an electron because of having functioned in the Compton effect. *Recoil rays* are streams of such recoiling particles. (See Rutherford, Chadwick, and Ellis, Radiations from Radioactive Substances, 1930, p. 157; Kovarik and McKeehan, Radioactivity, 1925, pp. 153 ff.)

recoil factor. The ratio of the intensity of scattered x-rays modified by the Compton effect, as calculated on the quantum theory, to its classical value. (See Compton and Allison, X-Rays in Theory and Experiment, 1935, p. 139.)

recombination coefficient. A coefficient which appears in the law expressing the rate of recombination of ions in a gas. If n_+ and n_- are the respective numbers of the two kinds of ions,

$$\frac{dn_+}{dt} = \frac{dn_-}{dt} = -An_+n_-.$$

A is the *recombination coefficient.* (See Darrow, Electrical Phenomena in Gases, 1932, p. 253; Luhr and Bradbury, *Phys. Rev.* 37, 998, 1931.)

recombination spectrum. A faint, continuous spectrum ascribed to the recombination of ions in an ionized gas. (See Moehler, *Phys. Rev.* 31(2), 187, 1928; *B.S.J.R.* 2, 489, 1929.)

rectify. 1. To change from alternating to unidirectional, as an electric current. Any device for securing this result is a *rectifier. Cf. valve* (2). 2. To replace (an inverted image) by one which is erect, as by the rectifying system in a field glass.

rectilinear. *In re* an optical system: forming images without distortion, so that the image of a straight line is straight, etc.

red shift. 1. A general shift of the lines of a spectrum in the direction of longer wave length, due to the Doppler or other effect. 2. In particular, an increase in wave length observed in the spectra of distant spiral nebulae or galaxies, which

appears to be progressively greater with greater distance, and the cause of which is not definitely known. *Cf. Einstein shift.*

reduced focal length. The first focal length of a spherical refracting surface, or of a lens, divided by the refractive index of the medium in which the light is incident; or the second focal length divided by the index of the medium into which the rays emerge. *Cf. focal point.* (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 281.)

reduced mass. 1. *In re* a heteropolar molecule: the value of the quantity

$$\frac{M_1 M_2}{M_1 + M_2},$$

in which M_1 and M_2 are the masses of the two ions. *Cf. effective ionic mass.* (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 124.) 2. *In re* an orbital electron: the value of

$$\frac{mM}{m + M},$$

in which m is the mass of the electron and M, that of the nucleus. (See White, Int. to Atomic Spectra, 1934, p. 34.)

reduced variables of state. The values of the pressure, specific volume, and absolute temperature of a gas expressed (as abstract ratios) in terms of their critical values, *i.e.*, the values of p/p_c, v/v_c, T/T_c. *Cf. law of corresponding states.* (See Jeans, Dynamical Theory of Gases, 1916, p. 162.)

reduction of area. The percentage ratio of the difference between the original and the broken area of cross section of a rod which has been pulled apart, to the original area. (See I.C.T., 1926, v. 2, p. viii.)

reflectance. Syn. *reflection factor.* (See McNicholas, *B.S.J.R.* 1, 31, 1928; Judd, *J.O.S.A.* 23, 360 1933.)

reflecting power. Syn. *reflectivity.* (Obsolescent.)

reflection, angle of. The angle between the direction of propagation of a reflected emission and the normal to the reflecting surface.

reflection coefficient. The square root of the reflectivity of a surface for any type of radiation. It is the ratio of the amplitude of the reflected radiation to that of the incident radiation.

reflection factor. The ratio of the total luminous flux reflected by a given surface to that incident upon it. Syn. *reflectance. Cf. reflectivity, albedo.* (See Taylor, *B.B.S.* 16, 421, 1920.)

reflectivity. The fraction of the radiant energy of a given character, normally incident upon the surface of a body, which is reflected by that surface. *Cf. reflection factor.* (See Richtmyer, Int. to Modern Phys., 1928, p. 182.)

reflectometer. An instrument for measuring the reflection factors of reflecting surfaces. (See Taylor, *B.B.S.* 17, 1, 1922; Karrer, *ibid.*, p. 203.)

refraction, angle of. The angle between the direction of propagation of a refracted emission and the normal to the refracting surface.

refractive index. The ratio of the speed of a refracted radiation before refraction to its speed after

refraction. If the radiation passes from a vacuum into a substance, this ratio is termed the *absolute index* of the substance; if from one substance into another, the *relative index* of the two substances. Syn. *index of refraction. Cf. Snell law, extraordinary index.*

refractivity. The refractive index minus 1. *Cf. specific refractivity, molar refractivity.* (See I.C.T., 1926, v. 1, p. 40.)

refractometer. An instrument for measuring the refractive indices of liquids or of solids, usually by determining the critical angle (*cf. total reflection*).

refrangible. Capable of being refracted, or measurably deviated by refraction.

regelation. The fusion and resolidification of ice below the normal freezing point, due to variations of pressure.

regeneration. A general term denoting various processes, the characteristic of which is that the result automatically enhances the cause, the action therefore tending to build itself up to greater and greater intensity. *E.g.*, in a regenerative vacuum-tube amplifying circuit, the fluctuations of the plate current, by means of a feedback arrangement, re-enforce the variations in grid potential, and thus increase the fluctuations in the plate current itself.

regressive effect. Syn. *Marx effect.*

regular reflection, refraction, or transmission. Reflection, refraction, or transmission in a definite direction, not diffused or scattered.

relative aperture. *Cf. aperture* (4).

relative humidity. *Cf. humidity.*

relativity. A modern system of natural philosophy, characterized by its recognition of the interdependence of the basic entities of matter, space, and time; introduced and largely developed by Albert Einstein. Adj., *relativistic.*

relativity contraction. Syn. *Lorentz-Fitzgerald contraction.*

relativity correction. A correction which must be applied to a formula derived or to a value calculated in accordance with classical theory in order to bring it into agreement with the relativity theory.

relaxation inverter. An inverter, the circuit of which is based upon that of the relaxation oscillator. (See Reich, *R.S.I.* 4, 147, 1932 and *Elec. Eng.* 53, 817, 1933.)

relaxation number. The reciprocal of the relaxation time (2). (See Bingham, Fluidity and Plasticity, 1922, p. 128.)

relaxation oscillator. An electric oscillator in which a condenser is charged periodically from a d.-c. source through the primary of a transformer and is discharged through a thyratron and a small series inductance when the condenser voltage is at or near its maximum. (See Reich, *R.S.I.* 3, 580, 1932.)

relaxation time. 1. The time required for the electric polarization at any point of a suitably charged dielectric to fall from its original value to $1/e$ of that value, due to the electric conductivity of the dielectric. (See Cohn, *Wied. Ann.* 40, 625, 1890.) 2. In general, the time required for an exponential variable to decrease to $1/e$ of its initial value. *Cf. half-value period,*

relaxation number. (See Robertson, *Phys. Rev.* 40, 583, 1932.) 3. The time required for a gas, in which the Maxwell distribution of velocities has been temporarily disturbed, to recover that state. (See Jeans, Dynamical Theory of Gases, 1916, p. 260.) 4. The time required for the shearing stress in a flowing viscous substance to disappear after the flow has ceased. *Cf. viscosity coefficient.* (See Newman and Searle, General Properties of Matter, 1929, p. 200.)

relay. Any device used to communicate or pass on impulses from one system to another system.

reluctance. The ratio of the magnetomotive force acting upon any part of a magnetic circuit to the resulting magnetic flux.

reluctivity. The ratio of the magnetic intensity H to the magnetic induction B in the same region. If B and H are parallel, the reluctivity is the reciprocal of the magnetic permeability. Syn. *specific reluctance.*

remanence. The residual magnetic induction B in a substance undergoing a symmetrical hysteresis cycle, when the magnetic intensity H is reduced to zero; represented by either intercept of the H-B hysteresis curve on the B axis. *Cf. remanent magnetization.* (See Auerbach, Modern Magnetics, 1925, p. 48; Epstein, *Phys. Rev.* 41, 108, 1932.)

remanent magnetization. The magnetization I retained by a substance undergoing a symmetrical hysteresis cycle, when the magnetic intensity H is reduced to zero; represented by either intercept of the H-I hysteresis curve on the I axis. *Cf. remanence.*

replacement. The occurrence of crystal faces which develop in place of edges or apexes, thus apparently truncating the latter. If such a face makes equal angles with two adjacent faces which would otherwise form an edge, it is said to be a *bevel face. Cf. suppression* (2).

residual. The result of a measurement upon a quantity, minus the most probable value of that quantity. (See Weld, Theory of Errors and Least Squares, 1929, p. 11.) *Cf.* also terms following.

residual blue. A phenomenon observed by Tyndall with white light scattered by small particles in suspension. Viewed through a suitably oriented nicol, the scattered light appears blue. (See Wood, Phys. Optics, 1929, p. 627.)

residual charge. The charge on the plates of a condenser, which remains temporarily bound, after an initial discharge, by that part of the polarization of its imperfect dielectric which is due to electron migration. *Cf. absorption* (3), *electret.*

residual ionization. Ionization of air or other gas in a closed vessel, not accounted for by recognizable agencies in the immediate neighborhood (x-rays, radioactivity, etc.). Formerly supposed to be an inherent property of the gas, but now attributed to the cosmic rays.

residual magnetic induction. The magnetic induction in a ferromagnetic body after the removal of the magnetizing force. It depends upon the material, the

shape, and the previous history of the specimen. *Cf. remanence.*

residual radiation. A nearly monochromatic infrared radiation isolated from the output of a white-hot solid by successive reflections from surfaces of a given crystalline material, as quartz or rock salt; a method due to Rubens and Nichols, who termed the rays *Reststrahlen.* (See Sidgwick, Electronic Theory of Valency, 1929, p. 90.)

residual stress. A stress which persists in a solid, due not to the existence of external forces but apparently to the fact that certain portions have been stressed beyond the elastic limit while the adjacent portions have not. (See Nádai, Plasticity, 1931, p. 259.)

resilience. 1. The work required to deform an elastic body to the elastic limit. Its value depends upon the elastic constants and the dimensions of the body. 2. The ability of a material to make internal adjustment to rapid deformation without the development of excessive stress; the opposite of *brittleness.*

resistance. That which limits the steady electric current in a conductor and is expressed by the ratio of the applied constant e.m.f. to the current. *Cf. Ohm law, ohm, resistivity, effective resistance, conductance.*

resistance neutralization. The effect of a triode associated with a circuit in such a way as to lower the effective resistance of certain branches. (See Peters, Theory of Thermionic Vacuum Tube Circuits, 1927, chap. 3.)

resistance thermometer. A thermometer based upon the variation of the electrical resistivity of a metal, *e.g.*, platinum, with temperature.

resistivity. That factor of the resistance of a conductor which depends upon the material and its physical condition. Its measure is the resistance of a specimen, in the form of a rod of unit length and unit cross section, to a current traversing it longitudinally. Usually expressed in ohm-centimeters. Syn. *specific resistance. Cf. conductivity* (2).

resistor. A device, the primary purpose of which is to introduce resistance into an electric circuit.

resolution. 1. The separation of a vector into its components. 2. The sharpness with which the images of two closely adjacent sources, two adjacent spectrum lines, etc., may be distinguished. *Cf. resolving power.*

resolving power. 1. Of an optical system: a measure of the distinctness with which the images of two point-sources of light may be separately detected. *E.g.*, for a telescope, it is the least angular separation of the two point-sources (as stars) which can be recognized, and exists when the center of the diffraction ring system of one falls on the first dark ring of the other. (See Page, Int. to Theoretical Phys., 1928, p. 508.) 2. (*Spectroscopic.*) Of a grating or a prism: the value of $\lambda/\Delta\lambda$ (where λ is the mean wave length for two close spectrum lines differing in wave length by $\Delta\lambda$) when the principal maximum of one line coincides with the first

minimum of the other, so that they are just distinguishable. (See Page, *ibid.*, p. 534.)

resonance. A term denoting a variety of phenomena characterized by the abnormally large response of a system having a natural vibration period to a stimulus of the same, or nearly the same, frequency. *Cf. resonator.*

resonance bridge. A type of a.-c. bridge, in one arm of which an inductance and a capacitance are adjusted to such values that the bridge is in resonance; their product is then equal to $1/4\pi^2n^2$, where n is the frequency. (See Brown, Radio Frequency Elec. Meas., 1931, p. 138.)

resonance penetration. The penetration of an atomic nucleus by a charged particle whose energy corresponds to one of the energy levels in the nucleus. The probability of penetration by such a particle is comparatively large. (See Cork and Lawrence, *Phys. Rev.* 49, 788, 1936.)

resonance potential. Syn. *radiation potential.* (Obsolescent.)

resonance radiation. Radiation from a gas or a vapor, due to states of excitation which may be brought about by radiation of the same frequencies; as in the case of sodium vapor traversed by sodium light. When so excited, it may be regarded as a type of fluorescence without degratation of frequency. First intensively studied by R. W. Wood. *Cf. resonance state.*

resonance radiometer. A modification of the thermorelay, for relative measurements of small radiation intensities in infrared spectrometers. (See Pfund, *Science* 11, 69, 1929.)

resonance state. A state of excitation which gives rise to resonance radiation.

resonator. An apparatus designed to resonate, or respond as the result of resonance, to a stimulus of given frequency.

rest mass. The mass of a body in the classical or Newtonian sense, *i.e.*, not including the additional mass which, according to the relativity theory, the body acquires when set in motion. *Cf. static length.*

rest potential. A residual p.d. between an electrode and the electrolyte, which remains after the electrode has become polarized; as distinct from the true *electrokinetic potential* developed when the solid and the liquid are in contact.

restitution coefficient. The ratio of the relative speed of two elastic spheres, after a collision in their line of centers, to the relative speed before the collision. According to Newton's experiments, this ratio is constant for the same two spheres.

Reststrahlen (Ger.). Syn. *residual radiation.*

retarded potential. The electric or magnetic potential at any point due to an electric or a magnetic system at a distance r and with due allowance for the time r/c required for the electric or magnetic effect to travel over that distance; c being the electromag-

netic constant. *Cf. Kirchhoff potential.*

retentivity. 1. The value of the remanence for the case of a symmetrical magnetic hysteresis cycle extending to practical saturation. 2. The ratio of the remanence to the magnetic induction at saturation under these same circumstances. Syn. *retentivity coefficient.*

reticle, reticule. A network or a single pair of cross hairs placed in the focal plane of an optical instrument to serve as a reference system. *Cf. graticule.*

retrograde rays. A type of corpuscular rays, of atomic dimensions, like positive rays, and magnetically deflected as positive rays are, but moving away from the cathode instead of toward it. They appear to be of complex character. (See Smith, *Phys. Rev.* 7(2), 625, 1916.)

reverberation. A succession of echoes, esp. of sound in a large room; the result of repeated reflections.

reverberation time. The time required for the average acoustic energy density in a reverberating enclosure to fall off to one-millionth of its initial, steady-state value, after the source has been silenced. It depends upon the geometrical form and equivalent absorption of the enclosure and upon the frequency of the sound. (See Acous. Soc. Comm. Rep., 1934.)

reversible. *In re* a succession of changes in a system: such that if the order in time of the changes is reversed, the only alteration in the corresponding changes in energy is reversal of sign.

reversible engine. A heat engine working in a reversible thermodynamic cycle, *e.g.*, a Carnot cycle.

reversible pendulum. A pendulum provided with two pivots at conjugate points, from which it swings in equal times. See *Kater pendulum.*

Reynolds laws. 1. States that for a mobile liquid in a straight tube, the gradient of the head is proportional to the speed of flow up to the critical velocity; whereas, at speeds above this, it is proportional to a higher power of the speed. Thus

$$\frac{dH}{dx} = -Av^n,$$

where $n \gtrless 1$. (See Royds, Heat Transmission by Radiation, etc., 1921, p. 61.) 2. States that the critical velocity of a liquid flowing in a straight tube is inversely proportional to $\rho\phi r$, in which ρ is the density and ϕ the fluidity coefficient of the liquid and r is the radius of the tube. (See Bingham, Fluidity and Plasticity, 1922, p. 40.)

rheograph. A type of magnetic vibration galvanometer or oscillograph, devised by Abraham, in which the effects of inertia and damping are neutralized by special means. (See Irwin, Oscillographs, 1925, p. 51.)

rheology. That branch of physics which deals with the permanent or plastic deformation or the flow of matter.

Richard rule. States that the ratio of the molar heat of fusion to the

absolute temperature of the melting point is the same for various solids.

Richardson equation. An expression for the saturation-current density of thermionic emission, in terms of the absolute temperature T of the filament:

$$I = AT^n e^{-\frac{B}{T}}.$$

Richardson used $n = \frac{1}{2}$; others have found $n = 2$ more accurate. B involves the thermionic work function. *Cf. thermionic emission constant.* (See Richardson, Emission of Electricity from Hot Bodies, 1916; Bloch, Thermionic Phenomena, 1927, chaps. 3 and 4.)

Righi-Leduc effect. A difference of temperature which develops between the two edges of a strip of metal, in which heat is flowing longitudinally, when the plane of the strip is placed perpendicularly across a magnetic field. *Cf. Nernst effect, Hall e.* (See Campbell, Galvanomagnetic and Thermomagnetic Effects, 1923, chap. 13.)

rigidity modulus. Syn. *shear modulus.*

Ritz formula, Rydberg-Ritz f. A somewhat complicated modification of the Rydberg (spectral series) formula, in which allowance is made for the variation of f with the number of the line in the series. *Cf. Hicks formula.* (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 193.)

Ritz principle. States that every wave number occurring in the spectrum of a substance may be expressed as a difference between two of a much smaller group of terms characteristic of the substance. These terms correspond to what are now recognized as quantum states, in accordance with the "combination principle" of Ritz.

