Electric and Salt Bath Furnace and Ovens.

Electrical Heating for Hardening and Tempering; Salt Bath Furnaces; High Speed Tools; Grinding Tools; Emery Wheels and Speeds for Same; Carborundum Wheels; Case Hardening; Objectionable Features of the Common Process; Browning and Bluing Steel.

The rapid advancement in modern steels and their treatments has developed innumerable accessories and appliances for handling the materials and for rapid and accurate treatment. Prominent among these appliances are the electrical and salt-bath furnaces and ovens. The salt-bath furnaces consist of a device heated by electricity, gas, oil or other methods, in which is a crucible containing fusible salts, such as barium chloride, sodium chloride, potassium chloride, etc., in which the steel may be heated. As various salts and combinations of salts fuse at different temperatures, it is evident that almost any certain degree of heat may be obtained by this method. Most of the salt-bath furnaces are controlled

by pyrometers, while others are regulated by an electrical switch ampmeter. A form of this type of electrical salt bath is shown in Fig. 166. This has an adjustable controller that will produce bath temperatures between 482 and 2462 degrees F. and consists of a crucible surrounded by asbestos, which is covered with fire clay and surrounded by an iron jacket. Two low carbon electrodes, while immersed, furnish the heat. As a direct current produces electrolysis in these baths a single-phase alternating current is used, which, at starting, may require 70 volts, but for maintaining the temperature requires but 25 volts. In starting this furnace, after the bath is filled with salts, a small piece of carbon is pressed

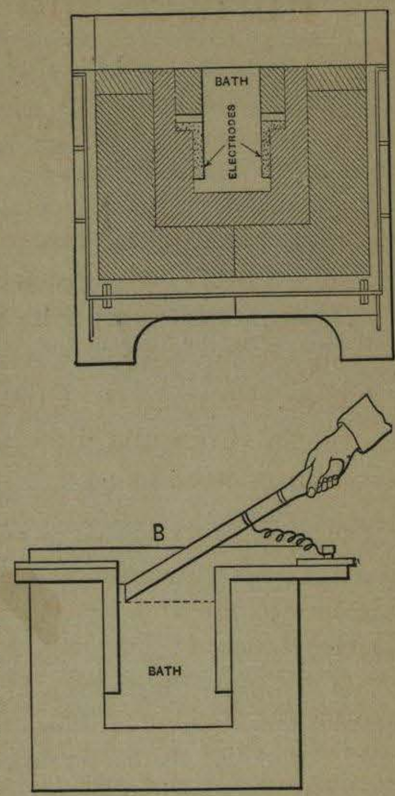

Fig. 166. Salt bath furnace.

against one of the electrodes by means of an auxiliary piece of carbon held in the hand, as shown at *B;* this produces an incandescence in the carbon and melts a channel across the salts. While melted salts have a high electrical conductivity, the dry ones are poor conductors, thus requiring this method of starting.

Electrical furnaces are made in various patterns and of all sizes and furnish a most cleanly, accurate and convenient method of heat treating.

Various methods of producing heat are employed, varying from the salt bath already employed to special furnaces for heating hollow and intricately shaped objects. In heating hollow objects by ordinary methods there is great difficulty in evenly heating and in preventing cracking from too sudden application of heat. By electrical methods these troubles are overcome, for the hollow tool may be placed over a rod and the current gradually increased until the proper temperature is reached, when the current may then be shut off slowly until thoroughly cooled. In operating any furnace a pyrometer of some sort is essential if an even and exact temperature is to be obtained. Modern pyrometers are of various forms and types, including electric-thermo, radium, electrical-resistance, color-screen and chemical. The electrical types are well known and widely used, but the color-screen and chemical forms are not so familiar. The former consists of numerous cells containing dyes, which absorb all the light of the color given off by a certain temperature of a heated object, and which is thus rendered invisible when viewed through the cells. On raising the temperature a portion of the light, due to an alteration in color, passes through the cell, thus rendering the object visible. Usually two pairs of cells are used, one pair being adjusted to a higher temperature than the other and the desired temperature being half way between the two. As the cells are marked with the temperature they represent the furnace and steel will

be at the proper heat when the observation opening is visible through one pair of cells and invisible through the others. When using one of these pyrometers with a single pair of cells the proper temperature may be ascertained when the work appears visible as deep crimson. Chemical pyrometers are of various forms, one of the cheapest and handiest being merely a cylinder of some salt, which is placed in a receptacle in the furnace and the furnace is then heated until the salt fuses. As long as the salt remains liquid the proper, or at least a sufficiently high, temperature is certain, for the cylinders are composed of various salts of known fusible temperatures and plainly marked.

