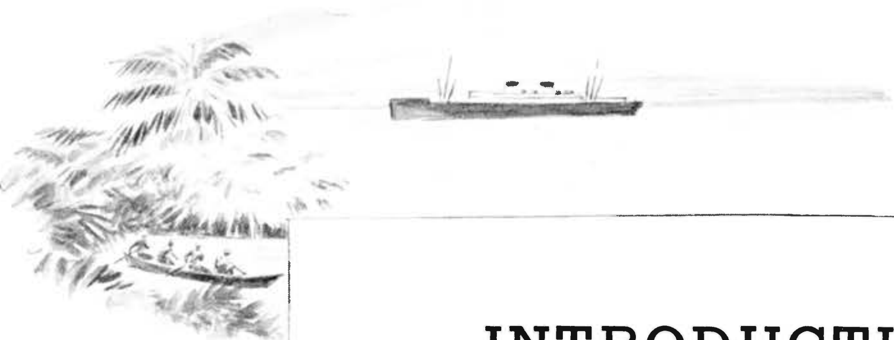

From the
FAR CORNERS
of the EARTH



INTRODUCTION

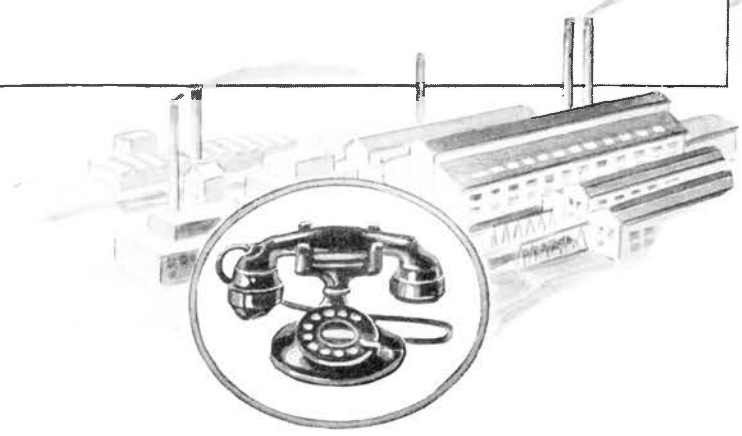
THIS FOURTH and enlarged edition, "From the Far Corners of the Earth" presents new pictures and stories of the world's raw materials—what they are, whence they come, how they are obtained, and what qualities make them most suitable for specific uses.

To engineers, chemists and other pioneers in the arts and sciences of industry, credit is due for developments which would have seemed miraculous to our forefathers, but today are taken as matters of course.

Production of many of these materials—some of them new in their industrial applications—is a complicated process and their use in some cases highly technical, but it has been the endeavor, in the space of a few pages, to make the story understandable.

Since these materials come from the far corners of the earth, the reader is taken into the hills of Pennsylvania, the treasure-laden Rocky Mountains, the Klondike, and far away India and Malaysia.

If reading these pages helps you discover anew some of the many interesting places in your own country, or in foreign lands, if it helps you learn more about far away people and their customs, this booklet will have justified its publication.



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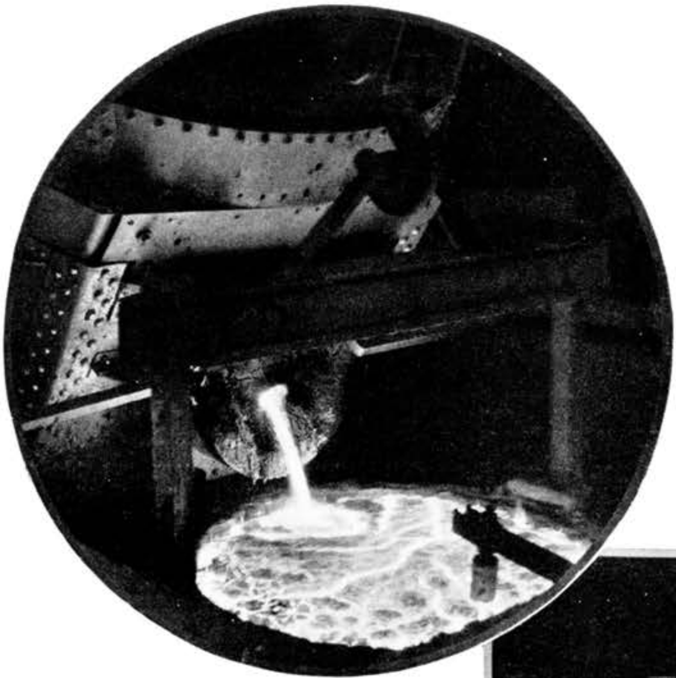
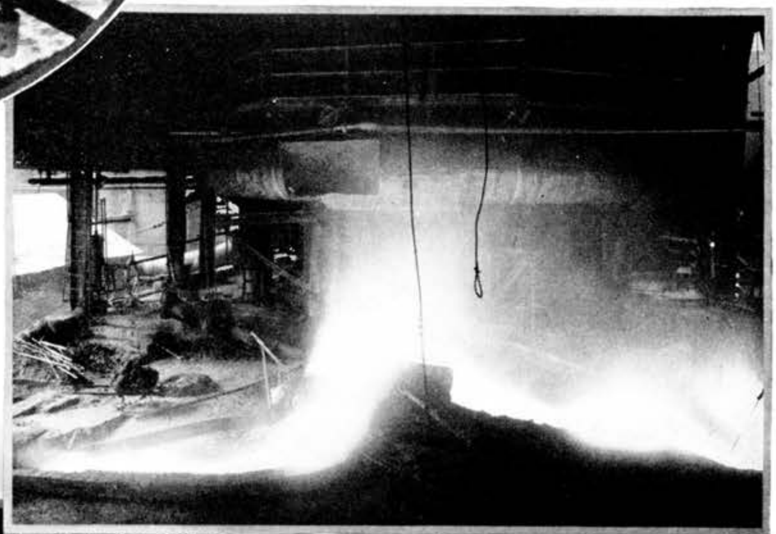
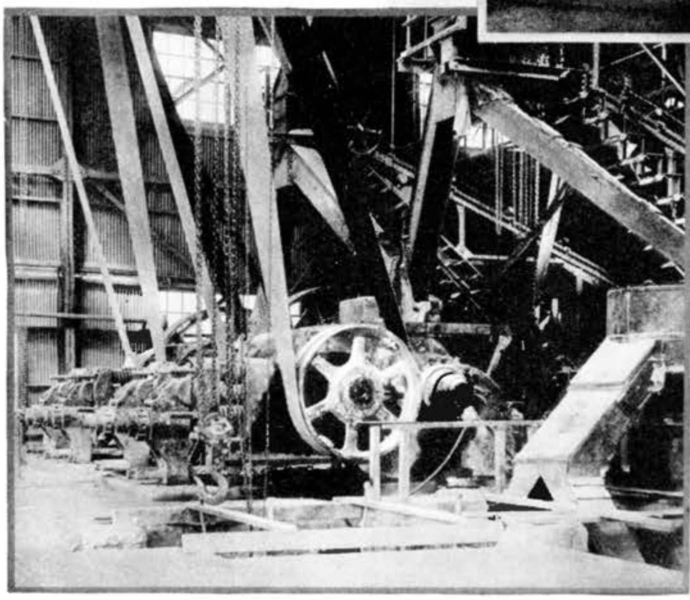
Since mankind first learned of iron stone, iron has played a part in the progress of the world. As arms and armor, it helped to open up the old trade routes and now that we have steel, shiny rails and sturdy ships bear trade to all parts of the world, and among their most important freight are products of iron and steel.



Left—Pouring a heat from an electric furnace.



The tapping floor of a blast furnace, showing molten iron issuing from the furnace. Molten slag, being lighter than iron, floats on the top and is skimmed off, going down the trough at the right into a slag car. The molten iron flows off to the left into a hot-metal car.



Iron ore, formed by concentration within or near molten rock, being crushed to get it ready for iron making.

The blooming mill handles the steel ingots as the blacksmith with his hammer and anvil shapes small pieces of iron and steel.

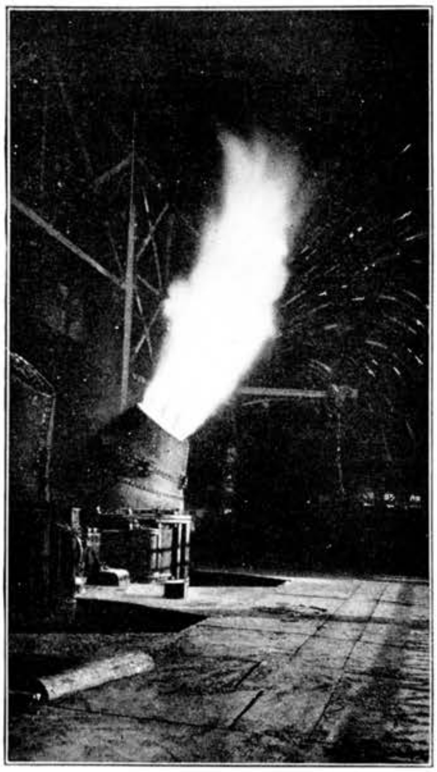
The Age of Alloys

The art of extracting metals from their ores and fitting them for use is metallurgy. It is really a new science, but one of the oldest of the arts. Its possibilities have been dimly realized for a long time. In the search for the finer metals most smelting operations take place at the mine because the ores are too lean in metal values to permit of profitable transportation to centers of consumption. Native gold or copper in visible amounts is found in few important mining operations. When gold is found in the amount of between one-tenth and one-fifth ounce per ton, the ore can be worked commercially. The development of modern machinery and of methods by metallurgical engineers has made this possible.

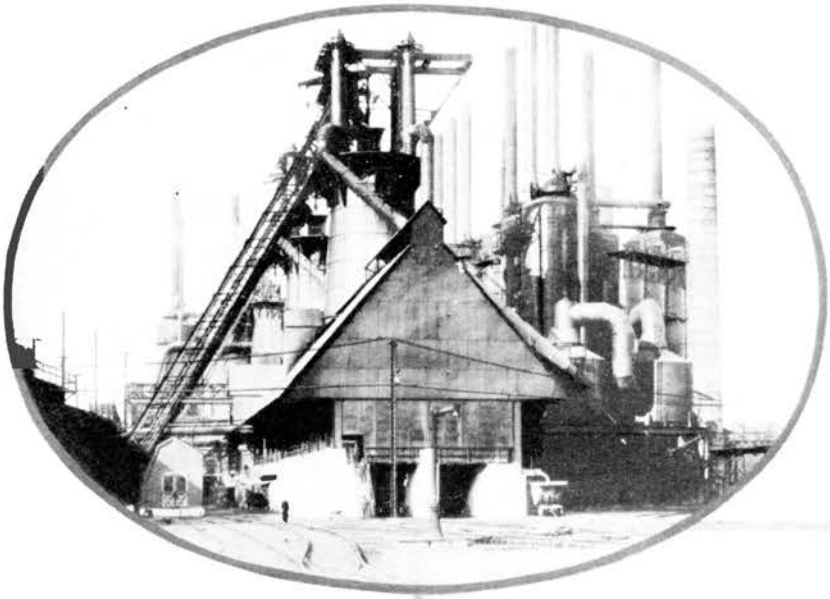
The romance of metallurgy is evidenced by the McArthur and Forest discoveries in the cyanide process of extracting gold, by reworking huge piles of refuse and obtaining yields of great fortunes from supposedly waste material. Sidney Thomas developed the celebrated basic process for making steel, which made it possible to produce good steel from phosphoritic iron ore, the by-products from the slags making cement and fertilizer. Still another illustration of accomplishments in metallurgy, a story fascinating in its plan and effort, is the work of Daniel C. Jackling on the low grade copper ores of Utah and adjoining states, which contain from 0.6 to 1.5 per cent of copper, finely disseminated or scattered. Jackling decided that these ores could be worked profitably if the operation were of great magnitude. After years of planning, his ideas were confirmed technically and commercially with the beginning of the Utah Copper Company, which operates the greatest single copper mine in the world. At this mine, each year, more material is moved than was taken out in the building of the Panama Canal, and at a present (1938) cost of 12 to 15 cents per ton, or about one-half of what it was at the beginning. The recovery of copper from these lean ores has been increased from 60 or 65 per cent to 85 or 90 per cent of the total copper in the ore. In the early days nothing below 1.5 per cent copper was considered pay ore. Now, at these surface copper mines, ore as low as 0.6 per cent copper and ore from underground mines showing 1.0 per cent copper are treated at a profit. Approximately 360,000,000 tons of ore have been mined and about the same number of dollars paid to stockholders. A substantial proportion of the entire population of Utah is dependent, in prosperous times, directly or indirectly, upon the Utah Copper Company.

Iron ores present different problems. Most iron ores contain over 50 per cent of iron and require an equal weight of coke and much limestone to smelt them in the blast furnace. Consequently the transportation of this ore, particularly by water, is practical and as a result the iron ore blast furnaces are usually near steel mills. By far the greater portion of pig iron never cools off but is carried molten in ladle cars, sometimes for considerable distances, to the open hearth and Bessemer furnaces for conversion into steel. Close to 60,000,000 tons of iron are brought down the Great Lakes in good

Thousands of years ago Prehistoric Man discovered "malleability" in certain "stones". It was the beginning of the Iron Age. The illustration above shows natives of the Belgian Congo smelting iron in a furnace made of lava. The men holding the sticks are operating crude bellows.



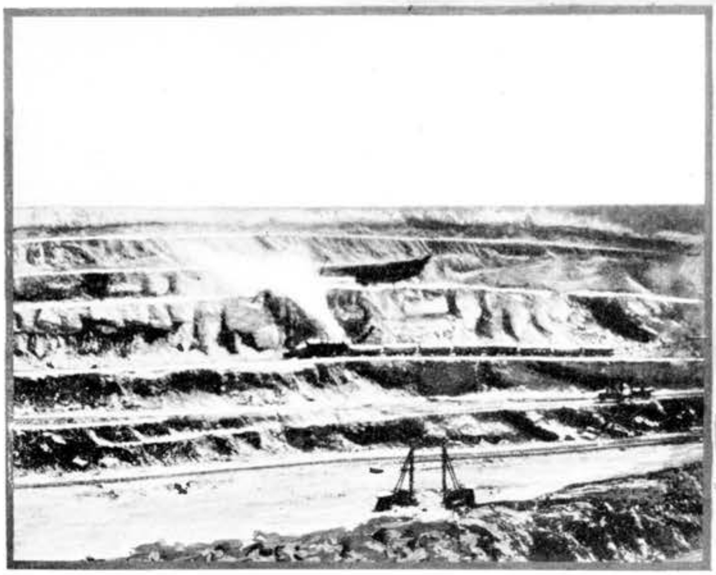
A modern Bessemer Converter in action. Hot metal from the blast furnace is poured into the pear-shaped converter and air is blown through for a short period, burning out the various impurities and converting the metal into Bessemer Steel.



