ENGINEERING ENCYCLOPEDIA

CONDENSED INFORMATION ON 4500 IMPORTANT ENGINEERING SUBJECTS

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A Condensed Encyclopedia and Mechanical Dictionary for Engineers, Mechanics, Technical Schools, Industrial Plants, and Public Libraries, Giving the Most Essential Facts about 4500 Important Engineering Subjects

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Lacquer. Lacquer is the general name used for colored and frequently opaque varnishes used for applying a protective finish to metallic objects. Lacquer is applied to polished metal surfaces, such as brass, pewter, and tin, in order to give them a golden, bronze-like, or other lustrous surface. The main constituents of lacquer are shellac and alcohol, to which are added a number of other substances to give the required tint.

Lag Angle. When two sinusoidal quantities, such as alternating current or voltage, have the same period but are displaced in phase, the angle of lag of the first quantity with respect to the second is the angular phase difference by which the second quantity must be assumed to be retarded to coincide with the first quantity.

Lag Screw. A large form of wood-screw having a square head (instead of the slotted form) so that it can be turned with a wrench. (See Wood-screws.)

Lame's Formula. Lame's formula is the generally accepted formula for calculating the strength of cylinders subjected to high internal pressure. By means of this formula, the thickness of the metal of the cylinder can be determined when the inside radius, the maximum allowable fiber stress per square inch, and the pressure within the cylinder in pounds per square inch, are known. It is one of the more important engineering formulas, and will be found in engineering handbooks.

Lamp Base and Socket Shell Threads. The "American Standard" threads for lamp base and socket shells are sponsored by the American Society of Mechanical Engineers, the National Electrical Manufacturers' Association and by most of the large manufacturers of products requiring rolled threads on sheet metal shells or parts, such as lamp bases, fuse plugs, attachment plugs, etc. There are five sizes, designated as the "miniature size," the "candelabra size," the "intermediate size," the "medium size" and the "mogul size." For table of dimensions see MACHINERY'S Handbook.

Lampblack. Lampblack is made by burning oils and is a very pure form of carbon. It has a specific gravity of 1.82, grinds in 75 per cent of oil, and has unusual tinting power, and is, therefore, used in large quantities for this purpose. Other characteristics are its great stability, its very slow rate of drying, and a preserving action on the oil with which it is combined. It resembles graphite in its property as a conductor of electricity.

Lancashire Process. The Lancashire process for producing wrought iron consists in melting pig iron between two layers of charcoal, the molten metal collecting in a pasty mass at the bottom of the furnace. In dropping to the bottom of the furnace, the molten iron passes through an air blast and is decarburized. The molten mass is permitted to remain at the bottom of the furnace for from 20 to 25 minutes, after which it is mixed with slag, remelted, and, while in a pasty state, formed into balls, removed from the furnace, and hammered or rolled. The process resembles the so-called "Walloon" process.

Land. The term "land" as applied to metal-cutting tools such as taps, reamers, milling cutters, etc., refers to the top surface of a tooth. In the case of a tap, the land is the surface between two flutes, the land width being measured along the outer circumference from the front face of the tooth to the heel. The land of a reamer or milling cutter tooth is the top or clearance surface back of the cutting edge, but does not include the steeper slope at the rear which forms the back of the tooth and part of the flute or chip clearance space.

"Lands" of Gearing. The *bottom land* is the surface of the gear body between adjacent teeth. The *top land* is the surface of the tooth which is farthest from its supporting body.

