

GLOSSARY OF TERMS

ACID STEEL

Steel melted in a furnace that has an acid bottom and lining and under a slag that is dominantly siliceous.

AGE HARDENING

A process of aging that increases hardness and strength and ordinarily decreases ductility. Age hardening usually follows rapid cooling or cold working.

AGING

Change in a metal by which its structure recovers from an unstable condition produced by quenching or by cold working such as cold reduction. The change in structure is marked by changes in physical properties. Aging which takes place slowly at room temperature may be accelerated by slight increase in temperature. See "strain aging".

AIR HARDENING STEEL

An alloy steel that is hardened by cooling in air from a temperature higher than the transformation range. Also called self-hardening steel.

ALLOY

A substance that has metallic properties and is composed of two or more chemical elements of which at least one is a metal.

ALLOYING ELEMENT

Chemical elements constituting an alloy; in steels, usually limited to the metallic elements added to modify the properties of steel.

ALLOY STEEL

Steel containing significant quantities of alloying elements (other than carbon and the commonly accepted amounts of manganese, silicon, sulfur and phosphorus) added to effect changes in the mechanical or physical properties.

ANNEALING

A process involving heating and cooling, usually applied to induce softening. The term also refers to treatments intended to alter mechanical or physical properties, produce a definite microstructure, or remove gases. When applicable, the following more specific terms should be used: black annealing, blue annealing, box annealing, bright annealing, full annealing, graphitizing, isothermal annealing, malleablizing, process annealing, spheroidizing, stabilizing annealing.

Definitions of some of these are given in their alphabetical positions in this glossary. When applied to ferrous alloys, the term "annealing", without qualifications, implies full annealing. Any process of annealing will usually reduce stresses, but if the treatment is applied for the sole purpose of such relief, it should be designated as "stress relieving".

ARTIFICIAL AGING

An aging treatment above room temperature.

AUSTEMPERING

A trade name for a patented heat treating process that consists in quenching a ferrous alloy from a temperature above the transformation range, in a medium having a rate of heat abstraction sufficiently high to prevent the formation of high-temperature transformation products; and in maintaining the alloy, until transformation is complete, at a temperature below that of pearlite formation and above that of martensite formation.

AUSTENITE

A solid solution in which gamma iron is the solvent; characterized by a face-centered cubic crystal structure.

AUSTENITIC STAINLESS STEEL

Steel having the microstructure substantially wholly austenitic at normal temperature: usually a steel of the chromium nickel type.

AUSTENITIZING

The process of forming austenite by heating ferrous alloy into the transformation range (partial austenitizing) or above the transformation range (complete austenitizing).

BALL MILL

A mill in which material is finely ground by rotation in a steel drum along with pebbles or steel balls. The grinding action is provided by the collision of the balls with one another and with the shell of the mill.

BANDED STRUCTURE

A segregated structure of nearly parallel bands aligned in the direction of working.

BASIC OXYGEN PROCESS

The family of named steelmaking processes in which certain oxidizable constituents in the charge serve as fuel for the melting and refining of the charge. High purity oxygen is injected through a lance against a charge and reacts to physically stir the bath and burn to oxidize the carbon, silicon, manganese, and even iron contents to predictable levels, thus creating the heat and refining the steel. Liquid fuels or fluxes may be injected along with the oxygen.

BASIC STEEL

Steel melted in a furnace that has a basic bottom and lining, and under a slag that is dominantly basic.

BAND TESTS

Various tests used to determine the ductility of sheet or plate that is subjected to bending. These tests may include determination of the minimum radius or diameter required to make satisfactory bend and the number of repeated bends that the material can withstand without failure when it is bent through a given angle and over a definite radius.

BESSEMER PROCESS

A process for making steel by blowing air through molten pig iron contained in a suitable vessel, and thus causing rapid oxidation mainly of silicon and carbon.

BILLET

See bloom.

BLANKING

Shearing out a piece of sheet metal in preparation for deep drawing.

GLOSSARY OF TERMS

BLAST FURNACE

A shaft furnace in which solid fuel is burned with an air blast to smelt ore in a continuous operation. Where the temperature must be high, as in the production of pig iron, the air is preheated. Where the temperature can be lower, as in smelting copper, lead and tin ores, a smaller furnace is economical, and preheating of the blast is not required.

BLISTER

A raised spot on the surface of metal, caused by expansion of gas in a subsurface zone during heat treatment. Very fine blisters are called "pinhead" or "pepper blisters".

BLOOM

(slab, billet). Semi-finished products hot rolled from ingots and rectangular in cross section, with rounded corners. The chief differences are in cross-sectional area, in ratio of width to thickness, and in the intended uses. The American Iron and Steel Products Manual Section 2 (1943) classifies general usage thus:

Type	Thickness Cross-Sectional		Area, sq. inches
	Width, inches	inches	
Bloom	Width equals thickness*		36+ (min)
Billet	1 1/2 (min)	1 1/2 (min)	2 1/4 to 36
Slab	2 x thickness (min)	1 1/2 (min)	16 (mm)*

* Generally

Blooms, slabs and billets of rerolling quality are intended for hot rolling into common products such as shapes, plates, strip, bars, wire rod, sheet and black plate. Blooms, slabs and billets of forging quality are intended for conversion into forgings or other products to be heat treated.

BLOWHOLE

A hole produced in a casting when gas, entrapped while the mould is being filled, or evolved during the solidification of metal, fails to escape and is held in pockets.

BLUE ANNEALING

A process of softening ferrous alloys in the form of hot rolled sheet, by heating in the open furnace to a temperature within the transformation range and then cooling in air. The formation of a bluish oxide on the surface is incidental.

BLUE BRITTLENESS

Reduced ductility occurring as a result of strain aging, when certain ferrous alloys are worked between 300 and 700° F. This phenomenon may be observed at the working temperature or subsequently at lower temperatures.

BOX ANNEALING

A process of annealing a ferrous alloy in a suitable closed metal container, with or without packing material, in order to minimize oxidation. The charge is usually heated slowly to a temperature below the transformation range, but sometimes above, or within it, and is then cooled slowly. This process is also called "close annealing" or "pot annealing".

BRAKE

A piece of equipment used for bending sheet; also called a "bar folder". If operated manually, it is called a "hand-brake"; if power driven, it is called a "press-brake".

BRAZING

Joining metals by fusion or nonferrous alloys, that have melting points above 800° F but lower than those of the metals being joined. This may be accomplished by means of a torch (torch brazing), in a furnace (furnace brazing) or by dipping in a molten flux bath (dip or flux brazing). The filler metal is ordinarily in rod form in torch brazing; whereas in furnace and dip brazing the work material is first assembled and the filler metal may then be applied as wire, washers, clips, bands, or may be integrally bonded, as in brazing sheet.