Rochon prism. A type of polarizer, consisting of two Iceland-spar prisms, one with its axis parallel to the entering beam of light, the other with its axis perpendicular to that beam. Upon passage from one prism into the other, the extraordinary ray is refracted while the ordinary is not, the separation being further increased upon emergence from the second prism. (See Glazebrook, Dict. of Applied Phys., 1923, v. 4, p. 499.)

rocking curve. The graph or contour of the intensity variation of the x-ray reflection from a crystal with the angle of incidence in the neighborhood of a diffraction maximum. The amplitude of variation of the incidence angle is the *rocking angle.* (See Hoyt, *Phys. Rev.* 40, 477, 1932; Parratt, *Phys. Rev.* 41, 1, 1932.)

roentgen. The absolute unit of x-ray dosage, *viz.*, that obtained from the x-ray energy which, when the secondary electrons are fully utilized and secondary radiation from the wall is avoided, produces in 1 cm^3 of air at N.T.P. such a degree of conductivity that the quantity of electricity measured at saturation current is 1 e.s.u. Syn. *r unit.*

Roentgen rays. Syn. *x-rays.*

roentgenization. The discoloration which develops in some transparent substances, such as glass, after prolonged irradiation with x-rays. *Cf. solarization* (1).

roentgenmeter. An instrument of the ionization-chamber type for measuring the intensity of x-rays or gamma rays. *Cf. iontoquantimeter.*

roentgenology. That branch of science which deals with x-rays, esp. with their biological effects and uses, including applications to medical diagnosis and therapy. *Cf. radiology.*

Roget spiral. A helix of wire which contracts in length when a current is sent through it, because of the mutual attraction of the turns.

rotary field. A magnetic field, of which the direction of the magnetic-intensity vector rotates about an axis perpendicular to itself. Such fields are commonly produced by means of magnets excited by polyphase currents, *e.g.*, in induction motors.

rotary voltmeter. A type of electrostatic voltmeter for high voltages. (See Kirkpatrick and Miyake, *R.S.I.* 3, 1, 1932; Gunn, *Phys. Rev.* 40, 307, 1932.)

rotation. A motion of a body or a figure, in which all the particles or points move in circles about the same axis with the same angular velocity. *Cf. optical rotation.*

rotation axis. 1. *Cf. rotation.* 2. A line within the structure of a unit crystal cell, about which atoms are arranged in regular plane polygons centered upon the axis; so that only simple rotation would be required to bring any atom into coincidence with another in the same plane. (See Davey, Study of Crystal Structure and Its Applications, 1934, pp. 211 ff.)

rotation diagram. The photographic record of diffracted beams produced when a slender beam of homogeneous x-rays impinges upon a rotating single crystal. *Cf. Laue pattern, rotation spectrum* (2).

rotation spectrum. 1. *Cf. molecular spectrum.* 2. An x-ray spectrum or diffraction pattern, produced by a crystal which is rotated while an x-ray beam traverses it.

rotational analysis. 1. The analysis of a molecular rotation spectrum, *i.e.*, a setting forth of the constants relating to the series of lines constituting such a spectrum. *Cf. molecular spectrum.* 2. The analysis of the rotational fine structure of an atomic spectrum, due to nuclear spin. *Cf. rotational structure.*

rotational entropy. That part of the entropy of a body which is concerned with molecular rotation. *Cf. rotational specific heat.* (See Sutherland, *Proc. Camb. Phil. Soc.* 26, 402, 1930.)

rotational inertia. Syn. *moment of inertia.*

rotational quantum number. A quantum number which determines the total angular momentum of a molecule, exclusive of nuclear spin, and either inclusive or exclusive of electron spin (for which it is denoted, respectively, by J and K.) *Cf. J value, inner quantum number.*

rotational specific heat. That part of the specific heat of a substance which pertains to the energy of molecular rotation, as distinct from translational motion and internal vibration. *Cf. vibra-*

tional specific heat, rotational entropy. (See Sutherland, *Proc. Camb. Phil. Soc.* 26, 402, 1930.)

rotational state. One of the quantum states or energy levels of molecular rotation, changes in which are responsible for molecular rotation spectral lines. *Cf. molecular spectrum.*

rotational structure. 1. The fine structure of an atomic spectrum supposed to be due to the rotation of the nucleus in conformity with quantum conditions. 2. The structure of a molecular rotation spectrum. *Cf. rotational analysis.* (See Loomis, *Phys. Rev.* 38, 2153, 1931.)

rotational temperature. The temperature of an excited vapor as indicated by the radiation energy distribution in the rotational spectrum. This may be quite different from the temperature deduced from the translational energy distribution, *i.e.*, from the true temperature as usually defined.

rotator. 1. An optical apparatus, as a quartz plate cut perpendicular to the optic axis, which rotates the polarization plane of light traversing it. 2. In quantum theory: a point-mass endowed with uniform motion about a fixed center. 3. A mechanism for giving objects mounted upon it a motion of rotation.

rotatory dispersion. A type of optical dispersion arising from the fact that the polarization plane of polarized light of different wave lengths is rotated at different rates by optically active substances, so that the light emerges from such a substance with different colors polarized in different planes.

rotatory polarization. Syn. *optical rotation.*

rotatory power. The amount of optical rotation produced in a beam of polarized light by an optically active substance, per unit length of path, in degrees per millimeter or per centimeter. Divided by the density, it gives the *specific rotatory power. Molar* (or *atomic*) *rotatory power* is the specific rotatory power multiplied by the molecular (or atomic) weight. The Verdet constant is sometimes called *specific magnetic rotatory power.* (See I.C.T., 1926, v. 1, p. 11.)

Rowland circle. The circle upon which lie the slit, grating, and line images in a Rowland concave grating spectrograph. *Cf. Rowland mounting.*

Rowland law. *Cf. Bosanquet law.*

Rowland mounting. A mounting for concave gratings, in which the slit is at the vertex of a right-triangular frame and the grating and the eyepiece or camera are at opposite ends of the (movable) hypothenuse. *Cf. trammel, Rowland circle, Eagle mounting.*

Rowland ring. A sample of magnetic material, prepared in the form of a ring in order to test its magnetic properties by using it as the core of a transformer arrangement. (See Smythe and Michels, Advanced Elec. Meas., 1932, p. 95.)

ruling engine. A mechanism operated by a long micrometer screw, for ruling the equally spaced lines on optical gratings. Its

principle is similar to that of a dividing machine.

Rumpf (Ger., "trunk"). The very stable electron group which remains when a chemically active atom is ionized by the removal of its incomplete outer shell of electrons. Syn. *core* (5), *kernel* (2).

Runge denominator. The smallest integer r such that the positions of the lines in a Zeeman pattern are integral multiples of $1/r$, when the unit used is the Lorentz unit. *Cf. Zeeman effect, Lorentz triplet.*

Runge law. States that the wave number for the first line of the second (diffuse) subsidiary series of the line spectrum of an element is equal to the difference between that for the common limit of the two subsidiary series and that for the limit of the fundamental or Bergmann series. *Cf. Rydberg-Schuster law.* (See Gibbs, *Rev. Mod. Phys.* 4, 285, 1932.)

Runge rule. States that in the anomalous Zeeman effect the separation in frequency, or resolution, for a given line bears a simple commensurable ratio (2:3, 5:3, etc.) to the separation in the normal Zeeman effect. *Cf. Runge denominator.* (See White, Int. to Atomic Spectra, 1934, chap. 10; Allen, The Quantum and Its Interpretation, 1928, p. 211.)

running term. One of a series of progressively different terms appearing in the energy differences which determine a series of spectral lines. Each line of the series is determined by the difference between one fixed term and one of the successive values of the running term. *Cf. spectral series.* (See White, Int. to Atomic Spectra, 1934, p. 13.)

Rupert drop. A globule of glass which has been suddenly congealed by allowing the fused drop to fall into water, and in which there are residual stresses which will cause it to explode violently upon a slight shock.

rupture, modulus of. A kind of ultimate strength of a material, intermediate between the ultimate tensile and compressive strengths, which pertains to the breaking of a rod by flexure; defined as the product of the bending torque required to rupture by the distance of the extreme fiber from the neutral axis, divided by the sectional moment of inertia. Syn. *ultimate flexural strength.*

Russell-Saunders coupling. A condition in an atom in which the torques between spins and those between orbital angular momenta are much stronger than the torque between the resultant of all spins and the resultant of all orbital angular momenta. (See Bacher and Goudsmit, Atomic Energy States, 1932, p. 6.)

Rutherford-Bohr atom. The atom as conceived, by Bohr and Rutherford, to consist of a positive nucleus about which circulate a number of "orbital" electrons.

Rutherford scattering law. A (classical) expression for the effective cross section about the nucleus of an atom, which an alpha particle must enter in order to be scattered into a solid angle $d\omega$ at a deviation θ from the initial direction; *viz.*, $(EE'/2mv^2)^2 \csc^4 \frac{1}{2}\theta \cdot d\omega$, in which E and E' are

the charges (in electronic units) of the nucleus and the alpha particle and m is the mass and v the speed of the alpha particle. (See Mott, Outlines of Wave Mech., 1930, p. 23.)

Rydberg constant. The coefficient R in the Rydberg formula for wave numbers of spectral lines. Its theoretical value is

$$R = \frac{2\pi^2 me^4}{ch^3\left(1 + \frac{m}{M}\right)};$$

in which m and e are electronic mass and charge, M is the molecular mass, c is the electromagnetic constant, and h is the Planck constant. For hydrogen its value is 109677.76 cm^{-1}; for an infinite nuclear mass it would be 109737.42 cm^{-1}. *Cf.* note under *Rydberg fundamental frequency.* (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

Rydberg denominator. The denominator (2^2, 3^2, etc.) of a spectral term. *Cf. quantum defect.*

Rydberg formula. An approximate formula for the wave numbers of lines in hydrogen-like atomic spectral series, *viz.*,

$$\frac{1}{\lambda} = \frac{1}{\lambda_\infty} - \frac{R(z+1)^2}{(m+f)^2};$$

in which λ_∞ is the wave length for the series limit, R is (approximately) the Rydberg constant, z indicates the state of ionization (0 if not ionized, 1 if singly ionized, etc.), f is a fraction common to all the lines of the series, and $m = 2, 3, 4, \ldots$. *Cf. Ritz formula.* (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 181.)

Rydberg fundamental frequency. The frequency equivalent to the wave number expressed by the Rydberg constant R, therefore equal to cR, in which c is the speed of light. Its value for hydrogen is 3.2878×10^{15}/sec. (NOTE.—Some authors have called this quantity the *Rydberg constant.*)

Rydberg-Schuster law. States that the wave number for the first line of the principal series of the line spectrum of an element is equal to the difference between that for the limit of the principal series and that for the common limit of the two subsidiary series. *Cf. Runge law.* (See Gibbs, *Rev. Mod. Phys.* 4, 285, 1932.)

S

(Please note purpose of references as explained in preface.)

s-electron. An orbital electron for which the azimuthal quantum number is zero. *Cf. S-state.*

S-state, S-level. The state of an atom in which the azimuthal quantum number is zero. *Cf. P-, D-,* and *F-states.*

sabin. A unit of (acoustic) equivalent absorption, equal in its absorbing effect to 1 ft^2 of a completely absorbing surface. Named for W. C. Sabine. (See Acous. Soc. Comm. Rep., 1934.)

Sabine law. Expresses the reverberation time of a hall or auditorium, in seconds, as

$$T = \frac{0.164V}{aS},$$

in which V is the volume of the room in m^3, S the total area of its exposed surfaces in m^2, and a the mean acoustic absorptivity of those surfaces for vocal sounds.

saccharimeter. A form of polariscope for measuring the rotatory power of sugar solutions and similarly active liquids.

Sackur equation. An expression for the molar entropy of a perfect monatomic gas in terms of its volume v, its atomic weight w, and its absolute temperature T *viz.*,

$$s = R \log_e [vw^{3/2}T^{3/2}] + s_0,$$

in which R is the ideal gas constant. s_0 is the *Sackur-Tetrode constant*, the value of which is about -11.05 cal/mol deg. (See Lewis and Randall, Thermodynamics, 1923, p. 455; Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

sagittal ray. Any one of a narrow bundle of rays in a symmetrical optical instrument which lies in the longitudinal section of the bundle made by the plane containing the chief ray and perpendicular to the meridian section. *Cf. meridian ray.* (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 311.)

Saint Venant equation. An equation relating to the adiabatic flow of a fluid, the form of which is

$$\tfrac{1}{2}(V_2^2 - V_1^2) = \int_{p_2}^{p_1} v\,dp;$$

where p is pressure (in absolute units), v is specific volume, and V is speed of flow, corresponding to two points denoted by the subscripts 1 and 2. It is due to Saint Venant and Wantzel. (See *J. École Polyt.* 16, 92, 1839; Mills, Int. to Thermodynamics, 1910, p. 107.)

satellite. One of the fainter components of a multiplet spectral line. (See Richtmyer, *Phys. Rev.* 38, 1802, 1931.)

saturation. 1. The condition of a space in which the vapor pressure of some substance contained therein has reached the highest value possible at the existing temperature; or that of a solution when at maximum concentration for the existing temperature. 2. (*Magnetic.*) The condition of a magnetic substance whose magnetization has reached its highest possible value. 3. That attribute of a chromatic color which determines its degree of difference from an achromatic color of the same brilliance.

saturation current. The limit which the current through an ionized gas, the thermionic current, or the photoelectric current approaches with increasing voltage, *i.e.*, its value when the ions are carried off as fast as they are released.

Savart plate. A device consisting of two calcite plates of equal thickness, cut parallel to the natural cleavage faces and mounted with corresponding edges at right angles. Used to detect the presence of polarized light by means of interference fringes, on a principle first described by Brewster. (See Wright, *J.O.S.A.* 24, 206, 1934.)

scalar product. *In re* two vectors, P_1, P_2: the product of the magnitudes of the two vectors by the cosine of the angle between them. Syn. *dot product*, because of the use of a dot between the two

vector symbols to indicate it: $P_1 \cdot P_2$. *Cf. vector product.*

scale of eight. A vacuum tube circuit for counting pulses, in groups of eight, from ion or photon counters. (See Lewis, *Proc. Camb. Phil. Soc.* 30, 543, 1934; Shepherd and Haxby, *R.S.I.* 7, 425, 1936.)

scatter. To diffuse in various directions by reflection from molecules, atoms, electrons, or other particles; *e.g.*, radiation and corpuscular emissions are scattered upon encountering matter.

scattering angle. The angle between the original direction of an emission and its direction after scattering.

scattering coefficient. That part of the extinction coefficient which is due to scattering. It is defined in a manner similar to the absorption coefficient and is added with it to form the total attenuation or extinction coefficient. Distinction must be made between the *spatial scattering coefficient* (for a given scattering angle) and the *total* or *spherical* s.c. (including all angles). The *mass s.c.* is the s.c. divided by the density. (See Jauncey, Modern Phys., 1932, p. 228.)

scattering factor. 1. The ratio S of the actual intensity of x-rays scattered in any direction by electrons to that which would exist if, in accordance with the classical theory of J. J. Thomson, the electrons acted independently. Syn. *S-value.* (See Compton and Allison, X-Rays in Theory and Experiment, 1935, p. 133.) 2. *Cf. atom form factor* (1).

scattering power. The ratio of the total energy of scattered radiation per unit length of path in a scattering medium to the energy of the incident beam. (See Armstrong, *Phys. Rev.* 34(2), 931, 1929; Wyckoff, *Phys. Rev.* 36, 1116, 1930.)

Schottky effect. 1. The dependence of the saturation current in a thermionic vacuum tube upon the electric intensity E at the cathode; expressed by

$$I_s = \frac{1.91}{T}\sqrt{E},$$

in which T is the absolute temperature of the cathode. 2. Syn. *shot effect.*

Schroedinger equation. A wave equation set up by Schroedinger to represent the deBroglie wave. It contains the wave function ψ in the form

$$\nabla^2\psi + \frac{8\pi^2 m}{h^2}(W - V)\psi = 0,$$

in which m is the particle mass, W the total energy, V the potential energy, and h the Planck constant. (See Debye, Polar Molecules, 1929, p. 140; Debye, Interference of Electrons, 1931, p. 35.)

Schüler tube. A vacuum tube having a hollow cathode, used for the production of ionized gas or vapor spectra.

Schumann plate. A type of photographic plate, containing very little gelatin, prepared by V. Schumann, and especially adapted to use in the extreme ultraviolet and in positive-ray analysis.

Schumann region. A range of very short ultraviolet wave lengths, extending down to about 1200 Å.

scintillation. A minute flash of light observed when an alpha particle strikes a suitable luminescent screen in the dark.

sclerometer. An apparatus for measuring the hardness of a substance by the rebound of a hammer falling upon it from a given height. Syn. *scleroscope. Cf. Brinell hardness.* (See Smiths. P. T., 1929, p. 74.)

screen-grid tube. A form of amplifier vacuum tube in which the plate is surrounded by a positively charged wire mesh, in order to prevent variations of plate potential from affecting the grid-filament circuit and thus causing feedback.

screening. 1. The effect of the inner orbital electrons of an atom upon the attraction of the nucleus for the outer electrons. *Cf. screening constant.* 2. The effect of the outer layers of atoms in a crystal upon radiation or upon fields of force reaching the inner layers. 3. The effect of a conducting shell upon an electric field, or of an iron shell on a magnetic field.

screening constant, s. number. A coefficient, such that if the electronic charge be multiplied by it, the product represents the apparent amount of reduction in the charge of the nucleus of an atom (as indicated by its effect on outer electrons), due to the screening effect of an inner electron group. With respect to corresponding x-ray spectrum lines, this coefficient is nearly the same for all elements of high atomic number.

secondary bow. A faint rainbow which sometimes appears outside the brighter primary bow and has its colors in the reverse order.

secondary cell. Syn. *storage cell. Cf. primary cell.*

secondary circuit. The circuit in which an e.m.f. is induced by the variation of the current in another circuit, the *primary*, as in a transformer.

secondary electron. 1. An electron belonging to a secondary emission, as those emitted in various directions by substances bombarded by cathode rays. 2. That electron which, after a collision of two electrons, has the less energy. *Cf. primary electron.* (See Farnsworth, *Phys. Rev.* 31(2), 419, 1928; Neher, *Phys. Rev.* 38, 1321, 1931.)

secondary emission. An emission from matter which results from exposure to a primary emission; *e.g.*, fluorescence or photoelectrons. If it is in the nature of radiation, it is usually called *secondary radiation.*

secondary spectrum. 1. The spectrum of the hydrogen molecule as distinct from that of the atom. 2. A spectrum overlapping from another order. (Rare or obs. in this sense.)

secondary standard. 1. A unit defined as a specified multiple or submultiple of a primary standard; *e.g.*, the centimeter and the foot, based, respectively, upon the standard meter and the standard yard. 2. Syn. *prototype.*

secondary structure. A regularly recurring variation which may exist in the atomic lattice arrangement or *primary structure* of a crystal by reason of electric or

other stresses inherent in its physical make-up and which is manifested as a distortion of the lattice and a variation of the lattice "constant" from point to point. (See Davey, Study of Crystal Structure and Its Applications, 1934, pp. 382 ff.)

section modulus. The product of the sectional moment of inertia of the cross section of a beam or rod by the distance from the neutral axis to the most distant point of the section.

sectional moment of inertia. The areal moment of inertia of the cross section of an elastic beam or column with respect to the neutral axis; a constant which appears in formulas for the flexure of such members.

sedimentation potential. A p.d. set up by the falling of a particle through a liquid. Syn. *Dorn effect.*

Seebeck effect. Syn. *thermoelectromotive force.*

seismograph. An apparatus for recording the time, the direction, and the intensity of seismic disturbances (earth tremors).

selectance. Any one of several measures for the falling off of the response of a resonance device with departure from resonance; *e.g.*, the ratio of the amplitude of response at resonant frequency to that at some frequency differing from it by a specified amount. (See I.R.E. Comm. Rep., 1933.)

selection principle. An empirical rule, which governs the electron transitions actually occurring within an atom, as distinguished from those which might be expected, but apparently do not occur. *Cf. forbidden.*

selective. 1. Operating on a group of individuals, in different degrees depending upon some variable attribute of the members of the group. *E.g.*, a selective reflector reflects a larger proportion of some wave lengths than of others. 2. *In re* an emitter of radiation: yielding radiation of different spectral energy distribution from that of a black body at the same temperature.

selectivity. The degree in which any operation is selective, expressed in suitable measure, *e.g.*, selectance, spectral resolving power, etc.

selenium cell. An arrangement in which is suitably mounted a thin film of selenium provided with electric terminals, for utilizing the photoconductive property of that element.

self-capacitance. Distributed capacitance of an electric circuit due to its containing closely wound coils of insulated wire, the adjacent turns of which have a condenser effect. *Cf. proximity effect.*

self-consistent field. The central field used by Hartree in the calculation of atomic wave functions. (See Hartree, *Proc. Camb. Phil. Soc.* 24, pp. 89, 111, and 426, 1928; Mott and Massey, Theory of Atomic Collisions, 1933, p. 123.)

self-induction. An e.m.f. induced in a circuit, due to the change in the magnetic flux linked with it as a result of the variation of current in the circuit itself. *Cf. inductance.*

Sellmeier dispersion formula. An approximate formula for the refractive index n of a substance in terms of the wave length λ:

$$n = 1 + \frac{A\lambda^2}{\lambda^2 - \lambda_1^2} + \frac{B\lambda^2}{\lambda^2 - \lambda_2^2} + \cdots$$