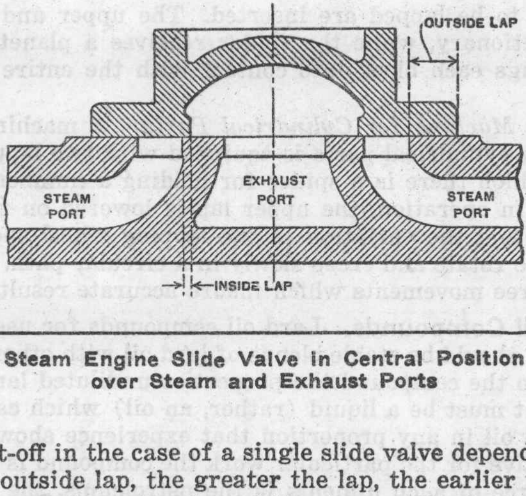
Lang's Lay Rope. In the regular type of wire rope, the wires of the strands are twisted in one direction and the strands themselves are laid into the rope in the other direction. In the Lang's lay rope, both the wires in the strands and the strands in the rope are twisted in the same direction. Such a rope is more easily untwisted than one made in the ordinary or "regular-lay" manner, and it is more difficult to tuck the strands securely in a splice, but the Lang's lay rope is, nevertheless, used to some extent, because it resists external wear and grip action much better than the regular-lay rope. This type of rope, however, should not be used unless assurance has been given by the rope manufacturers that it is adapted for the service for which it is intended. No universal rule can be given regarding its application, but its use is limited as compared with the regular-lay rope.

Lantern Pinions. Lantern pinions are formed of two disks between which are "rounds" of steel wire or rod to serve as teeth or "leaves." This type of pinion has been used extensively in clock mechanisms, and formerly was mployed in connection with primitive millwright work. Lantern pinions are not adapted to driving, and in clock mechanisms they are the driven members.

An accumulation of dirt that would stop the action of an ordinary cut pinion is simply pushed through between the rounds of a lantern pinion, which, therefore, continues to function. This is an important advantage of this type of pinion as applied particularly to low-priced clocks which frequently operate under unfavorable conditions.

Lap, Diamond. See Diamond Lap.

Lap of Slide Valve. The *outside lap* of a slide valve is the amount that the valve overlaps the outer edge of the steam port when the valve is in the central position over the ports. (See illustration.) If a valve did not have outside lap, steam would be admitted for the full length of the piston stroke; hence, the



Steam Engine Slide Valve in Central Position over Steam and Exhaust Ports

point of cut-off in the case of a single slide valve depends upon the amount of outside lap, the greater the lap, the earlier the cut-off, and the greater the expansion of the steam. The *inside lap* is the amount that the valve overlaps the inner edge of the steam port when in mid-position. Increasing the inside lap increases compression and delays the point at which the steam is released from the cylinder, whereas diminishing the inside lap decreases compression and hastens the point of release.

Lapping. Lapping is a refined abrading process generally employed for correcting errors in hardened steel parts and securing a smooth surface, or for reducing the size a very small amount. The lap is made of some soft metal, such as cast iron or brass, and it is "charged" with an abrasive which is imbedded into its surface. The grade or coarseness of the abrasive depends upon the finish required and the amount that must be removed by lapping. The form of the lap naturally depends upon the shape, size, and location of the surfaces upon which it is used.

Lapping Machines. There are several types of lapping machines. One special design used for lapping precision gage blocks has two flat laps of circular form. The lower lap is attached to the base of the machine, and the upper lap is secured to an arm by a connection which permits the lap to move freely in any direction but not to revolve. This arm is pivoted at one end so that the upper lap can be swung to one side to expose the lower lap and the work. When a machine is in use, one lap is above the other, and the gage blocks are between them, so that both the upper and lower surfaces of the blocks are lapped simultaneously. When the blocks are to be removed or inserted in the machine, the upper lap is swung out of the way. Between these two cast-iron laps, there is a steel plate or "spider" which contains holes into which the blocks to be lapped are inserted. The upper and lower laps remain stationary, while the spider receives a planetary motion which brings each block into contact with the entire surface of each lap.

Lapping Machine for Cylindrical Parts: A machine designed for lapping cylindrical parts is equipped with two lapping wheels between which there is a spider for holding a number of pins in position. In operation, the upper lap is lowered on the parts to be lapped, and the variation in the lapping wheel speeds causes the parts to rotate and creep slowly in a circular path. There are, in fact, three movements which insure accurate results.