By using three of these cylinders of different melting points an absolutely even heat may be obtained indefinitely, for as long as the lowest-limit cylinder and correct cylinder remain liquid and the excess-temperature cylinder remains solid the heat is known to be up to and not beyond that desired.

Great care and experience is required in grinding tools, and with the advent of modern high-speed machine tools and the various alloy steels and Tungsten tool steel, the grinding has become an art in itself. Nowadays emery wheels have given place largely to carborundum, and as these wheels can be obtained in practically any size or shape there is no excuse for not grinding your tools correctly. Emery and carborundum wheels should, however, be operated at definite speeds, and while it is best to ascertain the proper speed, grain and size of each wheel from the manufacturer the table or chart, Fig. 167, will give an idea of the ordinary speed required for emery wheels.

Fig. 168 shows some useful forms of wheels for various tools, and by following the directions furnished

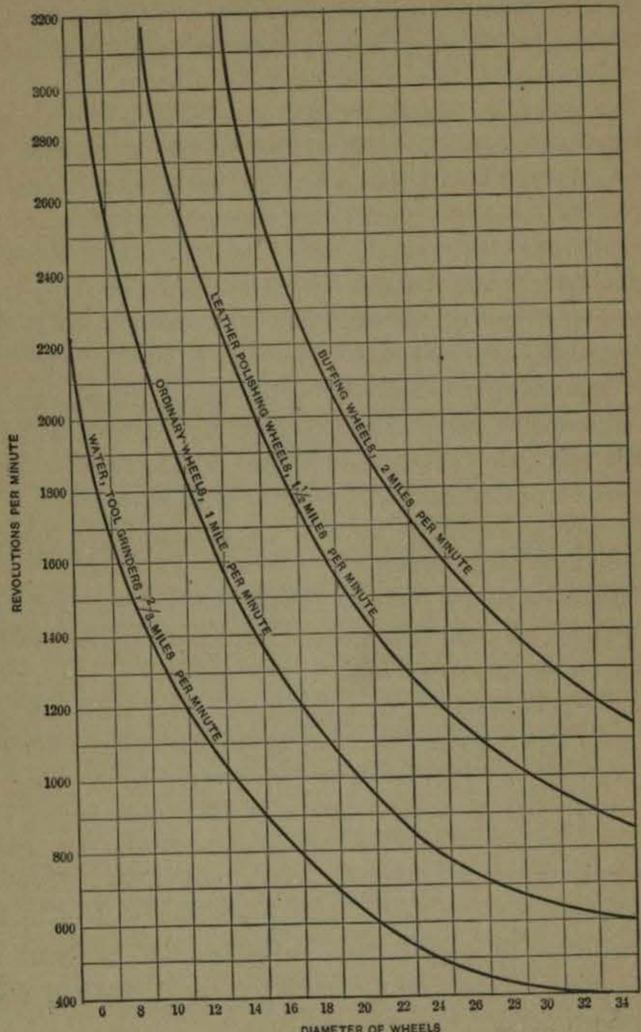

Fig. 167. **Emery wheel speeds.**

by specialists in this work most satisfactory results will be obtained.

High speed tool steel is designed and manufactured especially for rapid cutting in machines and is a self-hardening product, usually of tungsten steel alloy. Each manufacturer has his own formulæ and processes, and there is more or less variation in the treatment for each in hardening and tempering, as well as in the rapidity with which these tools may be operated and the amount of work they are capable of performing. It is impracticable to furnish complete data or directions in the present volume, but the following table and directions regarding the well-known "Novo" brand may be of interest and value, and is a fairly good example of this class of tools as a whole.