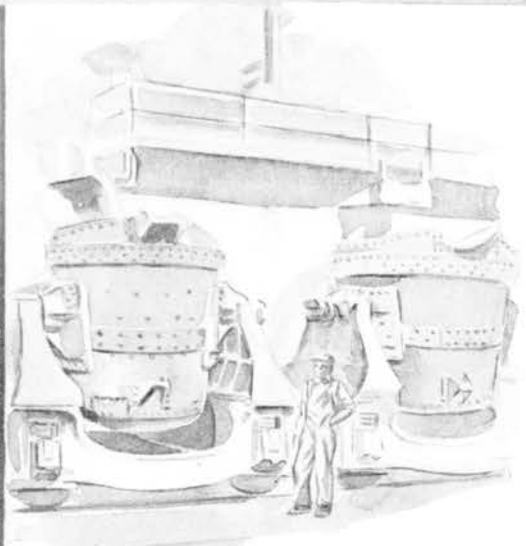
In most cases where electricity is used to produce magnetic effects iron is a necessity. And in innumerable instances where strength or keen cutting edges are needed iron or the steel made from it is used.

Left—A modern blast furnace where iron ore is reduced to metal by smelting with coke and limestone.

A million ton storage yard for ore and coke and the ore bridge 507 feet long that picks up 14 tons of iron ore at each scoop of the shovel.



In iron fields where the ore lies just under the surface, steam shovels scoop it up as the first step leading to the vessels which carry it through the Great Lakes to the important iron and steel manufacturing cities.



Pouring molten metal from a furnace into a kettle carried on its own car.

years. About half goes into the heavy forms of steel, such as rails, plates, bars, pipe and structural tubing; the other half into the more highly specialized steels which are made up principally into products by manufacturers of consumer goods: sheet and strip steel, tin plate, cutlery steels, safety razor steels, nails, barbed wire, fencing and fence posts.

Ninety to 94% of the entire U. S. production of steel of over 50,000,000 tons is plain carbon steel; that is, iron containing from a trace to 1.5% carbon with the addition of small amounts of silicon, manganese, and impurities. The varying properties of this steel, such as hardness, strength, toughness, etc., are mainly controlled by the amount of carbon. With varied heat treating, developed by metallurgists, steel is made hard and brittle, so that small pieces can be easily snapped in the fingers, or tough, so that it may be bent readily and will remain bent, or given a spring temper—fairly hard but elastic.

We have, therefore, the wide range of natural properties of steel, and also the much wider range made possible by heat treatment. But wide as are these possibilities, they are not wide enough to satisfy modern engineering requirements. So the metallurgist has turned to alloy steels and the alloys of other metals.

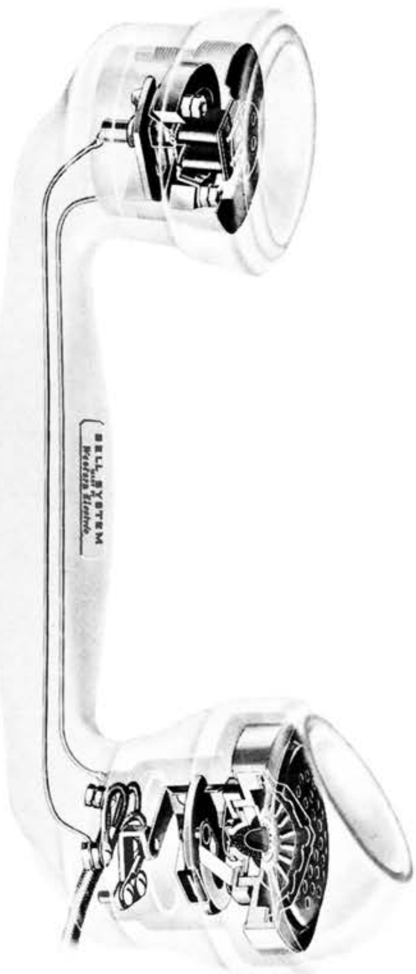
John A. Mathews, well-known metallurgist, called the twentieth century the "Age of Alloys" because alloys have assumed such wide importance within the past 30 years. Known for a long time, their use was not extensive until science began to understand the art of mixing metals. Michael Faraday, more than a century ago, experimented with synthetic alloys, and it has been known that meteors usually are of iron with nickel and cobalt. He is credited with the first attempt to improve the characteristics of iron by adding other metal to it. Faraday's fame, however, is due to his discovery of magnetic induction upon which the modern electrical industry is based.

Today, there are made annually some 3,000,000 tons of steel to which has been added one or more of the following metals: silicon, manganese, nickel, chromium, copper, tungsten, molybdenum, vanadium and cobalt. Occasionally other and rarer metals are added.

The resulting alloys have many special qualities suitable for a greatly increased variety of uses. Some excel in strength and toughness or possess greater magnetic and other electrical properties; increased corrosion resistance, or greater or less expansive or elastic properties, etc.

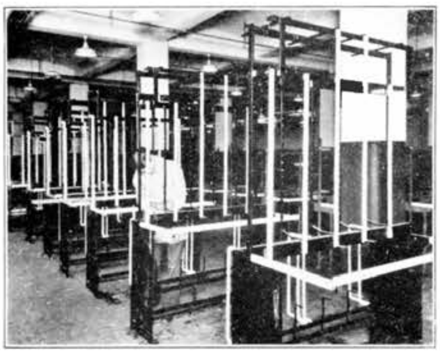
Permanent magnet alloys in your handset telephone may contain either tungsten from China or molybdenum from Colorado with cobalt from South Africa. Alloys of these elements with iron make highly efficient telephone magnets. Magnets of these alloys also are smaller and lighter in weight than those formerly made of other materials. Other alloys, containing nickel, copper, zinc, aluminum, magnesium, and precious metals, used in the manufacture of telephone and other electrical equipment, are described in the chapters dealing with those metals.

Alloy steel is used in the magnet and diaphragm of your handset telephone. The cradle and base are of zinc alloy, while the base plate, covered with leather, is of iron.

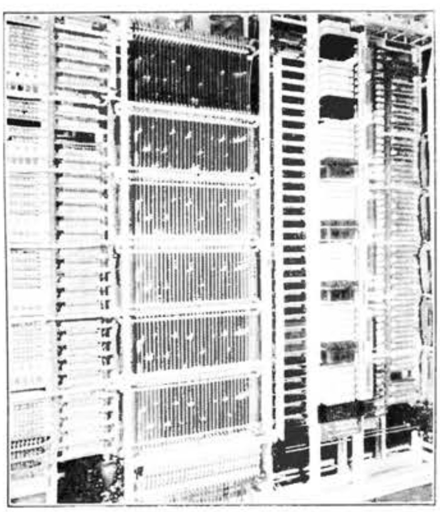


A phantom view of your handset telephone. Practically all of the metal parts are made of various alloys that serve best each part for its particular job of giving telephone service. Some of the details of the transmitter and receiver are explained in later chapters.

Alloy steel is used in the magnet and diaphragm of your deskstand receiver. The stem and base of this telephone are of brass, while the base plate (covered with felt) is of iron.



Iron is used to make up much of the framework of the switchboard sections where thousands of telephone lines come together and where the called party is selected. Both the black and white framework sections shown above are of iron.



An automatic or machine switching telephone exchange built almost entirely of iron and steel and non-ferrous alloys.

Gold is for the mistress—silver for the maid;
Copper for the craftsman, cunning at his trade.
"Good!" said the Baron, sitting in his hall,
"But Iron—Cold Iron—is master of them all".
(From Cold Iron—by R. Kipling)

Iron was used in the very early days of history, although our ancestors thousands of years ago knew very little about the metal compared to what we know today. But it marked a big advance when men began to use iron instead of copper and bronze for weapons and tools,—and so important was this in changing their way of living that historians today call that time the Iron Age.

Six thousand years have passed, and now, strangely enough, we are again in an Iron Age, or to be more exact a Steel Age, since our buildings, our machinery, our ocean steamers, our trains, all depend on steel in some form or other.

Iron is everywhere—in the leaves of trees, in plants, even in the blood of our veins and our arteries. If the iron-bearing corpuscles in our blood refused to work, all the color in our cheeks would fade, we would grow weak and finally die. But the iron in our blood is needed there and the iron in the soil is available only to the plants. So the iron for needles and sky-scrapers must be found elsewhere.

Up in Minnesota where the Father of Waters starts his journey to the Gulf as a small, clear, musical stream, are vast deposits of a red ore called *hematite,* which men have found to be of great value. Large prosperous mining towns have grown up because of the ore. It lies close to the surface, so that the work of the miners reminds one of excavators making ready to build gigantic buildings. Steam shovels lift the red earth into hopper cars, locomotives haul the long ore trains to the docks in the two cities at the head of the Great Lakes, the hopper cars empty into large bunkers, and huge derricks or chutes load the ore into ships for the long journey to Gary, Cleveland, Toledo, Pittsburgh, Buffalo and other cities.

During all this time other miners near these cities and on down into West Virginia have also been busy. The coal which they mine finds its way to coking ovens, where practically all the gas, moisture and ash are removed, leaving only the carbon.

The coke made from coal from the Connellsville and West Virginia mines is ready to meet the iron ore from the north. To the meeting is added a third product—common limestone. All three, the iron ore, the coke and limestone are dumped in layers through the top of a furnace. As the coke burns, creating a terrific heat, a blast of air is forced through the mass. The coke at the highest temperature combines with the oxygen contained in the ore and frees the metallic iron. The iron flows to the bottom of the furnaces, where it is "drawn off" and run out into molds, while the impurities which were in the iron ore are absorbed by the limestone and remain as "slag."

We now have pig iron but there are still carbon and other things in it which usually are not wanted. So the iron generally goes through selected additional processes.

Steel differs from iron in that more slag and carbon have been removed by either the Bessemer process or the open-hearth method. Ingot steel, for instance, is a true steel, free from slag but containing a small percentage of carbon. There are also commercial irons and steels which differ in the amount of other metals they contain. Among these are manganese steel, chrome steel, and nickel steel.

Iron ores are so common in the earth that there is hardly a country which does not have some iron, although many countries do not mine it. Besides the deposits around Lake Superior—which form the greatest iron mining district in the world—there are also great bodies of iron ore in Alabama, France, Brazil, Newfoundland, the United Kingdom, Germany, Luxembourg, Russia, Spain and Sweden.

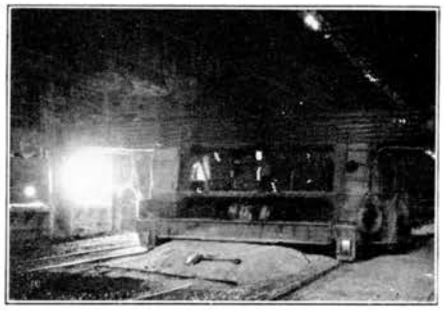
An interesting feature of iron making is that some countries which possess coal but have little iron, import the iron. Great Britain, for instance, is an important coal mining country, but before the War it mined only about two-thirds of the iron ore smelted in British furnaces.

There is another important iron ore besides the hematite which is mined in Minnesota. For many centuries men have known of the lodestone, which has the power of attracting iron. This name is given to any piece of iron which is a natural magnet made of the iron ore called magnetite. This kind of iron ore, which is supposed to have been discovered in Magnesia, a part of Asia Minor, is found in many places in this country as well as in Norway and Sweden.

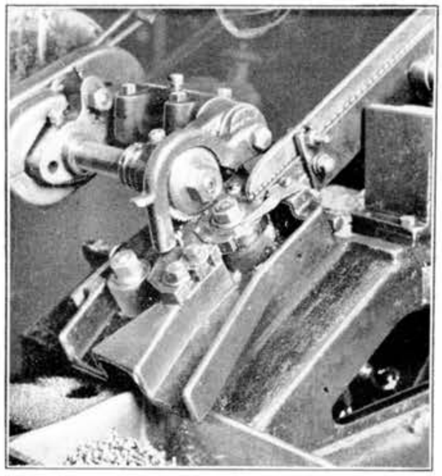
Iron which is not naturally a magnet, as you know, becomes one when a wire is wrapped around it and an electric current passed through the wire. For this reason iron is used in all electrical equipment which makes use of the principle of magnetism in its operation, except where there are air core inductances or loading coils in the system. For instance, in completing a telephone call from one party to another, an electric current puts a number of electro-magnets to work to make and break other contacts, so that electric currents may flow or cease to flow. If you are talking from one dial telephone to another, there are scores of relays which control circuits to light lamps and ring bells from the moment you pick up your receiver until you and the party called hang up. Many of these relays work, not once, but several times.

Then, too, iron is alloyed with nickel to make the permalloy that is wrapped around the Atlantic cables. By wrapping a thin tape of it (six-thousandths of an inch thick) around the copper wire beneath the gutta-percha insulation of telegraph cables, the speed of sending messages has been increased eight fold, so that 2,400 letters a minute can now be sent.

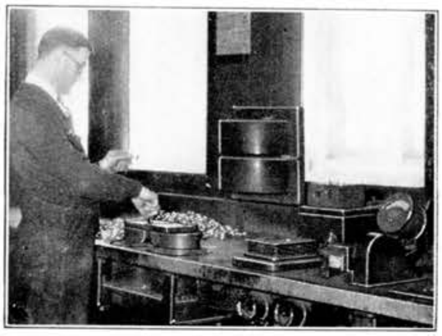
Another place where iron is used is in the receiver of your telephone instrument. That diaphragm you see when you look into your desk stand type receiver is of thin steel alloy and when you are listening to a message it is made to vibrate by a magnet made of two small coils wound on iron cores located just behind the diaphragm. The distance from the ends of these magnet cores to the diaphragm is carefully adjusted to within a few thousandths of an inch.