BRIGHT ANNEALING

A process of annealing usually carried out in a controlled furnace atmosphere so that surface oxidation is reduced to a minimum and the surface remains relatively bright.

BRINELL HARDNESS TEST

A test for determining the hardness of a material by forcing a hard steel or carbide ball of specified diameter into it under a specified load. The result is expressed as the Brinell hardness number, which is the value obtained by dividing the applied load in kilograms by the surface area of the resulting impression in square millimeters.

BRITTLE CRACK PROPAGATION

A very sudden propagation of a crack with the absorption of no energy except that stored elastically in the body. Microscopic examination may reveal some deformation even though it is not noticeable to the unaided eye.

BRITTLE FRACTURE

Fracture with little or no plastic deformation.

BRITTLENESS

A tendency to fracture without appreciable deformation.

BROACHING

Multiple shaving, accomplished by pushing a tool with stepped cutting edges along the work, particularly through holes.

BURNT

A term applied to a metal permanently damaged by having been heated to a temperature close to the melting point.

CAMBER

Curvature in the plane of rolled sheet or strip, or in the plane of the web of structural shapes.

CAPPED STEEL

Semi-killed steel cast in a bottle-top mold and covered with a cap fitting into the neck of the mold. The cap causes the top metal to solidify. Pressure is built up on the sealed-in molten metal and results in a surface condition much like that of rimmed steel.

CARBIDE

A compound of carbon with one or more metallic elements.

CARBON STEEL

Steel that owes its properties chiefly to the presence of carbon, without substantial amounts of other alloying elements; also termed "ordinary steel", "straight carbon steel", "plain carbon steel".

CARBURIZING

A process that introduces carbon into a solid ferrous alloy by heating the metal in contact with a carbonaceous material—solid, liquid or gas—to a temperature above the transformation range and holding at that temperature. Carburizing is generally followed by quenching to produce a hardened case.

CASE

In a ferrous alloy, the surface layer that has been made substantially harder than the interior or core by a process of case hardening.

CASE HARDENING

A process of hardening a ferrous alloy so that the surface layer or case is made substantially harder than the interior or core. Typical case-hardening processes are carburizing and quenching, cyaniding, carbonitriding, nitriding, induction hardening and flame hardening.

CAST IRON

An iron containing carbon in excess of the solubility in the austenite that exists in the alloy at the eutectic temperature.

CAST STEEL

Any object made by pouring molten steel into moulds.

CAST STRUCTURE

The structure, on a macroscopic or microscopic scale, of a cast alloy that consists of cord dendrites and, in some alloys, a network of other constituents.

CATHODIC PROTECTION

The use of a particular metal as cathode in the corrosion cell as a means of protecting that metal against electro-chemical corrosion. This may be accomplished by the attachment of a more anodic metal or by the use of an applied potential.

CEMENTITE

A compound of iron and carbon known as "iron carbide" which has the approximate chemical formula Fe_3C and is characterized by an orthorhombic crystal structure.

CHARGE

(1) The liquid and solid materials fed into a furnace for its operation. (2) Weights of various liquid and solid materials put into a furnace during one feeding cycle.

CHARPY TEST

A pendulum type single-blow impact test in which the specimen, usually notched, is supported at both ends as a simple beam and broken by a falling pendulum. The energy absorbed, as determined by the subsequent rise of the pendulum, is a measure of impact strength or notch toughness.

CHECK ANALYSIS

Chemical analysis made of drillings taken from semi-finished or finished products. The units are subject to certain specified variations from the ladle analysis.

CHIPPING

A method for removing seams and other surface defects with chisel or gouge so that such defects will not be worked into the finished product. Chipping is often employed to remove metal that is excessive but not defective. Removal of defects by gas cutting is known as "deseaming" or "scarfing".

CLINK

Internal crack, usually resulting from improper heating of cold steel.

CLUSTER MILL

A rolling mill where each of the two working rolls of small diameter is supported by two or more backup rolls.

COERCIVE FORCE

The magnetizing force that must be applied in the direction opposite to that of the previous magnetizing force in order to remove residual magnetism; thus, an indicator of the "strength" of magnetically hard materials.

COIL BREAK

Sharp bend in the surface of coiled strip, leaving a distinct mark after flattening. See "fluting".

COLD DRAWING

Method of cold working applied to bars, involving pulling of the bar through dies of smaller aperture than the original bar size.

COLD SHORT

The characteristic of metals that are brittle at ordinary or low temperatures.

COLD SHUT

(1) A discontinuity that appears on the surface of cast metal as a result of two streams of liquid meeting and failing to unite. Pouring the metal when it is too cold may cause such a discontinuity. (2) On a forging, a portion of the surface that is separated by oxide from the main body of metal.

COLD WORK

Plastic deformation at such temperatures and rates that substantial increases occur in the strength and hardness of the metal. Visible structural changes include changes in grain shape and, in some twinning or banding.

COLD WORKING

Deforming a metal plastically at such a temperature and rate that strain hardening occurs. The upper limit of temperature for this process is the recrystallization temperature.

GLOSSARY OF TERMS

COLUMNAR STRUCTURE

A coarse structure of parallel columns of grains, which is caused by highly directional solidification resulting from sharp thermal gradients.

COMBINED CARBON

The carbon that is combined with iron or alloying elements to form carbide in cast iron or steel.

COMPRESSIVE STRENGTH

Yield-The maximum stress that a metal, subjected to compression, can withstand without a predefined amount of deformation. Ultimate-The maximum stress that a brittle material can withstand without fracture when subjected to compression.

CONTINUOUS CASTING

A casting technique in which an ingot, billet, tube or other shape is continuously solidified while it is being poured, so that its length is not determined by mould dimensions.

CONTINUOUS MILL

A rolling mill consisting of a number of stands of synchronized rolls (in tandem) in which metal undergoes successive reductions as it passes through the various stands.

CONTROLLED COOLING

A process of cooling from an elevated temperature in a predetermined manner, to avoid hardening, cracking or internal damage, or to produce a desired microstructure. This cooling usually follows the final hot forming operation.

COOLING STRESSES

Stresses developed by uneven contraction or external constraint of metal during cooling; also those stresses resulting from localized plastic deformation during cooling, and retained.

CORE

In a ferrous alloy, the interior portion that is substantially softer than the surface layer or case, after case hardening.

CORE LOSS

The total of hysteresis and eddy current loss measured on standard laminations of electrical steel.

