Appendix - D

Material of Construction

Accordion reed steel

Hardened, tempered, polished and blued or yellow flat steel with dressed edges. Carbon content about 1.00%. Material has to possess good flatness, uniform hardness and high elasticity.

Acid-brittleness

Brittleness resulting from pickling steel in acid; hydrogen, formed by the interaction between iron and acid, is partially absorbed by the metal, causing acid brittleness.

Acid-process

A process of making steel, either bessemer, open-hearth or electric, in which the furnace is lined with a siliceous refractory and for which low phosphorous pig iron is required as this element is not removed.

Acid-steel

The term has no reference to the acidity of the steel.

Age hardening

The term as applied to soft or low carbon steels, relates to slow, gradual changes that take place in properties of steels after the final treatment. These changes, which bring about a condition of increased hardness, elastic limit, and tensile strength with a consequent loss in ductility, occur during the period in which the steel is at normal temperatures.

Aging

Spontaneous change in the physical properties of some metals, which occurs on standing, at atmospheric temperatures after final cold working or after a final heat treatment. Frequently synonymous with the term “age-hardening.”

Air cooling

Cooling of the heated metal, intermediate in rapidity between slow furnace cooling and quenching, in which the metal is permitted to stand in the open air.

Air hardening steel

Alloy Steel which may be hardened by cooling in air from a temperature above the transformation range. Such steels attain their martensitic structure without going through the quenching process. Additions of chromium, nickel, molybdenum and manganese are effective toward this end.

Alloy

Metal prepared by adding other metals or non-metals to a basic metal to secure desirable properties.

Alloy steel

Steel containing substantial quantities of elements other than carbon and the commonly-accepted limited amounts of manganese, sulfur, silicon, and phosphorous. Addition of such alloying elements is usually for the purpose of increased hardness, strength or chemical resistance. The metals most commonly used for forming alloy steels are: nickel, chromium, silicon, manganese, tungsten, molybdenum and vanadium. "**low alloy**" steels are usually considered to be those containing a total of less than 5% of such added constituents.

Aluminum

(chemical symbol **al**) element no. 13 of the periodic system;. Atomic weight 26.97; silvery white metal of valence 3; melting point 1220°f.; boiling point approximately 4118°f.; ductile and malleable; stable against normal atmospheric corrosion, but attacked by both acids and alkalis. **Aluminum** is used extensively in articles requiring lightness, corrosion resistance, electrical conductivity, etc. Its principal functions as an alloy in steel making are; (1) deoxidizes efficiently (see aluminum killed steel) (2) restricts grain growth (by forming dispersed oxides or nitrides) (3) alloying element in nitriding steel.

Annealing

A heating and cooling operation implying usually a relatively slow cooling. **Annealing** is a comprehensive term. The process of such a heat treatment may be: to remove stresses; to induce softness; to alter ductility; toughness; electrical magnetic, or other physical properties; to refine the crystalline structure; to remove gases; to produce a definite micro-structure. In **annealing**, the temperature of the operation and the rate of cooling depend upon the material being heat treated and the purpose of the treatment.

Anodizing (aluminum anodic oxide coating)

A process of coating aluminum by anodic treatment resulting in a thin film of aluminum oxide of extreme hardness. A wide variety of dye colored coatings are possible by impregnation in process.

Artificial aging

An aging treatment above room temperature. (see precipitation heat treatment and compare with natural aging)

A.s.t.m.

Abbreviation for american society for testing material. An organization for issuing standard specifications on materials, including metals and alloys.

Austenite

Phase in certain steels, characterized as a solid solution, usually off carbon or iron carbide, in the gamma form of iron. Such steels are known as "**austenitic**". **Austenite** is stable only above 1333°f. In a plain carbon steel, but the presence of certain alloying elements, such as nickel and manganese, stabilizes the **austenitic** form, even at normal temperatures.

Austenitic steel

Steel which, because of the presence of alloying elements, such as manganese, nickel, chromium, etc., shows stability of **austenite** at normal temperatures.

Basic oxygen process

A steel making process wherein oxygen of the highest purity is blown onto the surface of a bath of molten iron contained in a basic lined and ladle shaped vessel. The melting cycle duration is extremely short with quality comparable to open hearth steel.

Basic process

A steel making process either bessemer, open hearth or electric, in which the furnace is lined with a basic refractory. A slag, rich in lime, being formed and phosphorous removed.