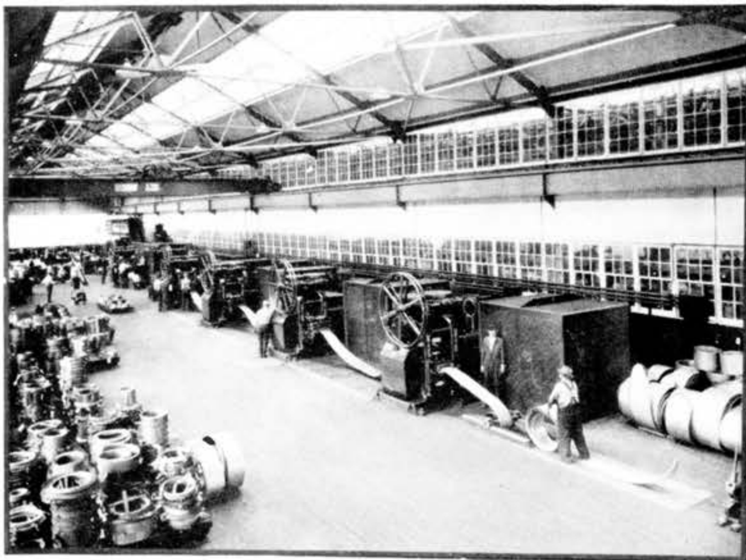
Charging an open-hearth furnace. The charge consists of a mixture of pig iron and steel scrap, loaded into rectangular steel boxes which are inserted through the furnace door by the charging machine which manipulates the boxes on the end of a long steel bar.



This automatic machine is one of a series of three which make iron screws; the first draws in the iron rod, forms the head and cuts off the proper length; the second slots the head; the third forms the thread. This is the machine which cuts the slots in the heads.

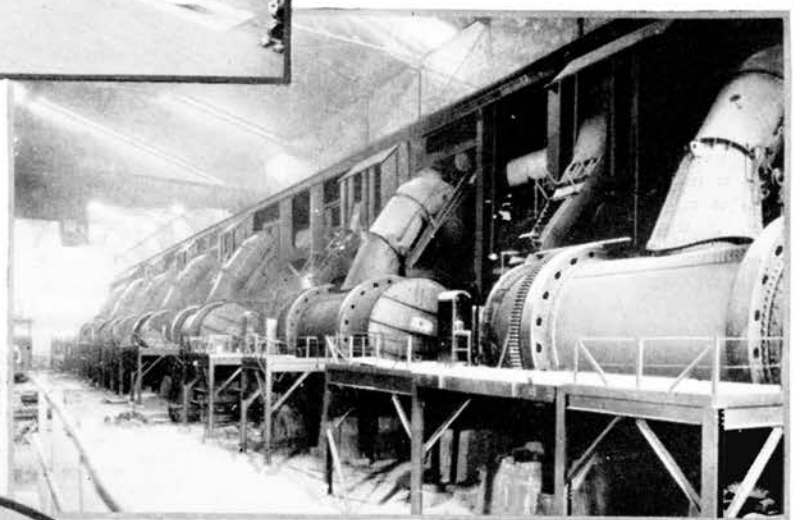


Some magnets in telephone systems must be permanent magnets. Permanent magnets are made by bringing the piece to be magnetized into the field of a powerful electro-magnet.

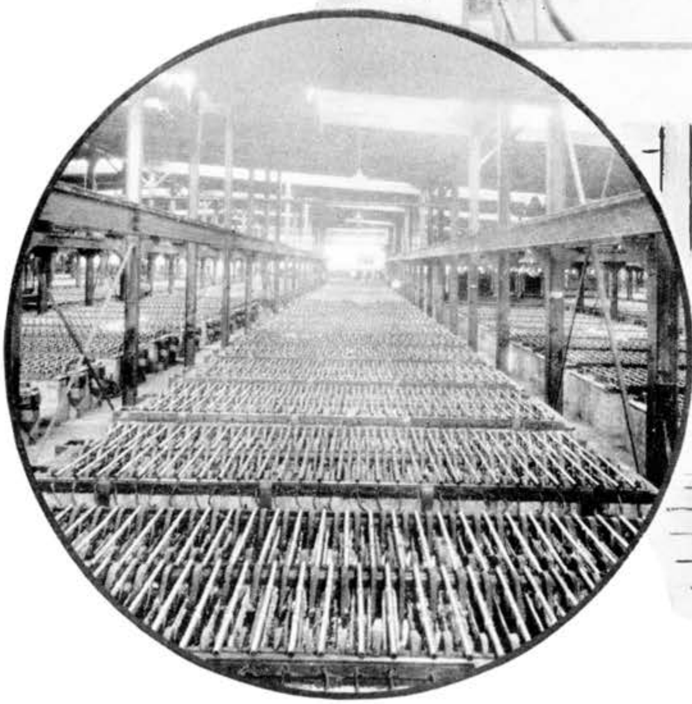


Nickel is used frequently and in large quantities to protect and preserve the metals that it covers or plates. Nickel as an alloying element adds toughness to steel.

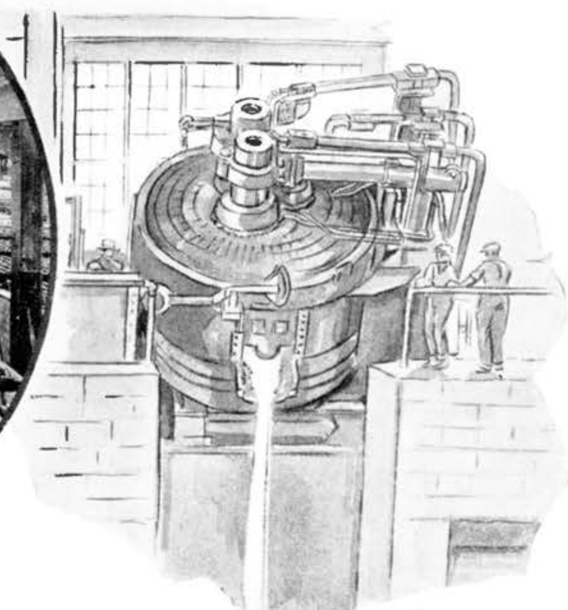
Left—A modern strip mill in West Virginia. Here workmen are rolling pure nickel. Each machine makes the nickel strip thinner and longer until the desired thickness is obtained.



Converters used for burning out impurities in nickel.



Six acres of cells for the production of pure electrolytic nickel.



A seven ton electric furnace.

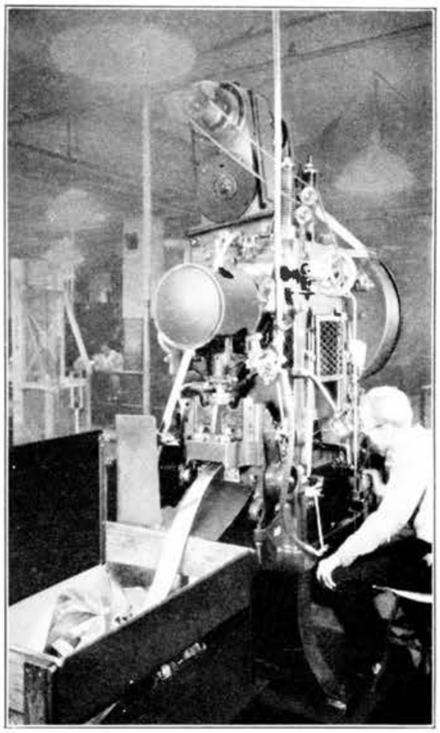
The superstitious people who lived during the period we call the "Dark Ages" believed that gnomes and even worse sprites were often behind the little petty troubles that arose from day to day. The old Saxon miners of the period, in fact, even went so far as to blame the "Old Nick" himself whenever they chanced upon copper ores which were hard to work and named one especially troublesome ore "Kupfer-nickel" because there was an "evil spirit in the copper" ("kupfer" meaning copper, and "nickel"—an old German name for the evil spirit).

The metal remained a rarity for many years until the owner of one of the new Canadian railroads, in an effort to stir up profitable tonnage, endeavored to work a large copper deposit located near the right of way. This Sudbury "copper" ore defied refiners for some years, due to their inability to separate commercially the copper from the nickel which it contained. Many thousands of dollars had been spent in unsuccessful efforts to solve this problem, when the more or less chance observation was made that copper and nickel sulphides (a compound of sulphur) when melted with sodium sulphide, would separate into two layers on cooling—like cream rising from milk—and that most of the nickel would collect in the bottom layer. This discovery forms the basis of the most practical nickel refining process known and has been employed in obtaining most of the nickel that is in use today.

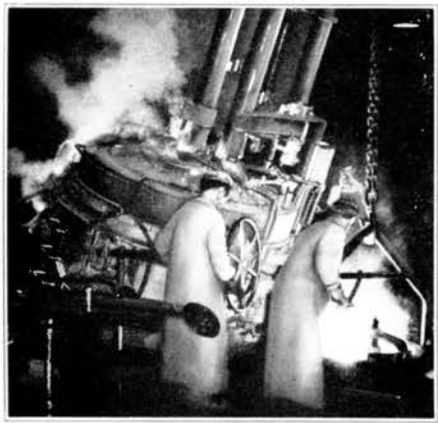
The nickel deposits of the Sudbury district in Canada are so rich and extensive that they will suffice to supply the world requirements for nickel for hundreds of years. They are the source of over ninety per cent of this metal. The only other known nickel deposits of much importance are located in New Caledonia, a small island in the South Pacific, and these have been worked on a rather small scale for many years.

The Sudbury ore contains nickel, iron, copper and sulphur together with small proportions of platinum, palladium and other precious metals. The ore is reduced to a fine powder and is then treated by the "flotation" process in which little air bubbles select one class of mineral and float it away, allowing the remainder to sink. By this treatment much of the copper is separated and can be refined directly as a copper ore. The remainder, containing nickel, iron and some copper, is roasted to remove about half of the sulphur; melted in a reverberatory furnace and then "Bessemerized" by blowing air through the molten mass, forming a matte rich in copper and nickel. This matte is then mixed with excess coke and nitre cake (sodium acid sulphate) to form sodium sulphide, and fused. The white-hot liquid is poured into great ladles holding ten tons, and is allowed to solidify. The nickel settles to the bottom layer. The solid mass is then broken apart and the bottoms are re-treated to form a mass containing some seventy-two per cent of nickel, while the tops are worked up for the copper which they contain. The second bottoms are ground to a fine powder and passed through a sintering machine which heats the powder until it forms a solid mass without really melting. This burns off most of the sulphur. The material is

Many parts of the telephone system are very delicate and must be protected against the effects of the atmosphere by plating.



Tens of thousands of springs containing nickel are used in making telephone equipment. Machines like this punch springs out of long strips of metal.



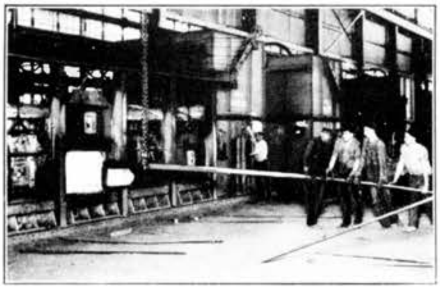
Molten nickel being discharged from a modern furnace into a special hopper.

then leached with water to remove the sodium salts, melted and cast into anodes for electrolytic refining.

The electrolytic refining process is essentially nickel plating on a grand scale. The impure anodes or positive terminals are hung in tanks containing a solution of nickel sulphate, which is continuously circulated and purified, and an electric current is passed from the anodes through the solution to thin nickel cathodes or negative terminals. The passage of current causes nickel to dissolve from the anodes and to deposit on the cathodes, which finally attain a thickness of about three-eighths of an inch. The cathodes are then removed, washed and cut up as the customer may desire. The cathode nickel will contain about 99.95% of nickel plus a small amount of cobalt, .015% copper, .01% iron and .002% sulphur.

The precious metals contained in the anodes do not dissolve but form a mud which is carefully saved and treated to recover the platinum, palladium, rhodium (found in platinum ores), gold and silver.

In addition to refining by electrolysis, nickel can be obtained by the Mond process, converting the nickel into a gaseous product, which is subsequently decomposed, depositing pure nickel. In this process impure nickel oxide is heated with water gas to reduce it to the metallic state. The resultant fine nickel powder is treated with carbon monoxide, which reacts with it to form a gas called nickel carbonyl. This gas is then heated to 180° C, which causes it to decompose, forming small, round onion-like pellets of pure nickel.



Nickel ingots are heated before they are put under the big hammer and sometimes before they go into the rollers.

By altering the refining process and purifying the nickel and copper simultaneously, the alloy known as Monel metal is secured. This strong, white, corrosion-resisting metal is used for sinks, table tops, food machinery, valves, hardware, condenser tubes, pickling crates and a host of other applications, and in many ways indirectly assists in the production of the parts of your telephone.

Pure nickel is used for certain parts of the thermionic amplifying tubes employed in the long distance lines of the telephone system, and a large tonnage is employed in the construction of tubes for radio receiving sets. Pure nickel is also used for food handling equipment, particularly that used for milk. The spark plugs of your motor car are in all probability equipped with electrodes made of an alloy of high nickel content.

Inspecting telephone parts. Nickel is used as a finish on many of the parts used in telephone apparatus to insure resistance to atmospheric effects.

Nickel alloys with most of the useful metals and generally confers the qualities of strength and whiteness; for instance, nickel alloyed with copper and zinc forms the nickel (or German) silver employed for springs in telephone relays and switch keys and for some contact-carrying members of the telephone instrument itself.

The alloys of chromium and nickel withstand prolonged heating at high temperatures without serious oxidation and are therefore used as heating elements in electric toasters, flatirons, etc. Similar alloys are resistant to tarnishing and corrosion, and are therefore of interest for domestic cooking utensils, food handling equipment and articles where appearance is important.

While nickel is less magnetic than iron it adds remarkably to the magnetic properties of iron when alloyed with it in varying amounts. An alloy containing about 78% nickel —with iron the principal remainder—produces one of a series of nickel-iron alloys known as permalloy.

Permalloy possesses an extremely high permeability in weak magnetic fields and is low in hysteretic losses. Seventy-eight % nickel alloy also is used for the cores of certain telephone relays and other telephone equipment where exceptional magnetic qualities are required. Similar alloys containing nickel, in the form of thin tape, are wrapped around the copper conductors of submarine telegraph cables and increase eight-fold the rate at which signals can be transmitted, so that 2,400 letters a minute can now be sent as already stated on page 7.

An alloy containing about 81% nickel—with or without 2% molybdenum—is employed in the loading coils used on long distance telephone lines with a resultant saving in space and cost.

Nickel iron alloys containing 45 to 50% nickel possess characteristics which result in low power losses and are, therefore, employed in instrument transformers and in special power transformers.