Table of tests of "Novo" steel on 8-in. high-speed power lathe. Job consisted in turning

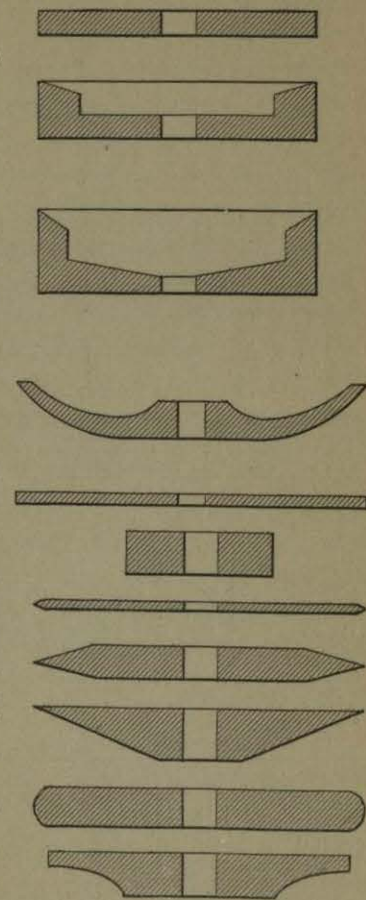

Fig. 168. **Emery wheel shapes.**

a forged steel dynamo spindle head of 0.40 carbon steel, 7¾ in. diam. x 6 in. wide, the whole work being done with 1¼-in. square tool, which was merely reground twice.

Speed, feet per minute.	Transverse Revs. per inch of feed.	Depth of cut.
475	220	1/16-in., twice across
650	220	1/32-in., twice across
800	220	1/64-in., twice across
500	220	1/16-in., twice across
500	220	1/16-in., twice across
500	132	1/16-in., twice across
450	220	3/32-in., twice across
800	220	1/64-in., three times across
100	220	9/32-in., twice across
100	132	9/32-in., twice across
100	80	9/32-in., twice across

A Novo punch will punch from 800 to 2,000 holes through nickel-plated armor plates 1-inch thick; a ¾-inch punch will punch 56,000 holes through ¾-inch structural steel; a ¾-inch drill at 650 revolutions will penetrate 4 inches of cast iron in 14 seconds. Three-inch cast iron can be regularly pierced by ½-inch drills at the rate of 18 inches per minute, and often at rate of 25 inches.

For hardening a heat of about 2300 F. is employed and cooling is in cold air blast, but good results are obtained by quenching in fish or lard oil. A most important point is to avoid all contact with water throughout hardening and heating operations. Grinding should be done on a wet wheel. This steel is furnished in all

sizes of flat, round, square, triangular, octagonal, diamond, bevel and irregular sections. "I" and "Z" sections, from which tools are made without forging by merely grinding and hardening, are particularly desirable, as there is no waste or breakage, and tools from such shapes are as strong and rigid as if solid and are much lighter. The "I" sections saving 30% in weight and the "Z" 40%.

The unannealed steel is glass-hard, but is readily machined when annealed. The process known commonly as "case-hardening" is for the purpose of infusing soft steel or iron with a small amount of carbon for increasing the hardness of the surface. Many parts of automobiles, guns and other objects are thus treated, for by using a soft, low-carbon steel in the machine work a great deal is saved in expense, and by afterward case-hardening a very hard, long-lived bearing or wearing surface is produced. The usual and old method of case-hardening was to use calcined bone, leather or similar material and heat the object, embedded in this material, to a red heat. The animal matter then gave off the carbon, which was absorbed by the steel or iron. Unfortunately, animal charcoal, while rich in carbon, also contains considerable phosphorus, which has a strong affinity for iron or steel, and is most objectionable in it.

While "red-shortness," or brittleness under heat, is due to too much sulphur in the iron, "cold-shortness," or brittleness when cold, is due to phosphorus; and while the former may be eliminated by using fuel free from sulphur, by using coke, charcoal or gas, phosphorus is very hard to remove, and in the open-hearth process is prevented from combining with the steel by using a lining to the furnace which has a stronger attraction for phosphorus than has the iron itself. In all modern processes the greatest care is taken to eliminate this undesirable element from the metal and, having taken this trouble, it appears foolish to deliberately use a material for hardening which will bring about the deleterious results that the steel manufacturers have spent time and money to prevent. Modern chemical products for case-hardening can now be procured which contain only carbon and alloy elements, and wherever the highest grade work in case-hardening is required such materials should be employed.

Where mere color, with the thinnest possible surface-hardening, is desired for a finish to steel, bone-charcoal, or better still, cyanide of potassium, may be employed, but for high-grade, lasting work the best process is the cheapest in the end.