A, B, . . . are constants and λ_1, λ_2, . . . are wave lengths of absorption lines, all characteristic of the substance. First stated by Sellmeier and later in modified form by Ketteler and Helmholtz. *Cf. Cauchy dispersion formula.* (See Wood, Phys. Optics, 1929, p. 376.)

semipermeable membrane. A membrane through which osmosis can take place, but which prevents the free mixing of the fluids.

sensitiveness. 1. A term applied to various measuring instruments, defined as the change in reading per unit of measured quantity. Syn. *sensibility, sensitivity. Cf. stability* (2). 2. (Phot.) The rate of chemical response of a photographic plate or film to light or other actinic emission. *Cf. speed* (2).

sensitized fluorescence. A "second-hand" fluorescence, *viz.*, the emission of radiation by one atom due to energy received in collision with another atom which has been excited by radiation. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 499.)

separation factor. *Cf. interval rule.*

series. An arrangement of electrical conductors, generators, condensers, etc. in succession, without any branching, so that each carries the whole conduction or displacement current. *Cf. radioactive series, spectral series.*

series limit. The convergence frequency of a series of spectral lines. No line occurs at this point, but a related continuous spectrum may begin just beyond it.

series-wound. *In re* a field magnet: having its winding in series with the external or line circuit.

shade. A chromatic color of relatively low saturation and relatively low brilliance.

sharp series. One of several spectral series in the characteristic spectrum of an element; so called because of the small half-widths of the lines. Sometimes called *second subordinate series.*

shatter oscillation. An oscillation in a liquid of such frequency and amplitude as to break the continuity of the liquid. (See Kennard, *Phys. Rev.* 35(2), 428, 1930.)

shear. A type of strain in which adjacent laminar elements have a progressive relative displacement; so that a cube is skewed into a rhombic prism, etc. Its measure is the amount of relative displacement per unit thickness perpendicular to the direction of the displacement; or, the tangent of the angle of shear.

shear, angle of. The angle through which any plane, originally perpendicular to the displacement laminae, is skewed in the process of shear, and whose tangent is the measure of the shear.

shear modulus. The ratio of the shearing stress in an elastic substance to the strain (shear) which accompanies it. Syn. *rigidity modulus.*

shear, rate of. The derivative of the speed of flow of a fluid with

respect to distance measured at right angles to the relatively moving layers. *Cf. viscosity coefficient.*

shearing stress. The stress which accompanies shear in an elastic body; measured by the tangential force per unit area parallel to the relatively displaced laminar elements.

sheath. A part of an electric discharge in a rarefied gas, in which there is a space charge because of the great predominance of particles of one sign over those of the other. *Cf. plasma.* (See Darrow, Electrical Phenomena in Gases, 1932, p. 330.)

shell. 1. (*Electronic.*) A group of electrons, supposed to form part of the outer structure of an atom, and having a common energy level. *Cf. subshell.* 2. (*Magnetic.*) A lamina of magnetic material in which the lines of induction are in the direction of its thickness. Its *strength* is the magnetic moment per unit area.

Shenstone effect. An increase in the photoelectric emission of certain metals immediately after having been traversed by an electric current. (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 500.)

shot effect (Ger., *Schroteffekt*). A statistical irregularity in the emission of thermions or photoelectrons, which, upon amplification, may be detected by a popping noise in a telephone receiver. First explained by Schottky. Syn. *Schottky effect* (2). (See Kingsbury, *Phys. Rev.* 38, 1458, 1931.)

shower (cosmic-ray). The production of from two to several associated ion pairs at the same instant, apparently due to cosmic rays. *Cf. burst.* (See Johnson, *Phys. Rev.* 45, 581, 1934; Compton, *Phys. Rev.* 50, 1119, 1936.)

shunt. A branch of an electric circuit in parallel with other parts of the same.

shunt-wound. *In re* a field magnet: having its winding in parallel with the external or line circuit.

side band. A component of a modulated carrier current (or carrier wave) which comprises frequencies either above or below the carrier frequency, including those current (or wave) components whose frequencies are the sum or the difference of the carrier and the modulation frequencies; called the *upper* and the *lower side band*, respectively.

sigma value. The value of the quantum number which quantizes the component of angular momentum of spin about the axis of figure in a diatomic molecule. *Cf. lambda value, omega value.* (See Mulliken, *Rev. Mod. Phys.* 2, 60, 1930.)

silica pencil. A rod of silica, electrically heated and used as a source of infrared. (See Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 110.)

similitude. 1. A principle, set forth by R. C. Tolman, which he states as follows (*Phys. Rev.* 3(2), 244, 1914): "The fundamental entities out of which the physical universe is constructed are of such a nature that from them a miniature universe could be constructed

exactly similar in every respect to the present universe." 2. A term used in connection with physical quantities having the same dimensional structure; *e.g.*, in the expression $\sqrt{R^2 + 4\pi^2 n^2 L^2}$ for the impedance of an inductive circuit, the two terms under the radical have dimensional similitude. (See Bridgman, Dimensional Analysis, 1922, p. 10.)

sine condition. A condition, stated by Abbe, which is fulfilled by any aplanatic optical system. If n_1 and n_2 are the refractive indices of the media in which the object and the image lie, if α_1 and α_2 are the angles made with the axis by any ray as it leaves the object and as it reaches the image, and if y_1 and y_2 are corresponding linear dimensions of object and image, the condition is expressed by

$$\frac{\sin \alpha_1}{\sin \alpha_2} = \frac{n_2 y_2}{n_1 y_1}.$$

sine galvanometer. An instrument resembling a tangent galvanometer, but in which the coil is turned until it lies in the plane of the deflected needle. The sine of the deflection is then proportional to the current.

singing arc. An electric arc of such characteristics as to generate an oscillating current of audio frequency when an inductance and a condenser are connected across it; *e.g.*, the Duddell carbon arc or the Poulsen carbon-copper arc. Syn. *oscillating arc.*

singing tube. A pipe or resonator set into musical vibration by local heating. Special forms have been devised by Bosscha, Knipp, Rijke, and others. (See Wood, Textbook of Sound, 1930, p. 202.)

single-phase. Utilizing a single a.c., as a single-phase motor. *Cf. polyphase.*

singular point (or line). 1. A point (or line) in a field of force, at which (or along which) the field intensity or the potential gradient is zero. (See Attwood, Electric and Magnetic Fields, 1932, p. 27.)

singular temperature. A temperature at which some property of a substance becomes discontinuous, *e.g.*, a transition temperature at which the specific heat has a discontinuity. (See Planck, Treatise on Thermodynamics, 1927, p. 39.)

sinusoidal. Varying in proportion to the sine (or the cosine) of an angle or of a time function.

siren. An acoustic instrument consisting of a revolving disk perforated with equally spaced holes, through which blasts of air escaping in rapid succession produce a musical tone.

skiascope. An instrument for studying the optical refraction within the eye. (See Southall, *J.O.S.A.* 13, 245, 1926.)

skin effect. A concentration of current density toward the surface of an a.-c. conductor, due to self-induced counter e.m.f., and resulting in an increase in effective resistance. The phenomenon is especially noticeable at higher frequencies. (See Page and Adams, Prin. of Electricity, 1931, p. 596; Attwood, Electric and Magnetic Fields, 1932, p. 194.)

slide-wire bridge. A bridge circuit, one or more branches of which

are controlled by a sliding contact whose position can be adjusted along a wire stretched upon a linear scale.

slip. The excess of the angular speed of the rotating field of an induction motor over that of the rotor, expressed either in rpm or as a fraction or percentage of the field speed. (See A.I.E.E. Comm. Rep., 1932.)

slip coefficient. A quantity connected with the slipping of a fluid at the surface of a capillary tube; defined as the ratio of the speed of slip to the transverse velocity gradient in the fluid. It is equal to the viscosity coefficient divided by the friction coefficient at the surface. (See Loeb, Kinetic Theory of Gases, 1927, p. 245.)

slip surface. A surface (often approximately plane) along which a solid under severe stress tends to crack or shear. The traces of such surfaces at an external face of the specimen are *slip lines*. *Cf. cone of rupture.* (See Nádai, Plasticity, 1921, pp. 38, 90.)

slug. A name proposed for a unit of mass in the British gravitational system; defined as the mass of a free body which, if acted upon by a force of 1 lb, would experience an acceleration of 1 ft/sec^2. Its value is thus about 32.17 lb. (See Brand, Vectorial Mech., 1930, p. 342.)

smectic. Syn. *mesomorphic.*

Smith-Helmholtz formula. An invariant relation concerning the imagery produced by paraxial rays in a centered system of spherical refracting surfaces. If θ_1, θ_2, θ_3, etc., denote the angles which a ray makes with the axis in the successive media of indices n_1, n_2, n_3, etc., and if the magnification ratios at the points where the ray crosses the axis are $y_2:y_1$, $y_3:y_1$, etc., then

$$n_1y_1\theta_1 = n_2y_2\theta_2 = n_3y_3\theta_3 = \cdots .$$

(See Southall, Mirrors, Prisms, and Lenses, 1923, p. 202.)

Snell law. The law of ordinary refraction of light, which states that the angles of incidence and of refraction have sines in a constant ratio to each other, and lie in the same plane. The constant ratio of the sines is equal to the refractive index.

sol. A highly disperse colloid (Graham).

solar constant. The total intensity of the solar radiation at the outer limit of the atmosphere, hence unaffected by atmospheric absorption. Its value is about 0.032 cal/cm^2 sec or 1.34×10^6 ergs/cm^2 sec. (See Abbot, The Sun, 1929, p. 298.)

solarimeter. A pyrheliometer devised by L. Gorczyński for direct readings of solar radiation intensity from sun and sky. (Gorczyński, *Monthly Weather Review* 54, 381, 1926 and *J.O.S.A.* 14, 149, 1927.)

solarization. 1. An actinic effect of sunlight or of artificial ultraviolet upon glass, which results in a reduction of its transparency to ultraviolet and is also usually accompanied by a permanent coloration. *Cf. roentgenization.* 2. A reversal of gradation sequence in a dense photographic image sometimes observed when the normal development is applied after overexposure. Still greater

exposure may restore the original sequence, or may even result in a second reversal.

Soleil plate. A type of optical compensator, somewhat like that of Babinet, but so constructed as to introduce the same relative phase change over the entire field at once, instead of varying it progressively across the field.

solenoid. A helix or cylindrical coil of wire, used to produce a magnetic field or to excite an electromagnet.

solenoidal. 1. *In re* a vector: having a divergence equal to zero, *e.g.*, the intensity of a Newtonian-force field in a vacuum. 2. In the form of a solenoid.

solid angle. A portion of the whole of space about a given point, bounded by a conical surface with vertex at that point and measured by the area cut by the bounding surface from the surface of a sphere of unit radius centered at that point. *Cf. spheradian.*

solid solution. A mixture having the intimacy of a true molecular solution, but in the solid state, *e.g.*, an alloy, also certain mixcrystals.

solubility. The equilibrium concentration of a solute in saturated solution.

solution. A mixture of substances whose intimacy is of molecular order and the proportion of whose ingredients (concentration) is subject to continuous variation over a certain range. *Cf. colloidal solution, solid s.*

solution pressure. 1. The osmotic pressure of a solution of a substance in equilibrium with its solid phase. 2. (*Electrolytic.*) The electrolytic influence which, according to Nernst's hypothesis, urges positive metallic ions to break away from the metal and enter the solution with which it is in contact. (See Taylor, Treatise on Phys. Chem., 2d ed., p. 834.)

Sommerfeld constant. A dimensionless constant, equal to $2\pi e^2/hc$; in which e is the elementary charge in e.s.u., h the Planck constant, and c the electromagnetic constant. Its value is about 0.007284. (See Haas, *Phys. Rev.* 49, 636, 1936.)

sonometer. An acoustic instrument consisting of one or more strings stretched on a resonating box; used for making measurements of musical pitch and for other acoustic experiments. Syn. *monochord*, esp. if only one string.

Soret effect. An inequality of concentration which develops in different parts of a solution, initially homogeneous, when these parts assume different temperatures; the cooler portions becoming more concentrated than the warmer. (See Jones, Nature of Solution, 1917, p. 75.)

sorption. A term including both (molecular) absorption and adsorption.

sound energy flux. The average rate of flow of sound energy through any specified area, taken over a complete period. (See Acous. Soc. Comm. Rep., 1934.)

sound intensity. The sound energy flux per unit area of a plane or spherical sound wave front. (See Acous. Soc. Comm. Rep., 1934.)

sounding balloon. A free, unmanned balloon designed to carry instruments such as thermographs, barographs, etc., into the upper atmosphere, for the purpose of obtaining meteorological or physical data. *Cf. pilot balloon.*

space charge. A charge of electricity distributed more or less continuously throughout a volume; as in any part of the electron stream in a thermionic vacuum tube or in a photoelectric cell.

space-charge equation. An equation which expresses the space-charge-limited current between a plane cathode and a parallel plane anode in a gas:

$$I = \frac{\sqrt{2}}{9\pi}\sqrt{\frac{e}{m}}\frac{V^{3/2}}{x^2};$$

in which e and m are the electronic charge and mass, V is the voltage, and x the distance between electrodes. A similar but more complex equation holds for a cylindrical cathode inside a cylindrical anode. (See Child, *Phys. Rev.* 32(1), 498, 1911; Langmuir, *Phys. Rev.* 2(2), 450, 1913.)

space function. A quantity connected with a region of space in such a way that its value depends upon the extent and the boundaries of that region. The "space" referred to may be of any number of dimensions. The element of such a function, used in integration, is equal to the element of space multiplied by some function of the co-ordinates of the space element. *E.g.*, an element of mass is equal to the density of the substance (which may vary from point to point) multiplied by the element of volume.

space group. A group of points in space which has one of the types of symmetry exhibited by crystals. (*See* Davey, Study of Crystal Structure and Its Applications, 1934, chap. 8.)

space quantization. Syn. *directional quantization.*

space-time. A four-dimensional continuum in which the four variable co-ordinates are the three ordinary space co-ordinates (as x, y, z) and the time t. The last may be expressed with an imaginary coefficient in order to make the resulting mathematical expressions closer in form to those of ordinary geometry. A concept due to Minkowski; *cf. Minkowski world.* (See Eddington, Space, Time, and Gravitation, 1920, p. 45.)

spark lag. A time interval between the attainment of the sparking voltage and the passage of a spark. (See Darrow, Electrical Phenomena in Gases, 1932, p. 290.)

spark spectrum. The spectrum of a substance produced with light from a spark between terminals composed of that substance, or in an atmosphere of that substance.

spatial distribution. A definite arrangement of particles or points in any type of space, usually specified by means of equations which express the number located in any element of space in terms of the co-ordinates of the element. *Cf. volume distribution, numerical density.*

specific charge. Syn. *charge-mass ratio.*

specific cohesion. A term used, in connection with Laplace's theory

of surface tension, to denote twice the ratio of the surface tension to the density of a liquid. (See Willows and Hatschek, Surface Tension and Surface Energy, 1923, pp. 8, 41.)

specific energy. The internal energy per unit mass of a body. (See Planck, Treatise on Thermodynamics, 1927, p. 163.)

specific entropy. The entropy per unit mass of a body. (See Planck, Treatise on Thermodynamics, 1927, p. 125.)

specific gravity. The ratio of the density of any substance to the maximum density of water.

specific-gravity bottle. A small flask with a perforated stopper, which may be filled completely full of a liquid for the purpose of obtaining its density and specific gravity by weighing. *Cf. pycnometer.*

specific heat. 1. The thermal capacity per unit mass of a substance; usually expressed in cal/g°C. 2. The abstract ratio of the therma[1] capacity of any mass of a substance to that of an equal mass of water at 15°C. *Cf. rotational s. h., vibrational s. h.*

specific inductive capacity. 1. The ratio of the dielectric constant of a substance to that of a vacuum. 2. The ratio of the capacitance of a condenser filled with a given dielectric to that of the same condenser when evacuated. (Equivalent to (1).) Syn. *dielectric constant* (3). (See I.C.T., 1926, v. 1, p. 41.)

specific ionization. Syn. *ionization coefficient.*

specific magnetic rotatory power. Syn. *Verdet constant.*

specific magnetization. *Cf. magnetization* (1).

specific refractive power. *Cf. Lorenz-Lorentz relation.* Syn. *specific refraction.* (Not to be confused with *specific refractivity.*)

specific refractivity. The refractivity divided by the density. *Cf. Gladstone-Dale law.* (Not to be confused with *specific refractive power* or *s. refraction.*)

specific rotatory power. *Cf. rotatory power.*

specific susceptibility. *Cf. susceptibility* (1).

specific viscosity. The ratio of the viscosity coefficient of a fluid to that of some standard substance, usually water at a specified temperature. (See Smiths. P. T., 1929, p. 205.)

specific volume. The volume of a substance per unit mass; the reciprocal of the density.

specific weight. The weight of a substance per unit volume; in absolute units equal to the density multiplied by gravity.

spectral centroid. The wave length which corresponds to the center of area of the wave-length-intensity (spectrophotometric) curve for light of a given quality. (See Gibson, *J.O.S.A.* 11, 473, 1925.)

spectral color. The color sensation produced by a narrow frequency range of stimulating radiation, *i.e.*, by monochromatic light. (A similar sensation may, however, be produced in other ways; the eye being unable to make the distinction.)

spectral energy distribution. The distribution of the intensity of radiation throughout the spec-

trum, *i.e.*, of the monochromatic flux density as a function of the wave length or frequency. Such distributions are commonly represented by graphs, *viz.*, by *spectral energy curves*. *Cf. spectroradiometer, spectrophotometer.*

spectral selectivity. The variation of some property of a substance or a surface with the wave length or frequency of incident radiation. *Cf. selectivity.*

spectral sensitivity. Syn. *photoelectric yield.* (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 39.)

spectral series. A series of frequencies occurring in a characteristic radiation or absorption spectrum, which converge, or appear at progressively shorter intervals, in the direction of decreasing wave length and in accordance with a definite numerical law. *E.g., cf. Balmer series.* In general, the spectrum of an element may have several series, designated as *principal, first subordinate* or *diffuse, second subordinate* or *sharp, fundamental* or *Bergmann*, etc. *Cf. spectral terms.*

spectral terms. The fractions occurring in the binomials which are proportional to the frequencies or wave numbers of a spectral series. *E.g., cf. Balmer series.*

spectrobolometer. An infrared spectrometer utilizing a bolometer as the receiving instrument.

spectrocomparator. A comparator designed especially for the measurement of line spectra. (See Stanley, *J.O.S.A.* 16, 208, 1928.)

spectrograph. A spectroscope which records a spectrum photographically. *Cf. mass spectrograph.*

spectrohelioscope. An instrument for observing an image of the entire sun by light of one wave length. If used photographically, it is called a *spectroheliograph.* (See Hale, *Astrophys. J.* 70, 265, 1929.)

spectrometer. A spectroscope provided with a graduated circle or other equipment for measuring the deviations, and, indirectly, the wave lengths, corresponding to spectral lines. *Cf. x-ray spectrometer.*

spectrophotoelectric. Pertaining to the dependence of photoelectric or photovoltaic phenomena upon the wave length of the incident radiation. (See Geiger, *Phys. Rev.* 22(2), 461, 1923.)

spectrophotometer. A combination of a photometer and a monochromator, used for making spectroradiometric measurements in the visible. *Cf. spectroradiometer.* (See Walsh, Photometry, 1926, p. 276.)

spectrophotometric analysis. A quantitative analysis based upon the spectral energy distribution in the absorption spectrum of a substance in solution. (See Peters and Phelps, *B.S.J.R.* 2, 335, 1929.)