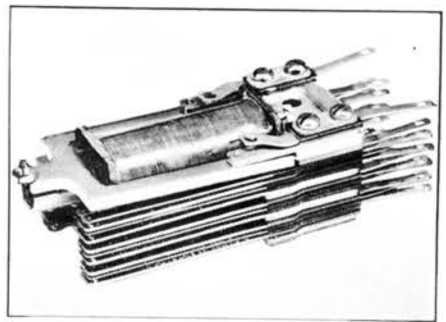
A nickel iron alloy containing about 35% nickel (low expansion nickel iron alloy) shows almost no expansion or contraction with changes in atmospheric temperature. It is consequently used for accurate measuring tapes, thermostats, struts in aluminum pistons for automobiles and other similar purposes.

Similar alloys (iron 60%, nickel 40%) coated with copper can be sealed through glass and are used for the lead-in wires of incandescent lamps and radio tubes; while alloys of slightly higher nickel content are used for producing fire resisting wire glass. Another alloy containing some 36% of nickel, 12% of chromium and the remainder iron, is valuable because its stiffness does not change with the temperature.

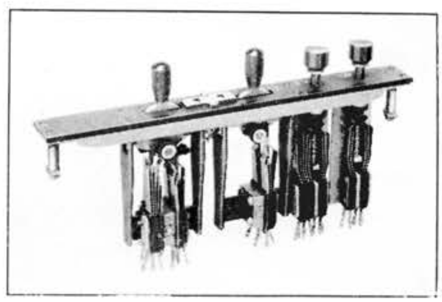
Steels containing from 1 to 5% of nickel and generally a small amount of chromium or molybdenum are strong and tough and are widely used for aircraft engines, automobiles, armor plate and locomotives. A high tensile nickel-chromium steel is required for the little pinions used in the operators' calling dials in automatic exchanges.

Nickel can readily be applied to metal surfaces by electroplating, and many small parts employed in the construction of telephones are protected from corrosion and made more pleasing in appearance by plating them with nickel. Many of your household electrical appliances also are plated with nickel to beautify them, and in some cases a thin plate of chromium is applied on top of the nickel to obtain a higher lustre—this is the finish that is so widely employed on automobile trim.

Nickel is sometimes used as a protective coating on the parts of the transmitter indicated by the three upper arrows and as plating on connectors in the receiver and for springs in the body of the instrument.



Nickel is part of the alloy used in the relay illustrated above, a type employed by the tens of thousands in telephone systems. Nickel is used in the winding wire, contact springs, magnetic structure and finish of the relay.



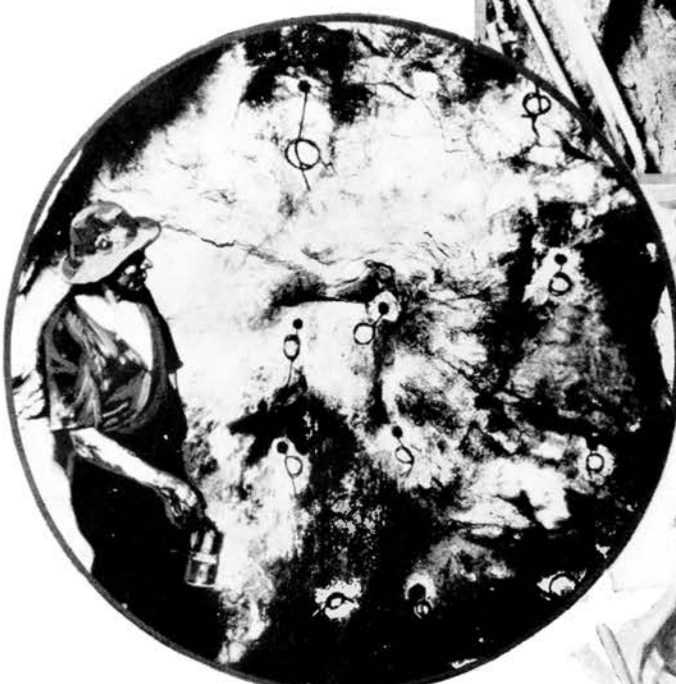
Nickel silver is used in the mechanism of the keys the switchboard operator manipulates to listen-in to learn what number is wanted and also to "ring" the called subscriber.

Copper in the form of wire is almost always used to carry electric currents. Copper, brass and bronze, the latter two being alloys of copper with zinc and tin, respectively, are essentials in automotive manufacture and for ships, buildings and the making of statues and other works of art.

Left—Copper ores in loose soil or from hillsides torn down by blasting are dug and loaded to send to the smelters by means of electric or steam shovels.

Right—Mining copper underground. The rock is hauled to the smelter where it is broken into small pieces and processed to obtain the various metals it may contain.

Below—Copper ores are obtained by blasting. Holes are drilled and packed with explosive. An electric current explodes the charge.



Right—Geologist and sampler at work in a copper mine.

Copper was used long before the beginning of the oldest written records, and today is second only to iron in its industrial value. For centuries it was used either alone or in bronze to make dishes and other vessels, and for ornaments, armor and weapons.

In those early days, too, copper coins came into use. Besides, a man's wealth was often measured by the weight of copper he owned. For instance, in the days of the early Roman republic, if a man was worth the equivalent of 150,000 pounds of copper, he had to provide himself with certain arms and armor suitable for fighting in the front ranks of the legion. If he were not quite so wealthy, the law made him serve as a certain class of soldier, and called for less complete equipment. And so it went down the scale of wealth until those who had property amounting to less than 1,500 pounds of copper went as orderlies to the lesser leaders and as "replacements". For those even less well off, military service was not required nor did they have to pay any taxes.

Probably the most widely known product of copper dating back to those days was the famous Colossus of Rhodes, one of the Seven Wonders of the ancient world. It was a bronze statue to the sun god Helios which the joyous people of Rhodes had made out of the spoils left by a besieging army which suddenly fled without waiting to gather up its belongings. It stood 70 cubits (105 feet) high and was thrown down by an earthquake about 225 B.C. One thousand years later it was sold by the conquering Arabs to a junk dealer.

The copper deposits of northern Michigan, visited by the Jesuit Fathers at about the time of La Salle's discoveries, were first worked for commercial purposes by white men about 1844. These deposits around Lake Superior contain what is called native (practically pure) copper and are quite different from the mines at Butte, Montana, in which the copper is combined with sulphur or other elements. Still a third kind of deposit is worked. It is called porphyry and in it the copper minerals are scattered through large masses of rock.

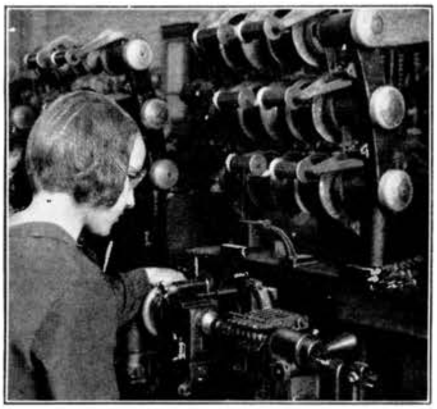
The deposits of *native* and of *sulphide* ores are mined by levels, drifts, crosscuts, stopes, and other underground workings. The ore is brought up through shafts, some of which are more than a mile deep.

Many of the porphyry deposits, on the other hand, are near the surface and mining is carried on in open cuts or pits, similar to those used to mine iron in the Lake Superior district.

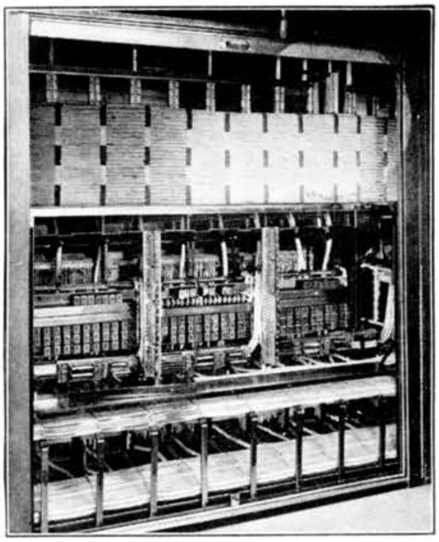
While copper does occur as pure copper, most copper ores contain different amounts of lead, zinc, gold, silver and in some cases platinum, palladium and other rare metals.

To obtain the copper from its ores different methods are used, depending on the character of the ore. In the flotation process, copper, finely ground, is separated from the dirt and rock—called gangue—dug up with it, by treating in a liquid made up of certain proportions of oil (coal tar and creosote) and water. In this mixture the copper ore floats but the

Copper is used in your telephone as an alloy in the brass for plates and screws and as bronze in the conductors of the connecting cords.

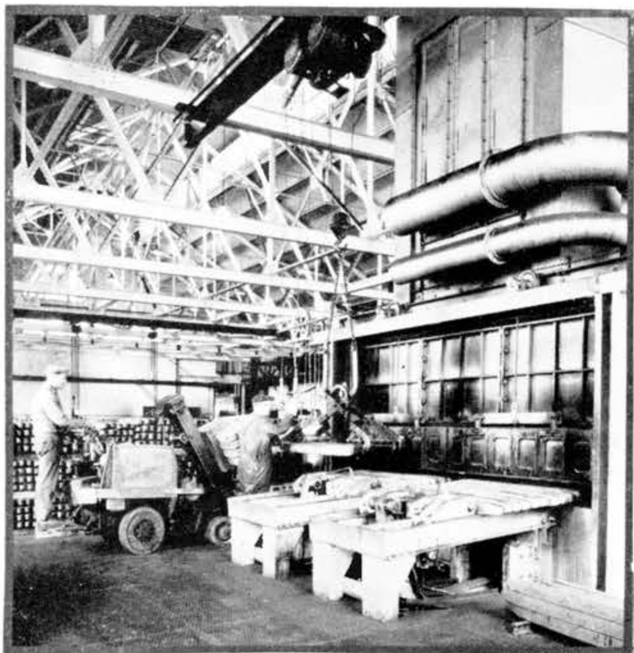


Insulated thin copper wire is wound around iron rods in your telephone receiver to make a magnet.

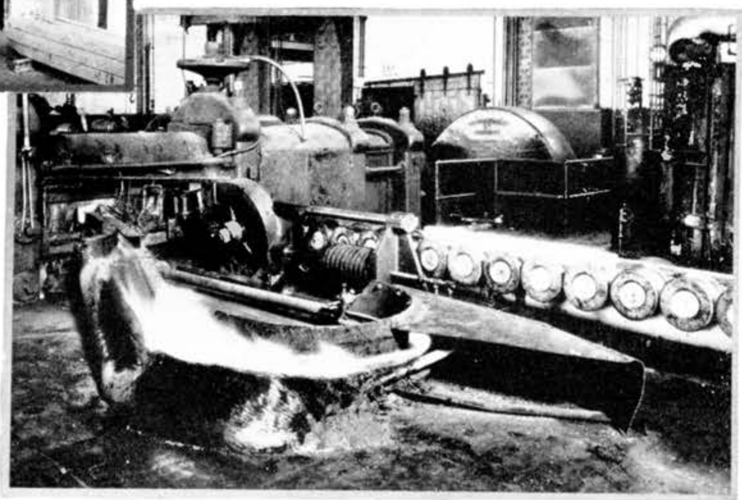


Copper wire by the mile is used in switchboards. This copper wire brings voices to the operator, completes voice pathways between talking subscribers, permits current to pass around iron bars to form magnets and leads current to lamps which flash signals on and off.

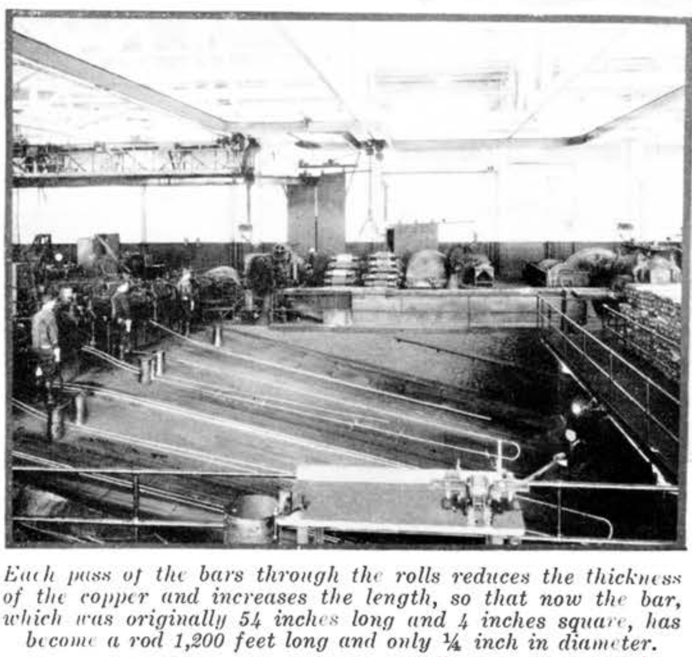
Copper lends itself admirably to change of shape when hot and even when cold. One of its greatest services to present-day life is a result of this characteristic, making it possible to change short thick bars of copper into long thin wires for carrying electric currents.



Left—Loading billets of copper in a modern heating furnace.



Right—This conveyor carries the hot copper bars to the rolls, where they are turned into rods from which wire is drawn. The copper billet furnace which heats the 225-pound bars is one of the largest in the world. It is capable of heating 60,000 pounds of the metal to 1,750 degrees F. each hour. The bars travel through a heating chamber in which enough bricks were used to build three six-room bungalows of solid brick construction.



Each pass of the bars through the rolls reduces the thickness of the copper and increases the length, so that now the bar, which was originally 54 inches long and 4 inches square, has become a rod 1,200 feet long and only ¼ inch in diameter.

Here the end of the red hot copper rod is being placed between the revolving rolls, reducing its size and increasing its length.

gangue sinks. The copper thus secured is then smelted and refined.

Oxidized ores—those in which oxygen is chemically combined with the copper—are crushed and then poured into an acid solution which dissolves the particles and separates the copper from its gangue. Pure copper is obtained by the electrolysis method, described under the picture illustrating the process.

The United States has produced from its own ore as much as 50 per cent of the total output of copper in the world. The known deposits not yet mined, and reserves already developed in the United States, exceed those of any other country. Chile continues to be the world's second reserve of copper, with Africa third, while the deposits in Spain, which have been mined since the days of the Phoenicians, are still rich.