CORE PLATING

Insulating varnish or surface applied to electrical steels, to improve interlamination resistance and to aid punching properties.

CORROSION

Gradual chemical or electrochemical attack on a metal by atmosphere, moisture, or other agents.

CREEP

The flow or plastic deformation of metals held for long periods of time at stresses lower than the normal yield strength. The effect is particularly important if the temperature of stressing is in the vicinity of the recrystallization temperature of the metal.

CREEP LIMIT

(1) The maximum stress that will cause less than a specified quantity of creep in a given time. (2) The maximum nominal stress under which the creep strain rate decreased continuously with time under constant load and at constant temperature. Sometimes used synonymously with creep strength.

CREEP STRENGTH

(1) The constant nominal stress that will cause a specified quantity of creep in a given time at constant temperature. (2) The constant nominal stress that will cause a specified creep rate at constant temperature.

CRITICAL COOLING RATE

The minimum rate of continuous cooling just sufficient to prevent undesired transformations. For steel, the slowest rate at which it can be cooled from above the upper critical temperature to prevent the decomposition of austenite at any temperature above the temperature at which the transformation of austenite to martensite starts during cooling.

CRITICAL POINT

Transformation temperature is the term preferred.

CRITICAL RANGE OR CRITICAL TEMPERATURE RANGE

Synonymous with transformation range, which is preferred.

CRITICAL STRAIN

The percentage strain at which, or immediately higher than which, large grain growth occurs during heating.

CRITICAL TEMPERATURE

Transformation temperature is the term preferred.

CROP

The end or ends of an ingot that contain the pipe or other defects to be cut off and discarded; also termed "crop end" and "discard".

CROSS-COUNTRY MILL

A rolling mill in which the mill stands are so arranged that their tables are parallel with a transfer (or cross-over) table connecting them. They are used for rolling structural shapes, rails and any special form of bar stock not rolled in the ordinary bar mill.

CROSS ROLLING

The rolling of sheet so that the direction of rolling is changed about 90° from the direction of the previous rolling.

CROWN

In the center of metal sheet or strip, thickness, greater than at the edge.

CRYSTAL

A physically homogeneous solid in which the atoms, ions or molecules are arranged in a three-dimensional repetitive pattern.

GLOSSARY OF TERMS

CRYSTALLIZATION

The formation of crystals by the atoms assuming definite positions in a crystal lattice. This is what happens when a liquid metal solidifies. (Fatigue, the failure of metals under repeated stresses, is sometimes falsely attributed to crystallization).

CUP FRACTURE (CUP AND CONE FRACTURE)

Fracture, frequently seen in tensile test pieces of a ductile material, in which the surface of failure on one portion shows a central flat area of failure in tension, with an exterior extended rim of failure in shear.

DECARBURIZATION

The loss of carbon from the surface of a ferrous alloy as a result of heating in a medium that reacts with the carbon.

DEEP DRAWING

Forming cup-shaped particles or shells by using a punch to force sheet metal into a die.

DEEP ETCHING

Macro-etching; etching, for examination at a low magnification, in a reagent that attacks the metal to much greater extent than normal for microscopic examination. Gross features may be developed—abnormal grain size, segregation, cracks or grain flow.

DEFECT

Internal or external flaw or blemish. Harmful defects can render material unsuitable for specific end use.

DEOXIDATION

Elimination of oxygen in liquid steel, usually by introduction of aluminum or silicon or other suitable element. This term is also used to denote reduction of surface scale (iron oxide).

DESEAMING

See chipping.

DIRECTIONAL PROPERTIES

Anisotropic condition where physical and mechanical properties vary, depending on the relation of the test axis to a specific direction of the metal; a result of preferred orientation or of fibering of inclusions during the working.

DIRECT QUENCHING

A process of quenching carburized parts directly from the carburizing operation.

DISCARD

See crop.

DRAWING

See tempering.

DRAWING QUALITY STEEL

Usually plate, sheet or strip of suitable temper for making various shapes involving severe stretching of the material.

DROP FORGING

Forming metal, usually under impact, by compression within dies designed to produce the required shape. The term is ordinarily used synonymously with hot die forging.

DROP HAMMER

A forging machine that employs the impact resulting from the action of gravity, with or without added steam or air pressure, on a falling ram.

DUCTILITY

The property that permits permanent deformation before fracture by stress in tension.

DIAMOND PYRAMID HARDNESS TEST

An indentation hardness test employing a 136° diamond pyramid indenter and variable loads enabling the use of one hardness scale for all ranges of hardness from very soft lead to tungsten carbide.

DIRECT CHILL (DC) CASTING

A continuous method of making ingots or billets for sheet or extrusion by pouring the metal into a short mould. The base of the mould is a platform that is gradually lowered while the metal solidifies, the frozen shell of metal acting as a retainer for the liquid cooled by the impingement of water directly on the mould or on the walls of the solid metal as it is lowered. The length of the ingot is limited by the depth to which the platform can be lowered: therefore, it is often called semi-continuous casting.

EAR

A wavy projection formed in the course of deep drawing, as a result of directional properties or anisotropy of the sheet.

ELASTIC LIMIT

The maximum stress that a material will withstand without permanent deformation. (Almost never determined experimentally; yield strength is customarily determined).

ELECTRIC FURNACE

A melting furnace with a shallow hearth and a low roof in which the charge is melted and refined by an electric arc between one or more electrodes and the charged material. The electrodes normally are suspended through the roof. No liquid or gaseous fuel is usually used; however, gaseous oxygen may be injected into the bath.

ELONGATION

The amount of permanent extension in the vicinity of the fracture in the tension test; usually expressed as a percentage of the original gauge length, as 25% in 2 in. Elongation may also refer to the amount of extension at any stage in any process that elongates a body continuously, as in rolling.

EMBOSSING

Raising a design in relief against a surface.

EMBRITTLEMENT

Reduction in the normal ductility of a metal due to a physical or chemical change.

GLOSSARY OF TERMS

ENDURANCE LIMIT

The maximum stress that a metal will withstand without failure during a specified large number of cycles of stress. If the term is employed without qualification, the cycles of stress are usually such as to produce complete reversal of flexural stress.

END USE

Specific detailed part to be made. End use is described by a specific phrase like "steel stiffener for back plate of model A refrigerator". End uses are not indicated by wide general terms such as "for refrigerators" or "for shipbuilding".

EQUILIBRIUM

A dynamic condition of balance between atomic movements, where the resultant is zero and the condition appears to be one of rest rather than change.

ERICHSEN TEST

A cupping test in which a piece of sheet metal, restrained except at the centre, is deformed by a cone-shaped spherical-end plunger until fracture occurs. The height of the cup in millimeters at fracture is a measure of the ductility.