Lard Oil Compounds. Lard oil compounds for use as cutting lubricants, should be stable blends of lard oil with other oils which will give to the compound the properties undiluted lard oil lacks. The diluent must be a liquid (rather, an oil) which can be added to the lard oil in any proportion that experience shows to be the most effective for the particular work the compound is to perform.

The source of such diluents is the petroleums, the mineral oil distillates of which can be obtained in numerous varieties. The proportions of mineral and lard oils vary, of course, as does also the viscosity of the mineral oil constituent, depending upon the nature and the severity of the work to be done. The mineral oil may be one of the pale amber mineral oils of medium viscosity, as used in the lard oil compounds suitable for high-speed operations, where a constant and abundant stream of cutting oil is required, or it may be a heavy-bodied viscous oil which is compounded with the lard oil for use in heavy, coarse work.

Classification of lard oil compounds has been carried out by certain leading producers of cutting lubricants. For instance, there are lard oil compounds designated by number, the number indicating the percentage of lard oil contained in the compound. With such an index as a guide, and the nature of the work to be performed known, a lard oil compound may be selected for any particular operation, embodying the qualities that experience has shown to be required.

Latent Heat. Latent heat is the heat which disappears when a solid is changed to a liquid, or a liquid to a gas, the former being called the *latent heat of fusion*, and the latter, the *latent heat of evaporation.* The heat which disappears in this manner is converted into mechanical work, and is used in tearing apart the molecules, and, hence, produces no change in the temperature of the substance. When the gas changes back to a liquid, or the liquid to a solid, the latent heat is again given out. The action described may be illustrated by the melting of ice into water, and the evaporation of the water into steam. When heat is applied to a piece of ice in an open vessel, it gradually melts, but the temperature of the water remains at 32 degrees until all of the ice has been melted, the heat having been used in the process of changing the ice into water. If heat is still applied, the temperature of the water will rise until it reaches 212 degrees F., at which point evaporation takes place, and although heat is constantly applied, the temperature of the water remains constant until it is all evaporated into steam. If the steam were collected and condensed, and the water cooled to 32 degrees F. and frozen, all of the heat which had been supplied would again be given out. Latent heat plays an important part in the operation of a boiler and the generation of steam. When it is said that the latent heat of evaporation of water is 966.6, this means that it takes 966.6 heat units to evaporate one pound of water after it has been raised to the boiling point, 212 degrees F.

Lathe Center Point Angle. In the United States the standard included angle for the work-supporting ends of lathe centers is 60 degrees. This angle is increased to 75 degrees for some axle turning or other heavy-duty lathes. British standard lathe centers have an angle of either 60 or 75 degrees as specified by the purchaser. For lathes engaged in turning axles for railway rolling stock, the angle of 75 degrees has been adopted by the British Railway Companies.

Lathe Classification. As lathes in general are used for a great variety of operations, naturally there are many different designs and sizes. The various types are usually classified, either with respect to some characteristic constructional feature, or with reference to the general class of work for which the lathe was designed. The most common type of lathe is usually known by manufacturers as an *engine lathe.* The term "engine," as used in this connection, simply means a machine, and it serves to designate that particular class of lathe which is hand manipulated and used by machinists for general work. In ordinary shop usage, the word "lathe" is commonly used to indicate a lathe of this class. Lathes having gears which are changed for cutting threads of different pitch are sometimes known as *plain* or *standard* engine lathes, whereas those having a gear-box by means of which the necessary gear combination may be obtained by simply shifting one or two levers are usually known as the "quick change-gear" type. The *tool-room* or *toolmaker's* lathe is classified according to the general class of work for which the lathe is designed. It is similar in appearance to an ordinary engine lathe, but has extra attachments and is generally considered a very accurate machine.