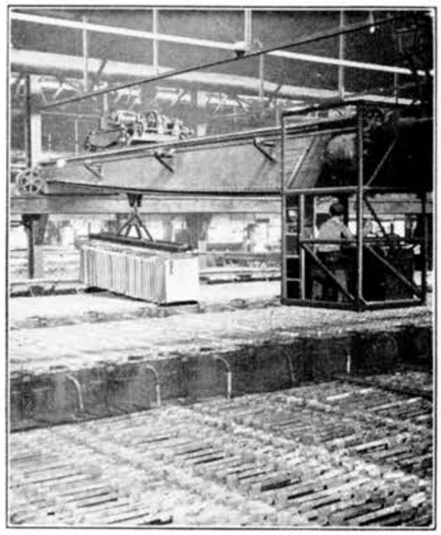
While for a long time copper has been one of the most valuable metals, it has become practically indispensable since the electrical industry was established. About half of the copper produced is used in that industry, where it provides pathways for electric current. A large part of the remainder is utilized in the manufacture of brass, bronze, and other alloys used in automobiles, electric railways, ships, in building construction and equipment.

Because copper is a good conductor of electricity it is extensively used as wire in your telephone system, and because of its other qualities, it is used in alloys with other metals.

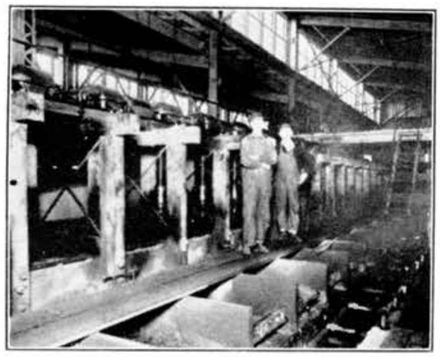
The making of copper wire is one of the most interesting processes in the country's largest telephone factory. To see the large, thick bar of copper taken red-hot from the furnace and started between a pair of massive revolving rolls — to see it next like a red-hot snake glide between other pairs of rolls again and again until it leaves the last roll as a rod 1,200 feet long, and a quarter of an inch in diameter, is a sight that few who see ever forget. This rod is then drawn through dies, each reducing the diameter and increasing the length. For the finer gauges of wire these dies are made out of diamonds, drilled to the proper size. A single billet will make 2,200 miles of 42 gauge wire, .00249 of an inch in diameter—finer than the average human hair.

Copper wire so produced is used in the lead covered cable you have seen in manholes leading to telephone conduits under the street and in cables suspended on poles. The Western Electric Company uses millions of miles of such copper wire in a year's output of cable. The wire used in your telephone, too, is made that way. There its chief use is in the wire coils of the receiver.

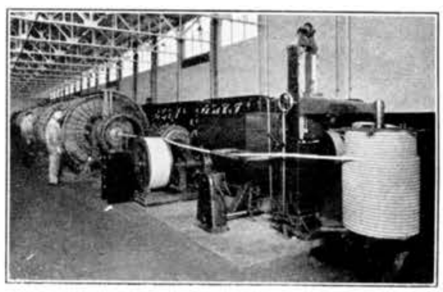
Still more copper is used in the brass screws of your telephone and in the terminals to which wires are attached. Coils for the bells that ring when you are called to the telephone, relay coils and many other types of coils for use in telephone circuits, annually make use of millions of feet of copper wire in various sizes. Copper foil is used in making certain types of telephone condensers.



In the electrolytic process the anode is made of the metal to be purified. The electrolyte is a copper sulphate solution containing free sulphuric acid and, usually, a small amount of common salt or some other soluble chloride. The current travels through the solution, carrying copper from the anode and depositing it on the cathode plate. The deposited metal is about 99.93 per cent pure copper.



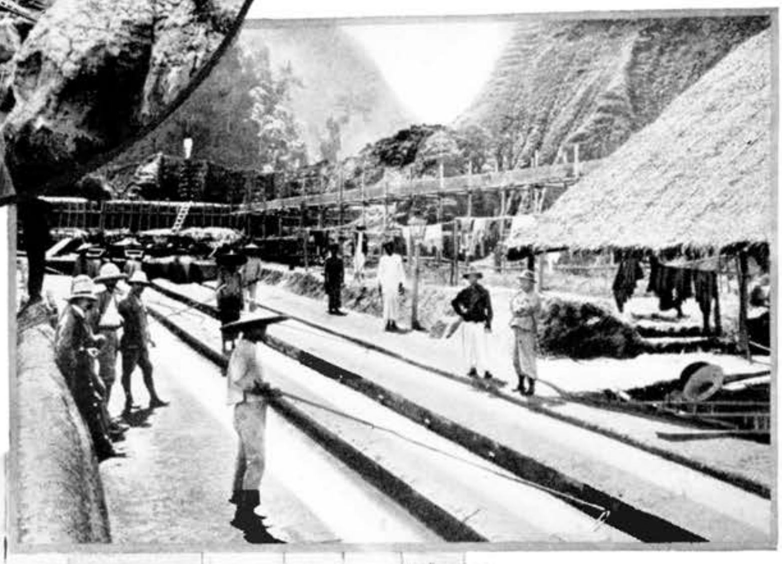
To get the grains of copper out of the ore by the frothing process the ore is first crushed to a powder. Then oil and water are mixed with it and air is forced through, forming a froth to which the copper grains adhere and from which they are skimmed off.



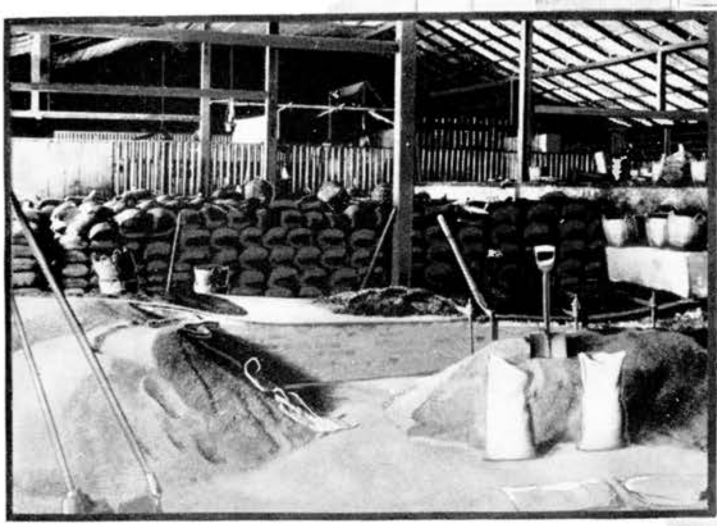
Cable making. A cable 2⅝ inches in diameter contains as many as 1,818 pairs of copper wires.

Tin has two chief uses in industry. It is one of the ingredients of solder and when lead-rich tin alloy is applied to steel plate as a coating, is commonly used for roofing. Tin also is used in making cans and pails for paints and in the construction of a thousand and one other articles. When suitably treated, tin also makes good containers for food.

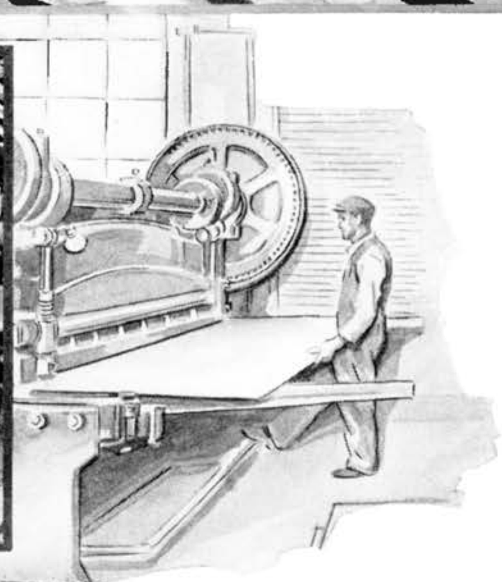
Left—To carry the soil containing grains of tin up from the mine it is dumped into the water that gathers in the low parts of the mine. Pumping the water to the surface brings the tin up too.



Right—These riffles for gathering tin from the gravel are long chutes with cleats across the bottom. As the water carrying the gravel and grains of tin flows along, the heavier tin sinks, is caught against the cleats and is recovered later, while the water carries the other material away.



After the tin has been separated from the gravel it is put in bags to go to the smelters from which it comes out as the tin of commerce.



Tinplate—the form most familiar to us.

About 1809 or 1810 one Nicholas Appert won the prize of 12,000 francs for discovering a way to can foods. Appert, however, was just one year ahead of Peter Durand, an Englishman, who was the first to preserve food in tin "canisters", Appert having used glass for his first containers.

In the United States today, where 5,000,000,000 cans of food are eaten every year, nearly 40% of all the tin used goes into tin plate for making tin cans.

Besides the use of tin for cans, which, by the way, are made from sheets of steel coated on both sides with tin, the metal is used in making solder, tin-foil, collapsible tubes for tooth paste, vaseline, shaving cream and similar articles—and to give weight to silk and make it rustle.

Tin has been used almost as long as any other metal. Copper was probably the first to be used and was followed by bronze, an alloy of copper and tin, the first use of which was for arms and armor. Later it was made into cannon—and bronze cannon were common up to a few decades ago.

The oldest tin mines of which history tells us are in Cornwall, England. Long before Caesar's time vessels from Carthage voyaged to what was called the Tin Islands.

These mines, which in times past were the only ones extensively worked, are now able to furnish but a small part of the world's tin supply. The United States, which uses more tin than any other country, has to import its supply. The Malay Peninsula and Banka, a small island across the Strait in the Dutch East Indies, now provides most of the tin. This tin finds its way to United States, England, Germany and France, as does that from Bolivia, a country which ranks second in tin production.

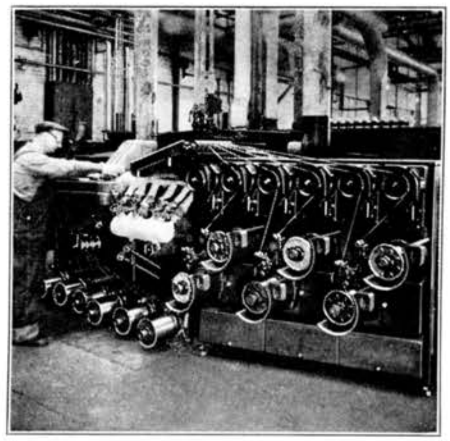
Tin is used in solder in your telephone and throughout telephone systems wherever wires are to be spliced, as in the case of cables; in telephone switchboards to fasten wires permanently to connectors, relays and coils; and in the terminal rooms of central offices, where thousands of wires coming from the switchboard are soldered to connectors from which wires go to homes, offices and factories.

Switchboard wire is coated with tin in an automatically controlled machine. The wire passes through an acid bath, through a bath of molten tin, then through a wiper, which removes all but a very thin film of tin. The wiper may be a wrapping of asbestos cord, a diamond die, or a jet of high temperature steam. The tinned wire is cooled in a water bath, dried, and wound on take-up spools.

Tin is utilized to coat some iron parts to keep them from rusting and is used instead of antimony in the lead sheaths of cables made for special purposes.

Also, the current is carried in the cord of the telephone by a special bronze alloy of tin and copper which is strong and highly conductive.

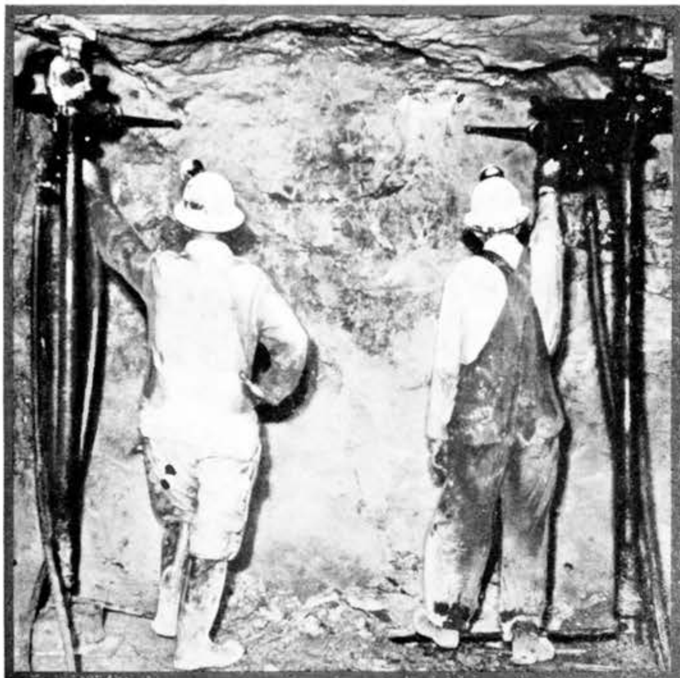
Tin is a part of the solder which makes firm good current carrying connections between many of the small parts in your telephone.



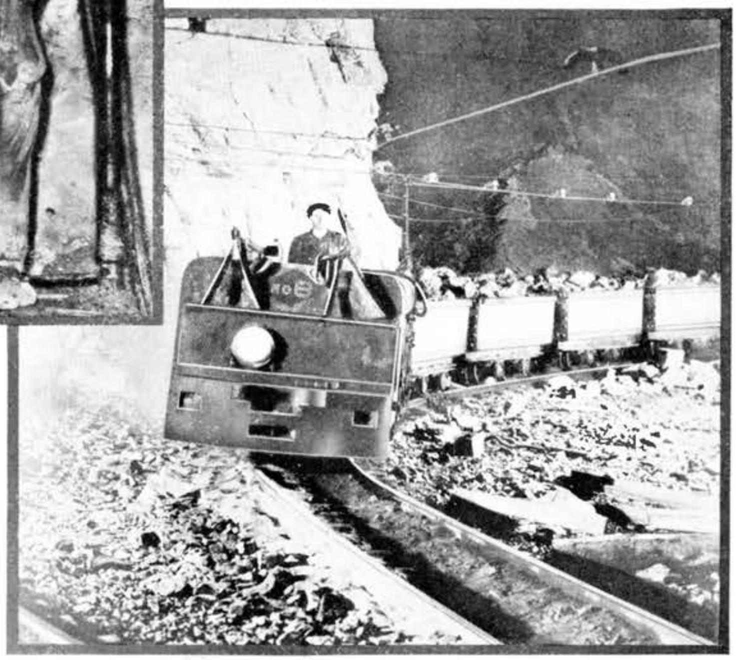
A "steam wipe" tinning machine, which puts a thin coat of tin on copper wire before it is insulated to facilitate soldering to other wire or to apparatus.

Solder joins the wires in lead covered cables and also joins the lead sheaths where two cables come together, thus preventing moisture from creeping in to injure the insulation.

The outstanding characteristic of lead is its ability to withstand corrosion. Its softness and flexibility make it suitable for many uses.



Left—Far beneath the earth's surface experienced miners plant dynamite deep in the sheer face of a huge rock cavern.