Bath annealing

Immersion in a liquid bath (such as molten lead or fused salts) held at an assigned temperature. When a lead bath is used, the process is known as lead annealing.

Bauxite

The only commercial ore of aluminum, corresponding essentially to the formula al2o3xh2o.

Bend test

Various tests used to determine the toughness and ductility of flat rolled metal sheet, strip or plate, in which the material is bent around its axis or around an outside radius. A complete test might specify such a **bend** to be both with and against the direction of grain. For testing, samples should be edge filed to remove burrs and any edgewise cracks resulting from slitting or shearing. If a vice is to be used then line the jaws with some soft metal or brass, so as to permit a free flow of the metal in the sample being tested.

Beryllium copper

An alloy of copper and 2-3% beryllium with optionally fractional percentages of nickel or cobalt. Alloys of this series show remarkable age-hardening properties and an ultimate hardness of about 400 brinell (rockwell c43). Because of such hardness and good electrical conductivity, **beryllium-copper** is used in electrical switches, springs, etc.

Bessemer process

A steel making process in which air is blown through the molten iron so that the impurities are thus removed by oxidation.

Binary alloy

An alloy containing two elements, apart from minor impurities, as brass containing the two elements copper and zinc.

Black annealing

A process of box annealing or pot annealing ferrous alloy sheet, strip or wire after hot working and pickling. (see box annealing)

Black oil tempered spring steel strip

(scaleless blue.) A flat cold rolled usually .70/.80% medium high carbon spring steel strip, blue-black in color, which has been quenched in oil and drawn to

desired hardness. While it looks and acts much like blue tempered spring steel and carries a rockwell hardness of c44/47, it has not been polished and is lower in carbon content. Used for less exacting requirements than clock spring steel, such as snaps, lock springs, hold down springs, trap springs, etc. It will take a more severe bend before fracture than will clock spring, but it does not have the same degree of spring-back.

Blast furnace

A vertical shaft type smelting furnace in which an air blast is used, usually hot, for producing pig iron . The furnace is continuous in operation using iron ore, coke, and limestone as raw materials which are charged at the top while the molten iron and slag are collected at the bottom and are tapped out at intervals.

Blister

A **defect** in metal produced by gas bubbles either on the surface or formed beneath the surface while the metal is hot or plastic. Very fine **blisters** are called "**pin-head**" or "**pepper**" blisters.

Boron

(chemical symbol **b**)- element no. 5 of the periodic system. Atomic weight 10.82. It is gray in color, ignites at about 1112°f. And burns with a brilliant green flame, but its melting point in a non-oxidizing atmosphere is about 4000°f. **Boron** is used in steel in minute quantities for one purpose only - to **increase** the hardenability as in case hardening and to **increase** strength and hardness penetration.

Brasses

Copper base alloys in which zinc is the principal added element. **Brass** is harder and stronger than either of its alloying elements copper or zinc; it is malleable and ductile; develops high tensile with cold-working and **not** heat treatable for purposes of hardness development.

Brinell hardness (test)

A common standard method of measuring the hardness of certain metals. The smooth surface of the metal is subjected to indentation by a hardened steel ball under pressure or load. The diameter of the resultant indentation, in the metal surface, is measured by a special microscope and the **brinell** hardness value read from a chart or calculated formula.

Brittleness

A tendency to fracture without appreciable deformation.

Bronze

Primarily an alloy of copper and tin but the name is now applied to other alloys not containing tin; e.g., aluminum, bronze, manganese bronze, and beryllium bronze. For varieties and uses of tin bronze see (alpha bronze and phosphor bronze).

Buckle

Alternate bulges or hollows recurring along the length of the product with the edges remaining relatively flat.

Burning

Heating a metal beyond the temperature limits allowable for the desired heat treatment, or beyond the point where serious oxidation or other detrimental action begins.

Butt welding

Joining two edges or ends by placing one against the other and welding them.

Carbide

A compound of carbon with one or more metallic elements.

Carbon

(chemical symbol **c**) - element no. 6 of the periodic system; atomic weight 12.01; has three allotropic modifications, all non-metallic. **Carbon** is preset in practically all ferrous alloys, and has tremendous effect on the properties of the resultant metal. **Carbon** is also an essential compound of the cemented carbides. Its metallurgical use, in the form of coke, for reduction of oxides, is very extensive.