Other types of lathes which have some distinguishing characteristic are: The *turret lathe,* which is so named because tools for performing successive operations are held in a revolvable turret; the *bench lathe,* which is so small that it is mounted on a bench, and intended for delicate work usually requiring considerable accuracy; the *precision lathe,* which is usually a bench type that is capable of very accurate work and is more expensive than an ordinary bench lathe; the *gap lathe,* which has a gap formed in the bed in front of the faceplate in order to increase the "swing" or maximum diameter that may be revolved; the *extension gap lathe,* which has a double form of bed, the upper section of which may be extended in order to form a gap for increasing the swing, and also the distance between the centers; the *crankshaft lathe,* which is especially arranged for turning crankshafts; the *wheel lathe,* which is a large design intended especially for turning locomotive driving wheels; the *axle lathe,* which is a powerful design for turning car axles; the *foot-power lathe,* which is driven by a foot-treadle and is intended for small work; the *speed lathe,* which is without back-gears and is used for rotating parts rapidly for polishing, hand turning, or filing; the *chucking lathe,* which is especially adapted for parts that must be held in a chuck while being operated upon; and the *automatic lathe,* which is designed for the duplicate production. See Automatic Lathe; Bench Lathe; Blanchard Lathe; Burnishing Lathe; Capstan Lathe; Turret Lathes.

Lathe Development. An early treatise by Moxon, published in 1680, in England, shows that at that time the lathe had developed to a point where it was possible to turn out high-class ornamental woodwork, including oval shapes, but anything more than this was beyond its capacity until the slide-rest was invented. (See Slide-rest Development.) About 1800, Maudslay provided his lathe, having a slide-rest, with lead-screw and change-gears, and from then onward the development of the modern machine tool has been continuous and rapid. This combination is distinctly Maudslay's, and deserves to be classed as one of the greatest inventions of history. In the South Kensington Museum (London) are three lathes which show how rapidly the idea developed. The first is an old wooden pole lathe, with two dead centers set in wooden blocks. A string or strap went from a foot-treadle below, around the piece to be turned, and up to a wooden spring-pole attached to the ceiling. By working the treadle, the piece was rotated alternately backwards and forwards, the cut being made with a hand tool during the forward movement. This lathe fairly represents the state of the art in 1800. The second is one of Maudslay's first screw-cutting lathes. It has two triangular bars for a bed, cast-iron head- and tail-stocks, and a lower spindle in the headstock between the bars connected to the live spindle by a single pair of gears. This lower spindle carried on the end toward the slide-rest a forked clutch into which was fitted a lead-screw of the desired pitch, which controlled the longitudinal movement of the tool. When a screw of another pitch was desired, the lead-screw was changed for one of the required pitch. This machine was built about 1797. The third machine was built in 1800. It has a well-designed cast-iron bed, a single lead-screw with 30 threads to the inch, change-gears, and a strong, well-built carriage with a back-rest to prevent the springing of the work. There are 28 change-gears with teeth varying in number from 15 to 50. With the machine are sample screws, about 2 leet long, which were cut on it, with threads varying from 16 to 100 threads per inch. Shortly before his death in 1831, Maudslay built a lathe having a faceplate 9 feet in diameter, capable of turning flywheels 20 feet in diameter and boring steam cylinders up to 10 feet in diameter.

Lathe Size. The size of an engine lathe, according to the practice followed in the United States, is based upon the "swing" or the maximum diameter that can be rotated over the ways or shears of the bed. The nominal sizes listed by lathe manufacturers, however, ordinarily do not represent the maximum swing, but a diameter which is somewhat less. For instance, a lathe which is listed as a 24-inch size may actually swing 24½ or 25 inches. The variations between the nominal and actual sizes range from about ½ to ¾ inch up to 1½, or even 2 inches. According to the English practice, the size of a lathe is defined by the height of the centers above the top of the bed.

Lathe Tools, Right- and Left-Hand. The tools used on lathes may be either right-hand or left-hand, depending upon the location of the cutting end. According to common usage, lathe tools are classed as "right-hand" when the tool is adapted for cutting from right to left, the cutting edge being on the left-hand side as the tool is seen from above. Thus, a right-hand side tool, for example, is adapted for facing the right-hand side of a collar or the right-hand end of a shaft, and vice versa for left-hand side tools. The "hand" of a lathe tool, therefore, seems to be related to the location of the surfaces the tool is adapted for cutting, rather than to the position of the cutting edge, since a right-hand tool has its edge on the left-hand side, as seen from the top, and the the reverse is true for a left-hand side tool. See also Planer Tools, Right- and Left-hand.