spectropyrheliometer. An instrument used for the determination of the spectral distribution of the total solar radiation. *Cf. pyrheliometer.* (See Coblentz, *B.B.S.* 16, 233, 1920.)

spectroradiometer. 1. An instrument for ascertaining the spectral energy distribution of any type of

radiation, *e.g.*, a spectrophotometer, but esp. in the infrared. 2. An infrared spectrometer. (See Coblentz, *J.O.S.A.* 7, 439, 1923.) 3. An apparatus of the wavemeter type arranged to analyze the wave-length-intensity characteristic of the output from a radio transmitter. (See Snow, *B.B.S.* 19, 231, 1923.)

spectroscope. Any one of various forms of instrument for dispersing radiation and observing the resulting spectrum.

spectrothermograph. A spectrograph for the study of thermal radiation. (See Ellis, *J.O.S.A.* 11, 647, 1925.)

spectrum. The result of separating or dispersing an emission (such as light) and arranging it in accordance with some progressive property (as its frequency), which thus constitutes a systematic analysis. *Cf. emission spectrum, absorption s., band s., magnetic s.*, etc.

spectrum analysis. The analysis of chemical substances by means of their spectra.

spectrum line. 1. A definite wave length or very narrow range of wave lengths; the spectrum of monochromatic radiation. It corresponds to a distinct image of the spectroscope slit made by the single wave length. 2. One of the traces made by a mass spectrograph, which correspond to atoms of different mass.

specular reflection. Syn. *regular reflection.*

speculum metal. An alloy of tin and copper, (about 33 per cent Sn), capable of taking a very high polish; used for optical mirrors and especially for reflecting gratings.

speed. 1. The scalar time rate at which distance is covered by a moving point or body, without reference to direction. *Cf. velocity, angular speed.* 2. (Phot.) A value used to specify the sensitiveness of a photographic material to light, and computed according to any one of several methods. 3. (Of an objective.) A quantity determining the shortness of exposure adequate for taking a photograph under given conditions. Its most appropriate measure is the inverse square of the relative aperture or *F*-number.

spheradian. The unit solid angle, which cuts unit area from the surface of a sphere of unit radius centered at its vertex. Syn. *steradian.* (See I.C.T., 1926, v. 1, p. 41.)

sphere gap. A spark gap between two spherical knobs of equal diameter. From the width of the gap and the diameter of the knobs, it is possible to calculate the approximate spark potential; hence the gap may be used as a simple voltmeter for high potentials.

sphere of exclusion. The spherical surface drawn about any molecule, from which the center of any other molecule is excluded. (See Loeb, Kinetic Theory of Gases, 2d ed., pp. 43, 149, 175.)

sphere of influence. The region surrounding a gas molecule, within which its van der Waals force of attraction exerts an appreciable effect upon other molecules.

sphere photometer. An integrating photometer in which the source

of light is placed inside a spherical cavity with white walls, the light from which, reflected through a suitably placed opening, is used in the measurement of the mean spherical candle power of the source. *Cf. Sumptner principle, Ulbricht sphere, cube photometer.* (See Walsh, Photometry, 1926, pp. 219 ff.)

spheroidal state. A term applied to the condition of a liquid in apparent contact with a hot solid, but with a layer of the liquid's vapor between; *e.g.*, a drop of water on a hot plate.

spherometer. One of several types of instrument for measuring the curvature of spherical surfaces, *e.g.*, of lens surfaces.

spin coupling. The interaction between the fields due to the spins of electrons. The energy differences between singlets and triplets are associated with differences in resultant spins. The term is also occasionally used for the interaction of the resultant electron spin with the resultant orbital angular momentum. Syn. *spin-spin interaction.*

spin moment. The rotational moment of momentum of an electron on its own axis. (See Bacher and Goudsmit, Atomic Energy States, 1932, p. 6.)

spin quantum number. The quantum number associated with the quantization of the angular momentum arising from the internal spin of the electrons. For a system containing a single electron, its value is ½; in general, it is an odd or even multiple of ½ according as the number of electrons is odd or even. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 297.)

spinor. A two-dimensional, complex vector; so named because it may be used to define the spin of an electron. (See Wolfe, *Phys. Rev.* 41, 443, 1932.)

spinthariscope. An instrument devised by Crookes for conveniently viewing the scintillations of alpha particles upon a luminescent screen.

spreading coefficient. The absolute value of the change in free energy which takes place when one liquid spreads on the surface of another, *e.g.*, a drop of oil on water. (See Taylor, Treatise on Phys. Chem., 2d ed., p. 1642.)

Sprengel pump. A type of mercury air pump, dependent upon the dropping of mercury down a tube. *Cf. jet pump.*

sputter, splutter. To apply, as a metal, to a surface exposed to the material particles from a disintegrating cathode. (*Splutter* is used by English writers.) *Cf. cathodic disintegration.* (See Fruth, *Bell Syst. Tech. J.* 11, 283, 1932.)

squared scale. A linear scale so graduated and numbered as to indicate the square of the distance from the zero point; used on some photometer benches.

stability. 1. That property of the stable equilibrium of a body or a system, which is measured by the amount of energy which must be applied to render it unstable. *Cf. equilibrium, kinetic stability.* 2. The reciprocal of the sensitiveness of an instrument such as a balance.

stalagmometer. An instrument for measuring the size of liquid drops, or for measuring the liquid by drops; esp. in the study of surface tension. Syn. *stactometer.*

standing wave. Syn. *stationary wave.*

Stark effect. A somewhat complicated effect upon the spectral series of gaseous elements, produced by subjecting the radiating atoms to a strong, transverse electric field (*e.g.*, 100,000 v/cm); discovered in the case of hydrogen by J. Stark in 1913. Each spectral line becomes split up into polarized components. (See Pauling and Goudsmit, Structure of line Spectra, 1930, pp. 78 ff.; Foster and Douglas, *Phys. Rev.* 44, 325, 1933.)

Stark-Lunelund effect. The polarization of light emitted by a beam of moving atoms in the absence of a field. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 711.)

static. 1. (adj.) Pertaining to the phenomena and laws of statics. *Cf.* terms following. 2. (n.) Radio disturbance due to natural causes, of whatever origin. *Cf. atmospheric* (2).

static atom. Syn. *Lewis-Langmuir atom.*

static electricity. Electricity in the form of a charge in equilibrium, or considered irrespective of the effects of its motion. *Cf. electrostatic.*

static equilibrium. Equilibrium in which all parts of the system are relatively at rest. *Cf. kinetic equilibrium, isostatic.*

static hysteresis. A type of permanent deformation or elastic lag in a stressed solid, which is independent of the rate of loading. (See Keulegan, *B.S.J.R.* 8, 635, 1932.)

static length. The length of a body in the classical or Newtonian sense, *i.e.*, not affected by the Lorentz-Fitzgerald contraction. *Cf. rest mass.*

static machine. A machine for generating electric charges, usually by electric induction. Syn. *electrostatic machine, induction m. Cf. Toepler-Holtz machine, Wimshurst m., electrostatic generator.*

statics. That branch of dynamics which deals with bodies at rest relative to some given frame of reference and with the interaction of forces between them.

stationary beats. *Cf. dissonance* (2).

stationary line. An absorption line in the spectrum of a star which does not exhibit the Doppler shift observed in the other lines, and is attributed to the existence of absorbing gas in interstellar space. Syn. *interstellar line.*

stationary wave. A condition of equilibrium at certain points or along certain lines or surfaces (nodes) in a medium, with regions of vibration between them; brought about by the interference of similar wave trains traveling in opposite directions. Syn. *standing wave.*

statistical equilibrium. That state of a statistical variable in which all variations are due to a distribution of chance causes. *E.g.*, the molecular velocities in a gas at constant volume and tempera-

ture are in a state of statistical equilibrium, which is altered to another such state when the volume is changed.

statistical mechanics. That branch of physical science in which the laws describing the gross behavior of systems composed of many particles (*e.g.*, molecules) are investigated by statistical methods. (See Tolman, Statistical Mech., 1927, p. 17.)

statistical variable. A variable whose observable magnitude is subject to chance, *i.e.*, is under incomplete control; *e.g.*, accidental error, the range of individual alpha particles in air, etc.

statistical weight. An integer corresponding to the number of different levels into which a given state is subdivided when the degeneracy is completely removed. *Cf. degenerate system* (2). Syn. *quantum weight.* (See Pauling and Goudsmit, Structure of Line Spectra, 1930, p. 77.)

statoscope. A very sensitive aneroid altimeter. (See *U. S. Weather Bureau Circular* M.)

steady flow. A condition of flow such that the velocity of the fluid at any fixed point in the space occupied by the flow remains unchanged; though the velocity of any given particle of the fluid may be continually changing. *Cf. uniform flow.*

steam calorimeter. A calorimeter in which a known quantity of heat is imparted by the condensation of a known mass of steam. Developed by Joly.

steam-engine indicator. An instrument which, connected with the cylinder of a steam engine, automatically draws a trace of the volume-pressure cycle. *Cf. thermodynamic cycle, indicator diagram.*

steam table. A table giving certain properties of steam as functions of the temperature or the pressure; including usually the density, specific volume, heat of vaporization, etc. (See Callendar, Steam Tables.)

Stefan-Boltzmann constant. The constant of proportionality in the Stefan-Boltzmann law for the emissive power of a black body. Its experimental value is 5.735×10^{-5} erg cm^{-2} sec^{-1} deg^{-4}. (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

Stefan-Boltzmann law. States that the total emissive power of a black body is proportional to the fourth power of its absolute temperature. First arrived at empirically by Stefan and later deduced theoretically by Boltzmann. *Cf. Stefan-Boltzmann constant.*

Steinmetz coefficient. *Cf. Steinmetz formula.* Numerical values of the coefficient are based upon the measurement of the hysteresis loss in ergs per cubic centimeter per cycle and the maximum induction in gausses.

Steinmetz formula. An empirical formula for the magnetic hysteresis loss of energy per unit volume per cycle, *viz.*,

$$w = aB_m^{1.6};$$

in which B_m is the maximum induction during the cycle, and a a constant known as the *Steinmetz coefficient* (*q. v.*), *hysteretic constant,* or *hysteresis-loss constant.* Valid in the range of a.-c. power

transformers. (See Page and Adams, Prin. of Electricity, 1931, p. 412.)

stellar interferometer. An attachment for astronomical telescopes, consisting of an opaque cover over the objective in which are two parallel slits at an adjustable distance apart. Two images thus produced overlap and give rise to interference phenomena by means of which angular diameters of very small objects may be measured. Developed by Michelson. *Cf. beam interferometer.*

stem correction. A correction applied to the reading of a liquid-in-glass thermometer because of the fact that the liquid in the stem is at a different temperature from that in the bulb.

step-up, step-down. Terms relating to the increase or decrease of voltage by a transformer or equivalent device.

steradian. Syn. *spheradian.*

stereo power. *In re* a prism binocular or similar optical system: the ratio of the distance between objective axes to the distance between eyepiece axes, multiplied by the magnifying power. It indicates how many times the stereoscopic radius is increased by the instrument. (See Martin, Optical Meas. Instr., 1924, p. 118; Southall, Mirrors, Prisms, and Lenses, 1923, p. 759.)

stereophotometer. A type of photometer in which light from the two sources compared falls simultaneously upon the same moving object. If a straight path is to appear straight, the two illuminations must be equal. Devised by Pulfrich. Syn. *stereoscopic photometer.* (See Walsh, Photometry, 1926, p. 184.)

stereoscopic. Exhibiting a three-dimensional character, as in binocular vision of near-by objects.

stereoscopic radius. The greatest distance at which the stereoscopic effect can be perceived. For the unaided eyes, it is about 1500 ft; with the aid of a prism binocular, it is greater. *Cf. stereo power.* (See Martin, Optical Meas. Instr., 1924, p. 118.)

Stern-Gerlach experiment. An experiment in which a stream of metallic atoms, deflected by a strong, nonuniform magnetic field, is split into two parts, one part deflected toward the higher magnetic intensity, the other toward the lower. It gives evidence of directional quantization, and thus supports the quantum theory of atomic magnetic moments. *Cf. Stern-Gerlach field.* (See Gerlach, Matter, Electricity, Energy, 1928, pp. 136 ff.; Sidgwick, Electronic Theory of Valency, 1929, p. 208; Rosen and Zener, *Phys. Rev.* 40, 502, 1932.)

Stern-Gerlach field. A special, nonhomogeneous magnetic field used in studying molecular rays. It is produced by a wedge-shaped pole piece facing another pole in which there is a deep notch or channel. (See Fraser, Molecular Rays, 1931, p. 120.)

Stern multiplier. A device due to Stern for converging a number of narrow beams of molecular rays at one point, thus securing an enhanced effect. (See Fraser, Molecular Rays, 1931, p. 148.)

stigmatic. 1. *In re* a bundle of rays: syn. *homocentric.* 2. *In re* an

optical system: having equal focal power in all meridians. *Cf. astigmatic.*

stilb. A name proposed by Blondel for the unit of brightness of a luminous surface, *viz.*, 1 candle/cm^2. (See Walsh, Photometry, 1926, p. 122.)

Stokes laws. 1. States that the force required to propel a spherical body of radius r at uniform speed v through a viscous medium of viscosity coefficient η is $6\pi\eta vr$. 2. States that the wave length of luminescence excited by radiation is always greater than that of the exciting radiation; in general valid, but with notable exceptions. (See Nichols and Merritt, *Phys. Rev.* 18(1), 403, 1904; Wood, Phys. Optics, 3d ed., p. 653.)

Stokes line. A line of the Raman spectrum which is displaced toward the long-wave-length side of the incident light; so called by analogy with the Stokes law (2) of luminescence. Lines displaced to the short-wave-length side are called *anti-Stokes lines.* (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 361.)

stopping condenser. A condenser in series with some branch of a circuit, the purpose of which is to introduce a comparatively high impedance and thus cut down the direct or low-frequency current without materially affecting the h.-f. component. Syn. *blocking condenser.* (See A.I.E.E. Comm. Rep. 1932.)

stopping potential. A p.d. sufficient to stop the outward movement of photoelectrons or thermions, and used in the determination of the speed of the emission. *Cf. potential barrier, photoelectric limiting potential.* (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 116.)

stopping power. 1. The effect of a layer of matter upon the motion of alpha particles, expressed in terms of the thickness of ordinary air which would have the same effect. 2. The mass per cm^2 of a given filter which is equivalent to 1 cm of air in reducing the speed of alpha particles. 3. For a gas: the ratio of the range of alpha particles in the given gas to that in air at N.T.P. (See Rutherford, Chadwick, and Ellis, Radiations from Radioactive Substances, 1930, p. 95; I.C.T., 1926, v. 1, pp. 368, 370.)

Stoss (Ger.). *Cf. burst.*

straggling. The statistical variation in the range of different alpha particles, all of the same initial speed, in the same gas. The (Gaussian) distribution corresponding to this variation is represented by the *straggling curve*, similar to the normal error curve. (See Rutherford, Chadwick, and Ellis, Radiations from Radioactive Substances, 1930, p. 111.)

straggling coefficient. A measure of the straggling observed in the range of alpha particles in an absorbing medium, relative to the range itself. Its value is approximately 2.096 times the ratio of the probable error of the (Gaussian) straggling distribution to the mean range of the particles. (See King and Rayton, *Phys. Rev.* 51, 826, 1937.)

strain. 1. The change in the relative positions of the particles of

a substance, which accompanies a deformation of the body or specimen of the substance in question. Strains may be analyzed into certain elementary types, as *elongation, rectilinear compression, shear, torsion, volume expansion,* and *volume compression.* 2. Syn. *deformation,* and applied to the external form rather than to the substance.

strain axes. Three mutually perpendicular lines through any point of an elastic solid, which remain mutually perpendicular when the solid is subjected to strain. *Cf. principal strains.* (See Newman and Searle, General Properties of Matter, 1929, p. 139.)

strain ellipsoid. The ellipsoid resulting from the strain of a small portion of matter which, in its unstrained condition, was spherical.

stratosphere. The atmosphere above the tropopause. Through its explored portion (the lower 20 km or so), the temperature normally changes but little with altitude, vertical convection is slight, and the winds are essentially horizontal; the term is limited by some to this portion. Syn. *isothermal region.*

streamline. 1. The contour of a longitudinal section of an object, such as a boat or an airplane, so shaped as to move through a fluid medium with minimum friction. 2. Syn. *line of flow.*

stream tube. A portion of a moving fluid bounded by lines of flow. Syn. *tube of flow.*

streaming potential. A p.d. produced by the flow, under pressure, of a liquid through a capillary tube or a membrane. It may be regarded as the inverse of electro-osmosis. Syn. *flow potential.*

stress. A quantity measured by the force per unit area exerted by one portion of a strained elastic substance upon a contiguous portion, and which is due to the external forces responsible for the deformation; *e.g., tensile stress, compressive s., shearing s., pressure,* etc.

stress couple. The couple due to the integrated stress over any cross section of a bent elastic rod or beam; equal and opposite to the bending moment.

stress diagram, s. sheet. An adaptation of the Maxwell diagram to the computation of stresses in a framed structure.

stress, modulus of. The ratio of the stress to the strain for any kind of elastic deformation. *Cf. elastic modulus, bulk m., shear m., Young m.*

stress-optical coefficient. The difference, per unit stress, between the refractive indices for two beams of light traversing a photoelastic medium, one polarized in and the other perpendicular to the direction of stress. (See Filon and Harris, *Proc. Roy. Soc.* 130, 410, 1931.)

striation. 1. A striped appearance of the positive column in a Crookes tube at suitable pressures, consisting of transverse, alternate bright and dark bands. (See Darrow, Electrical Phenomena in Gases, 1932, p. 438.) 2. One of the minute, parallel ridges sometimes visible on the natural faces of crystals.

strike. An initial electrochemical deposit; or sometimes the electrolyte from which such deposit is made.

striking potential. The p.d. necessary to start an electric arc. (See Scott, *Phys. Rev.* 22(2), 447, 1923.)

string electrometer. An electrometer consisting of a conducting fiber stretched midway between two conducting plates parallel to it. The field between the plates displaces the fiber laterally by an amount dependent upon the p.d.

string galvanometer. A type of galvanometer in which the current is measured by the lateral displacement of a wire carrying the current across a strong magnetic field. Devised by Einthoven.

stripped atom. An atom which has in some manner lost most of its outer electrons. (See Jauncey, Modern Phys., 1932, p. 428.)

structure amplitude factor, structure f. Syn. *atom form factor* (1).

sublevel. The energy level or quantum state of the electrons in an atomic subshell.

sublimation. The transition of a substance from the solid directly to the vapor state, or vice versa. In the latter case, the solid formed is called a *sublimate*, *e.g.*, white frost.

sublimation curve. *Cf. equilibrium curve.*

sublimation pressure. The solid-vapor equilibrium pressure of a volatile solid at a given temperature. (See I.C.T., 1926, v. 3, p. 203.)

submultiple resonance. The excitation of resonance of a frequency which is a submultiple of that of the exciting impulses. *Cf. subsynchronous.*

subshell. A subdivision of an electron shell, all the electrons of which have the same azimuthal quantum number. *Cf. sublevel.* (See White, Int. to Atomic Spectra, 1934, p. 80.)

subsynchronous. Having a frequency which is a submultiple of the driving frequency. *Cf. submultiple resonance.* (See Richardson, Sound, 1929, p. 57.)

subtractive color. A color produced by the removal of some part of white light, as by passage through one or more filters. *Cf. additive color.*

sum rule. Syn. *permanence principle.*

summation tone. A combination tone, heard under certain circumstances, whose pitch corresponds to a frequency equal to the sum of the frequencies of the two components. *Cf. difference tone.* (See Richardson, Sound, 1929, p. 61.)