Carbon steel

Common or ordinary steel as contrasted with special or alloy steels, which contain other alloying metals in addition to the usual constituents of **steel** in their common percentages.

Carburizing

(**cementation**) adding carbon to the surface of iron-base alloys by absorption through heating the metal at a temperature below its melting point in contact with carbonaceous solids, liquids or gasses. The oldest method of **case hardening**.

Case hardening

Carburizing and subsequently hardening by suitable heat-treatment, all or part of the surface portions of a piece of iron-base alloy.

Cast steel

Any object made by pouring molten steel into molds.

Chipping

A method for removing seams and surface defects with chisel or gouge so that such defects will not be working 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."

Chromium

(chemical symbol **cr**.) - element no. 24 of the periodic system; atomic weight 52.01. It is of bright silvery color, relatively hard. It is strongly resistant to atmospheric and other oxidation. It is of great value in the manufacture of stainless steel as an iron-base alloy. **Chromium** plating has also become a large outlet for the metal. Its principal functions as an alloy in steel making; (1) increases resistance to corrosion and oxidation (2) increases hardenability (3) adds some strength at high temperatures (4) resists abrasions and wear (with high carbon).

Chromium-nickel steel

Steel usually made by the electric furnace process in which **chromium** and nickel participate as alloying elements. The stainless steel of 18% **chromium** and 8% nickel are the better known of the **chromium-nickel** types.

Cladding

A process for covering one metal with another. Usually the surfaces of fairly thick slabs of two metals are brought carefully into contact and are then subjected to co-rolling so that a **clad** composition results. In some instances a thick electroplate may be deposited before rolling.

Cobalt

(chemical symbol **co**.) Element no. 27 of the periodic system; atomic weight 58.94. A gray magnetic metal of medium hardness; it resists corrosion like nickel, which it resembles closely; melting point 2696°f.; boiling point about 5250°f.; specific gravity 8.9. It is used as the matrix metal in most cemented carbides and is occasionally electroplated instead of nickel, the sulfate being used as electrolyte. Its principal function as an alloy in tool steel; it contributes to red hardness by hardening ferrite.

Cold rolling

Rolling metal at a temperature below the softening point of the metal to create strain hardening (work-hardening). Same as cold reduction, except that the working method is limited to rolling. **Cold rolling changes the mechanical properties** of strip and produces certain useful combinations of hardness, strength, stiffness, ductility and other characteristics known as tempers.

Copper

(chemical symbol **cu**) - element no. 29 of the periodic system, atomic weight 63.57. A characteristically reddish metal of bright luster, highly malleable and ductile and having high electrical and heat conductivity; melting point 1981°f.; boiling point 4237°f.; specific gravity 8.94. Universally used in the pure state as sheet, tube, rod and wire and also as alloyed by other elements (see brass and bronze), as an alloy with other metals.

Corrosion

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

Corrosion embrittlement

The embrittlement caused in certain alloys by exposure to a corrosive environment. Such material is usually susceptible to the intergranular type of corrosion attack.

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 above the recrystallization temperature of the metal.

Crystalline

Composed of **crystals**.

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.)

Decarburization

Removal of carbon from the outer surface of iron or steel, usually by heating in an oxidizing or reducing atmosphere. Water vapor, oxygen and carbon dioxide are strong **decarburizers**. Reheating with adhering scale is also strongly **decarburizing** in action.

Degassing process

(**in steel making**) - removing gases from the molten metal by means of a vacuum process in combination with mechanical action.

Deoxidizing

Removal of oxygen. In steel sheet, strip, and wire technology, the term refers to heat treatment in a reducing atmosphere, to lessen the amount of scale. (see controlled atmosphere furnaces)

Ductility

The property of metals that enables them to be mechanically deformed when cold, **without** fracture. In steel, **ductility** is usually measured by elongation and reduction of area as determined in a tensile test.

Elastic limit

Maximum stress that a material will stand before permanent deformation occurs.

Elongation

Increase in length which occurs before a metal is fractured, when subjected to stress. This is usually expressed as a percentage of the original length and is a measure of the ductility of the metal.

Endurance limit

Maximum alternating stress, which a given material will withstand for an indefinite number of times, without causing fatigue failure.

Erichsen test

Similar to the olsen test. Readings are in millimeters.

Etching

In metallography, the process of revealing structural details by the preferential attack of reagents on a metal surface.