In this connection it may be well to mention the fact that many steel workers send out beautifully made and finished products which are merely ground and polished and soon become rusty or corroded, even with the best of care. Gunmakers and others have long ago adopted various methods of coloring their products by processes known as "browning" and "bluing." When properly done these colors are quite permanent and wear a long time and resist corrosion far better than polished or bright steel objects. For the benefit of those unfamiliar with coloring methods, as well as for amateurs desiring to "brown" or "blue" steel objects that are uncolored, the following recipes and directions are given:

Hard steel tools may be given a beautiful glossy black by the use of wax or oil, but as this treatment softens the tools somewhat they should be made a little too hard before treatment. The best and most durable color

is obtained by first polishing the object after hardening and when it assumes the proper tempering color it should be dipped in melted yellow wax. The wax should then be burned off by quick exposure to flame and this process repeated until the rich black color is obtained. The only difficulty encountered is in burning off the wax quickly enough to prevent overheating after tempering and with practice this can be readily accomplished. When the color is satisfactory the tool should be cooled in water, rubbed with an oily rag and dried.

Another process for imparting a deep blue or black is as follows. Have the object perfectly clean and free from rust, oil or grease and dip or swab over it the following mixture:

Bismuth chloride	1 part
Mercury bichloride	2 parts
Copper chloride	1 part
Muriatic acid	6 parts
Alcohol	5 parts

Water to make 64 parts.

The color obtained by this formula is very lasting and proof against oxidization.

Small articles may be blued by placing them on a red-hot iron plate or bar laid across a tub or other receptacle filled with water. As soon as the articles to be colored assume the proper tint they should be dumped quickly into the water.

The objects to be treated should always be previously cleaned and polished and should be placed on the hot plate with polished side up.

Small screws, etc., may be blued by placing them head up in a ladle or other receptacle partly filled with brass filings and exposing to heat until the proper color is obtained. A simple way to accomplish this is to drill holes in a ladle just large enough to receive the screws and then after placing them in the holes fill around them with the filings.

Bluing may also be accomplished by the following method:

Crystallized chloride of iron......	2 parts
Solid chloride of antimony.......	2 parts
Gallid acid	1 part
Water	4 to 5 parts

Apply with sponge and dry in the air. Repeat the process until the proper tint is obtained: wash with water: dry and polish with linseed oil.

Browns may be obtained in various ways but the following will be found to answer all ordinary requirements:

U. S. ORDNANCE FORMULA.

Spirits of wine..............	1½ ounces
Tincture of iron.............	1½ ounces
Corrosive sublimate	1½ ounces
Sweet spirits nitre...........	1½ ounces
Sulphate of copper..........	1 ounce
Nitric acid	¾ ounce

Mix in 1 quart warm water and keep in glass jar.

To use, the steel should be thoroughly cleaned with caustic soda to remove any traces of grease and then carefully polish with emery paper. Apply the mixture with sponge or rag and expose to air for 24 hours. Rub off the outer rust and rub with a scratch brush. Repeat the operation twice or more if necessary and finally wash

in boiling water, dry rapidly and rub with linseed oil or apply transparent lacquer.

Sulphate of copper, sweet spirits of nitre, and distilled water in the proportion of one ounce of the first two to one pint of water, repeatedly applied and dried for intervals of a few hours and finally rubbed with oil, will also impart a rich brown color.

If the color after tempering an article is uneven or in other ways not satisfactory, it may be altered by blanching or whitening by dipping in a bath of hydrochloric acid and afterward heating to the proper shade.

Special Steel Treatments for Ball Bearings and Similar Purposes; Special Steels for Automobile and Gas Engine Construction; Various Useful Hints for Working Steel.

The automobile and gas engine require specially high grade, hard, tough steels in their construction and in ball bearings, especially, the greatest care should be taken to select the most perfect and suitable steel and to harden and temper the cones, races and balls with the utmost uniformity and care.

If the balls are too hard they will crack or chip, causing the bearing to rapidly break down, while if too soft they will wear out of true and ruin the bearing. Cones or races that are too hard, or too soft, will act in the same way, while unevenly hardened races or cones will wear rough in spots, a ball will then soon break or chip and the bearing be ruined. Some makers merely case-harden the surface of the cones after turning from tool steel, and while for light loads such work often answers fairly well, the thin layer of hard steel on the surface soon breaks through under heavy loads and ruins balls and bearings.