Sumptner principle. The principle, stated by Sumptner, which is employed in the Ulbricht sphere, *viz.*, that when a source of light is placed at any point inside a sphere with perfectly diffusing walls, every part of the interior appears equally illuminated when viewed through an opening. *Cf. sphere photometer.* (See Hardy and Perrin, Prin. of Optics, 1932, pp. 268 ff.)

superconductivity, suprac. The greatly enhanced electrical conductivity attained by certain metals when cooled to a sufficiently low temperature, at which the

resistance suddenly drops to a very low value. (See Smith and Wilhelm, *Rev. Mod. Phys.* 7, 237, 1935; Darrow, *R.S.I.* 7, 124, 1936.)

supercool. To reduce the temperature of a liquid below its freezing point or that of a solution below its saturation point. Syn. *undercool.*

superheat. 1. (v.) To raise the temperature of a vapor, as steam, above the saturation point. 2. To raise the temperature of a liquid above its boiling point at the existing pressure, without ebullition; facilitated by covering the surface with another, immiscible liquid, as oil on water. 3. (n.) The number of degrees by which the temperature of a vapor at a given pressure exceeds the temperature at which the vapor is saturated.

supersaturate. To cause a solution to attain a condition of greater concentration than its normal saturation concentration at the existing temperature, without initiating precipitation of the solute. This may sometimes be done by careful supercooling.

supersonic. Syn. *ultrasonic.*

superstructure. A regular, periodic spacing found in the structure of a solid solution; exhibited by certain alloys. It is due to a systematic configuration of atoms of the solute in the solvent crystal, and is not characteristic of the solvent. (See Laue, *Ann. d. Phys.* 78, 167, 1925; Bragg and Williams, *Proc. Roy. Soc.* 145A, 699, 1934.)

suppression. 1. The elimination of any component of an emission, as of a given frequency in a radio wave train. 2. The nonappearance of a normally occurring natural face on a crystal, due to the adjacent faces coming together to a point or an edge. *Cf. replacement.*

surface density. The quantity per unit area of anything distributed over a surface, *e.g.* of an electric charge.

surface energy. Energy which depends upon the surface area and configuration of a body, *e.g.*, a bubble or a drop of liquid, and which varies when either is varied isothermally.

surface heat of charging. Heat theoretically developed when an electric charge is imparted to a metallic surface. (See Tonks and Langmuir, *Phys. Rev.* 29(2), 524, 1927; Herzfeld, *Phys. Rev.* 35(2), 248, 1930.)

surface integral of normal field. The surface integral of the normal component of the field intensity over any given surface, *i.e.*, the sum of the products obtained by multiplying each element of the surface by the component of intensity perpendicular to the surface at the point occupied by the element. *Cf. Gauss theorem.*

surface lattice. A structural pattern manifested at a natural cleavage surface of a crystal, and recognized by effects analogous to those of a plane grating. *Cf. lattice.*

surface of buoyancy. The surface described by the center of displacement as a floating body is tipped through various angles and in various directions without altering the volume of displacement. Any vertical section of this

surface through the metacenter is a *curve of buoyancy*. (See Laws, Stability and Equilibrium of Floating Bodies, 1914, p. 13.)

surface photoelectric effect. Syn. *photoelectric emission* (*cf. photoelectric*).

surface resistivity. The electric resistance of the surface of an insulator, measured between the opposite edges of a centimeter square of the surface. (See Smiths. P. T., 1929, p. 331.)

surface tension. The peculiar effect of cohesion manifested at the free surface of a liquid, or at the interface of two immiscible liquids, and giving the impression of a tense, elastic skin or membrane. It is measured in units of force per unit length, *e.g.*, dynes per centimeter, along any line on the surface.

surge. 1. A highly accelerated flow, *e.g.*, that due to suddenly applied pressure or voltage. 2. A general change of atmospheric pressure, distinct from local cyclonic and diurnal changes. (See *U. S. Weather Bureau Circular* M.)

surge chamber. A cavity connecting with a water pipe or other conduit and containing air, which acts as a cushion to shocks caused by sudden pressure or stoppage of the flow, *e.g.*, in a force pump.

susceptance. *In re* an a.-c. circuit having inductance L and capacitance C: the value of the quantity

$$\frac{1}{2\pi nL} - 2\pi nC,$$

in which n is the frequency. (See Page and Adams, Prin. of Electricity, 1931, p. 456.)

susceptibility. 1. (*Magnetic.*) The ratio of the magnetization in a substance to the magnetizing force responsible for it. Divided by the density, it gives the *mass susceptibility* or *specific susceptibility* of the substance. *Cf. atomic susceptibility, molar s.* 2. (*Dielectric.*) The ratio of the polarization in a dielectric to the electric intensity responsible for it.

suspension. 1. The state of a finely divided material sustained by thermal agitation in a fluid medium, as smoke particles in the air. 2. Any material so sustained. 3. A fine wire or filament by which a galvanometer coil or similar apparatus is suspended in an instrument.

suspensoid. A colloidal sol in which the particles do not unite with the suspending medium. Called by Perrin a *lyophobe* sol. *Cf. emulsoid.* (See Taylor, Treatise on Phys. Chem., 2d ed., p. 1303.)

Sutherland law. Expresses the viscosity coefficient η of a gas in terms of its absolute temperature T, as follows:

$$\eta = \eta_0 \frac{T_0 + C}{T + C}\left(\frac{T}{T_0}\right)^{3/2},$$

in which C is a constant. η_0 is the value of η at the ice point T_0. (See I.C.T., 1926, v. 5, p. 1; Loeb, Kinetic Theory of Gases, 2d ed., pp. 221 ff.)

sweep oscillator. An oscillator used to deflect periodically the beam of a cathode-ray oscillograph or television tube so as to give a displacement which is a function of the time. The voltage applied to the deflecting plates is the *sweep voltage*, and the amplitude

of the displacement of the spot is the *sweep amplitude*. (See Bedell and Reich, *J.A.I.E.E.* 46, 563, 1927; Reich and Marvin, *R.S.I.* 5, 7, 1934.)

sylphon. A closed cell with thin, corrugated metal walls, resembling the bellows of an accordion; used in high-pressure research on fluids, and in certain thermostats. (See Bridgman, Physics of High Pressure, 1931, p. 126.)

symmetry. 1. An arrangement of objects or parts of a figure with reference to a point, a line, or a plane so that for each particle or point on one side there is a corresponding one at an equal distance on the other side of the reference zero. If the reference zero is a point, the term *point symmetry* or *radial symmetry* is used; if a line, the *symmetry* is said to be axial; if a plane, it is *bilateral*. 2. (Cryst.) An arrangement of objects or parts of a figure such that they appear to be hung, either singly or in groups of constant configuration, on a space lattice whose structure regularly repeats itself in three dimensions in space. (See Davey, Study of Crystal Structure and Its Applications, 1934, chap. 8.)

symmetry number. The number of different symmetry planes of a body or a group of atoms. *E.g.*, for a regular tetrahedron the number is 12. The term was applied to molecules by Ehrenfest.

symmetry plane. A plane which divides a body or a figure in such a way that any line perpendicular to the plane and terminated by the boundaries of the object or figure is bisected by the plane. A *principal s.p.* is one having at least two other s.p.'s perpendicular to it, which could be interchanged without apparently altering the orientation of the object or figure. (See Butler, Manual of Geometrical Crystallography, 1918, pp. 5, 146.)

sympathetic vibration. Vibration due to resonance.

synchrono-phosphoroscope. An apparatus for examining phosphorescence of brief duration. (See Nichols and Howes, *Phys. Rev.* 7(2), 586, 1916).

synchroscope. A form of oscillograph used to test the phase difference or synchronism of two a.c.'s or electric oscillations.

T

(Please note purpose of references as explained in preface.)

tachometer, tachymeter. Any instrument for measuring linear or angular speeds, or the rates of flow of liquids.

Talbot bands. Interference bands appearing in a prism spectrum when half of the aperture is covered by a thin glass plate with the edge parallel to the edge of the prism. *Cf. Powell bands.* (See Talbot, *Phil. Mag.* 72(3), 364, 1837; Doubt, *Phys. Rev.* 10(2), 322, 1917.)

Talbot law. States that when two or more luminous areas are presented to the eye at regular intervals, so that each is seen in turn for a certain time, *e.g.*, on a

rotating color disk, there is a definite frequency of alternation for which the resultant color impression is invariable and is identical with the impression which would result if all the lights were seen simultaneously at their mean intensities. (See Hyde, *B.B.S.* 2, 1, 1906.)

tangent galvanometer. A galvanometer with a fixed field coil, for which the tangent of the deflection is proportional to the current.

target. 1. Syn. *anticathode.* 2. A cold plate placed in the path of a beam of molecular rays, which condense in a spot on the cold surface. (See Fraser, Molecular Rays, 1931, p. 26.)

telecentric. *In re* an optical instrument: having either the entrance-pupil or the exit-pupil at infinity, *e.g.*, when a front stop is placed in the anterior focal plane of a convergent lens—a device commonly used in optical measurements to avoid parallax between image and scale. *Cf. collimator.* (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 420.)

telephotography. 1. Photography of distant objects by means of a special magnifying camera objective system. 2. The reproduction of photographs or other pictures at a distance by means of electric currents or radio.

telethermometer. An apparatus in which temperature effects are electrically communicated to a measuring or recording instrument at some distance away; commonly a thermocouple or a resistance thermometer circuit. *Cf. thermophone* (2).

temperature coefficient. The increment of a quantity, which is a function of the temperature, due to unit change of temperature; *i.e.*, the temperature rate or derivative of a quantity. *E.g.*, the t.c. of a standard cell is its change in voltage per degree.

temperature factor. *Cf. Debye temperature factor, Debye-Waller f.*

temperature wave. A progressing variation of temperature, such as that inaugurated by strongly heating one end of a long bar of cold metal. A succession of such waves would result from alternately heating and cooling the end of the bar. *Cf. thermal diffusivity.*

tensile strength. The ultimate strength of a substance under tension.

tensimeter. An apparatus for measuring vapor pressure. (See Hickman, *J. Phys. Chem.* 34, 627, 1930.)

tension. 1. A force applied to a body in such a way as to produce elongation in the direction of the force. 2. Syn. *pressure*, esp. of a vapor. (Obsolescent.) 3. Syn. *voltage*, as in "high-tension line."

tensor. The absolute or numerical value of a vector. *Cf. versor.*

terminal velocity. The equilibrium velocity attained by a body or a particle moving in a field of force through a resisting medium, *e.g.*, the velocity finally attained by a body falling freely through the air, when the frictional resistance becomes equal to the weight of the body.

Tesla coil. A helix of many turns in which very high p.d.'s are produced by means of inductive coupling with a circuit containing

a condenser and a spark gap. A transformer having such a coil as its secondary, with the condenser and gap in the primary circuit, is called a *Tesla oscillation transformer.*

tetragonal. *In re* crystal structure: having three mutually rectangular axes, two of which only are equal. *Cf. crystal system.*

tetrode. A vacuum tube having four electrodes, *e.g.*, a screen-grid tube. (See Robinson, *Proc. I.R.E.* 20, 131, 1932.)

thalofide. A photoconductive composition of thallium, oxygen, and sulphur, developed by T. W. Case. (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 326; Kaplan, *J.O.S.A.* 14, 251, 1927.)

thermal agitation. A random movement of the molecules of a substance, which is believed to give rise to the phenomena associated with heat and the kinetic energy of which is the usual interpretation of that term.

thermal analysis, thermoanalysis. The investigation of physical transition processes or of chemical reactions by observing discontinuities in the absorption or evolution of heat, *e.g.*, the recalescence transitions in iron, manifested by abrupt changes in temperature. (See Merica, *B.B.S.* 15, 101, 1918–1920; Germann, *Phys. Rev.* 19(2), 623, 1922.)

thermal capacity. The quantity of heat required to increase the temperature of a body by unity, or which the body yields when its temperature is lowered by unity, without change of state.

thermal conductivity. *Cf. conductivity.*

thermal diffusivity. The ratio of the thermal conductivity of a substance to the product of the density by the specific heat. Upon it depends the rate at which a temperature wave is propagated in a conducting substance. (See Smiths. P. T., 1929, p. 217; Starr, *R.S.I.* 8, 61, 1937.)

thermal effusion. Syn. *thermal transpiration, thermodiffusion.*

thermal equilibrium. That condition of a system in which the net rate of exchange of heat among its parts has become zero; a special feature of thermodynamic equilibrium.

thermal ionization. Ionization due to high temperature, as in the electrically conducting gases of a Bunsen flame. Syn. *temperature ionization.* (See Darrow, Electrical Phenomena in Gases, 1932, p. 72 and *J.O.S.A.* 9, 453, 1924.)

thermal radiation. Radiation excited by the thermal agitation of molecules or atoms, irrespective of other causes of excitation. Its existence is observable from the far infrared to the extreme ultraviolet. Syn. *temperature radiation, heat r., radiant heat.*

thermal transpiration. A pressure difference which develops between two bodies of gas, initially at the same low pressure but at different temperatures, when they are joined by a capillary tube. The flow is from the colder to the warmer gas. Discovered by Feddersen and Reynolds. Syn. *thermal effusion, thermodiffusion.* (See Loeb, Kinetic Theory of Gases, 2d ed., pp. 353 ff.)

thermel. A term used to cover all forms of thermoelectric thermometer, whether single thermocouples or series of couples (thermopiles or multiple thermels). (See White, *Science* 55, 617, 1922.)

thermion. An ion, either positive or negative, which has been emitted from a heated body. Negative thermions are electrons (*thermoelectrons*). *Cf. positive ion emission.*

thermionic emission. A stream of thermions emitted by a heated body.

thermionic emission constant. A constant A appearing in the Richardson equation for thermionic emission when written in the form

$$I = AT^2 e^{-\frac{w}{T}},$$

in which w is the thermionic work function. It has the same value for all metals, *viz.*, about 120 amp/cm^2 deg^2. (See Dushman, *Phys. Rev.* 21(2), 623, 1923; Becker and Brattain, *Phys. Rev.* 45, 694, 1934.)

thermionic valve. An electric-current rectifier based on the unidirectional character of the thermionic current.

thermionic work function. *Cf. work function, Richardson equation, thermionic emission constant.*

thermocouple. A pair of metals forming a junction (*thermojunction*), considered as the seat of a thermoelectromotive force.

thermodiffusion. Syn. *thermal transpiration, thermal effusion.*

thermodynamic cycle. A cyclic change of state of a body or a system which involves changes of temperature or the transmission of heat to or from the body or system.

thermodynamic equilibrium. The condition of a system whose members have conformed to the principle of equipartition of energy. *Cf. thermal equilibrium.*

thermodynamic laws. Two laws upon which rests the classical thermodynamic theory: 1. When work is expended in generating heat, the quantity of heat produced is proportional to the work expended; and, conversely, when heat is employed in the performance of work, the quantity of heat which disappears is proportional to the work done. (Joule.) 2. It is impossible for a self-acting machine, unaided by any external agency, to convey heat from a body of lower to one of higher temperature. (Clausius.) Or, it is impossible to derive mechanical work from heat taken from a body unless there is available a body of lower temperature into which the residue not so used may be discharged. (Kelvin.) 3. In addition to these, some writers refer to the following as the "third law of thermodynamics": Every system has a finite, positive entropy, but at the absolute zero of temperature, the entropy may become zero, and does so become in the case of perfect crystalline substances. This statement, formulated by Planck, is closely related to the Nernst heat theorem.

thermodynamic potential. *In re* any thermodynamic state of a substance: a mathematical expres-

sion for the work or change in energy per unit mass involved in bringing it to that state. It is, in general, a function of the variables which determine the state of the substance. So named by reason of the analogy to such cases as the energy of a body with reference to its position in a field of force (*cf. potential*). Syn. *thermal potential, thermal head.*

thermodynamic probability. The probability of a given state of distribution and motion of the molecules of a body, as compared with that of some arbitrarily chosen reference state. It is proportional to the number of complexions which would result in that state. (See Page, Int. to Theoretical Phys., 1928, p. 281.)

thermodynamic scale. Syn. *Kelvin scale.*

thermodynamic transformation. A change in the state of a body or system which involves changes of temperature or the emission or absorption of heat; *e.g.*, the expansion of a gas, with accompanying decrease of pressure and temperature.

thermodynamics. That branch of physical science which treats of processes involving the conversion of heat into other forms of energy, and vice versa.

thermoelastic. Pertaining to the thermodynamics of elastic processes, *e.g.*, the heat generated by the deformation of an elastic body or the fall of temperature when it recovers, etc. (See McNally and Sheppard, *J. Phys. Chem.* 35, 100, 1931.)

thermoelastic coefficients. Two quantities relating to an elastic body, and defined by the expressions $-v(\partial p/\partial v)_T$, $-v(\partial p/\partial v)_s$. In these v is volume, p is pressure, T is temperature, s is entropy; and the subscripts denote that the corresponding quantity is to be kept constant. These quantities are the reciprocals, respectively, of the isothermal and isentropic compressibilities. *Cf. calorimetric coefficients, thermometric c.* (See Page, Int. to Theoretical Phys., 1928, p. 261.)

thermoelectric inversion. The phenomenon, exhibited by a thermocouple, of decreasing its e.m.f. with increasing temperature beyond a certain neutral point. *Cf. inversion.*

thermoelectric manometer. A manometer which depends upon the variation of thermoelectromotive force with pressure; devised by Rohn. (See Newman, Production and Meas. of Low Pressures, 1925, p. 159.)

thermoelectric power. The change in the thermoelectromotive force of a thermocouple per degree of change in its temperature. The thermoelectric power of any metal is that of a couple composed of the given metal against some standard metal, usually lead.

thermoelectromotive force. The e.m.f. given by two contacting metals and depending upon the metals and upon the temperature distribution in them. In a circuit of different metals joined in series, the resultant e.m.f. is the algebraic sum of the e.m.f.'s due to the several conjoined pairs. Discovered by Seebeck in 1821. Syn. *Seebeck effect. Cf. Peltier*

e.m.f., Thomson e.m.f., thermoelectric power.

thermoelectron. *Cf. thermion.*

thermoelement. A combination of a thermocouple with a heating filament, used for measuring small currents. (See I.R.E. Comm. Rep., 1933.)

thermogalvanometer. A galvanometer for the measurement of feeble h.-f. a. c.'s by their heating effect, detected by a sensitive thermocouple. Devised by W. Duddell in 1904. (See Brown, Radiofrequency Elec. Meas., 1931, p. 296.)

thermogauge. A form of optical pyrometer, devised by Morse. (See Ferry, Practical Pyrometry, 1917, p. 104.)

thermograph. A recording thermometer.

thermojunction. *Cf. thermocouple.*

thermoluminescence. Luminescence exhibited by certain substances, as fluorite, when heated, but of wave length distinctly shorter than that of the incandescence corresponding to the exciting high temperature. Thus fluorite crystals heated on an iron plate may give off white light before the adjacent iron is even red hot. *Cf. cathodothermoluminescence, tribothermoluminescence.*

thermomagnetic. Pertaining to the effects of a magnetic field upon the flow of heat or the temperature distribution in a conductor, *e.g.*, in the Nernst effect; or to the effects of temperature upon the magnetic properties of a substance. (See Campbell, Galvanomagnetic and Thermomagnetic Effects, 1923.)

thermomagnetic potential difference. A change in the e.m.f. of a thermojunction, due to placing it in a magnetic field. (See Heaps, *Phys. Rev.* 31(2), 648, 1928.)

thermometric coefficients. Two quantities relating to a body of working substance; defined by the expressions

$$\frac{1}{p}\left(\frac{\partial p}{\partial T}\right)_v, \quad \frac{1}{v}\left(\frac{\partial v}{\partial T}\right)_p.$$

In these T is temperature, v is volume, p is pressure; and the subscripts denote that the corresponding quantity is to be kept constant. *Cf. calorimetric coefficients, thermoelastic c.* (See Page, Int. to Theoretical Phys., 1928, p. 261.)

thermomotive force. That which, in thermal phenomena, is analogous to electromotive force in the corresponding electrical phenomena; *e.g.*, the temperature difference developed in the Ettingshausen effect. (See Bridgman, Thermodynamics of Electrical Phenomena in Metals, 1934, p. 137.)

thermophone. 1. A musical tone generator composed of a thin strip of metal immersed in a gas or a volatile liquid and periodically heated by an a.c. (See Arnold and Crandall, *Phys. Rev.* 10(2), 22, 1917; Wente, *Phys. Rev.* 19(2), 333, 1922.) 2. A form of telethermometer in which a telephone receiver is used.

thermophosphorescence. Phosphorescence developed by heating after exposure to some exciting agency. (See Nyswander and Lind, *J.O.S.A.* 13, 651, 1926; Stuhlman, *J.O.S.A.* 18, 365, 1929.)

thermopile. A thermel consisting of a number of thermocouples in series, which amplifies the temperature effect.

thermorelay. A device, due to Moll, for amplifying small galvanometer deflections. The galvanometer mirror reflects a bright beam of light upon a sensitive thermojunction in such a way that very slight deflections of the beam cause relatively large changes at the junction. A second galvanometer actuated by the thermocouple may thus be made to show deflections many times as large as the original. *Cf. resonance radiometer.*

Thévenin theorem. States that when two points A and B of a circuit or network carrying a current (either steady or alternating) are connected by a shunt S, the resulting current in S is equal to the original p.d. between A and B, divided by the sum of the parallel impedances of the shunt S and the portion AB of the original circuit. (See Shea, Transmission Networks and Wave Filters, 1930, p. 55.)

thixotropy. A phenomenon exhibited by some gels, which, when gently shaken, break up and form a fluid with all the properties of the original sol, but which, when left undisturbed, resume the form of a gel again. This process may be repeated indefinitely. (See Svedberg, Colloid Chem., 1928, p. 278.)