Right—Powerful electric trains are loaded to begin their long haul to the base of the shaft.

Mechanically activated casting wheels mold the lead into silvery "pigs" ready to begin its final, vital job of protecting the nation's speechways.

Electrically operated shovel loading ore in gallery.

It is a clear crisp day and you are out skating. As you cut fancy eights and double eights on the ice you feel as warm as toast, while George or Jim or Susie or Anne, dressed as warmly as you and skating just as fast, is cold, with chattering teeth and numb fingers. Back indoors, however, you immediately begin to feel drowsy, while the person whose teeth were chattering is wide awake.

In much the same way the more than fifty metals in the world differ from each other. Iron, for instance, is tough and can be made into everything from soft iron magnets, cast iron radiators, and malleable iron for railway cars, to steel axles, steel girders, steel wire and steel tools.

Yet there is one thing about commercial forms of iron that makes them unsuitable for certain uses. They quickly rust if not protected and will, in time, completely change into iron rust (or, as it is technically called, iron oxide).

By giving iron a coat of lead in the form of paint we help to keep it from rusting and thus give to it one of the good qualities of lead.

Lead possesses scarcely one of the good qualities of iron. It cannot be made into rails or girders. It is so soft it can be cut with a pocket knife or dented with a finger nail, *but it will not rust.* A thin film or tarnish quickly forms which acts as a protection against further oxidation.

Lead pipes have come down to us from the days of Rome, Pompeii and Herculaneum, while iron pipes and other iron objects of even later periods have long ago rusted and turned to dust.

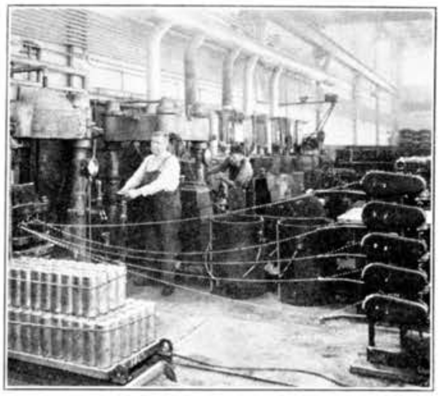
But this is only one good point about lead, which we have come to think of as almost a precious metal because it has become so necessary to us. Besides its uses in paint it is used for roofing, to make queer-looking gargoyles, and water pipes —in bearings for crankshafts, driving shafts, and connecting rod bearings—in solder—in type metal—in ammunition—in musical instruments—in petroleum refining—in glass, rubber, pottery enamels—and in storage batteries.

Many of these uses are almost as old as civilization. The Romans made water pipes of lead and soldered them with lead. The slingers of Hannibal's army that invaded Italy used little lead balls for sniping at the Romans.

In those early days the mining of lead was sometimes done by prisoners of war of the Roman government; and in the remains of some of the old mines in Sardinia there are shafts so narrow that it is believed the men who cut them must have been lowered head downward and worked in that position.

In an old book, "Diary of Lady Willoughby," which tells of the English revolution in the reign of Charles I, there is an entry dated Monday, October 20, 1644, as follows: "Lieutenant General Cromwell wrote a Letter acquainting the Governour that if any violence were offered these Men, the best in the House should not expect Quarter. The Countesse of Win-

There is lead in the telephone fuse wires which protect the telephone circuits.

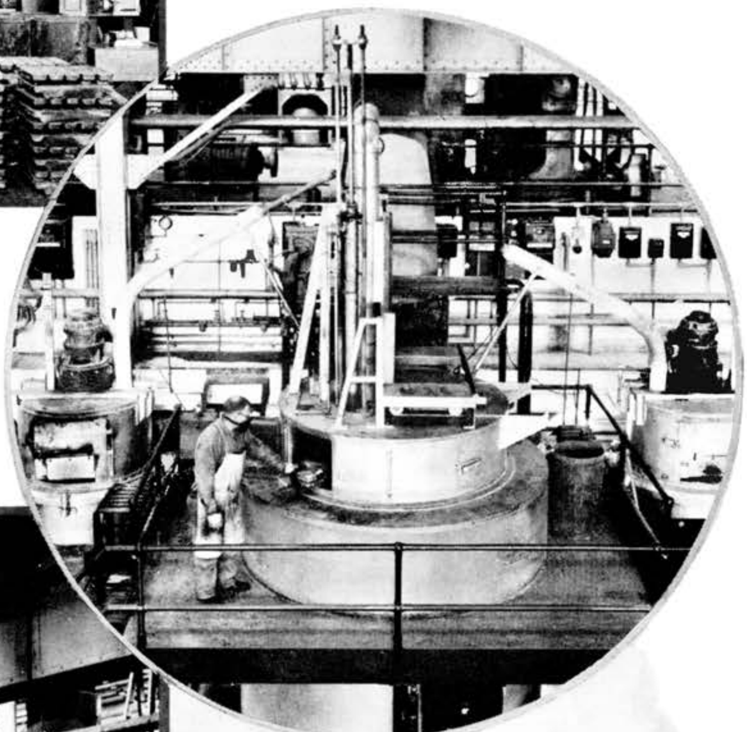


In these presses, thin, hollow, lead-tin piping is filled with rosin to make easy-to-use rosin core solder.

In this familiar scene the telephone wires are being put underground, enclosed in their protective sheath of lead.

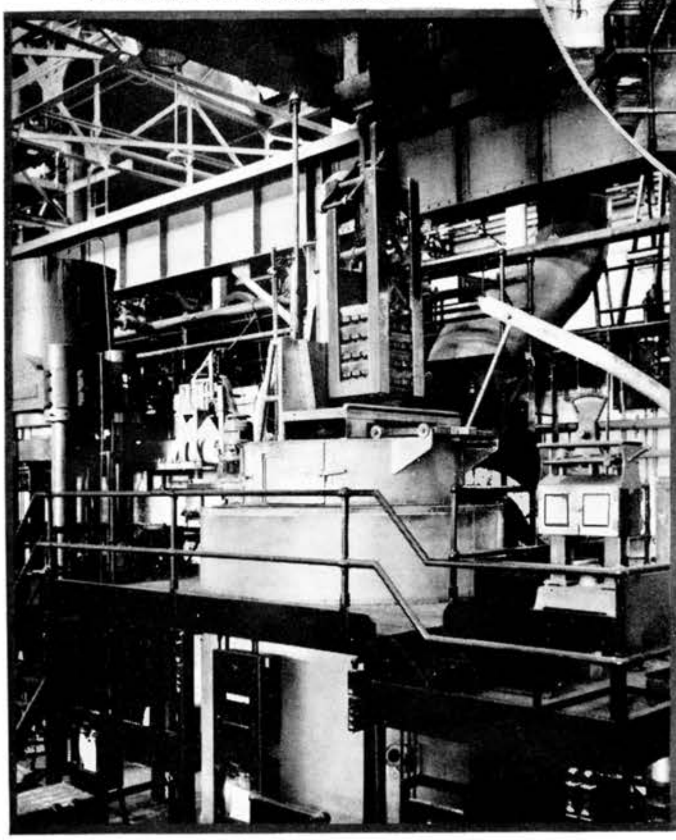
Lead easily combines with many other metals. Therefore, it is useful in electrical goods, making type and paints, and in the widely used combination of lead and tin we know as solder. Another valuable characteristic of lead is that acids do not easily eat it up or change its chemical nature.

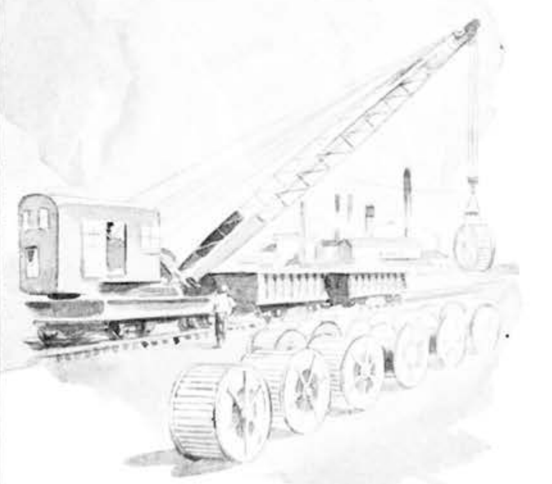
Left—Melting and supply kettles, oil heated, which handle the lead alloy used in cable sheaths. The pipe and valve arrangements are such that the middle kettle is available for melting the alloy.



Right—Antimony charging mechanism of a centrally controlled lead melting system.

Below—This kettle for melting and preparing lead antimony alloy will hold 50,000 pounds of metal. The melting capacity of the system is 40,000 pounds per hour. The lead handling grapple suspended from the crane hook can accommodate 50 standard size lead billets, or a total weight of about 5,000 pounds. Two or three of these charges, or about 10,000 to 15,000 pounds of metal, constitute one melting cycle.





This crane locomotive, operated by an electric storage battery, handles heavy cable reels.

chester's Gentlewoman and Waiting-woman were killed by a Cannon-shot. Sir Marmaduke Rawdon declared to the Marquesse who proposed to surrender, he would not, so long as a dog, or a cat or rat did remaine: yet it would seeme there was not much Danger of such Extremity, there being found in the Castle vast store of Wheat and 300 Flitches of Bacon, and forty-thousand pounds weight of Cheese, besides Beef. They took off the Lead from the Turrets, to use for Bullets: and the Marchionesse with her Ladies did helpe to cast them."

Lead miners have to deal principally with an ore called galena, in which the lead is found joined together with sulphur.

Lead ores found near the earth's surface are usually easily smelted and sometimes contain considerable silver, but the ores for which miners go down into the bowels of the earth are more complex and generally contain zinc, copper and iron sulphides. To smelt the lead out of these ores and not lose the tricky, valuable zinc in the form of vapor was for a long time impossible. Now through a flotation process enormous amounts of lead-zinc ores, formerly thrown away, make up an important part of the world's yearly supply of these two metals.

Zinc and lead, by the way, are almost always found together, the lead mines of southeast Missouri and Spain being the only ones with large outputs that do not also produce a large amount of zinc.

Among the largest users of lead are the telephone companies. The cables which you have seen strung on poles along streets, or at which you have peeked through manholes are covered with a jacket or sheath of lead and antimony.

The largest manufacturers of telephone cable have turned out enough of this cable in a year to reach from New York to Shanghai, by way of the Suez Canal. The largest of these cables is two and five-eighths inches in diameter and contains 3,636 separate wires. The average number of wires per cable is 460.

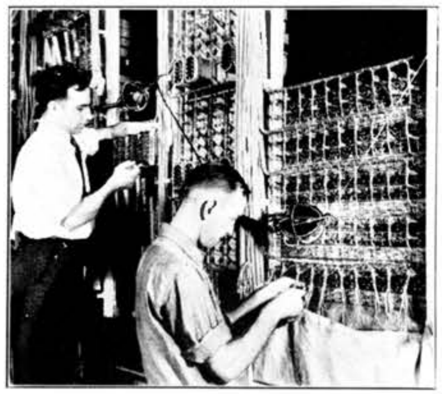
Wires are assembled into cable to protect them and because they can thus be carried in a small space. If these wires were strung separately the pole would have to be very high, many cross arms would be needed, and in addition to this inconvenience, there would be danger of the wires breaking under the strain of heavy gales or from the weight of sleet and ice. By using a cable, many pairs of wires can be brought together in a very small space and protected by the lead covering.

Toll cable, consisting of 148 quads (double pairs) of 19 gauge wire, six pairs of 16 gauge wire for radio program transmission, and a quad of 22 gauge wire—a total of 608 wires —is usually carried on poles.

Lead is used in the sheath of cables because it is flexible; will bend without breaking and can be handled easily. Besides, it is not greatly affected by changes in temperature.

Lead is also used in your telephone instrument as solder, and on the switchboards in the central offices to solder together thousands and tens of thousands of wires. There is lead in switchboard cord weights that keep the connecting cords out of the operators' way.

Solder, a lead and tin alloy, joins connectors to the telephone cord wires and receiver coil terminals.



On telephone equipment in the large central offices (exchanges) there are several million soldered joints containing lead.

In the yard of the world's largest telephone factory an overhead traveling crane picks up heavy reels of lead covered cable and carries them the length of the yard or across it in a very few minutes.

Antimony is widely used with lead for storage battery grids, type casting for linotype machines, and for telephone cable sheath. Its value for these purposes is in increasing hardness and strength of the alloy.

Left—Inside an antimony plant in the metal's home among the mountains of China where native laborers produce the antimony of commerce.

Right—Chinese antimony smelter where the first processes of separating antimony from the ore take place.

Below — Chinese at work near the mines.

Below—Native antimony smelter back among the hills in China.

A story by the noted French writer, Flaubert, tells how Hamilcar, the father of the great Hannibal, upon returning to Carthage from a campaign in Sicily, made a tour of inspection through his slave-operated factories. In time he came to the departments which were making and preparing expensive perfumes and dyes for shipment. Hamilcar was displeased especially with the weight of the spikenard, an expensive perfume which was then worth about fifty dollars a pound. He found it took too much valuable spikenard to make a pound for commercial uses, so he ordered the overseer to add antimony to increase its weight. Today we find honest uses for the silver colored metal.

Antimony is one of the metals that has few uses in industry. Yet no American daily newspaper is printed without the help of antimony, which with lead and tin forms the liquid metal out of which type is made.

The use of antimony dates back a great many centuries. It was employed by the ancients to color the hair and eyebrows and to make the eye seem larger—all of which were thought to be marks of beauty.

In the middle ages antimony was prescribed as a medicine and as early as 1500 A.D. it was used in type metal and for mirrors and bells.

While we as a nation produce many of the raw materials that we use, there are a number of commodities which we have to go half way around the globe to obtain. Antimony is one of these. The world's demand for antimony is not large, but we use more than any other country and require more each year.

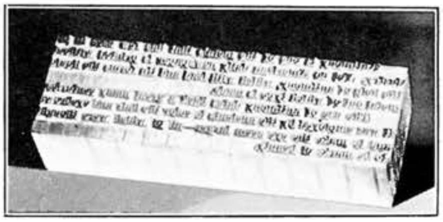
Antimony ordinarily comes from Hunan, China, a province especially noted for its mineral deposits. It is also obtained from Belgium and Mexico. During the Great War when large quantities of antimony were mixed with lead to make bullets and when sulphide went into the primers to fire the shells and was used as a powder in smoke shells, some of our Western States mined antimony. The price of antimony, however, is not high enough to induce American mines to produce it in peace times.