Extrusion

Shaping metal into a chosen continuous form by forcing it through a die of appropriate shape.

Fatigue

The phenomenon leading to fracture under repeated or fluctuating stress. **Fatigue** fractures are progressive beginning as minute cracks and grow under the action of fluctuating stress.

Ferritic stainless steel

Has a body centered cubic (bcc) structure. These alloys are the chromium stainless steels containing low carbon levels. They are hardenable primarily by cold working, although some will harden slightly by heat treating. **Ferritic stainless steels** work harden much slower than austentitic stainless steels.

Ferroalloy

An alloy of iron with a sufficient amount of some element or elements such as manganese, chromium or vanadium for use as a means in adding these elements into molten steel.

Ferro-manganese

An alloy of iron and manganese (80% manganese) used in making additions of manganese to steel or cast-iron.

Ferrous

Related to iron (derived from the latin ferrum.) **Ferrous** alloys are, therefore, iron base alloys.

Finishing temperature

Temperature of final hot-working of a metal.

Fracture

Surface appearance of metals when **broken**.

Fracture test

Nicking and breaking a bar by means of sudden impact, to enable macroscopic study of the **fracture**.

Galling

The **damaging** of one or both metallic surfaces by removal of particles from localized areas due to seizure curing sliding friction.

Galvanizing

Coating steel with zinc and tin (principally zinc) for rust proofing purposes. Formerly for the purpose of **galvanizing**, cut length steel sheets were passed singly through a bath of the molten metal. Today's **galvanizing** processing method consists of uncoiling and passing the continuous length of successive coils either through a molten bath of the metal termed hot dipped **galvanizing** or by continuously zinc coating the uncoiled sheet electrolytically - termed electro-galvanizing.

Granulated

A coarse grain or pebbly surface condition which becomes evident during drawing. (see orange peel)

Hardenability

The ability of a metal, usually steel, to **harden** in depth as distinguished from the terms "hardness."

Hardness

Degree to which a metal will resist cutting, abrasion, penetration, bending and stretching. The indicated **hardness** of metals will differ somewhat with the specific apparatus measuring **hardness**. (see brinell hardness, rockwell hardness, vickers hardness, scleroscope hardness) tensile strength also is an indication of **hardness**.

Hooke's law

Stress is proportional to strain in the elastic range. The value of the stress at which a material ceases to obey **hooke's law** is known as the elastic limit.

Hydrogen embrittlement

(1) brittleness of metal, resulting from the occlusion of hydrogen (usually as a by-product of pickling or by co-deposition in electroplating). (2) a condition of low ductility resulting from hydrogen absorption and internal pressure developed subsequently. Electrolytic copper exhibits similar results when exposed to reducing atmosphere at elevated temperature.

Impact test

Test designed to determine, the resistance of metal to breakage by **impact**, usually by concentrating the applied stress to a notched specimen.

Iron

(chemical symbol **fe**.) Element no. 26 of the periodic system; atomic weight 55.85. A magnetic silver-white metal of high tensile strength ductile and malleable. Melting point of pure iron about 2795°f. Chemically iron is chiefly base forming. The principal forms of commercial iron are steel, cast iron and wrought iron.

Ironing

Thinning the walls of deep drawn articles by reducing the clearance between punch and die.

Magnesium

(chemical symbol **mg**.) - element no. 12 of the periodic system; atomic weight 24.305. Specific gravity 1.77 with a melting point of approximately 1160°f. A silver-white light malleable, ductile metallic element that occurs abundantly in nature. The metal is used in metallurgical and chemical processes; in photography, in signaling, and in the manufacture of pyrotechnics because of the intense white light it produces on burning. **Metalmart** is the world's largest stocking distributor of **magnesium** alloys including; sheet, plate, bar, castings, forgings, and extrusions. Check out our magnesium page for complete details.

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.

Manganese

(chemical symbol **mn**.) - element no. 25 of the periodic system; atomic weight 54.93. Lustrous, reddish-white metal of hard brittle and, therefore, non-malleable character. The metal is used in large quantities in the form of spiegel and ferromanganese for steel manufacture as well as in manganese and many copper-base alloys. Its principal function is as an alloy in steel making: (1) it is a ferrite-strengthening and carbide forming element. It increases hardenability inexpensively, with a tendency toward embrittlement when too high carbon and too high manganese accompany each other. (2) it counteracts brittleness from sulfur.