Latimer-Clark Cell. This is a primary cell or battery having a zinc anode, a mercury cathode, a zinc sulphate electrolyte, and a paste of mercurous sulphate and zinc sulphate for a depolarizer. This is a so-called "standard cell" producing 1.43 volts at 15 degrees C.

Latten Alloy. Latten is an alloy of copper and zinc, and belongs, therefore, to the class of alloys generally known as brasses. Latten is made in thin sheets and used especially for monumental brasses and figures. It is made in three commercial forms: black latten, which is rolled but unpolished; shaven latten, which is unpolished, but of extreme thinness; and rolled latten, which may be similar to either black or shaven latten in thickness, but which has both sides polished.

Lavite. "Lavite" is a trade name for certain salt baths used in heat-treating steel. These salt-bath heating mediums may be used for a wide range of temperatures, varying from 500 degrees F. for tempering up to 2300 degrees F. for heating high-speed steel for hardening. A Lavite bath transmits heat to steel in a manner quite different from a lead bath or an oven furnace. When the steel is introduced into a bath of carbon steel Lavite, which has a melting point of 1300 degrees F., the Lavite freezes around the steel, and forms an insulating jacket which prevents too rapid transfer of heat in the initial stages of the heating period. This jacket is also slow in melting, and the composition of "Lavite" is such that the melting of the jacket proceeds at a rate that permits of a uniform transmission of heat to the metal. The high specific heat of "Lavite" and its high heat of fusion account for the slow rate at which the insulating jacket melts. When the temperature of the steel has reached 1300 degrees F., the jacket has entirely disappeared, and at this point also, there is a favorable condition for heat transfer, because the temperature difference between the steel and the bath is comparatively small. Beyond 1300 degrees F., the full heating effect of the bath is obtained, and this effect is enhanced by the low viscosity of the salt bath, which permits free circulation of the heated salt around the steel.

With lead, no insulating jacket—or at best a very thin jacket—is formed.

Law of Charles. See Charles' Law.

Law of Conservation of Mass. This is a chemical law, applying to all chemical reactions, which states that whenever a change in the composition of substances takes place, the amount of matter after the change is the same as before the change.

Law of Multiple Proportion. Same as Dalton's law.

Law of Sines and Cosines. In a triangle, any side is to any other side as the sine of the angle opposite the first side is to the sine of the angle opposite the other side; or, if a and b be the sides, and A and B the angles opposite them:

$$\frac{a}{b} = \frac{\sin A}{\sin B}.$$

In a triangle, the square of any side is equal to the sum of the squares of the other two sides minus twice their product times the cosine of the included angle; or if a, b, and c be the sides and the angle opposite side a be denoted A, then:

$$a^2 = b^2 + c^2 - 2bc \cos A$$

and

$$a = \sqrt{b^2 + c^2 - 2bc \cos A}.$$

These two laws, together with the proposition that the sum of the three angles equals 180 degrees, are the basis of all formulas relating to the solution of triangles.

Laying-Out Plate. Surface plates are sometimes formed of large castings which are mounted on a special bed. Large plates of this kind are commonly used to provide a flat surface for laying out machine parts rather than for testing the accuracy of flat surfaces and they are commonly known as laying-out plates.