EXTENSOMETER

Device, usually mechanical, for indicating the deformation of metal while it is subjected to stress.

EXTRUSION

Conversion of a billet into lengths of uniform cross-section by forcing the plastic metal through a die orifice of the desired cross-sectional outline. In "direct extrusion", the die and ram are at opposite ends of the billet, and the product and ram travel in the same direction. In "indirect extrusion" (rare), the die is at the ram end of the billet and the product travels through and in the opposite direction to the hollow ram. A "stepped extrusion" is a single product with one or more abrupt cross-section changes and is obtained by interrupting the extrusion by die changes. "Impact extrusion" (cold extrusion) is the process or resultant product of a punch striking an unheated slug in a confining die. The metal flow may be either between the punch and die or through another opening. "Hot extrusion" is similar to cold extrusion except that a preheated slug is used and the pressure application is slower.

FATIGUE

The tendency for a metal to break under conditions of repeated cyclic stressing considerably below the ultimate tensile strength.

FATIGUE CRACK OF FAILURE

A fracture starting from a nucleus where there is an abnormal concentration of cyclic stress and propagating through the metal. The surface is smooth and frequently shows concentric (sea shell) markings with a nucleus as a center.

FATIGUE LIFE

The number of cycles of stress that can be sustained prior to failure for a stated test condition.

FATIGUE LIMIT

The maximum stress that a metal will withstand without failure for a specified large number of cycles of stress. Usually synonymous with endurance limit.

FATIGUE RATIO

The ratio of the fatigue limit for cycles of reversed flexural stress to the tensile strength.

FATIGUE STRENGTH

The maximum stress that can be sustained for a specified number of cycles without failure, the stress being completely reversed within each cycle unless otherwise stated.

FERRITE

A solid solution in which alpha iron is the solvent, and which is characterized by a body-centered cubic crystal structure.

FERRITIC STAINLESS STEEL

Steel having the microstructure substantially wholly ferritic at normal temperature: usually a steel of the chromium type.

FERRO-ALLOY

An alloy of iron that contains a sufficient amount of one or more chemical elements—such as manganese, chromium, or silicon—to be useful as an agent for introducing these elements into steel by admixture with molten steel.

FILLET

A concave junction of two (usually perpendicular) surfaces.

FINISHED STEEL

Steel that is ready for the market without further work or treatment. Blooms, billets, slabs, sheet bars, and wire rods are termed "semi-finished".

FINISHED TEMPERATURE

The temperature at which hot mechanical working of metal is completed.

FISHTAIL

An overlapping at the back end of rolled sheet or bar.

FLAKES

Internal fissures in ferrous metals. In a fractured surface these fissures may appear as sizable areas of silvery brightness and coarse texture; in wrought products such fissures may appear as short discontinuities on an etched section. Also called "shatter cracks", "chrome cracks", "fish eyes" and "snowflakes".

FLAME HARDENING

A process of hardening a ferrous alloy by heating it above the transformation range by means of a high-temperature flame, and then cooling as required.

FLANGE

(1) A projection of metal on formed objects. (2) The parts of a channel at right angles to the central section or web.

GLOSSARY OF TERMS

FLASH

A thin fin of metal formed at the sides of a forging or weld when a small portion of metal is forced out between the edges of the forging or welding dies.

FLATNESS

Relative term for the measure of deviation of flat rolled material from a plane surface: usually determined as the height of ripples of waves above a horizontal level surface.

FLUTING

Kinking or breaking caused by the curving of metal strip on a radius so small, in relation to the thickness, as to stretch the outer surface well beyond its elastic limit.

FRACTURE TEST

Breaking a piece of metal for the purpose of examining the fractured surface to determine the structure or carbon content of the metal or to detect the presence of internal defects.

FULL ANNEALING

A softening process in which a ferrous alloy is heated to a temperature above the transformation range and, after being held for a sufficient time at this temperature, is cooled slowly to a temperature below the transformation range. The alloy is ordinarily allowed to cool slowly in the furnace, although it may be removed and cooled in some medium that ensures a slow rate of cooling.

GRAIN GROWTH

An increase in the grain size of metal.

GRAIN REFINER

Any material added to a liquid metal for the purpose of producing a finer grain size in the subsequent casting, or of retaining fine grains during the heat treatment of wrought structures.

GRAINS

Individual crystals in metals.

GRAPHITIZING

A heating and cooling process by which the combined carbon in cast iron or steel is transformed, wholly or partly, to graphitic or free carbon.

HARDENABILITY

In a ferrous alloy, the property that determines the depth and distribution of hardness induced by quenching.

HARDENING

Any process for increasing the hardness of metal by suitable treatment, usually involving heating and cooling.

HARDNESS

Defined in terms of the method of measurement. (1) Usually the resistance to indentation. (2) Stiffness or temper of wrought products. (3) Machinability characteristics.

HARDNESS TESTS

(A) Brinell Hardness A hardness test performed on a Brinell hardness testing machine. The smooth surface of a specimen is indented with a spherical-shaped hardened steel ball of known diameter by means of a predetermined load applied to the ball. The diameter of the impression is measured in millimeters with a micrometer microscope, and the reading is compared with a chart to determine the Brinell Hardness number (BHN).

(B) Rockwell Hardness A hardness test performed on a Rockwell hardness testing machine. Hardness is determined by a dial reading which indicates the depth of penetration of a steel ball or diamond cone when a load is applied.

(C) Scleroscope or Shore Hardness A hardness test performed on a Shore Scleroscope Hardness Tester. The hardness is determined by the rebound of a diamond pointed hammer (or tup) when it strikes the surface of a specimen. The hammer (or tup) is enclosed in a glass tube and the height of the rebound is read either against a graduated scale inscribed on the tube, or on a dial, depending on the model instrument used.

HEARTH

The bottom portion of certain furnaces, such as the blast furnace, air furnace and other reverberatory furnaces, in which the molten metal is collected or held.

HEAT TREATMENT

A combination of heating and cooling operations, timed and applied to a metal or alloy in the solid state in a way that will produce desired properties. Heating for the sole purpose of hot working is excluded from the meaning of this definition.

HOLD DOWN

The tool that exerts pressure normal to a sheet blank during deep drawing, in order to prevent wrinkling.

HOMOGENOUS

Usually defined as having identical characteristics throughout. However, physical homogeneity may require only an identity of lattice type throughout, while chemical homogeneity requires uniform distribution of alloying elements.

HOMOGENIZING

A process of heat treatment at high temperature intended to eliminate or decrease chemical segregation by diffusion.