Thomas precession. The precession of the spin axis of an electron due to the acceleration given to the electron by the electric field of the nucleus. (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 162; Dancoff and Inglis, *Phys. Rev.* 50, 784, 1936.)

Thomson coefficient. The ratio of the Thomson e.m.f. in a metal to the corresponding difference in temperature. Syn. *specific heat of electricity.*

Thomson (Kelvin) double bridge. A bridge having eight arms, used for comparing two resistance standards having both current and potential terminals. (See Gray, Absolute Meas. in Elec. and Mag., 1921, pp. 349 ff.)

Thomson (Kelvin) effect. An effect manifested when an electric current is passed through a metallic conductor of nonuniform temperature, *e.g.*, in the simplest case, a wire on which there is a sharp temperature maximum. When the current flows, the maximum is observed to move, with the current in some metals, against it in others.

Thomson electromotive force. A p.d. existing between two points of different temperature on a metallic conductor; studied by William Thomson (Kelvin). *Cf. Thomson coefficient.*

Thomson heat. The quantity of heat which must be supplied or withdrawn in order to maintain a unit temperature difference between two points of a conductor at a given mean temperature when unit quantity of electricity flows from one point to the other, and thus to neutralize the Thomson effect. (See Bridgman, Thermodynamics of Electrical Phenomena in Metals, 1934, p. 44.)

Thomson polarization factor. A factor to which the intensity of an x-ray beam reflected from a crystal is proportional and which, as derived by J. J. Thomson, is equal to the function

$$\tfrac{1}{2}(1 + \cos^2 2\theta)$$

of the glancing angle θ. (See Blake, *Rev. Mod. Phys.* 5, 169, 1933.)

Thomson-Whiddington-Bohr law. Expresses the depth to which cathode electrons penetrate a material target in the production of x-rays as V^2/b, in which V is the voltage and b a constant, known as the *Thomson-Whiddington constant*, dependent upon the material and other circumstances. (See Nicholas, *B.S.J.R.* 5, 843, 1930.)

thorium series. One of the principal radioactive series, beginning with thorium.

three-body problem. A famous kinetic problem, dealing with the motions of three particles or spherical bodies under their mutual gravitational attraction.

three-phase current. A polyphase current delivered through three wires, the components in which differ in phase successively by one-third cycle; each wire serving as the return for the other two. A *three-phase generator* supplies, and a *three-phase motor* is operated by, such a current. *Cf. two-phase current.*

three-phase equilibrium. The equilibrium which may exist, at a suitable temperature and pressure, among all three phases of a pure substance, solid, liquid, and vapor. The *triple point* on the temperature-pressure diagram corresponds to this condition.

threshold frequency. *Cf. photoelectric threshold.*

throttling. The irreversible process of a fluid flowing through an opening from a higher to a lower pressure region. Syn. *wiredrawing.* (See Goodenough, Prin. of Thermodynamics, 1920, p. 52.)

thyratron. An arc discharge tube containing inert gas or vapor at low pressure, in which a grid is employed to control the starting of the discharge. (See Hull, *Trans. A.I.E.E.* 47, 753, 1928; Hughes and DuBridge, Photoelectric Phenomena, 1932, pp. 482 ff.)

tiltometer. An instrument which measures inclination to the horizontal. (See Karrer and Poritsky, *J.O.S.A.* 10, 257, 1925.)

time constant. *In re* an electric circuit: the ratio of the inductance to the resistance; so called because it may be expressed dimensionally in time units, and measures the relaxation time of the current when the e.m.f. is removed. (See Page and Adams, Prin. of Electricity, 1931, p. 337.)

time integral. *In re* any variable f which is a function of the time: the definite integral of the product of the variable by the element of time, *viz.*, $\int f dt$, between specified limits of t. *E.g., cf. impulse.*

tint. A chromatic color of relatively low saturation and relatively high brilliance.

Toepler-Holtz machine. A type of static machine having one stationary and one rotating plate, or a number of such pairs.

tolerance. The maximum error, or variation from the standard, permissible in a measuring instrument, *e.g.*, a weight.

tonvariator. An adjustable resonator for comparison of musical pitches, the frequency of which is varied by means of a piston having a graduated scale. Designed by Stern.

toric lens. A lens, one surface of which is a portion of the surface of a tore. Much used for spectacles. (See Southall, Mirrors, Prisms, and Lenses, 1923, p. 316; Hardy and Perrin, Prin. of Optics, 1932, p. 436.)

torque. Syn. *moment* (1); or the integrated resultant of such moments, *e.g.*, that arising from a system of forces equivalent to a couple.

Torricelli law. States that the speed of efflux of a nonviscous fluid issuing from an orifice at a depth h below the level of the free surface in the container, under the influence of gravity alone, is $v = \sqrt{2gh}$.

Torricellian vacuum. A space evacuated by filling it with mercury and then lowering the reservoir more than 76 cm below the bulb, as in a barometer. *Cf. Geissler pump.*

torsion. The strain due to twisting a rod, wire, or filament; measured by the angle of rotation of one cross section with respect to another at unit distance from it.

torsion balance. One of a variety of instruments which measure small torques by their torsional effect upon elastic filaments or wires. *E.g., cf. Cavendish experiment, Eötvös balance.*

torsion coefficient, t. constant. The torque exerted in twisting an elastic rod per unit total angle of twist.

torsion head. A rotary cap, often graduated in degrees, atop the vertical tube supporting a torsion suspension, *e.g.*, in a galvanometer or a magnetometer.

torsion modulus. Syn. *shear modulus, rigidity m.*

torsion pendulum. A pendulum actuated by the torsion of an elastic wire.

torsometer. An instrument for studying the elastic behavior of solids under torsion, esp. by optical methods. (See Tutton, Natural History of Crystals, 1924, p. 238.)

total absorption coefficient. Syn. *extinction coefficient.*

total elastic cross section. *In re* atoms scattering electrons of given velocity: the number of electrons scattered per atom from an electron beam whose intensity is 1 electron per unit area per unit time. (See Mott and Massey, Theory of Atomic Collisions, 1933, p. 24.)

total emissive power. *Cf. emissive power.*

total heat. *Cf. enthalpy.*

total quantum number. Syn. *principal quantum number.*

total reflection. Internal reflection in which the angle of incidence exceeds a value, known as the *critical angle*, whose sine is the relative refractive index from the more to the less refractive me-

dium; so called because all the radiation is reflected and none transmitted.

Townsend characteristic. The current-voltage characteristic curve for a photoelectric cell at constant illumination and at voltages below the glow potential. (See Campbell and Ritchie, Photoelectric Cells, 1930, pp. 81 ff.)

Townsend coefficient. *Cf. Townsend equation.*

Townsend discharge. 1. Any space-charge-free electrical discharge in a gas at moderate pressure above 0.1 mm, whether self- or externally maintained. 2. More loosely, syn. *corona.*

Townsend equation. An expression for the photoelectric current in a gas, as a function of the distance d between plates, and having the form

$$I = I_0 e^{\alpha d}.$$

α is the *Townsend coefficient,* which may be interpreted as the number of new ion pairs produced by the impacts per unit length of electron path. (See Sanders, *Phys. Rev.* 41, 667, 1932.)

track. *Cf. cloud track.*

trajectory. The path followed by a projectile under the influence of gravity.

trammel. A mechanism consisting of a movable, straight bar, two relatively fixed points of which are constrained to move along grooves or tracks intersecting at right angles. Used for drawing ellipses, and in the Rowland mounting for concave gratings.

transconductance. Syn. *mutual conductance.*

transducer. Any device for transmitting energy from one system to another, esp. from one electric transmission or communication system to another, *e.g.,* a transformer. (See A.I.E.E. Comm. Rep., 1932.)

transference numbers. A term applied by Hittorf to the fractions of an electrolytic current carried by the anions and by the cations, respectively, the sum of which is unity. Syn. *transport numbers, Hittorf numbers. Cf. Kohlrausch law.* (See Newman, Electrolytic Conduction, 1931, p. 45; Kraus, Properties of Electrically Conducting Systems, 1922, p. 21.)

transformation constant. Syn. *disintegration constant.*

transformation period. The half-value period for the decay of the activity of a radioactive substance.

transformation ratio. The ratio of the voltage in the secondary to that in the primary of a transformer.

transformer. A device which, through magnetoelectric induction but without the use of moving parts, transforms alternating or intermittent electric energy in one circuit into energy of similar type in another circuit, commonly with altered values of the voltage and current.

transient. A temporary component of the current in a circuit which is adjusting itself to a new condition of load or of impressed e.m.f. In the current-time equation for such a circuit, the transient component may be represented by a term which rapidly approaches zero. (See Page and Adams,

Prin. of Electricity, 1931, p. 340.)

transition probability. 1. (Spect.) The number of spontaneous transitions from one given state to another given state which a single atom would perform, on the average, in 1 sec, if the initial state were restored immediately after each transition. It is a function of the frequency of the radiation emitted, and of the atomic structure. 2. The number of induced transitions per single atom per second, as above, due to unit intensity of the incident radiation. It is likewise a function of the frequency and of the atomic structure. (See Slater, *Phys. Rev.* 25(2), 783, 1925; Christensen and Rollefson, *Phys. Rev.* 34(2), 1157, 1929.) 3. (Radioact.) The probability that a radioactive atom of a given species will disintegrate within unit time. It is numerically equal to the disintegration constant.

translation. A displacement of a body or a figure in which the line joining any two points remains parallel to its original direction and its length remains unchanged.

transmission coefficient. 1. *In re* the separation of radiation into parts at the interface between two media: the ratio of the amplitude of the transmitted radiation to that of the incident radiation. 2. *In re* the passage of radiation through an absorbing medium: one minus the absorption coefficient. Syn. *transmissivity, percentage transmission.* (See Page and Adams, Prin. of Electricity, 1931, p. 572; Smiths. P. T., 1929, p. 308.)

transmission factor. Syn. *attenuation factor.* (See I.C.T., 1926, v. 5, p. 264.)

transmission limit. A limiting wave length or frequency, above (or below) which a given type of radiation is practically all absorbed by a given medium. If the limits are sharply defined, the medium acts as a radiation filter.

transmission plane. The plane of vibration of polarized light which will pass through a given polarizer, *e.g.*, a Nicol prism.

transmissivity. Syn. *transmission coefficient* (2).

transmissometer. An instrument for measuring the transmission factor of semitransparent bodies. (See Karrer, *B.B.S.* 17, 203, 1922.)

transmittance. The fraction of the radiant energy entering a layer of a medium which reaches its further boundary.

transmutation. A change from one chemical element into another, or the derivation of one element from another; sought for by the alchemists, and now recognized as actually taking place through either natural or induced radioactivity.

transmutation function. A function which expresses the probability of an induced nuclear transmutation in terms of the energy of the bombarding particle; the target being considered infinitely thin. (See Lawrence, Macmillan, and Thornton, *Phys. Rev.* 48, 493, 1935.)

transpiration. The passage of a gas or a vapor through a capillary, or its exhalation from the pores of an

absorbing substance. *Cf. thermal transpiration.*

transport numbers. Syn. *transference numbers, Hittorf numbers.*

transport phenomena. A class of phenomena due to the transfer of mass, energy, or momentum across any given surface or interface as a result of molecular or electronic agitation, in accordance with the kinetic theory. *E.g.*, momentum may be so transferred from a rotating disk to an adjacent parallel disk by means of air molecules receiving momentum from the one and subsequently impinging upon the other.

transverse effects. A term collectively applied to the Hall, Ettingshausen, Nernst, and Righi-Leduc effects (*q.v.*). (See Campbell, Galvanomagnetic and Thermomagnetic Effects, 1923; Bridgman, *Phys. Rev.* 24(2), 644, 1924.)

transverse mass. The mass of a body measured in the relativistic sense, in a direction perpendicular to that of its motion relative to the observer; in contradistinction to its *longitudinal mass* (*q.v.*).

Trevelyan rocker. A mechanical oscillator which depends upon the alternate expansion and contraction, at the points of contact, of a heated solid in contact with a cold one. (See Hagenow, *R.S.I.* 2, 194, 1931.)

triboelectric. Pertaining to electrification generated by friction. A *triboelectric series* is a list of substances so arranged that any one of them becomes positively electrified when rubbed with one farther down the list. (See Richards, *Phys. Rev.* 22(2), 122, 1923; Shaw and Hanstock, *Proc. Roy. Soc.* 128, 474, 1930.)

triboluminescence. Luminescence caused by grinding, in such substances as glass and certain crystals. *Tribothermoluminescence* refers to the same phenomenon, when heat is required subsequent to the grinding. Syn. *piezoluminescence.* (See Nyswander and Cohn, *Phys. Rev.* 36, 1257, 1930.)

tribophosphorescence. The enduring or phosphorescent type of triboluminescence. (See Nyswander and Cohn, *Phys. Rev.* 36, 1257, 1930.)

tribothermoluminescence. *Cf. triboluminescence.*

trichromatic coefficient. The fraction of a three-color mixture which consists of any one of the three standard colors used to obtain a match for any given color, in accordance with the three-color method of Maxwell. *Cf. Maxwell triangle.* (See Luckiesh, Color and Its Applications, 1915, p. 73; Judd, *J.O.S.A.* 23, 360, 1933.)

trickle charger. A device for charging a storage battery at a very slow rate. (See A.I.E.E. Comm. Rep., 1932.)

triclinic. *In re* crystal structure: having three unequal axes intersecting at angles, not more than two of which are equal, and not more than one of which is 90 deg. *Cf. crystal system.*

triode. A vacuum tube having three electrodes, *viz.*, a *filament*, a *grid*, and a *plate;* used in radio and other h.-f. apparatus. Syn. *radiotron, audion, pliotron.*

triple point. *Cf. three-phase equilibrium.*

triple scalar product. *In re* three vectors, p, q, r: any one of the identical scalar quantities

$$(p \times q) \cdot r = r \cdot (p \times q) = -r \cdot (q \times p) = -(q \times p) \cdot r.$$

Cf. scalar product, vector product. (See Page, Int. to Theoretical Phys., 1928, p. 9.)

triple vector product. *In re* three vectors, p, q, r: any one of the identical vector quantities

$$(p \times q) \times r = -r \times (p \times q) = r \times (q \times p) = -(q \times p) \times r.$$

Cf. vector product. (See Page, Int. to Theoretical Phys., 1928, p. 10.)

triplet. A multiplet of three components.

tropism. A directional property of a substance, esp. a crystal, dependent upon the vector quantities which determine the states of the constituent atoms or molecules. (See Bitter, *Phys. Rev.* 42, 731, 1932.)

tropopause. The upper limit of the troposphere, in middle latitudes generally 10 to 12 km above the earth's surface.

troposphere. All that portion of the atmosphere, next above the earth's surface, in which vertical convection is frequently active and in which clouds usually occur.

Trouton law. States that the molar heat of vaporization of a liquid at a given temperature, divided by its absolute boiling point (the *Trouton ratio*), is approximately the same for all liquids. (See I.C.T., 1926, v. 5, p. 136.)

Trouton-Noble experiment. An attempt to detect an ether drift by the possible electromagnetic effect of the motion of an electric charge as carried with the velocity of the earth. No effect was observed. *Cf. Michelson-Morley experiment.*

tube coefficients. The constants which serve to describe the characteristics of a thermionic vacuum tube, *viz.*, the amplification factor, the mutual conductance, the a.-c. filament-to-plate resistance, the detection coefficient, etc. (Brown, Radio Frequency Elec. Meas., 1931, p. 223.)

tube counter. An ion counter of tubular form. *Cf. Geiger-Müller counter.*

tube electrometer. An adaptation of the thermionic vacuum tube to use as an electrometer. (See DuBridge, *Phys. Rev.* 37, 392, 1931; Burroughs and Ferguson, *R.S.I.* 4, 406, 1933.)

tube of displacement. Defined in a manner similar to *tube of force*, with *lines of* (electric) *displacement* substituted for *lines of force.*

tube of flow. Syn. *stream tube.*

tube of force. A region in a field of force, of tubular form, having its lateral surface made up of lines of force, so that the intensity at any point of that surface is tangential to it, and the flux is the same through all cross sections.

tube of magnetic induction. A magnetic circuit so bounded as to have the same magnetic flux, (esp. unit flux) through every cross section.

tube spectrometer. A type of photographic x-ray spectrometer, devised by Siegbahn and Larsson. (See Larsson, *Phil. Mag.* 3, 1136, 1927.)

tube voltmeter. An adaptation of the thermionic vacuum tube to the measurement of small a.-c. voltages. (See Powers and Alderman, *J.O.S.A.* 17, 379, 1928.)

tuning coil. A coil of variable inductance, used to adjust the natural frequency of an oscillatory circuit.

tuning condenser. A condenser of variable capacitance, used to adjust the natural frequency of an oscillatory circuit.

tuning fork siren. An apparatus designed by Lord Rayleigh, having an adjustable slit in the side of a wind chest, the width of which is controlled by the vibrations of a tuning fork. When air emerges through the slit, the tuning fork is thereby maintained in vibration. (See Rayleigh, *Phil. Mag.* 13, 329, 1907; Jones, *R.S.I.* 5, 193, 1934.)

turbidimeter. An instrument for measuring the turbidity of a liquid, as in water-purification plants. Syn. *opacimeter. Cf. nephelometer.* (See Walsh, Photometry, 1926, p. 385; Weir, *J. Am. Water Works Assoc.* 25, 584, 1933.)

turbidity. A property of a medium which renders it imperfectly transparent, due to having particles in suspension, *e.g.*, milky or muddy water.

turbidity coefficient. Syn. *Ångström coefficient.*

turbidity factor. The percentage of reduction of solar radiation of a given wave length received upon the earth's surface, because of haze or other type of turbidity in the atmosphere.

turbulence. Irregular motion of a moving fluid, caused by an impediment in the stream, by friction, or by vortex action. Syn. *sinuosity.*

turn-flux. Syn. *linkage* (2), *flux-turns.*

turnover. The lack of symmetry in the filament-plate current fluctuations of a vacuum tube circuit, due to the fact that the increase in current caused by a given increase in grid potential is not equal to the decrease in current caused by an equal decrease in grid potential. (See Brown, Radio Frequency Elec. Meas., 1931, p. 271.)

twin axis. The line perpendicular to both crystalline axes of a twin crystal.

twin crystal. A crystal composed of two parts having axes in different directions, usually at right angles. They may be *juxtaposed twins, i.e.*, merely grown together, with a plane of separation between; or *interpenetrant twins, i.e.*, having their structures intimately commingled.

two-phase current. 1. A current service delivered through two pairs of wires forming separate circuits in which a phase difference of one-quarter cycle is maintained. A *two-phase generator* supplies, and a *two-phase motor* is operated by, such a current. 2. The same as (1), except that the two circuits are con-

nected and usually grounded at their extremities or neutral points, forming a true polyphase system of four components. *Cf. three-phase current.* (See A.I.E.E. Comm. Rep., 1932.)