Antimony ores, like those of mercury, occur in rocks of all geologic ages. Veins bearing antimony are as a rule rich only near the surface or to a moderate depth below. The Chinese having located a fairly rich vein, work out the ore as they find it without using any particular system and leave irregular-shaped chambers behind them. These are often of considerable size and without proper protection, as the Chinese do not use timber supports in their mines.

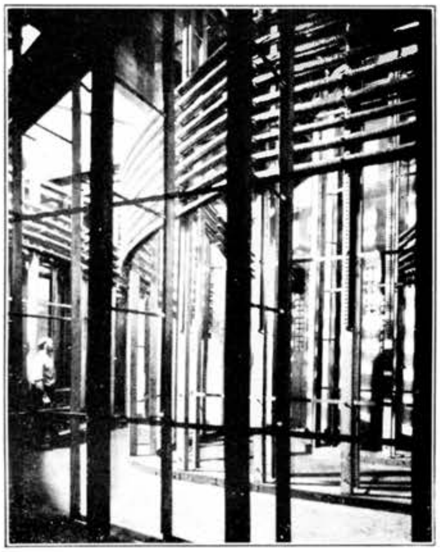
In Bolivia, where the deposits of antimony are scattered over the high Andean plateau, the ore is dumped into sacks, which are loaded on llamas, burros or mules. The llama is the principal beast of burden in these high altitudes, mainly because it will forage for its own food, no matter how barren the country may be. These animals will carry a load of 100 pounds of ore—but should the pack be made much heavier, they will refuse to proceed. Once ready for the journey only an Indian can drive the llamas, although one Indian can drive several hundred.

One of the largest uses of the silver-white, hard, brittle antimony in this country is to harden the lead sheaths which carry telephone wires under the streets and on lines of poles. By making the sheaths ninety-nine parts lead and one part antimony, they are well protected against breaks and from wear by friction. While the percentage of antimony is small, it serves the purpose.

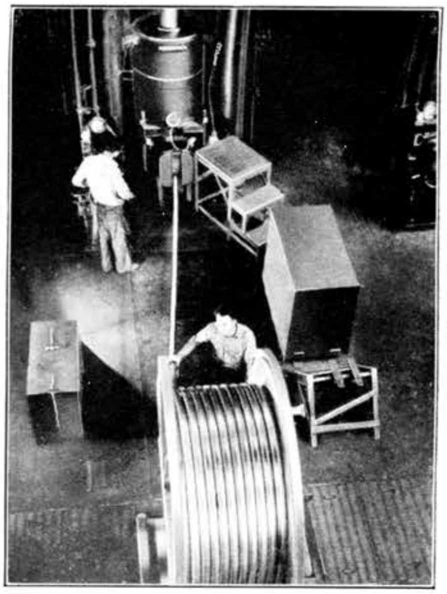
Other uses for antimony are in cheap tableware, toys, battery plates and acid-resisting valves, while antimony oxides are used in glass, enamels, paints, and in antique silver finish.



There is antimony in the type which was used to print this page. Antimony readily forms alloys with most of the heavy metals, and is chiefly used with lead, tin, and copper.

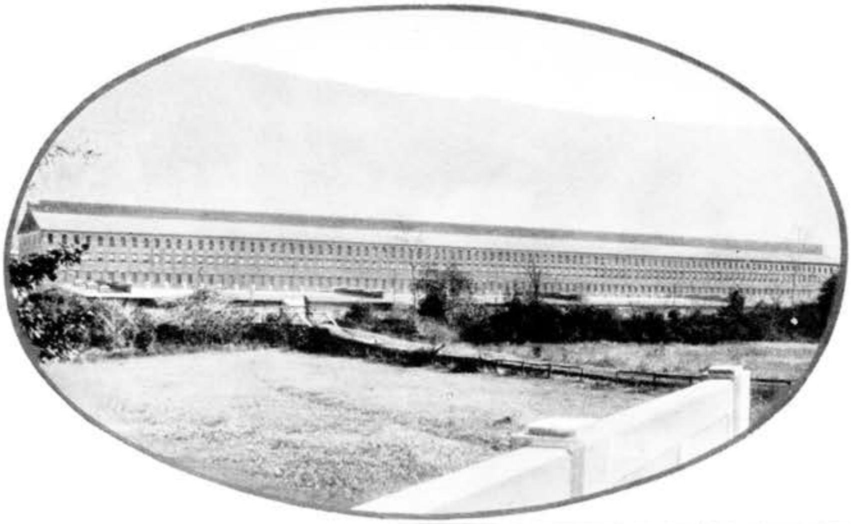


A cable vault located far below a city street. Here is an orderly array of myriad telephone wires collected into cables and sheathed in coats of lead and antimony.



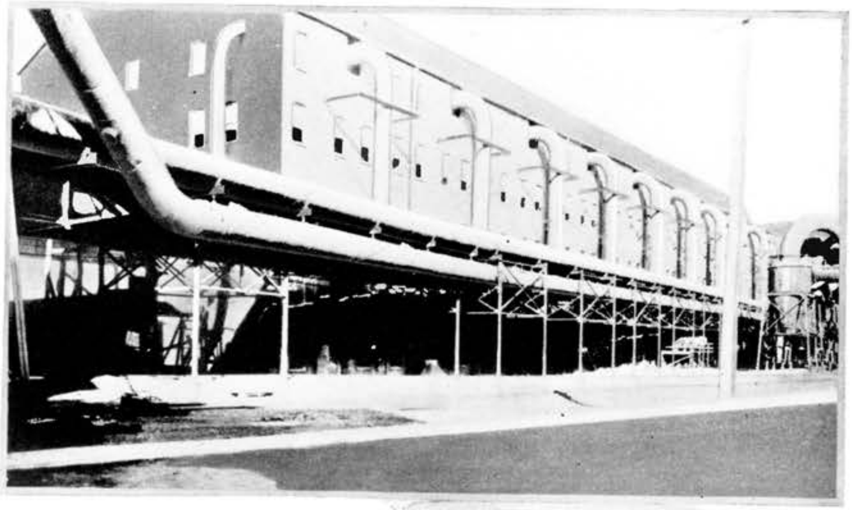
Covering a cable with lead and antimony alloy sheath at the Point Breeze works of the Western Electric Company.

Zinc is almost as widely used as is lead but usually teams up with some other metal to form a useful alloy. It is not often used alone.



Left—Zinc oxide, used in making paint and rubber, is collected in this building which contains what is probably the largest undivided single room in the world.

Right—Zinc oxide is sent through these big pipes by means of powerful blasts of air which blow the oxide to its destination.



Below—In zinc roasting furnaces the zinc and lead sulphides are converted into sulphate and oxide, the excess of sulphur is expelled and the iron and other metallic substances in the ore are oxidized to make a product suitable for leaching.

The head-frame of the shaft at a zinc mine.

Metallic zinc was first made from zinc ore by the Chinese and introduced into Europe by eastern traders. Zinc ore is found in all parts of the world, but today the United States produces and uses more than any other nation. The tri-state district near Joplin, Missouri, in the Ozark Mountains, is the largest producing center, but ore from Franklin, New Jersey, has long been used to produce metal of the highest natural grade.

The first zinc made in the United States was produced from this Franklin ore at the Government Arsenal in Washington, D. C., in 1838, by Belgium workmen, who were brought to this country to manufacture the first set of standard weights and measures from brass. It was not many years later that the production of slab zinc for industry began in commercial quantities. Today zinc is obtained from the ore by two processes, distillation and electrolysis.

By far the largest tonnage of slab zinc is employed in the process of galvanizing. Galvanizing consists of covering sheet iron or steel with a thin coating of zinc in order to protect it from the corroding effects of moisture. It is used to prolong the life of the hardware for pole lines that carry electric light, power, telephone and telegraph wires. The hardware which consists of iron and steel bolts, nuts, braces and clamps, is zinc-coated or galvanized to prevent rusting and thus prolong its life. Wire, wire cloth, tubing and wire cables are also among the many products which consume hundreds of tons of zinc annually.

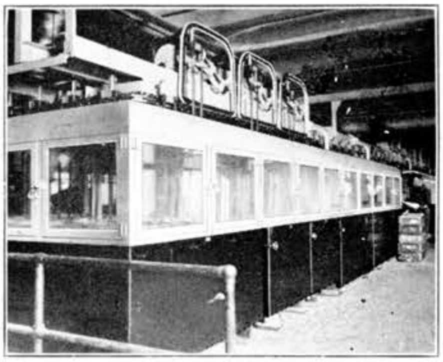
Second in importance among the major consumers of slab zinc is the brass industry. As high as 39,000 tons of brass piping were used in the United States in one year, and most of this pipe was made from an alloy of 25% zinc and 75% copper. So the tremendous amount of zinc that went into the manufacture of this commodity is apparent. Thousands of smaller articles—many of them electrical products and hardware—are manufactured in brass. Some contain as high as 50% zinc and others as low as 15%. Brass sand castings also consume zinc in considerable quantities.

Brass is an alloy of copper and zinc. Aluminum brass usually contains about 3% of aluminum. It casts well and may be forged or rolled. Tin is often added to brass rendering the alloy less liable to corrosion in sea water. As it is used a great deal in naval construction it is often called naval brass. Zinc bronzes usually contain from 2 to 4% of zinc.

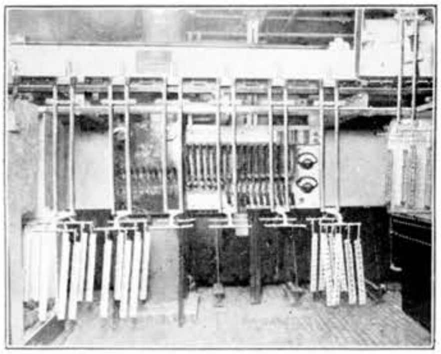
The upright rod, or plunger, that holds the "cradle" of your handset type telephone is made of brass—an alloy of copper and zinc. Handset telephones of recent design have the transmitter "bridge" and receiver frame die cast of a zinc alloy.

Zinc is in the brass screws and nickel silver springs used in your telephone instrument; in the brass which forms the front and back of the transmitter case of your deskstand telephone.

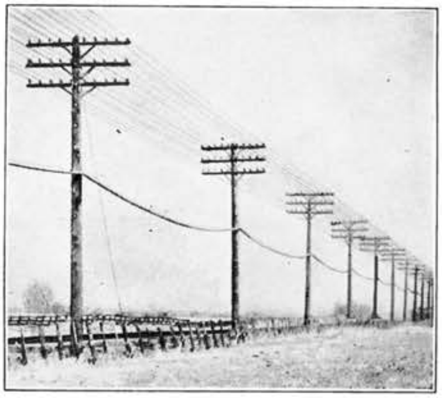
The manufacture of die casting alloys required about five thousand tons of zinc in 1921. In 1937, nearly ninety thousand tons of 99.99+% pure zinc went into these alloys. The development of new alloys containing approximately 93% zinc of this purity has enabled manufacturers in many industries to



Zinc plating, a process that protects iron from moisture and rust, is done by immersing the parts to be coated in a plating solution and depositing zinc on them by electrolysis.

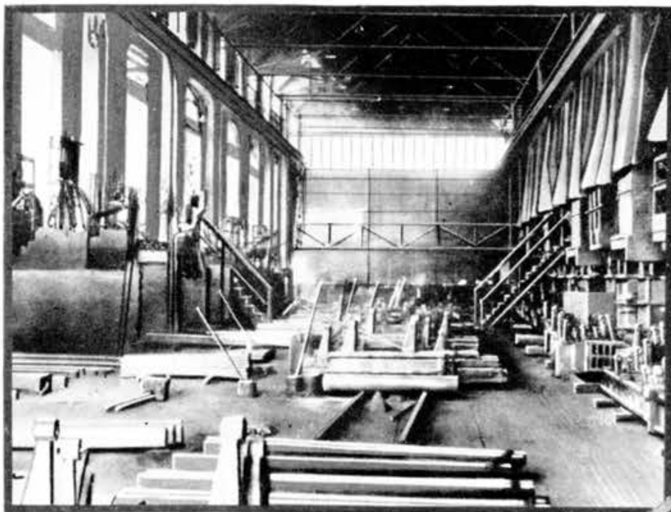


Parts to be electro-galvanized are loaded on racks, which carry them automatically through the various cleaning solutions, and the electrolyte. Operators load the racks and unload the plated parts; the machine does the rest.



On telephone poles practically all steel parts are thoroughly galvanized so they will be long lived and strong.

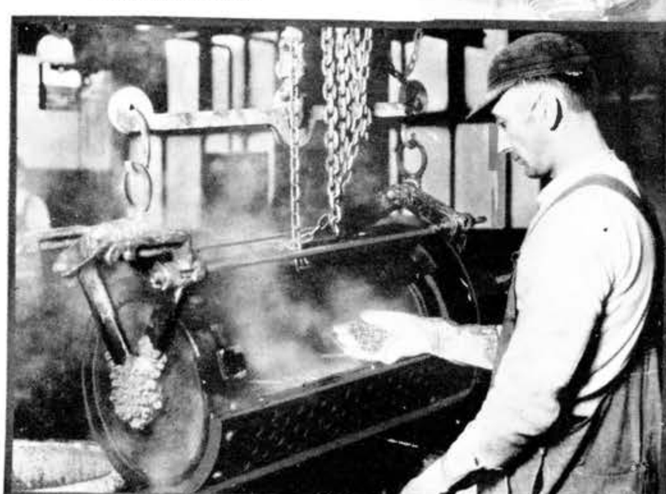
Zinc is the great protector of iron and steel products, which it shields from rusting from the effects of air and water, with a protective coating called galvanizing.



Left—Molding floor of a brass foundry with spare molds on the floor and electric furnaces on the right.

A section of the casting floor in a brass foundry with furnace, exhausters and other equipment.

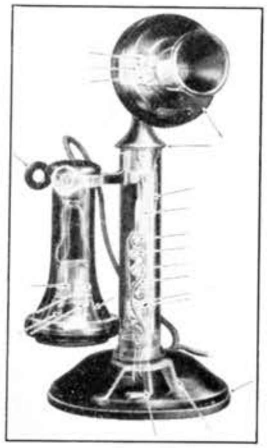
Below—Galvanizing, a process that protects iron from moisture and rust, is done by immersing the parts in molten zinc or by applying the zinc electrolytically.



Filling sacks with zinc oxide.

utilize zinc alloy die castings. The automobile industry is the leader in the use of such castings in carburetors, fuel pumps, radiator ornaments, hardware and speedometers. It has standardized on zinc die castings for over fifty separate parts. Makers of washing machines, household utilities, electric motors and fans, vending machines, refrigerators, cash registers, toys, novelties, etc., rely upon zinc-base die castings.