HOT FORMING

Working operations, such as bending and drawing sheet and plate, forging, pressing, and heading, performed on metal heated to temperatures above room temperature.

HOT SHORTNESS.

Brittleness in hot metal.

GLOSSARY OF TERMS

HOT TOP

See sinkhead.

HOT QUENCHING

A process of quenching in a medium at a temperature substantially higher than atmospheric temperature.

HOT WORKING

Plastic deformation of metal at such a temperature and rate that strain hardening does not occur. The lower limit of temperature for this process is the recrystallization temperature.

HYDROGEN EMBRITTLEMENT

A condition of low ductility resulting from hydrogen absorption and internal pressure developed subsequently.

IMPACT ENERGY (IMPACT VALUE)

The amount of energy required to fracture a material, usually measured by means of an Izod or Charpy test. The type of specimen and testing conditions affect the values and therefore should be specified.

IMPACT TEST

A test to determine the energy absorbed in fracturing a test bar at high velocity. The test may be in tension or in bending, or it may properly be a notch test if a notch is present, creating multiaxial stresses.

INCIDENTAL ELEMENTS

Small quantities of non-specified elements commonly introduced into product from the use of scrap metal with the raw materials.

INCLUSIONS

Particles of impurities (usually oxides, sulfides, silicates and such) that are held mechanically, or are formed during solidification or by subsequent reaction within the solid metal.

INDUCTION HARDENING

A process of hardening a ferrous alloy by heating it above the transformation range by means of electrical induction, and cooling as required.

INGOT

A casting intended for subsequent rolling or forging.

INTERGRANULAR CORROSION

A type of electrochemical corrosion that progresses preferentially along the grain boundaries of an alloy, usually because the grain boundary regions contain material anodic to the central regions of the grains.

IRON

(1) Element No. 26 of the periodic system, the average atomic weight of the naturally occurring isotopes being 55.85 (2) Iron-base materials not falling into the steel classification.

ISOTHERMAL ANNEALING

A process in which a ferrous alloy is heated to produce a structure partly or wholly austenitic, and is then cooled to and held at a temperature that causes transformation of the austenite to a relatively soft ferrite-carbide aggregate.

ISOTHERMAL TRANSFORMATION

The process of transforming austenite in a ferrous alloy to ferrite or a ferrite-carbide aggregate at any constant temperature within the transformation range.

IZOD TEST

A pendulum type of single-blow impact test in which the specimen, usually notched, is fixed at one end and broken by a falling pendulum. The energy absorbed, as measured by the subsequent rise of the pendulum, is a measure of impact strength or notch toughness.

KALDO PROCESS

One of the family of basic oxygen steelmaking processes which uses an inclined, rotating cylindrical furnace in which oxygen is injected through a lance in the centre line of the furnace. This furnace uses a basic refractory lining and normally no fuels or fluxes are injected with the oxygen.

KILLED STEEL

Steel deoxidized with a strong deoxidizing agent such as silicon or aluminum in order to reduce the oxygen content to a minimum so that no reaction occurs between carbon and oxygen during solidification.

LADLE ANALYSIS

Chemical analysis made from samples obtained during original casting of ingots. This is normally to controlling analysis for satisfying the specifications.

LAMINATIONS

Defects resulting from the presence of blisters, seams or foreign inclusions aligned parallel to the worked surface of a metal.

LAP

A surface defect appearing as a seam, caused by folding over hot metal, fins or sharp corners and then rolling or forging them into the surface, but not welding them.

L-D PROCESS

One of the basic oxygen steelmaking processes using a vertical cylindrical furnace in which oxygen is injected from above by a lance. The furnace has a basic refractory lining. Some variations of this process include the injection of liquid or gaseous fuels and fluxes along with the gaseous oxygen.

LEVELLING

Flattening rolled metal sheet. See roller flattening.

LONGITUDINAL DIRECTION

The direction in a wrought metal product parallel to the direction of working (drawing, extruding, rolling).

GLOSSARY OF TERMS

LÜDER'S LINES OR LÜDER LINES

(stretcher strains, flow figures) Elongated markings that appear on the surface of some materials, particularly iron and low-carbon steel, when deformed just past the yield point. These markings lie approximately parallel to the direction of maximum shear stress and are the result of localized yielding. They consist of depressions when produced in tension and of elevations when produced in compression. They may be made evident by localized roughening of a polished surface or by localized flaking from an oxidized surface.

MACROSCOPIC

Visible either with the naked eye or under low magnification (as great as about 10 diameters).

MACROSTRUCTURE

The structure of metals as revealed by macroscopic examination.

MALLEABILITY

The property that determines the ease of deforming a metal when the metal is subjected to rolling or hammering. The more malleable metals can be hammered or rolled into thin sheet more easily than others.

MALLEABILIZING

A process of annealing white cast iron in such a way that the combined carbon is wholly or partly transformed to graphite or free carbon or, in some instances, part of the carbon is removed completely.

MANNESMANN PROCESS

A process used for piercing tube billets in making seamless tubing. The billet is rotated between two heavy rolls mounted at an angle, and is forced over a fixed mandrel. Billets are called "tube rounds".

MARTEMPERING

The process of quenching an austenitized ferrous alloy in a medium at a temperature in the upper portion of the temperature range of martensite formation, or slightly above that range, and holding in the medium until the temperature throughout the alloy is substantially uniform. The alloy is then allowed to cool in air through the temperature range of martensite formation.

MARTENSITE

An unstable constituent in quenched steel, formed without diffusion and only during cooling below a certain temperature known as the M_s (or A_r) temperature. The structure is characterized by its acicular appearance on the surface of a polished and etched specimen. Martensite is the hardest of the transformation products of austenite. Tetragonality of the crystal structure is observed when the carbon content is greater than about 0.05%.

MARTENSITIC STAINLESS STEEL

Steel having the microstructure substantially wholly martensitic at normal temperature: usually a steel of medium carbon high alloy type.

MECHANICAL PROPERTIES

Those properties of a material that reveal the elastic and inelastic reaction when force is applied, or that involve the relationship between stress and strain; for example, the modulus of elasticity, tensile strength and fatigue limit. These properties have often been designated as "physical properties", but the term "mechanical properties" is preferred.

MECHANICAL WORKING

Subjecting metal to pressure exerted by rolls, dies, presses, or hammers, to change its form or to affect the structure and consequently the mechanical and physical properties.

MERCHANT MILL

A mill, consisting of a group of stands of three rolls each arranged in a straight line and driven by one power unit, used to roll rounds, squares or flats of smaller dimensions that would be rolled on the bar mill.