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 much to be preferred. The **mechanical properties** of steel are dependent on its microstructure. (see physical properties)

Medium-carbon steel

Contains from 0.30% to 0.60% carbon and less than 1.00% manganese. May be made by any of the standard processes.

Melting range

The range of temperature in which an alloy **melts**, that is the range between **solidus** and **liquidus** temperatures.

Modulus of elasticity

(**tension**) - force which would be required to stretch a substance to double its normal length, on the assumption that it would remain perfectly elastic, i.e., obey hooke's law throughout the test. The ratio of stress to strain within the perfectly elastic range.

Modulus of rigidity

Of a material suffering shear, the ratio of the intensity of the shear stress across the section to the shear strain, i.e., to the angle of distortion in radians; expressed on pounds or tons per square inch.

Molybdenum

(chemical symbol **mo**) - element no. 42 of the periodic system; atomic weight 95.95. Hard, tough metal of grayish-white color, becoming very ductile and malleable when properly treated at high temperatures; melting point 4748°f .; boiling point about 6600°f; specific gravity 10.2. Pure **molybdenum** can best be obtained as a black powder, by reduction of **molybdenum** trioxide or ammonium molybdate with hydrogen. From this powder, ductile sheet and wire are made by powder metallurgy techniques; these are used on radio and related work. Its principal functions as an alloy in steel making: (1) raises grain-coarsening temperature of austenite. (2) deepens hardening. (3) counteracts tendency toward temper brittleness. (4) raises hot and creep strength, red hardness. (5) enhances corrosion resistance in stainless steel. (6) forms abrasion-resisting particles.

Nickel

(chemical symbol **ni**) - element no. 28 of the periodic system; atomic weight 58.69. Silvery white, slightly magnetic metal, of medium hardness and high degree of ductility and malleability and resistance to chemical and atmospheric corrosion; melting point 265l°f.; boiling point about 5250°f., specific gravity 8.90. Used for electroplating. Used as an alloying agent, it is of great importance in iron-base alloys in stainless steels and in copper-base alloys such as cupro-nickel, as well as in nickel-base alloys such as monel metal. Its principal functions as an alloy in steel making: (1) strengthens unquenched or annealed steels. (2) toughens pearlitic-ferritic steels (especially at low temperature). (3) renders high-chromium iron alloys austenitic.

Non-ferrous metals

Metals or alloys that are **free** of iron or comparatively so.

Non-metallic inclusions

Impurities (commonly oxides), sulphides, silicates or similar substances held in metals mechanically during solidification or formed by reactions in the solid state.

Normalizing

A heat treatment applied to steel. Involves heating above the critical range followed by cooling in still air. Is performed to refine the crystal structure and eliminate internal stress.

Oil hardening

A process of hardening a ferrous alloy of suitable composition by heating within or above the transformation range and quenching in oil.

Olsen (ductility) test

A method of measuring the ductility and drawing properties of strip or sheet metal which involves determination of the width and depth of impression. The **test** simulating a deep drawing operation is made by a standard steel ball under pressure, continuing until the cup formed from the metal sample fractures. Readings are in thousandths of an inch. This test is sometimes used to detect stretcher straining and indicates the surface finish after drawing, similar to the erichsen **ductility test**.

Open-hearth process

Process of making steel by heating the metal in the hearth of a regenerative furnace. In the basic open-hearth steel process, the lining of the hearth is basic, usually magnesite; whereas in the acid open-hearth steel process, an acid material, silica, is used as the furnace lining and pig iron, extremely low in phosphorous (less than 0.04%), is the raw material charged in.

Ore

A **mineral** from which metal is (or may be) extracted.

Oxidation

The addition of **oxygen** to a compound. Exposure to atmosphere sometimes results in **oxidation** of the exposed surface, hence a staining or discoloration. This effect is increased with temperature increase.

Oxide

Compound of **oxygen** with another element.

Phosphor bronze

Copper base alloys, with 3.5 to 10% of tin, to which has been added in the molten state phosphorous in varying amounts of less than 1% for deoxidizing and strengthening purposes. Because of excellent toughness, strength, fine grain, resistance to fatigue and wear, and chemical resistance, these alloys find general use as springs and in making fittings. It has corrosion resisting properties comparable to copper.