Lay of Wire Rope. The lay of wire rope is the distance parallel to the axis of the rope in which a strand makes one complete turn about the axis of the rope. The lay of the strand, similarly, is the distance in which a wire makes one complete turn about the axis of the strand. According to U. S. Government specifications, wire rope shall be regular lay; that is, the strands shall form a helix about the axis of the rope similar to the threads of a right-hand screw and the wires form a left-hand helix about the axis of the strand. The lay of the wires in the strand should make them approximately parallel to the axis of the rope where they would come into contact with a cylindrical surface which inclosed the rope. Seizing strand shall be standard lay; that is, the wires shall form a helix about the axis of the strand similar to the threads of a left-hand screw. The lay of wire rope shall be obtained by measuring, parallel to the axis of the rope, the distance in which a strand makes five or more complete turns around the rope. This distance divided by the number of turns is the lay of the rope. When measuring the lay, there shall be no axial load on the rope, and the measured distance shall not be within 10 feet of the end of the rope.

Lay-Out Lines, Coatings. See Coatings for Laying-out Lines.

Laytex. Highly flexible, high tensile strength, great resistance to compression, high dielectric strength, and important insulation properties. Has a stretch of 750 per cent and a tensile strength of 5000 pounds per square inch. Especially suitable as an electrical insulation material, both because of its high dielectric strength and because it is not susceptible to moisture.

Lead and Its Properties. Lead rarely occurs free in nature, and then only in minute quantities, but it is found abundantly in combination with other elements. Its strength in both compression and tension is very small, so that it cannot be drawn into fine wire, although it can be rolled into very thin sheets. The most important lead mines are in Nevada and Colorado, and in England, Wales, Germany, Spain, Mexico, and Brazil. As lead unites readily with almost all other metals, it is used in many alloys for bearing metals, electrotype metal, type metal, "white metal," etc. Alloys composed of lead, bismuth, and tin are noted for their low melting points. The chief uses for lead, except in alloys, are for service pipes in water piping, as a base for a number of paints, and for shot and bullets. Lead is easily dissolved in nitric acid; it is dissolved in acetic acid only when in contact with air; and is scarcely affected by sulphuric acid lower than 66 degrees Baume. Hydrochloric acid attacks it very slowly, because of the layer of insoluble chloride formed. The chemical symbol of lead is Pb; atomic weight, 207.1; melting point, 327 degrees C. (621 degrees F.); linear expansion per unit of length, per degree F., 0.0000157; specific heat, 0.031; and conductivity for both heat and electricity (silver = 100), 8.5. The ultimate tensile strength of cast lead is about 2000 pounds per square inch; and the ultimate tensile strength of lead pipe, about 2200 pounds per square inch. The specific gravity of lead varies from 11.35 to 11.37, and, hence, its weight per cubic inch equals 0.41 pound. It vaporizes at a bright-red heat and burns at from 1480 to 1540 degrees C. (about from 2700 to 2800 degrees F.).

Lead in Bearings: Lead flows more easily under pressure than any of the common metals, and it has great anti-frictional properties. A number of metals exceed lead in this property, but their cost or some other factor renders them unavailable. As the amount of lead that is used in a given bearing is increased, the lower the frictional resistance; the bearing also becomes softer and less expensive. Lead, however, is too soft to be used alone, as it cannot be retained in the recesses of the bearing even when used simply as a liner and run into a shell of brass, bronze, gun-metal, or some other alloy. Hence, various other metals are alloyed with it, such as tin, antimony, copper, zinc, iron, and a number of non-metallic compounds, such as sodium, phosphorus, and carbon. If antimony is added to lead, the hardness and brittleness is increased and if tin is added as well, it makes a tougher alloy than lead or antimony alone. Nearly all of the various babbitt metals are alloys of lead, tin, and antimony in various proportions, with or without other ingredients. In such babbitts, the wear increases with the amount of antimony and the price with the amount of tin. The higher antimony babbitts are used in heavy machinery, as they are harder, while those low in antimony are used in high-speed machinery.

Lead Angle. When two sinusoidal quantities, such as alternating current or voltage, have the same period but are displaced in phase, the angle of lead of first quantity with respect to the second is the angular phase difference by which the second quantity must be assumed to be advanced to coincide with the first quantity.