METALLOGRAPHY

The science concerning the constitution and structure of metals and alloys as revealed by the microscope.

MICROSTRUCTURE

The structure of polished and etched metal and alloy specimens as revealed by the microscope.

MODULUS OF ELASTICITY

The slope of the elastic portion of the stress-strain curve in mechanical testing. The stress is divided by the unit elongation. The tensile or compressive elastic modulus is called "Young's modulus"; the torsional elastic modulus is known as the "shear modulus", or "modulus of rigidity".

NITRIDING

A process of case hardening in which a ferrous alloy, usually of special composition, is heated in an atmosphere of ammonia or in contact with nitrogenous material to produce surface hardening by the absorption of nitrogen, without quenching.

NON-SCALLOPING QUALITY

Steel specially made to be substantially free from scallops or ears during pressing and drawing.

NORMALIZING

A process in which a ferrous alloy is heated to a suitable temperature above the transformation range and is subsequently cooled in still air at room temperature.

NORMAL SEGREGATION

Concentration of alloying constituents that have low melting points, in those portions of a casting that solidify last.

NOTCH BRITTLENESS

Susceptibility of a material to brittleness in areas containing a groove, scratch, sharp fillet or notch.

GLOSSARY OF TERMS

NOTCH SENSITIVITY

The reduction caused in nominal strength, impact or static, by the presence of a stress concentration, usually expressed as the ratio of the notched to the unnotched strength.

OPEN HEARTH FURNACE

A furnace for melting metal, in which the bath is heated by the convection of hot gases over the surface of the metal and by radiation from the roof.

ORANGE PEEL EFFECT

A surface roughening encountered in forming products from metal stock that has a coarse grain size, also referred to as "pebbles" and "alligator skin".

ORIENTATION

The angular relationship between the axes of a crystal and an external reference system. The orientation of individual crystals is most conveniently represented by poles of simple planes plotted stereo-graphically.

OUT-OF-ROUND

Deviation of cross section of a round bar from a true circle: normally measured as difference between maximum and minimum diameters at the same cross section of the bar.

OUT-OF-SQUARE

For square bars this is the deviation of cross section from a true square; normally measured as the difference between the two diagonal dimensions at one cross section.

For structural shapes, the term out-of-square indicates the deviation from a right angle of the plane of flanges in relation to the plane of webs.

OVERHEATED

A term applied when, after exposure to an excessively high temperature, a metal develops an undesirably coarse grain structure but is not permanently damaged. Unlike a burnt structure, the structure produced by overheating can be corrected by suitable heat treatment, by mechanical work, or by a combination of the two.

PEARLITE

The lamellar aggregate of ferrite and carbide. Note: It is recommended that this word be reserved for the microstructures consisting of thin plate or lamellae—that is, those that may have a pearly luster in white light. The lamellae can be very thin and resolvable only with the best microscopic equipment and technique.

PERMEABILITY

(1) Magnetic permeability, the ratio of the magnetic induction to the intensity of the magnetizing field. (2) In a mould, the porosity of foundry sands and the ability of trapped gases to escape through the sand.

PHYSICAL PROPERTIES

Those properties familiarly discussed in physics exclusive of those described under mechanical properties; for example, density, electrical conductivity, coefficient of thermal expansion. This term has often been used to describe mechanical properties but this usage is not recommended. See mechanical properties.

PICKLE

Chemical or electrochemical removal of surface oxides.

PIG IRON

Iron produced by reduction of iron ore in the blast furnace.

PINHOLE POROSITY

Very small holes scattered through a casting, possibly by micro-shrinkage or gas evolution during solidification.

PIPE

A cavity formed by contraction in metal (especially ingots) during solidification of the last portion of liquid metal.

PIT

A sharp depression in the surface of metal.

PLASTIC DEFORMATION

Permanent distortion of a material under the action of applied stresses.

PLASTICITY

The ability of a metal to be deformed extensively without rupture.

POISSON'S RATIO

The absolute value of the ratio of the transverse strain to the corresponding axial strain, in a body subjected to uniaxial stress; usually applied to elastic conditions.

POROSITY

Unsoundness caused in cast metals by the presence of blow-holes and shrinkage cavities.

POSTHEATING

A process used immediately after welding, whereby heat is applied to the weld zone either for tempering or for providing a controlled rate of cooling, in order to avoid a hard or brittle structure.

PRECIPITATION HARDENING

A process of hardening an alloy in which a constituent precipitates from a supersaturated solid solution. See also age hardening and aging.

PREFERRED ORIENTATION

In a polycrystalline structure, a departure from crystallographic randomness.

PREHEATING

(1) A general term used to describe heating applied as a preliminary to some further thermal or mechanical treatment. (2) a term applied specifically to tool steel to describe a process in which the steel is heated slowly and uniformly to a temperature below the hardening temperature and is then transferred to a furnace in which the temperature is substantially above the preheating temperature.

GLOSSARY OF TERMS

PRIMARY MILL

A mill for rolling ingots or the rolled products of ingots to blooms, billets or slabs. This type of mill is often called a blooming mill and sometimes a cogging mill.

PROCESS ANNEALING

In the sheet and wire industries, a process by which a ferrous alloy is heated to a temperature close to, but below, the lower limit of the transformation range and is subsequently cooled. This process is applied in order to soften the alloy for further cold working.

PROOF STRESS

In a test, stress that will cause a specified permanent deformation in a material, usually 0.01% or less.

PROPORTIONAL LIMIT

The greatest stress that the material is capable of sustaining without a deviation from the law of proportionality of stress to strain (Hooke's Law).

QUENCH HARDENING

A process of hardening a ferrous alloy of suitable composition by heating within or above the transformation range and cooling at a rate sufficient to increase the hardness substantially. The process usually involves the formation of martensite.

QUENCHING

A process of rapid cooling from an elevated temperature by contact with liquids, gases or solids.

QUENCHING CRACK

A fracture resulting from thermal stresses induced during rapid cooling or quenching; frequently encountered in alloys that have been overheated and liquated and are thus "hot short".

RECRYSTALLIZATION

A process whereby the distorted grain structure of cold worked metals is replaced by a new, strain-free grain structure during annealing above a specific minimum temperature.

RED SHORTNESS

Brittleness in steel when it is red hot.

REDUCTION IN AREA

The difference between the original cross-sectional area and that of the smallest area at the point of rupture; usually stated as a percentage of the original area; also called "contraction of area".

REFINING TEMPERATURE

A temperature, usually just higher than the transformation range, employed in the heat treatment of steel to refine the structure - in particular, the grain size.