Phosphorus

(chemical symbol **p**) - element no. 15 of the periodic system; atomic weight 30.98. Non-metallic element occurring in at least three allotropic forms; melting point 111°f.; boiling point 536°f.; specific gravity 1.82. In steels it is usually undesirable with limits set in most specifications. However, it is specified as an alloy in steel to prevent the sticking of light-gage sheets; to a degree it strengthens low carbon steel; increases resistance to corrosion, and improves machinability in free-cutting steels. In the manufacture of **phosphor bronze** it is used as a deoxidizing agent.

Physical properties

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

Pickling

The process of chemically removing oxides and scale from the surface of a metal by the action of water solutions of inorganic acids.

Pig iron

Iron produced by reduction of iron ore in a blast furnace. **Pig iron** contains approximately 92% iron and about 3.5% carbon. The balance is largely silicone and manganese with a small percentage of phosphorus, sulphur, and other impurities.

Pipe

Contraction cavity, essentially cone-like in shape, which occurs in the approximate center, at the top and reaching down into a casting; caused by the shrinkage of cast metal.

Plasticity

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

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)

Quenching

In the heat treating of metals, the step of cooling metals rapidly in order to obtain desired properties; most commonly accomplished by immersing the metal in oil or water. In the case of most copper base alloys, **quenching** has no effect other than to hasten cooling.

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.

Radiography

A nondestructive method of internal examination in which metal objects are exposed to a beam of x-ray or gamma radiation. Differences in thickness, density or absorption, caused by internal defects or inclusions, are apparent in the shadow image either on a fluorescent screen or on photographic film placed behind the object.

Refractory

A heat-resistant material, usually nonmetallic, which is used for furnace linings and such.

Resilience

The tendency of welding process in which the work pieces are heated by the passage of an electric current through the contact. Such processes include spot welding, seam or line welding and percussion welding. Flash and butt welding are sometimes considered as resistance welding processes.

Rockwell hardness (test)

A standard method for measuring the hardness of metals. The **hardness** is expressed as a number related to the depth of residual penetration of a steel ball or diamond cone ("brale") after a minor load of 10 kilograms has been applied to hold the penetrator in position. This residual penetration is automatically registered on a dial when the major load is removed from the penetrator. Various dial readings combined with different major loads, give "**scales**" designated by letters varying from "a" to "h"; the "b" and "c" scales are most commonly in use.

Scaling

(1) oxidation of metal due to heat resulting in relatively heavy surface layers of oxide. (2) removal of scale from metal.

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. Similar to cold shut and laminations.

Shear

A type of cutting operation in which the metal object is cut by means of a moving blade and fixed edge or by a pair of moving blades that may be either flat or curved.

Silicon

(chemical symbol **si**) - element no. 14 of the periodic system; atomic weight 28.06. Extremely common element, the major component of all rocks and sands; its chemical reactions, however, are those of a metalloid. Used in metallurgy as a deoxidizing scavenger. **Silicon** is present, to some extent, in all steels, and is deliberately added to the extent of approximately 4% for electric sheets, extensively used in alternating current magnetic circuits. **Silicon** cannot be electrodeposited.

Silicon steel

Steel usually made in the basic open-hearth or electric furnace, with about 0.50-5.% silicon, other elements are usually kept as low as possible. Because of high electrical resistance and low hysteresis loss, silicon sheet and strip are standard in electric magnet manufacture.

Sliver

Loose metal piece rolled down onto the surface of the metal during the rolling operations.

Stainless steel

Corrosion resistant steel of a wide variety, but always containing a high percentage of chromium. These are highly resistant to corrosion attack by organic acids, weak mineral acids, atmospheric oxidation, etc.

Steel

Iron, malleable in at least one range of temperature below its melting point without special heat treatment substantially free from slag, and containing carbon more than about 0.05% and less than about 2.00%. Other alloying elements may be present in significant quantities, but all steels contain at least small amounts of manganese and silicon, and usually as undesirable constituents, also sulfur and phosphorus.

Stress relieving

Reducing residual stresses by heating.

Tempering

A process of re-heating quench-hardened or normalized steel to a temperature below the transformation range and then cooling at any rate desired. The primary purpose of tempering is to impart a degree of plasticity or toughness to the steel to alleviate the brittleness of its martensite.

Tensile strength

Breaking strength of a material when subjected to a tensile (stretching) force. Usually measured by placing a standard test piece in the jaws of a tensile machine, gradually separating the jaws, and measuring the stretching force

necessary to break the test piece. **Tensile strength** is commonly expressed as pounds (or tons) per square inch of original cross section.