Lead Angle of Screw Thread. The helix angle of a screw thread, according to customary practice, is not measured relative to the axis but from a plane perpendicular to the axis, and it is known as the "lead angle." The helix angle of a helical gear is measured from the axis. The helix angle in each case and for any given diameter of screw thread or gear, depends upon the lead of the thread or gear tooth. The term "lead angle," however, is applied only to screw threads, worms, etc., to indicate that the angle is measured from a plane perpendicular to the axis. This angle is more useful in connection with screw threads, and the angle relative to the axis is more useful in designing helical gears.

Lead Angle of Turning Tool. The term "lead angle" is sometimes applied to the angle of the side or leading cutting edge of a turning tool. The angle thus designated is the same as the one known as "side cutting-edge angle" in the American Standard for single-point tools.

Lead Baths. The lead bath is extensively used in connection with the heat-treatment of steel, but is not adapted to the high temperatures required for hardening high-speed steel, as it begins to vaporize at about 1190 degrees F., and, if heated much above that point, rapidly volatilizes and gives off poisonous vapors. Lead furnaces should be equipped with hoods to carry away the fumes. Lead baths are especially adapted for heating small pieces that must be hardened in quantities. Gas is a satisfactory fuel for heating the crucible. It is important to use pure lead that is free from sulphur. Melting pots for molten lead baths, etc., should preferably be made from seamless drawn steel rather than from cast iron. Cast-steel melting pots, if properly made, are as durable as those made of seamless drawn steel.

Lead Burning. Lead burning may be defined as a form of autogenous welding, by means of which the parts to be united are joined by melting metal between them. This molten metal is obtained by heating the end of a strip of lead of the same composition as that of the lead plates to be united. The addition of metal at the joint is not actually necessary, but it serves to replace the material that is usually cut away before welding. The term "lead burning" is really a misnomer, because the lead is not burned so long as the welder does the work properly. The operation is essentially one of welding the lead with heat furnished by the combustion of hydrogen, and the technique of the operation is almost exactly the same as that of ordinary oxy-acetylene welding. Lead burning may be effectively performed with an oxy-acetylene welding torch, but great care must be taken, because the temperature of the oxy-acetylene flame is really too high for working on lead.

Leaded Bronze. This is an alloy containing 80 per cent of copper, 10 per cent of tin, and 10 per cent of lead, which melts at 945 degrees C. (1735 degrees F.).

Leaded Gun-Metal. This is an alloy consisting chiefly of copper and tin. The S. A. E. composition No. 63 follows: Copper, 86-89; tin, 9-11; lead, 1-2.5; zinc and other impurities, 0.50 max.; phosphorus, 0.25 max. This is a general utility bronze especially useful for bushings subjected to heavy loads.

Lead Foil. See Tin Foil and Lead Foil.

Lead Joint. This is a term generally used to signify the connection between pipes which is made by pouring molten lead into the annular space between a bell and spigot, and then making the lead tight by calking. The term is rarely used to mean the joint made by pressing the lead between adjacent pieces, as when a lead gasket is used between flanges.

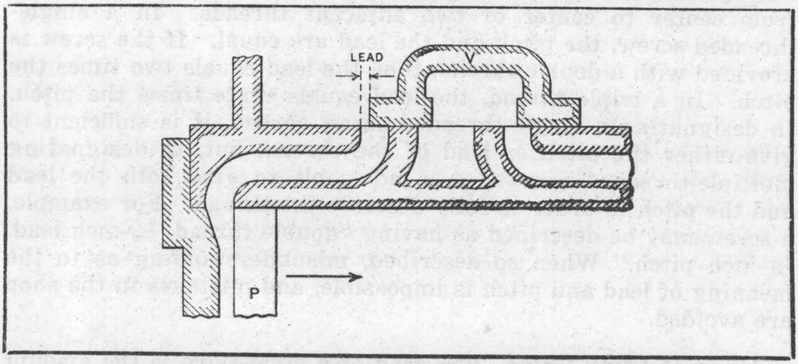
Lead Monoxide. See Litharge.