The best makes of bearings, such as those produced by the Bantam Anti-friction Co. and others, are made from special chrome steel of great strength and toughness and are carbonized or "case-hardened" with the latest and most improved methods, and in furnaces equipped with accurate pyrometers, and are quenched with oil or water baths. Carbonizing in these factories is carried to any desired depth by use of the scleroscope while heating is carried on for five, six, eight, ten or twelve hours according to the size and depth of the work. Bearings made in these careful, accurate, up-to-date shops are remarkable for their strength, wearing properties and silence in operation and if properly adjusted and lubricated are almost free from friction and last almost forever.

In automobile construction high grade chrome, nickel and vanadium steels are used and practically each maker of steel and each manufacturer of automobiles employs distinct treatments. Gasoline engines for high grade automobile and marine use call for the finest and strongest steel while the motors used in aeroplanes demand an even higher grade of material. These motors operate at speeds of from 1000 to 1800 revolutions per minute and under terrific strains and great heats, and when it is realized that some of the multiple cylinder and rotating engines deliver as many as ten thousand explosive impulses per minute and produce one horse-power for every two pounds of weight, we can appreciate the great strength and durability required of the materials

used in their construction. To produce cylinders and parts of sufficient strength and lightness, they are usually turned and bored from solid steel bars while such parts as crank shafts, cam rods, etc., are cut from solid ingots of chrome nickel steel. Krupp steel from Germany and nickel chrome steel from England are widely used and such steel must be capable of showing a strength of from 150,000 to 170,000 pounds per inch to be satisfactory.

Even these high grade steels must be treated with the utmost care in heating, hardening and tempering, for the slightest unevenness or inequality will result in disaster and death in most cases. In fact the treatment and working of modern alloy steels for gas engine use is a special art in itself, and while Americans lead in steel production our mechanics have never yet attained the high efficiency of alloy steel treatment that is found in the best European mechanics.

Every artisan or mechanic will from time to time hit upon new and valuable methods or "wrinkles" for accomplishing various results that are of great value to his fellows when they are made public. Many of these are never known outside the shop wherein they were developed and when now and then one is published it usually escapes the notice of innumerable workers to whom it would be of great use. The following are a few of the many hints that may prove valuable to steel workers, especially in small shops, and each has been furnished by competent men who have tried them repeatedly with success.

To case-harden parts of an object only: First coat the parts to be hardened with japan or lacquer, and dry. Next electroplate the object with copper or nickel, thus covering the parts that are to remain soft with the metal. If the object is then case-hardened the nickel or copper prevents the carbon from reaching the steel and thus the parts so protected remain soft.

Steel wire may be hardened by passing through a lead bath, at a temperature of 1200 to 1500 degrees F., which has been covered with a layer of chalk or charcoal. If desired hard, it is dipped in water; if elastic, in oil.

To harden without scale: Tool-steel articles which are polished may be hardened without scaling by dipping in water and then in a mixture of equal parts of fine corn meal and common salt. Heat the coated object in a fire until the mixture melts and then dip again in the mixture after which it can be heated to the hardening point without scaling. When the object is cooled in water or oil the mixture comes off, readily leaving the object as smooth and polished as before treating.

By using a mixture of glycerine, 80 parts; salt, 5 parts; sal ammoniac, 1 part; concentrated muriatic acid, ½ part; and water, 10 parts (by weight), as a bath for quenching, no reheating of the steel is necessary.

Burnt cast steel may be restored by bringing to a red heat and sprinkling with a mixture of red chromate of potassium, 32 parts; saltpeter, 16 parts; aloes, ½ part; gum arabic, ½ part, and rosin, 1 part.

Very minute cracks, flaws and holes in tools or steel may be rendered easily visible by dipping the object in kerosene; then wipe dry and rub with powdered chalk.

The kerosene that has penetrated the invisible cracks will ooze out and trace its position on the chalk in a dark line.

For drilling exceedingly hard metal a cast steel drill should be used, heated to a cherry red, scales rubbed off and the point dipped in mercury and then quenched in cold water.

Steel may be frosted or etched by a mixture composed of vinegar, 150 parts; blue vitriol, 30 parts; alum, 8 parts; salt, 12 parts; to which a few drops of nitric acid are added. By allowing the liquid to remain a longer or shorter time, shallow or deep lines may be cut while a very short treatment gives a beautiful frosted surface.

Steel and iron may be readily distinguished by filing with a clean new file over a flame. Steel filings will crackle as they burn, whereas iron filings burn brightly but will not crackle.