Tyndall effect. The scattering of light by very small suspended particles, which was theoretically investigated by Tyndall, but first described by Faraday. The scattered light is polarized to an extent which is greater, the smaller the particles. For diameters less that 0.1 micron the polarization is complete. (See Burton, Phys. Properties of Colloidal Solutions, 1921, p. 2.)

U

(Please note purpose of references as explained in preface.)

Ulbricht sphere. An integrating sphere used in a sphere photometer; so called because of the first adaptation of the Sumptner principle to this use by Ulbricht in 1900. (See Hardy and Perrin, Prin. of Optics, 1932, pp. 268 ff.)

ultimate strength. The limiting stress for which a material completely breaks down and gives way, *e.g.*, when a steel rod is pulled asunder or a block of stone is crushed.

ultra-ionization potential. A definite electron potential which elicits a responsive ionization, but which is greater than that corresponding to the ordinary excitation limit. (See Shenstone, *Phys. Rev.* 38, 873, 1931.)

ultramicrometer. An instrument for the measurement of very small displacements, esp. by electrical means, *e.g.*, by the variation of an electrical capacitance. (See Obata, *J.O.S.A.* 16, 419, 1928; Ekelöf, *J.O.S.A.* 18, 337, 1929.)

ultramicroscope. An arrangement consisting of a powerful microscope whose field is illuminated by a strong beam of light from one side, so that extremely minute objects (or the diffraction patterns produced by them) are visible against a dark background.

ultrashort waves. The shortest electromagnetic waves employed in radio communication; specifically, those below 10 m in wave length or above 30,000 kc per second in frequency. Syn. *microwaves.*

ultrasonic. Having a frequency above that of audible sound. Syn. *supersonic. Cf. infrasonic.*

ultraviolet. A range of invisible radiation frequencies immediately adjoining the visible violet, and extending into the region of low-frequency x-rays.

umbra. That part of a shadow from which light from the source is completely excluded by the opaque obstacle. *Cf. penumbra.*

uncertainty principle. A feature of the quantum mechanics of Heisenberg, which postulates that complete information as to the mechanism of processes taking place on the electronic scale of magnitude, in terms of the usual geometrical co-ordinates and of time, is impossible. *E.g.*, the position and the velocity of an electron are, according to this

principle, incapable of simultaneous expression in terms of these conventions. Syn. *indetermination principle.* (See Ruark and Urey, Atoms, Molecules, and Quanta, 1930, p. 617; Darwin, *Science* 73, 653, 1931.)

undulatory. Pertaining to or consisting of waves.

uniaxial. Having but one optic axis. *Cf. double refraction.*

unified field theory, unitary f. t. A phase of the general relativity theory which seeks to treat gravitational, electric, and magnetic fields as aspects of a single entity.

uniform flow. A condition of flow in which the cross section of every stream tube remains constant, each particle moving along its streamline with constant speed. *Cf. steady flow.* (See Daugherty, Hydraulics, 1937, p. 267.)

unipolar induction. The generation of an e.m.f. by a continuous cutting of magnetic flux in one direction, without reversal or cyclic action; *e.g.*, as in a metal disk rotating continuously between the poles of a magnet. (See Pegram, *Phys. Rev.* 10(2), 591, 1917.)

unit cell. The simplest geometric figure which includes all the characteristics of, and is repeated indefinitely to form, the lattice structure of a crystal. Syn. *elementary cell, lattice unit.* (See Davey, Study of Crystal Structure and Its Applications, 1934, p. 28.)

unit crystal. Syn. *unit cell, lattice unit, elementary cell.*

unit planes. *Cf. principal plane* (2).

unit points. Syn. *principal points.*

unit pole (c.g.s. magnetic). An ideal magnetic point pole, two of which, at a distance of 1 cm apart in a vacuum, would exert a mutual repulsion (or attraction) of 1 dyne. Such a pole gives rise to 4π maxwells of free magnetism. Actual magnetic poles are often treated quantitatively as if made up of a number of unit poles equal to the "pole strength." (See A.I.E.E. Comm. Rep., 1932.)

united atom. An ideal atom which would be formed from a given molecule if all its atomic nuclei were united into one.

univariant. Having one degree of freedom, *i.e.*, variance unity. (See Planck, Treatise on Thermodynamics, 1927, p. 187.)

universal shunt. A type of shunt devised by Ayrton for use with galvanometers in order to increase their range, but without change of damping. Syn. *Ayrton shunt.* (See Ferry, Handbook of Phys. Meas., 1918, v. 2, p. 145.)

unmodified line. *Cf. Compton effect, Raman e.*

unquantized state. A state of an atom in which there are electrons whose motion is not subject to quantum conditions, and which give rise to continuous spectral bands rather than lines. (See White, Int. to Atomic Spectra, 1934, p. 33.)

upper state. That one of the two energy states or levels, before and after a quantum transition, in which the atom or the molecule has greater electronic energy. *Cf. lower state.* (See Kaplan, *Phys. Rev.* 45, 675, 1934.)

uranium series, uranium-radium s. One of the principal radioactive series, beginning with uranium and including radium.

uviol glass. A glass developed by Schott, highly transparent to ultraviolet. (See Luckiesh, Ultraviolet Radiation, 1922, p. 83.)

V

(Please note purpose of references as explained in preface.)

vacancy principle. (Ger. *Lückensatz.*) States that a configuration of q of the p electrons of given principal and azimuthal quantum numbers, required to complete a closed group, gives rise to spectral terms having the same J values as those which arise from a configuration of $p - q$ of the same electrons. (See Compton and Allison, X-Rays in Theory and Experiment, 1935, p. 613.)

vacuum spectrograph. A spectrograph which operates in a vacuum, so as to introduce no air-absorption of the emission under examination.

vacuum tube. A general term applying to tubes or bulbs supplied with electrodes between which electric discharge takes place, and operated at pressures ranging from slightly below atmospheric to the lowest attainable. Syn. *discharge tube.* Radio tubes and other triodes are also included. *Cf. Crookes tube, electron t.*

vacuum weight. The weight obtained for an object when the result of weighing is corrected for the buoyancy of the air, *i.e.*, the weight *in vacuo.*

valence, valency. *In re* an electronegative chemical ion: the number of hydrogen ions or other univalent ions with which it is combined or is capable of combining. *In re* a positive ion: its combining power as compared with hydrogen, or the number of hydrogen ions which it displaces in chemical combination. Grimm defines the *absolute valence* of an atom as the number of its electrons which are engaged in attaching the other atoms of the molecule to it. *Cf. orbital valence, valence electron.* (See Sidgwick, Electronic Theory of Valency, 1929, p. 181.)

valence electron. An outer electron of an atom, which does not form part of a closed shell, and which apparently is concerned in chemical combination. Syn. *peripheral electron.*

valve. 1. A controlled inlet or outlet, esp. one permitting only a unidirectional flow. 2. An electric current rectifier, esp. of the electrolytic or thermionic type. *Cf. light valve.*

van der Bijl equation. An empirical equation which expresses the plate current I_P in a triode in terms of the plate voltage V_P and the grid voltage V_G:

$$I_P = a(V_P + \mu V_G + c);$$

in which a and c are constants and μ is the amplification factor. (See Hoag, Electron Phys., 1929, p. 54.)

van der Waals equation. An empirical, or partially empirical, characteristic equation, the first

successful approximation of the behavior of real gases:

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT,$$

in which p is the pressure in atmospheres, v is the volume of the gas *in terms of its volume at N.T.P. as the unit*, and a and b are the van der Waals constants, dependent upon the gas.

van der Waals forces. The molecular interactions in a gas, of which account is taken in the construction of the van der Waals equation; the attractive forces by the constant a and the repulsive forces by the constant b of that equation.

van der Waals potential. A term used in connection with the potential energies corresponding to the attractive forces between atoms and atoms or between molecules and molecules in a gas, which are taken into account by the use of the constant a in the van der Waals equation. (See Mayer, *J. Chem. Phys.* 1, 270, 1933.)

van't Hoff factor. A factor by which, according to van't Hoff, the molecular weight of an electrolyte as calculated from the freezing point law must be multiplied to give its true molecular weight. (See Kraus, Properties of Electrically Conducting Systems, 1922, p. 38.)

van't Hoff law. States that the vapor pressure of a solvent is lowered by the addition of a nonvolatile solute in proportion to the molar concentration of the solute. Syn. *Wüllner law. Cf. Raoult law.* (See Planck, Treatise on Thermodynamics, 1927, pp. 207, 255; Lewis and Randall, Thermodynamics, 1923, p. 236.)

vapor. A gaseous substance at a temperature below the critical temperature. *Cf. gas.*

vapor density. 1. The density of a vapor in the usual mass and volume units. 2. The ratio of the density of a vapor or of a gas to that of hydrogen at the same temperature and pressure.

vapor pressure. The pressure of the vapor of a liquid kept in confinement so that the vapor can accumulate above it. At any temperature it approaches a fixed maximum limit, called the *maximum vapor pressure* or *saturated v.p.*, dependent only upon the liquid and the temperature. Syn. *vapor tension* (obsolescent).

vapor-pressure constant. A constant term which appears in the formula for the logarithm of the vapor pressure of a liquid in terms of temperature, in accordance with thermodynamic theory. (See Sterne, *Phys. Rev.* 39, 993, 1932.)

vapor-pressure thermometer. A thermometer whose indications are based upon the maximum vapor pressure of a liquid.

vaporimeter. An instrument for measuring vapor pressures of volatile liquids. (See Couch, Dict. of Chem. Terms, 1920.)

vaporization curve. *Cf. equilibrium curve.*

variables of state. The variables, *e.g.*, pressure, volume, temperature, and entropy, which determine the physical state of a body, and in terms of which its thermo-

dynamic transformations are expressed. *Cf. reduced variables of state, equation of state.*

variance. The number of degrees of freedom of a system. *Cf. phase rule.*

variation principle. States that if the kinetic energy minus the potential energy of a particle is denoted by L, and if we assume a slightly different, arbitrary path to be followed, in the time interval t_1 to t_2, from the one actually followed under the forces in operation, then the resulting variation of the integral

$$\int_{t_1}^{t_2} L dt$$

is equal to zero. (See Birtwistle, Quantum Theory of the Atom, 1929, p. 48.)

variometer. 1. A variable inductance provided with a scale, arbitrary or otherwise. *Cf. inductometer.* 2. A device for measuring or recording variations in terrestrial magnetism.

vector. A quantity which is fully specified when and only when there are given its magnitude and an associated direction in space; *e.g.*, a velocity or a magnetic intensity.

vector polygon. A polygon (not necessarily plane) whose sides represent a number of similar vectors, and the completion or "closing" of which indicates that the vector sum is zero; *e.g.*, the force polygon for a set of forces in equilibrium.

vector potential function. A variable vector V, so related to another variable vector R that R is the curl of V. V is then said to be a vector potential function of R. (See Peirce, Newtonian Potential Function, 1902, p. 112.)

vector product. *In re* two vectors, P_1, P_2: a vector whose magnitude is the product of the magnitudes of the two vectors and the sine of the angle between them; and whose direction is that of the perpendicular to both of them, such that while looking along this direction one would have to turn the vector P_1 clockwise to make it coincide with the vector P_2. Designated by $P_1 \times P_2$. *Cf. scalar product.*

vector radiant. Syn. *Poynting vector. Cf. Poynting theorem.*

Vegard-Kaplan bands. Spectral bands due to metastable nitrogen molecules; discovered by Vegard in the spectrum of the aurora borealis and by Kaplan in the nitrogen afterglow. (Kaplan, *Phys. Rev.* 45, 675, 1934.)

Vegard law. States that when two substances A and B having similar crystalline structure form together a solid solution, the lattice constant of the solution divides the interval between the lattice constants of A and of B in proportion to the relative amounts of A and of B present. (See Clark, Applied X-Rays, 1927, p. 160; Havighurst, Mack, and Blake, *J. Am. Chem. Soc.* 47, 29, 1925.)

velocity. 1. (*Linear.*) A vector quantity which denotes at once the time rate and the direction of a linear motion. *Cf. speed* (1). 2. (*Angular.*) A vector quantity which denotes both the time rate and the direction of the axis of a rotation. Syn. *rotational velocity.* 3. A general term for time rate,

e.g., the velocity of a chemical reaction.

velocity of escape. 1. The speed with which a projectile or a particle would have to leave the surface of the earth or other planet in order never to return. *Cf. parabolic velocity.* 2. The speed with which an electron or other ion escapes from a conductor in thermionic or photoelectric emission, or with which a molecule emerges from a liquid in evaporation.

velocity potential. A function ϕ associated with the motion of a fluid and such that when the motion is referred to three coordinate axes x, y, z and the respective velocity components are denoted by u, v, w, then

$$-\frac{\partial \phi}{\partial x} = u, \quad -\frac{\partial \phi}{\partial y} = v, \quad -\frac{\partial \phi}{\partial z} = w.$$

(See Lamb, Hydrodynamics, 5th ed., p. 15.)

velocity space. Defined in the same manner as *momentum space* (*q.v.*), but with *velocity* substituted for *momentum.*

velocity spectrograph, v. analyzer. An apparatus for separating an emission of electrically charged particles into distinct streams in accordance with their speeds, by means of magnetic or electric deflection. *Cf. magnetic spectrograph, mass s.*

vena contracta (Lat.). The contracted jet in which a liquid emerges from an orifice. The ratio of its area of smallest cross section to the area of the orifice is the *contraction coefficient.*

Venturi meter. An hourglass-shaped constriction in a pipe carrying a fluid, by means of which it is possible to compute the rate of flow from the pressure difference between the main pipe and the point of least diameter, in accordance with the Bernoulli law.

Verdet constant. The angle of optical rotation per oersted intensity per centimeter thickness in the Faraday effect. Syn. *specific magnetic rotatory power. Cf. Kundt constant.* (See Williams, Magnetic Phenomena, 1931, p. 167; Serber, *Phys. Rev.* 41, 490, 1932.)

vergency. Either divergence or convergence of rays from a lens or a mirror, expressed as the reciprocal of the distance from lens or mirror to the focus of the rays. (See Moffitt, *J.O.S.A.* 12, 47, 1926.)

vernier. A device applied to the graduated scale on many instruments, which serves at the same time as an index and as a means of subdividing the smallest scale unit into tenths or other aliquot parts. Named for its inventor, Pierre Vernier.

versor. That factor of a vector which determines its geometrical direction and which is multiplied by the tensor to give the complete expression for the vector.

vertex. That point of a refracting or a reflecting surface at which the axis of the optical system intersects it.

vertical. 1. The direction of gravity. 2. (*Geocentric.*) The direction of the radius of the earth. The two coincide, in general, only at the poles and at points on the equator.

vertical intensity. The intensity of the vertical component of the earth's magnetic field at any point. *Cf. magnetic element* (3).

vibration galvanometer. A type of a.-c. galvanometer in which the natural oscillation frequency of the moving element is equal to the frequency of the a. c. applied to it. (See Smythe and Michels, Advanced Elec. Meas., 1932, p. 154.)

vibration spectrum. *Cf. molecular spectrum.*

vibrational analysis. The analysis of a molecular spectrum into bands, with the assignment of a definite pair of vibrational quantum numbers to each band, and the determination of a formula for all the bands in terms of these two quantum numbers. (See Brown, *Phys. Rev.* 42, 355, 1932; Jevons, Report on Band Spectra of Diatomic Molecules.)

vibrational quantum number. A quantum number, associated with the vibration of the atoms about mean positions in a molecule, which must be an integer for any permissible stationary state of such vibration.

vibrational specific heat. That part of the specific heat of a substance which pertains to the energy of internal vibration within the molecule, as distinct from translational motion and rotation. *Cf. rotational specific heat.*

vibroscope. An apparatus, consisting of tuning forks vibrating at right angles, used by Lissajous for studying harmonic motions. *Cf. Lissajous curves.* (See Richardson, Sound, 1929, p. 84.)

vicinal. *In re* a crystal face: lying in a subordinate plane, not one of the usual planes of cleavage or of external growth, and not in accordance with the Haüy law. (See Tutton, Natural History of Crystals, 1924, pp. 51, 270.)

Victor-Meyer apparatus. A volumetric apparatus for measuring vapor densities of volatile substances, and hence, indirectly, their molecular weights.