RESIDUAL STRESS

Macroscopic stresses that are set up within a metal as the result of non-uniform plastic deformation. This deformation may be caused by cold working or by drastic gradients of temperature from quenching or welding.

RESQUARED

Flat rolled material (plate, sheet or strip) firstly cut to approximate size and finally resheared to very close tolerance: also any material having been cut to equally close tolerances as to dimensions and squareness, by whatever method.

REVERBERATORY FURNACE

A furnace with a shallow hearth, usually nonregenerative, having a roof that deflects the flame and radiates heat toward the hearth or the surface of the charge.

RIMMED STEEL

An incompletely deoxidized steel normally containing less than 0.25% C and having the following characteristics: (a) During solidification an evolution of gas occurs sufficient to maintain a liquid ingot top ("open" steel) until a side and bottom rim of substantial thickness has formed. If the rimming action is intentionally stopped shortly after the mould is filled, the product is termed capped steel. (b) After complete solidification, the ingots consists of two distinct zones - a rim somewhat purer than when poured and a core containing scattered blowholes, a minimum amount of pipe and an average percentage of metal-oids somewhat higher than when poured and markedly higher in the upper portion of the ingot.

ROCKWELL HARDNESS TEST

A test for determining the hardness of a material based upon the depth of penetration of a specified penetration into the specimen under certain arbitrarily fixed conditions of test.

ROLLER FLATTENING OR ROLLER LEVELLING

The process in which a series of staggered rolls of small diameter is used to remove bow and waves from sheet. While passing through the rolls, the sheet is bent back and forth slightly and is delivered approximately flat.

ROLLER STRAIGHTENING

A process involving a series of staggered rolls of small diameter, between which rod, tubing and shapes are passed for the purpose of straightening. The process consists of a series of bending operations.

ROLL FORMING

(1) An operation used in forming sheet. Strips of sheet are passed between rolls of definite settings that bend the sheet progressively into structural members of various contours, sometimes called "moulded sections". (2) A process of coiling sheet into open cylinders.

ROLLING

Reducing the cross-sectional area of metal stock, or otherwise shaping metal products, through the use of rotating rolls.

ROLLING MILLS

Machines used to decrease the cross-sectional area of metal stock and produce certain desired shapes as the metal passes between rotating rolls mounted in a framework comprising a basic unit called a stand. Cylindrical rolls produce flat shapes; grooved rolls produce rounds, squares and structural shapes. Among rolling mills may be listed the billet mill, blooming mill, breakdown mill, plate mill, sheet mill, slabbing mill, strip mill and temper mill.

GLOSSARY OF TERMS

SCAB

(scabby) A blemish caused on a casting by eruption of gas from the mould face, or by uneven mould surfaces; or occurring where the skin from a blowhole has partly burned away and is not welded.

SCALING

Surface oxidation caused on metals by heating in air or in other oxidizing atmospheres.

SCALLOPS

See "ears".

SCARFING

Cutting surface areas of metal objects, ordinarily by using a gas torch. The operation permits surface defects to be cut from ingots, billets, or the edges of plate that is to be bevelled for butt welding. See chipping.

SCLEROSCOPE TEST

A hardness where the loss in kinetic energy of a falling metal "tup", absorbed by indentation upon the impact of the tup on the metal being tested, is indicated by the height of rebound.

SEAM

On the surface of metal, a crack that has been closed but not welded; usually produced by some defect either in casting or in working, such as blowholes that have become oxidized or folds and laps that have been formed during working. Seam also refers to lap joints, as in seam welding.

SEGREGATION

In an alloy object, concentration of alloying elements at specific regions, usually as a result of the primary crystallization of one phase with the subsequent concentration of other elements in the remaining liquid. Microsegregation refers to normal segregation on a microscopic scale whereby material richer in alloying elements freezes in successive layers on the dendrites (coring) and in the constituent network. Macrosegregation refers to gross differences in concentration (for example, from one area of an ingot to another) which may be normal, inverse or gravity segregation.

SEMIKILLED STEEL

Steel incompletely deoxidized, to permit evolution of sufficient carbon monoxide to offset solidification shrinkage.

SHEARED EDGES

Sheared edge is obtained when rolled edge is removed by rotary slitter or mechanical shear.

SHORTNESS

A form of brittleness in metal. It is designated as "cold", "hot", and "red" to indicate the temperature range in which the brittleness occurs.

SINGLE-STAND MILL

A rolling mill of such design that the product contacts only two rolls at a given moment. Contrast with "tandem mill".

SINKHEAD OR HOT TOP

A reservoir insulated to retain heat and to hold excess molten metal on top of an ingot mold, in order to feed the shrinkage of the ingot. Also called "shrink head" or "feeder head".

SINTERING

(1) The bonding of adjacent surfaces of particles in a mass of metal powders or a compact, by heating. (2) A shaped body composed of metal powders and produced by sintering with or without prior compacting.

SKELP

A plate of steel or wrought iron from which pipe or tubing is made by rolling the skelp into shape longitudinally and welding the edges together.

SKIN

A thin surface layer that is different from the main mass of a metal object, in composition, structure or other characteristics.

SLAB

See bloom.

SLAG

A nonmetallic product resulting from the mutual dissolution of flux and nonmetallic impurities in smelting and refining operations.

SOAKING

Prolonged heating of a metal at a selected temperature.

SPHEROIDIZING

Any process of heating and cooling that produces a rounded or globular form of carbide in steel. Spheroidizing methods frequently used are: (1) Prolonged holding a temperature just below Ae_1 . (2) Heating and cooling alternately between temperatures that are just above and just below Ae_1 . (3) Heating to a temperature above Ae_1 or Ae_3 , and then cooling very slowly in the furnace, or holding at a temperature just below Ae_1 . (4) Cooling at a suitable rate from the minimum temperature at which all carbide is dissolved, to prevent the re-formation of a carbide network, and then reheating in accordance with method 1 or 2 above (applicable to hypereutectoid steel containing a carbide network).

STEEL

An iron base alloy, malleable in some temperature range as initially cast, containing manganese, usually carbon, and often other alloying elements. In carbon steel and low-alloy steel, the maximum carbon is about 2.0%; in high-alloy steel, about 2.5%. The dividing line between low-alloy and high-alloy steels is generally regarded as being about 5% metallic alloying elements. Steel is to be differentiated from two general classes of "irons": the cast irons, on the high-carbon side, and the relatively pure irons such as ingot iron, carbonyl iron, and electrolytic iron, on the low-carbon side. In some steels containing extremely low carbon, the manganese content is the principal differentiating factor, steel usually containing at least 0.25%; ingot iron contains considerably less.