Lead of Milling Machine. The lead of a helix (or "spiral" as it is commonly called) that would be generated in a milling machine during one revolution of the dividing-head, when the dividing-head is connected to the table feed-screw by gearing giving a speed ratio of 1 to 1, is known as the *lead of the machine.* Suppose the table feed-screw has 4 threads per inch, that 40 turns of the indexing crank or worm-shaft are required for one revolution of the dividing-head spindle, and that the worm-shaft and feed-screw are connected by gearing which causes them to rotate at the same speed; then, 40 turns of the feed-screw will be required for one complete revolution of the dividing-head spindle, and, as the feed-screw has 4 threads per inch, the total lengthwise movement of the table for one revolution of the dividing-head spindle will equal $40 \div 4 = 10$ inches; therefore, the lead of the spiral generated during one revolution of the dividing-head spindle will equal 10 inches, which is the lead of this particular milling machine.

Lead of Screw Threads. The lead of a screw thread is the distance the screw will travel forward in the nut if revolved one complete revolution. The lead of a screw thread should be distinguished from the *pitch* of the thread, which is the distance from center to center of two adjacent threads. In a single-threaded screw, the pitch and the lead are equal. If the screw is provided with a double thread, then the lead equals two times the pitch. In a triple thread, the lead equals three times the pitch. In designating a single-threaded screw thread, it is sufficient to give either the pitch or lead of the thread, but, in designating multiple-threaded screws, it is advisable to give both the lead and the pitch in order to fully describe the thread. For example, a screw may be described as having "double thread, ½-inch lead, ¼-inch pitch." When so described, misunderstanding as to the meaning of lead and pitch is impossible, and mistakes in the shop are avoided.

Lead of Slide-Valve. The lead of a slide-valve is the amount of port opening when the piston is at the end of its stroke and the engine is on the dead center. This is the condition in the illustration, for the piston *P* is ready to start on its forward stroke, as indicated by the arrow. With the piston in this position the valve has already opened a distance equal to the lead, and the steam has had an opportunity to enter and fill the clearance space before the beginning of the stroke, thus giving the piston full steam pressure at this point. The lead ordinarily varies on engines of different size, from 0 to about 3/16 inch, 1/16 inch being a fair average for ordinary slide-valves. The amount of lead is sometimes determined by experiment after the engine is erected. When there is little or no lead, the tendency is for the piston to move under reduced pressure through part of its stroke, especially if the ports are small and the clearance space large. In some cases, however, a small amount of lead gives good results, especially when the compression is sufficient to produce a pressure at the beginning of the stroke nearly equal to the boiler pressure. Naturally a quick-acting valve requires less lead than one that opens more slowly.

Lead Pipe. Lead pipe is used to a very large extent for water systems for domestic purposes. It has been used for this purpose for centuries with entire satisfaction. Lead pipe for water systems, made from pure lead, is considered harmless as regards its influence on health, but mixtures with other metals, such as zinc, antimony, or tin, are dangerous and objectionable. The ultimate tensile strength of lead may be assumed to vary from 1600 to 2400 pounds per square inch. It is difficult to give the strength of lead with any certainty, because lead produced in Missouri, for example, is very much harder and stronger than so-called "desilverized" lead, and pipe made from the harder lead will stand a greater pressure.



Lead or Steam Port Opening of Steam Engine Slide Valve at Beginning of Stroke

Lead-Proof. A term applied to a method of testing the impression in a drop-forging die. See Drop-forging Dies, Lead-proof.

Lead-Screw. The lead-screw of an engine lathe is used for feeding the carriage when cutting threads. The carriage is engaged with this screw by means of two half-nuts that are free to slide vertically and are closed around the screw by operating a lever. Any screw which performs a similar function on other machine tools may properly be classed as a lead-screw.

Lead-Screw Steel. Lead-screw steel is a better grade than machine steel, and contains from 0.60 to 0.70 per cent carbon. Where machine parts are subjected to strain and shock such as shafts, studs, arbors, etc., which require a tough steel without hardening, lead-screw steel is commonly used.