Villari reversal. A change in the sign of the Joule effect (1) as the magnetization increases. First detected (in iron) by E. Villari, 1865.

virial. A quantity which appears in the general dynamic equation of a mass of gas molecules. It is half of the sum of the average products of the co-ordinates of the molecules by the corresponding components of force acting upon them, and, according to the *virial theorem* of Clausius, is equal to the negative of the total kinetic energy of the molecules. (See Tolman, Statistical Mech., 1926, p. 62; Loeb, Kinetic Theory of Gases, 2d ed., pp. 151 ff.)

virial coefficients. The coefficients A, B, . . . , of an inverse-power series in v representing the product pv in the equation of state for a real gas:

$$pv = A + Bv^{-1} + Cv^{-2} + Dv^{-4} + \cdots.$$

The coefficients are functions of the temperature. (See Loeb, Kinetic Theory of Gases, 2d ed., pp. 195 ff.; Gropper, *Phys. Rev.* 50, 963, 1936.)

virtual displacement. The projection, on the original line of action

of a force, of the path followed by the point of application of the force during an infinitely small displacement.

virtual image. *Cf. image.*

virtual oscillator. An ideal electric oscillator, consisting of a charged point executing harmonic motion; a concept used in developing the classical theories of radiation. (See Breit, *Rev. Mod. Phys.* 5, 91, 1933.)

virtual velocity. That component of the velocity (of a particle) which is in the direction of a given force, in any assumed displacement through the position of equilibrium. *Cf. virtual displacement.*

virtual work. The quantity of work done during an infinitely small displacement ds under the action of either a constant or a variable force f. If the force and the displacement are at an angle ϕ, then the virtual work is $dw = f \cos \phi \, ds$.

virtual-work principle. States that a condition for the equilibrium of a system is that the total virtual work due to all internal and external forces acting upon the system is zero; or in other words, that the potential energy of the system is a minimum or a maximum or constant. (See Newman and Searle, General Properties of Matter, 1929, p. 30.)

viscidity. That combination of cohesion and viscosity in a liquid which results in its being "sticky" and capable of being drawn out into fine threads, *e.g.*, glue.

visco-elasticity. That property of a body, by virtue of which deformations are reversible and without dissipation of energy when produced at infinitely slow rates, but not so at finite rates.

viscometer, viscosimeter. An apparatus for measuring the viscosity of a fluid.

viscosity. 1. A property of fluids, by virtue of which they offer a resistance to flow, and which involves their yielding to a certain amount of shearing stress. A fluid is said to be *viscous* or *limpid* according as this property is conspicuous or negligible. 2. Syn. *viscosity coefficient.*

viscosity coefficient. The shearing stress involved in maintaining the uniform flow of a fluid, per unit rate of shear. Syn. *viscosity* (2). *Cf. kinematic viscosity coefficient, relaxation time* (4).

viscosity manometer, v. gauge. A low-pressure manometer dependent upon the variation of the viscosity of the gas with pressure; *e.g.*, the molecular gauge. (See Dunoyer, Vacuum Practice, 1926, pp. 112 ff.)

visibility factor. For radiation of a given wave length: the ratio of the luminous flux at that wave length to the corresponding radiant flux. For the normal eye it has a maximum in the green, of about 660 lumens per watt. An expression for this factor in terms of wave length is called a *visibility function. Cf. luminous efficiency.* (See Walsh, Photometry, 1926, p. 464.)

visibility function. *Cf. visibility factor.*

visibility meter. An instrument for measuring the clearness of definition with which an object can be

seen under given circumstances. (See Bennett, *J.S.I.* 8, 122, 1931.)

visual angle. The angle formed at the eye by any two rays of light entering it. *Cf. apparent diameter.*

visual axis. The line joining the fixation point of the ocular field of view with the first nodal point of the eye.

Voigt-Thomson symmetry relation. An expression for the value of a (vector) property of a crystal in a given direction in terms of two principal values, one parallel to a rotation axis of symmetry and the other perpendicular thereto. When the relation holds, the value in a direction making an angle θ with this axis is a linear function of $\cos^2\theta$. The two principal values correspond to $\theta = 0$ and $\theta = 90$ deg., respectively. (See Linder, *Phys. Rev.* 29(2), 554, 1927; Cinnamon, *Phys. Rev.* 46, 215, 1934.)

volt. The practical unit of e.m.f. and potential. The *absolute volt* is equal to 10^8 abvolts. The *international volt* is that e.m.f. which, when applied to a resistance of 1 international ohm, maintains a current of 1 international amp. The ratio of the international to the absolute volt is about 1.00046. *Cf. electron-volt.* (See A.I.E.E. Comm. Rep., 1932; Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

volt-ampere. The practical unit of apparent power (effective volts times effective amperes) in a variable-current circuit.

volt box. A series arrangement of fixed resistances, used to obtain the value of a voltage by measuring a known fraction of it, in accordance with the law of fall of potential. (See A.I.E.E. Comm. Rep., 1932; Zeleny and Erikson, Manual of Phys. Meas., 1923, p. 152.)

volt-electron. Syn. *electron-volt.*

volt-second. The practical unit of magnetic flux, equal to 10^8 maxwells. Syn. *weber* (1). (See I.C.T., 1926, v. 1, p. 42.)

Volta effect, V. potential. Syn. *contact potential difference.*

Volta law. States that the contact p.d. of two conductors is the same, whether they are in direct contact or joined through one or more intermediate conductors.

voltage multiplier. A series arrangement of condensers charged by rapidly rotating brushes, resulting in a high d.-c. voltage. (See Anderson, *R.S.I.* 7, 243, 1936.)

voltaic couple. A pair of dissimilar metals in contact, which results in a contact p.d. *Cf. Volta law.*

voltaic potential difference. Syn. *contact potential difference, Volta effect.*

voltameter. Syn. *coulombmeter.* Not to be confused with *volt-ammeter* (*q.v.*).

volt-ammeter. An instrument which may be used either as a voltmeter or as an ammeter. Not to be confused with *voltameter* (*q.v.*).

voltmeter. An instrument for measuring e.m.f., usually directly in volts or in multiples or submultiples thereof.

voltmeter resistor. A resistance used with a galvanometer or other current-measuring instrument to convert it into a voltmeter. *Cf. potential galvanometer.*

volume photoelectric effect. True or primary photoconductivity, apart from the secondary effects usually associated with it. (See Hughes and DuBridge, Photoelectric Phenomena, 1932, p. 284.)

volume velocity. *In re* any flow or flux across a plane: the product of the linear speed of flow, or of propagation, by the cross-sectional area through which the flow is considered. Multiplied by the density (quantity per unit volume), it gives the flux; in case quantity is measured by volume, it equals the flux.

vortex. A portion of a fluid which rotates about an axis with resulting centrifugal force and reduced pressure at the axis, and which is surrounded by a relatively stationary portion of the same fluid. The *strength* of an ideal vortex is its integrated vorticity, or twice the product of its angular speed of rotation by its cross section. (See Richardson, Sound, 1929, pp. 143 ff.)

vortex ring. A type of votex motion of a fluid, illustrated by the familiar smoke ring.

vorticity. A measure of the extent to which the motion of a fluid is rotational. Its value at any point is the curl of the particle velocity, or twice the angular velocity of rotation of the fluid element, at that point; it is thus a vector quantity. (See Lamb, Hydrodynamics, 5th ed., p. 30.)

Vreeland oscillator. A device for producing a sinusoidal electric current by means of a mercury arc in a periodically varying magnetic field. (See Smythe and Michels, Advanced Elec. Meas., 1932, p. 130.)

W

(*Please note purpose of references as explained in preface.*)

Wadsworth mirror. A plane mirror used in certain forms of prism spectrometer in which the prism is used at minimum deviation. (See Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 113.)

Wagner ground. A device for preventing false indications of the detector in a.-c. bridge measurements, due to capacitance effects between the bridge and the ground. (See Brown, Radio Frequency Elec. Meas., 1931, p. 66; Stratton, *J.O.S.A.* 13, 471, 1926.)

Waidner-Burgess standard. A standard of luminous intensity, designed to supplant the Bureau of Standards *candle.* Defined as the luminous intensity of 1 cm^2 of a black body at the melting point of platinum. *Cf. platinum standard.*

Walden law. States that the limiting equivalent conductance of a solution (at infinite dilution) is inversely proportional to the viscosity coefficient of the solvent, the constant being the same for all solvents. (See Newman, Electrolytic Conduction, 1931, p. 86.)

water calorimeter. A calorimeter which measures quantities of heat by the change in temperature of a known mass of water.

water equivalent. The mass of water which would have the same thermal capacity as a given body, such as a calorimeter cup.

water of crystallization. Water molecules incorporated in the structure of a crystal.

watt. A unit of power, defined as 1 joule of work per second.

watt-hour. A unit of work or energy, equivalent to 1 watt of power operating for 1 hr, and equal therefore to 3,600 joules or 3.6×10^{10} ergs.

wattmeter. An instrument for measuring electric power in watts.

wave equation. An equation which gives a mathematical specification of a wave process, or describes the performance of a medium through which a wave is passing.

wave filter. *Cf. filter* (2), (3), and (4).

wave form. A curve which graphically represents the magnitude of a wave variable (as ordinate) in its relation to distance along the path of propagation (as abscissa).

wave front. A surface connecting all points of a wave-propagating medium which are in the same given phase of the same order.

wave function. A point function, commonly represented by ψ, which in a wave equation specifies the amplitude of a wave variable at any point of the region traversed by the waves.

wave group. The resultant of two or more wave trains of different frequency traversing the same path. *Cf. group velocity, wave packet.* (See Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 148.)

wave guide. A dielectric of limited cross section, used to transmit electromagnetic waves. (See Southworth, *Bell Syst. Tech. J.* 15, 284, 1936.)

wave length. The distance between successive points in the same phase along a line in the direction of propagation of a wave train.

wave mechanics. A general physical theory which ascribes wave characteristics to the fundamental entities of atomic structure and seeks to interpret all physical phenomena in terms of hypothetical wave forms. Introduced by Schroedinger in 1926.

wave meter. A calibrated electric resonator of variable frequency, used for measuring electric oscillation or wave frequencies. *Cf. heterodyne wave meter, frequency m.*

wave number. The reciprocal of a wave length, *i.e.*, the number of waves per unit distance in the direction of propagation.

wave packet. 1. A group of wave trains so related as to wave length, velocity, phase, and amplitude that when they are combined the resultant wave is approximately a single pulse of definite amplitude advancing with a definite speed. 2. In general, a wave disturbance which is confined to a limited volume of space. *Cf. wave group, group velocity.* (See Mott, Outlines of Wave Mech., 1930, p. 39; MacColl, *Phys. Rev.* 40, 621, 1932.)

wave plate. *Cf. quarter-wave plate, half-wave plate.*

wave variable. A quantity which varies progressively and periodically at any point in a field of

waves, and whose variations, moving forward, constitute a characteristic feature of the wave propagation. *E.g.*, in the case of sound, pressure is a wave variable. *Cf. wave form.*

wave velocity. Syn. *phase velocity.*

weber. 1. Syn. *volt-second.* 2. An obsolete name for the coulomb. 3. An obsolete name for the ampere. 4. An obsolete unit of magnetic pole strength, equal to 10^8 times the (c.g.s.) unit magnetic pole.

Weber energy equation. An equation developed in 1846, expressing the total mutual electric and magnetic energy of two moving charges e_1, e_2 at distance r apart, as follows:

$$\psi = \frac{e_1 e_2}{r}\left[1 - \frac{1}{2c^2}\left(\frac{dr}{dt}\right)^2\right],$$

in which c is the electromagnetic constant.

Weber unit. An electromagnetic unit of electric current based on the millimeter, milligram, and second; hence equal to 0.01 c.g.s. electromagnetic unit (abampere). Not to be confused with *weber* (*q.v.*).

wedge photometer. A photometer in which the intensity of the light from one source or both sources to be compared is varied by means of a wedge of absorbing material pushed into the beam until the requisite thickness has been interposed. (See Walsh, Photometry, 1926, p. 179.)

Wehnelt cathode. A type of hot cathode consisting of a metallic core coated with alkaline earth oxides. (See Hoag, Electron Phys., 1929, p. 28.)

Wehnelt interrupter. An interrupter in which the current passes between a fine wire and an electrolytic solution, and is interrupted by the formation and collapse of small bubbles of vapor.

weight. 1. (n.) The force which a mass experiences because of being in a gravity field, esp. that of the earth. 2. A body of known mass, used in measuring the masses of other bodies by weighing. 3. One of the abstract numbers sometimes assigned to each of a set of data, such as results of measurements, to denote their relative importance or reliability, and taken into account in averaging or adjusting them. (See Weld, Theory of Errors and Least Squares, 1929, p. 124.) 4. (v.) To apply or assign a weight, *e.g.*, a weighted float, the weighted mean of several measurements, etc.

Wertheim effect. A change in the helical (circular) magnetization of a ferromagnetic wire or rod when twisted; detected by the corresponding longitudinal e.m.f. Discovered by G. Wertheim in 1852, and by G. Wiedemann in 1862. Syn. *Wiedemann effect* (1). *Cf. Matteucci effect.*

Weston cell. A standard cell whose positive electrode is mercury and negative electrode cadmium, with a saturated cadmium sulphate solution as electrolyte. Mercurous sulphate is added as a depolarizer.

wet-and-dry-bulb thermometer. A hygrometer consisting of two identical thermometers, the bulb of one of which is kept wet with water supplied by a wick. The lowering of the temperature by

evaporation indicates the relative humidity of the air. Syn. *psychrometer.*

Wheatstone bridge. A branched electric circuit used for the measurement of resistances by a balance method.

white light. Any one of a variety of spectral energy distributions producing the same color sensation as average noon sunlight. (See Judd, *J.O.S.A.* 23, 361, 1933.)

white radiation. Any radiation which produces a continuous spectrum. For x-rays there is a sharply defined short-wave-length limit determined by the Duane-Hunt law. *Cf. white light.* (See Wollan, *Rev. Mod. Phys.* 4, 216, 1932.)

width-at-half-maximum. Syn. *half-width.*

Wiedemann effect. 1. Syn. *Wertheim effect.* 2. Torsional magnetostriction in a ferromagnetic wire or rod; discovered by G. Wiedemann in 1862.

Wiedemann-Franz law. States that the ratio of the thermal conductivity of a metal to the product of the electrical conductivity by the absolute temperature (*Wiedemann-Franz ratio*) has for all metals approximately the same value, *viz.* 5.345×10^{-9} cal ohm/sec deg^2. Known also as the *Wiedemann-Franz-Lorenz law.*

Wiedemann law. States that the molar susceptibility of a substance in solution is independent of the concentration. (See I.C.T., 1926, v. 6, p. 349.)

Wien bridge. A type of capacitance bridge circuit developed by M. Wien. (See Smythe and Michels, Advanced Elec. Meas., 1932, p. 159.)

Wien displacement constant. The constant which in accordance with the Wien displacement law (*cf. Wien laws* (1)) represents the product of the maximum-emissivity wave length and the absolute temperature of the radiator. Its value is about 0.2884 cm-deg. (See Birge, *Rev. Mod. Phys.* 1, 1, 1929.)

Wien laws (of thermal radiation.) Three laws formulated by W. Wien in the 1890's: 1. The wave length at which the monochromatic emissivity of a black body is a maximum is inversely proportional to the absolute temperature of the body (Wien "displacement law"). *Cf. Wien displacement constant.* 2. The monochromatic emissive power for this "peak" wave length is proportional to the fifth power of the absolute temperature. 3. The spectral energy distribution of black-body radiation for temperature T is given by the formula

$$dE_\lambda = A\lambda^{-5}e^{-\frac{B}{\lambda T}}d\lambda;$$

in which dE_λ is the emissive power within wave-length range $d\lambda$ and A and R are constants. Not accurate at long wave lengths. *Cf. Rayleigh-Jeans law, Planck equation.*

Wilson (cloud) chamber. An enclosure containing air supersaturated by sudden expansion, in which rapidly moving particles, *e.g.*, alpha or beta rays, produce ionization tracks by condensation on the ions. These may be observed or photographed through a suitable window. *Cf. cloud track.*

Wilson experiment. An experiment of H. A. Wilson, which consisted in the rotation of a hollow dielectric cylinder about an axis parallel to a magnetic field, with arrangements for detecting the resulting electric polarization in the dielectric. (See Tolman, Theory of Relativity of Motion, 1917, p. 186.)

Wimshurst machine. A type of static machine having two plates, or two sets of plates, rotating in opposite directions.

wind meter. Syn. *anemometer.* (See Hulburt, *R.S.I.* 4, 501, 1933.)

wiredrawing. Syn. *throttling.*

Wollaston prism. 1. Syn. *double-image prism.* 2. A large, quadrilateral reflecting prism of glass, used for sketching. (See Percival, Geometrical Optics, 1913, p. 111.)

work. A physical magnitude relating to the transfer of energy from one body to another through the agency of mechanical force. Its measure is the scalar product of the force by the simultaneous linear displacement.

work function. A general term applied to the energy required to transfer electrons, ions, molecules, etc. from the interior of one medium across the boundary into an adjacent medium. It is of especial significance in photoelectric and thermionic emission, sometimes referring to energy per unit charge and expressed in ergs or joules, sometimes to energy per electron and then expressed in electron-volts. *Cf. photoelectric work function, thermionic w.f.*

working substance. A substance whose changes of volume and pressure figure in a thermodynamic process, as in the operation of a heat engine. *Cf. thermodynamic transformation.*

world line. The graph in space-time co-ordinates which represents any continuous sequence of events relating to a given particle. (See Jeans, New Background of Science, 1933, p. 101; Birkhoff, Relativity and Modern Phys., 1923, p. 23.)

X

(*Please note purpose of references as explained in preface.*)

x-ray spectrometer, x-r. spectrograph. An apparatus for measuring the wave lengths of x-rays by means of their reflection by crystals; somewhat analogous to a grating spectrometer for light, the crystal taking the place of the grating. In the spectrograph form the reflected rays are photographically recorded.

x-ray vacuum. A region in which the gas pressure has been reduced below 0.01 mm; so called because a pressure as low as this is necessary in an x-ray tube.

x-rays. A type of electromagnetic radiation of wave length varying from 10^{-9} to 10^{-7} cm, and highly penetrating; discovered by Roentgen in 1895. Syn. *Roentgen rays, R. radiation.*

x-unit. A unit of wave length, equal to 10^{-11} cm or 0.001Å; commonly used for x-rays and other highly penetrating radiation. Syn. *Siegbahn unit.*

Y

(Please note purpose of references as explained in preface.)

yield point, y. value. A value of the tensile stress, somewhat greater than the elastic limit, for which a rod of elastic material under tension begins to exhibit plasticity and stretches irregularly. Sometimes applied also to the corresponding shearing stress. (See I.C.T., 1926, v. 2, p. viii; Bingham, Fluidity and Plasticity, 1922, p. 217.)

Young interference experiment. An epochal experiment, performed by Thomas Young in 1801, which demonstrated the interference of light from two sources and thereby established its undulatory character.

Young modulus. The ratio of the tensile stress, or longitudinal force per unit cross section, in a stretched elastic solid to the change in length per unit length. *Cf. stress, modulus of, elastic m.*

Z

(Please note purpose of references as explained in preface.)

Zeeman effect. An effect upon the spectral series of gaseous elements produced by subjecting the radiating atoms to a strong magnetic field; discovered by Zeeman in 1896. The lines are split up into more or less complicated multiplets, depending upon the direction of the field and other circumstances; and the effect may be either "normal" or "anomalous," *i.e.*, it may or may not be subject to a comparatively simple quantum explanation. *Cf. Runge rule, Lorentz triplet, L. unit.* (See Pauling and Goudsmit, Structure of Line Spectra, 1930, p. 69.)

zero branch. A series of lines in an absorption band of a molecular spectrum, in the production of any one of which there is no change in the rotational quantum number. (See Rawlins and Taylor, Infrared Analysis of Molecular Structure, 1929, p. 26.)

zero-field emission. The thermionic emission from a hot conductor surrounded by a region of uniform electric potential. (See Found, *Phys. Rev.* 45, 519, 1934.)

zero line. A wave length in an absorption band in certain types of molecular spectrum, which corresponds to a gap in the sequence of absorption lines, and which marks an origin or axis for the band as a whole. Syn. *missing line. Cf. branch.*

zero-point energy. The energy possessed by a thermodynamic system in any prescribed condition taken as a zero of reference; in particular, at the absolute zero of temperature.

zonal aberration. Spherical or monochromatic aberration of a lens of wide aperture, due to the

fact that the refracting power is different for different zones concentric at the axis.

zone. 1. A belt of crystal faces extending around a crystal, the planes of which form a prismatic surface, *e.g.*, the lateral facets of a quartz crystal. 2. A portion of the surface of a sphere included between two parallel circles or bounded by one circle.

zone axis, zonal a. 1. A line through the origin or center of a crystal which has a zone of faces, the line being parallel to each of those faces. 2. A row of atoms, ions, or molecules located at the intersection of two or more atomic planes in a crystal.

zone plate. A transparent screen placed in a beam of light and having photographed on it a series of concentric opaque rings corresponding to alternate half-period elements of the intercepted waves. It exhibits effects similar to those of a converging lens. (See Wood, Phys. Optics, 1929, p. 38.)