Tin

(chemical symbol **sn**) - element no. 50 of the periodic system; atomic weight 118.70. Soft silvery white metal of high malleability and ductility, but low tensile strength; melting point 449°f., boiling point 4384°f., yielding the longest molten-state range for any common metal; specific gravity 7.28. Principal use as a coating on steel in tin plate; also as a constituent in alloys.

Titanium

(chemical symbol **ti**) - element no. 22 of the periodic system; atomic weight 47.90, melting point about 3270°f.; boiling point over 5430°f; specific gravity 4.5. Bright white metal, very malleable and ductile when exceedingly pure. Its principal functions as an alloy in the making of steel (1) fixes carbon in inert particles (a) reduces martensitic hardness and hardenability in medium chromium steel (b) prevents formation of austenite in high-chromium steels (c) prevents localized depletion of chromium in stainless steel during long heating. Now finding application in its own right because of its high strength and good corrosion resistance.

Tolerance limit

The permissible deviation from the desired value.

Toughness

Property of resisting fracture or distortion. Usually measured by impact test, high impact values indicating high toughness.

Tungsten

(chemical symbol **w**) - element no. 74 of the periodic system; atomic weight 183.92. Gray metal of high tensile strength, ductile and malleable when specially handled. It is immune to atmospheric influences and most acids, but not to strong alkalies. The metal is used as filament and in thin sheet form in incandescent bulbs and radio tubes. (1) forms hard abrasion resistant particles in tool steels. (2) promotes hardness and strength at elevated temperatures.

Vanadium

(chemical symbol **v**) - element no. 23 of the periodic system; atomic weight 50.95. Gray-white, hard metal, unaffected by atmospheric influences or alkalies but soluble in most strong acids; melting point 31190°f.; boiling point about 61500°f.; specific gravity 5.87. It cannot be electrodeposited. Its principal functions as an alloy in the making of tool steels. (1) elevates coarsening temperature of austenite (promotes fine grain). (2) increases hardenability (when dissolved). (3) resists tempering and causes marked secondary hardening.

Vickers hardness (test)

Standard method for measuring the hardness of metals, particularly those with extremely hard surfaces: the surface is subjected to a standard pressure for a standard length of time by means of a pyramid-shaped diamond. The diagonal of the resulting indention is measured under a microscope and the **vickers hardness** value read from a conversion table.

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 recrystalization occurs across the interface.

Work hardening

Increase in resistant to deformation (i.e. in hardness) produced by cold working.

Wrought iron

Iron containing only a very small amount of other elements, but containing 1-3% by weight of slag in the form of particles elongated in one direction, giving the iron a characteristic grain. Is more rust-resistant than steel and welds more easily.

X-rays

Light rays, excited usually by the impact of cathode rays on matter, which have wave lengths between about 10-6 cm, and 10-9 cm; also written **x-rays**, same as roentgen rays.

Yield point

The load per unit of original cross section at which, in soft steel, a marked increase in deformation occurs without increase in load.

Yield strength (ys)

The stress (load/area) at which the metal changes from elastic to plastic in behavior, i.e., takes a permanent set.

Young's modulus

The coefficient of elasticity of stretching. For a stretched wire, **young's modulus** is the ratio of stretching force per unit cross-sectional area to the elongation per unit length. The values of **young's modulus** for metals are of the order 10 12 dynes per square cm. (see modulus of elasticity)

Zinc

(chemical symbol **zn**) - element no. 30 of the periodic system. Atomic weight 65.38. Blue-white metal; when pure, malleable and ductile even at ordinary temperatures; melting point 7870°f., boiling point 16650°f., specific gravity 7.14. It can be electrodeposited and is used extensively as a coating for steel (see galvanizing) and sheet. **Zinc** finds many outlets, such as dry batteries, etc. Zinc-base alloys are of great importance in die casting. Its most important alloy is brass.

Zirconium

(chemical symbol **zr**.) - element no. 40 of the periodic system. Atomic weight 91.22. Specific gravity 6.5 and melting point at about 3200° +/- 1300°f. Because of its great affinity for oxygen and combines readily with nitrogen and sulfur, it is used as a deoxidizer and scavenger in steel making. It is used as an alloy with nickel for cutting tools and is used in copper alloys.