GLOSSARY OF TERMS

STRAIGHTNESS

Measure of adherence to or deviation from a straight line, normally expressed as sweep or camber, according to the plane.

STRAIN AGING

Aging induced by cold working. See aging.

STRAIN ENERGY

(1) The work done in deforming a body. (2) The work done in deforming a body within the elastic limit of the material. It is more properly elastic strain energy and can be recovered as work rather than heat.

STRAIN HARDENING

An increase in hardness and strength caused by plastic deformation at temperatures lower than the recrystallization range.

STRESS

The load per unit of area. Ordinarily stress-strain curves do not show the true stress (load divided by area at that moment) but a fictitious value obtained by using the original area.

STRESS-CORROSION CRACKING

Failure by cracking under combined action of corrosion and stress, either external (applied) or internal (residual). Cracking may be either intergranular or transgranular, depending on metal and corrosive medium.

STRESS RAISERS

Factors such as sharp changes in contour or surface defects, which concentrate stresses locally.

STRESS RELIEVING

A process of reducing residual stresses in a metal object by heating the object to a suitable temperature and holding for a sufficient time. This treatment may be applied to relieve stresses induced by casting, quenching, normalizing, machining, cold working, or welding.

STRETCHER FLATTENING OR STRETCHER LEVELLING

A process for removing bow and warpage from sheet by applying a uniform tension at the ends so that the piece is elongated to a definite amount of permanent set.

STRETCHER LEVELLED FLATNESS

Steel sheets or strip subjected to stretcher levelling thereby acquire a high degree of flatness (together with some increase of stiffness). When the same degree of flatness is procured by other methods like roller levelling, it is then described as "stretcher levelled standard of flatness".

STRETCHER STRAINS

See "Lüder lines".

SWEEP

Curvature in structural and other similar shapes normal to the plane of the web.

TANDEM MILL

A rolling mill consisting of two or more stands arranged so that the metal being processed travels in a straight line from stand to stand. In continuous rolling, the various stands are synchronized so that the strip may be rolled in all stands simultaneously. Contrast with "single-stand mill".

TEMPER

A measure of the mechanical characteristics of cold rolled steel strip obtained by various degrees of cold working.

TEMPERING

A process of reheating quench-hardened or normalized steel to a temperature below the transformation range, and then cooling at any rate desired.

TEMPER BRITTLINESS

Brittleness that results when certain steels are held within, or are cooled slowly through, a certain range of temperature below the transformation range. The brittleness is revealed by notched-bar impact tests at room temperature or lower temperatures.

TEMPER ROLLING

This is a skin-rolling of steel sheet or strip when cold, to impart a required degree of stiffness, hardness or surface condition. It should not be confused with "cold rolling" which implies cold reduction on terms of thickness.

TENSILE STRENGTH

The value obtained by dividing the maximum load observed during tensile straining by the specimen cross-sectional area before straining. Also called "ultimate strength".

THERMAL FATIGUE

Fracture resulting from the presence of temperature gradients which vary with time in such a manner as to produce cyclic stresses in a structure.

TOLERANCES

Allowable variations from specified dimensions.

TOUGHNESS

Property of absorbing considerable energy before fracture; usually represented by the area under a stress-strain curve, and therefore involving both ductility and strength.

TRACE

Extremely small quantity of an element, usually too small to determine quantitatively.

TRANSFORMATION RANGE OR TRANSFORMATION TEMPERATURE RANGE

The temperature interval within which austenite forms while ferrous alloys are being heated. Also the temperature interval within which austenite disappears while ferrous alloys are being cooled. The two ranges are distinct, sometimes overlapping but never coinciding. The limiting temperatures of the ranges depend on the composition of the alloy and on the rate of change of temperature, particularly during cooling. See transformation temperature.

GLOSSARY OF TERMS

TRANSFORMATION TEMPERATURE

The temperature at which a change in phase occurs. The term is sometimes used to denote the limiting temperature of a transformation range. The following symbols are used for iron and steel:

- Ac₁ The temperature at which austenite begins to form during heating.
- Ac₃ The temperature at which transformation of ferrite to austenite is completed during heating.
- Ac_{CM} In hypereutectoid steel, the temperature at which solution of cementite in austenite is completed during heating.
- Ar₁ The temperature at which transformation of austenite to ferrite or to ferrite plus cementite is completed during cooling.
- Ar₃ The temperature at which austenite begins to transform to ferrite during cooling.
- Ar_{CM} In hypereutectoid steel, the temperature at which solution of cementite in austenite is completed during heating.
- A₄ The temperature at which austenite transforms to delta ferrite during heating; the reverse process occurs during cooling.
- M_s (or Ar["]) The temperature at which transformation of austenite to martensite starts during cooling.
- M_f The temperature at which transformation of austenite to martensite is completed during cooling.

Note: All these changes (except the formation of martensite) occur at lower temperatures during cooling than during heating, and depend on the rate of change of temperature. The temperatures of phase changes at equilibrium are denoted by the symbols Ae₁ Ae₃ Ae_{CM} and Ae₄.

TRANSVERSE

Literally "across" signifying a direction or plane perpendicular to the direction of working.

ULTIMATE STRENGTH

See tensile strength.

UNIVERSAL MILL

A rolling mill in which rolls with a vertical axis roll the edges of the metal stock between some of the passes through the horizontal rolls.

UNIVERSAL MILL PLATE

Plate rolled on a universal mill having vertical (edge) rolls as well as horizontal rolls; also any plate having characteristics identical to plate produced on a universal mill.

UPSETTING

(1) A metal working operation similar to forging. (2) The process of axial flow under axial compression of metal, as in forming heads on rivets by flattening the end of wire.

VICKERS HARDNESS TEST

Same as "diamond pyramid hardness test".

WELDING

A process used to join metals by the application of heat. Fusion welding, which includes gas, arc, and resistance welding, requires that the parent metals be melted. This distinguishes fusion welding from brazing. In pressure welding joining is accomplished by the use of heat and pressure without melting. The parts that are being welded are pressed together and heated simultaneously, so that recrystallization occurs across the interface.

WOODY FRACTURE

Fractures having a fibrous appearance.

YIELD POINT

In mild or medium-carbon steel, the stress at which a marked increase in deformation occurs without increase in load. In other steels, and in nonferrous metals this phenomenon is not observed. See Yield Strength.

YIELD STRENGTH

The stress at which a material exhibits a specified limiting deviation from proportionality of stress to strain. An offset of 0.2% is used for many metals such as aluminum-base and magnesium-base alloys, while a 0.5% total elongation under load is frequently used for copper alloys.

YOUNG'S STRENGTH

The modulus of elasticity in tension or compression.