Practically any type of commercial finish can be applied to these castings. They may be electroplated with chromium, nickel, copper, brass, bronze, gold or silver, as well as coated with paints, varnishes, lacquers and enamels. The smooth surface on die castings requires little preparation for plating—usually only a light polishing. The electrical field also uses many die castings, and they are being employed more and more in business machines, household and plumbing hardware, toys and novelties.



The brass in your telephone instrument contains zinc and zinc is also used to galvanize parts susceptible to moisture and other atmospheric conditions.

A goodly portion of the slab zinc produced is converted into rolled metal. In the electrical industry rolled zinc is used in all dry batteries and in most wet primary batteries. In the familiar dry cells it is used as the shell because of the comparatively large voltage that can be obtained with it as one electrode with carbon as the other. Some other important uses for rolled zinc are weatherstrip, running board moulding, roofing, photo-engravers' plates and lithographers' sheets. For these uses there are different "mixes," that is, different alloys of zinc and other intentionally added elements. And there is a rolled zinc alloy which is used for industrial corrugated roofing and siding, as well as other alloys that are drawn into wire and rolled into foil.

Zinc alloy forms the base of handset type telephones. Zinc is also used in making conduit fittings, lighting fixtures, switch parts and plates, push buttons and bells.

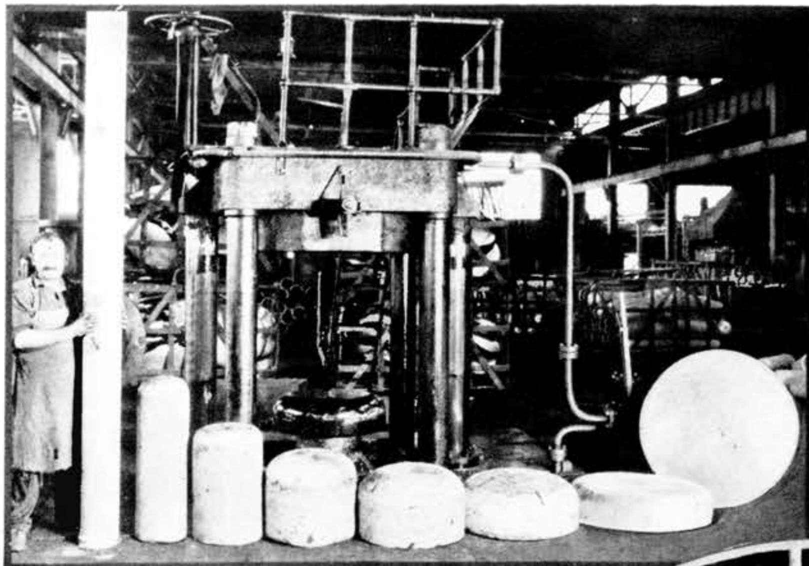
So much for zinc as a metal. As pigment for paints, the zinc oxides and zinc sulphides are basic materials in many products. In this country most of the zinc oxide is produced by mixing crushed zinc ore and powdered coal, and burning them in a furnace, the resulting white fume being drawn through long pipes to a bag room, where the zinc oxide is collected. This method of making zinc oxide is known as the American process, and was developed by an American zinc company. Lithopone, the most important of the zinc sulphide pigments, is made by a complicated process, which can best be described as co-precipitating (pouring together) barium sulphide and zinc sulphate, followed by filtering, drying, washing and grinding to get a fine and densely white pigment.

Both the zinc oxide and zinc sulphide pigments give paint a permanent whiteness, better color, high covering power, and a tough and elastic film of great durability.

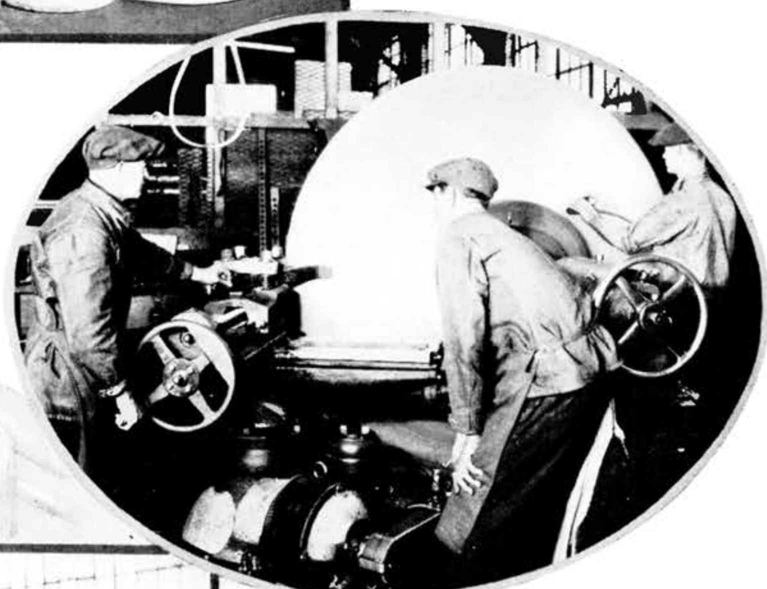
In this brass foundry, equipped with electric furnaces, large quantities of zinc are alloyed with other metals to make the many brass parts used in telephone apparatus.

The rubber industry is another large consumer of zinc oxide because of the good strengthening properties of this pigment. For this reason, zinc oxide is used in rubber insulation on telephone wires. Zinc oxide adds longer life to solid and pneumatic tires, inner tubes, rubber hose, boots and shoes, and a host of other rubber articles. Other important uses of zinc oxide are in the manufacture of linoleum, oilcloth, cosmetics, leather finishes, printing inks, and ceramic products.

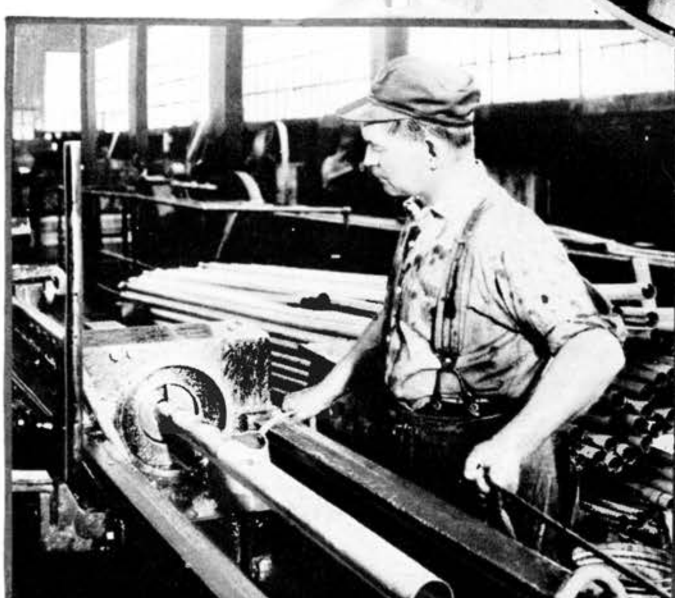
Aluminum has brought to Industry strengths comparable with steel in beams and rods and castings but weighing only a fraction as much.



The flat disk of aluminum at the left changes shape, as shown from right to left, with each drawing process until it becomes the tubing at the extreme left.



Right—To form aluminum disks into bowl-like shapes, the disk is spun rapidly like a wheel and while it is turning, the machine presses against it, so it gradually curves more and more into the bowl shape wanted.



Drawing aluminum tubing.

Open-hearth furnaces used in making aluminum alloys. Furnace in the foreground is being tapped.

About eighty years ago a distinguished group of Frenchmen sat about a dinner table that has a place in the history of metals. On the table lay a scant dozen forks and spoons of a new metal; a metal as bright as silver and with a beautiful sheen. They were remarkable for their lightness, for at least a half dozen of them were needed to balance even one of the decorative silver forks which also appeared on the table.

These utensils were made of aluminum, then so rare as to place it with gold and silver in the ranks of precious metals.

Since those days the process of procuring aluminum has moved from the laboratory to great factories, usually located near waterfalls; for cheap electricity, as produced by water power, is an essential in making aluminum at the costs which have brought it wide use in industry.

Aluminum is derived from bauxite, which gets its name from the French district of Les Baux, where the ore was discovered.

The ores containing aluminum are found in many parts of the world. In the United States the deposits in Arkansas have in recent years produced most of the output of the country. Bauxite is also mined in Dutch and British Guiana.

Aluminum is one of the chemical elements of clay and of many rocks and minerals, including ruby, sapphire, garnet and turquoise. As far back as 1826 the Danish scientist—Oersted—extracted from the minerals in clay a tiny button of this silvery metal, then recognized for the first time by science. A quarter of a century later a French chemist, Deville, succeeded in producing enough aluminum to make a famous watch-charm presented to the King of Siam, and then in turn came the previously mentioned dinner with the forks and spoons of aluminum.

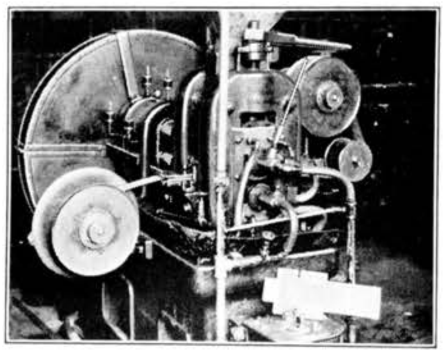
Aluminum making, as we know it today, began with the experiments of a college student, Charles Martin Hall, in the family woodshed at Oberlin, Ohio. His method differed from the chemical processes of Oersted and Deville. He used electricity, which was then just coming into its own. In the summer of 1886, Hall, reaching into the tiny crucible containing his chemicals and into which he dipped the wires connected to a string of electric batteries, fished out a lump of aluminum about the size of a pea.

Hall's principle for making aluminum is the one used today in the great industry which rose from a production of thirty pounds a day after he started to make commercial aluminum, until in 1938, twelve months' production amounted to 566,929 metric tons.

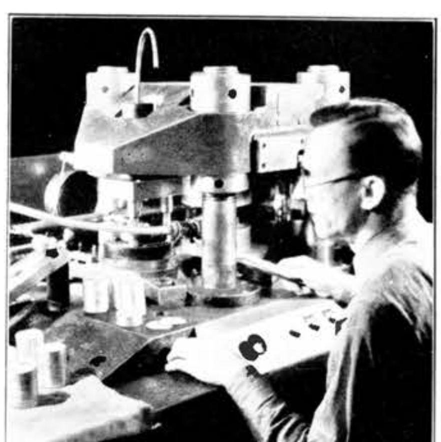
The Hall process does not produce the metal from clay. That world-wide material is too difficult to handle commercially. Another raw material was used, the chemical compound called alumina. This is the same compound of which rubies and sapphires are composed.

With increased demand for aluminum, the available supply of raw alumina was insufficient and hence gradually the aluminum industry started to use bauxite, which contains the necessary alumina.

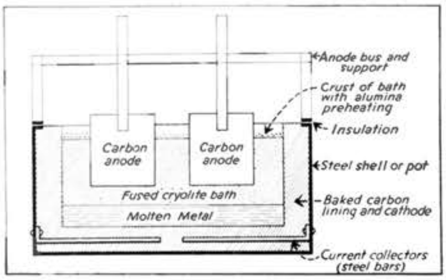
Aluminum foil is used in the manufacture of condensers. At the top are rolls of insulating paper and foil; in the center a condenser unit, slightly unrolled; while in the lower view are (left to right) a condenser unit before and after baking and waxing; a potted condenser before cleaning and painting—the unit having been inserted in a can which was then filled with asphalt compound; and at the extreme right the finished product.



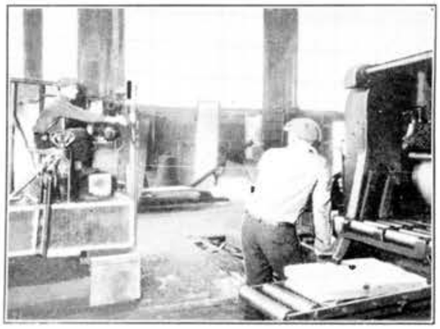
This rolling mill is used to make the thin strips of aluminum—chromium—magnesium alloy from which is made the diaphragm in the transmitter of your telephone.



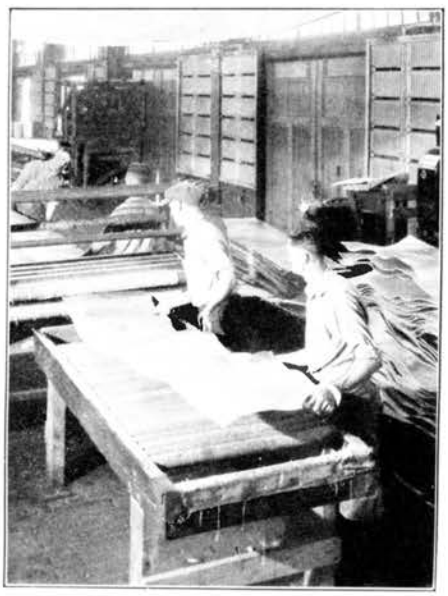
Diaphragms for telephone transmitters are blanked, formed and perforated out of strips of the aluminum alloy by machines like this.



This sectional view of an aluminum furnace or "pot" shows the arrangement of the parts and materials described in the text.



Taking the temperature of an ingot of aluminum alloy is very important if it is to be rolled still more to change its shape.



Straightening sheets of aluminum by rolling them.

With the adoption of bauxite as the raw material there followed a process of development to solve the scientific problems in mining engineering, chemical engineering and electrical engineering.

Aluminum is a jack of many trades. It helps, as pots and pans, to prepare our meals and enables us to eat them by means of aluminum handles on knives, forks, and spoons; it floats in the air as parts of planes and dirigibles; it carries electric current as wire; it protects buildings as paint; in radio receivers, it assists in our entertainment, and in small metal tubes brings to us the materials with which we brush our teeth and shave. Gongs, too, are made of aluminum, for it helps retain the tone of gongs and bells longer than do the more usual bell metals.

Aluminum foil is used for taping switchboard cables to keep out moisture.

Since aluminum can be rolled into very thin sheets. it is part of the diaphragms which assist to reproduce sound in the telephone as already mentioned.

The base metal, aluminum, as already explained, comes from bauxite, a hydrated aluminum oxide, containing the oxides of iron and silicon as impurities. After drying and crushing, the bauxite is chemically treated to remove the impurities and finally calcined to pure alumina, chemically labelled Al_2O_3. This is reduced to aluminum in an electrolytic cell containing a bath of molten cryolite.

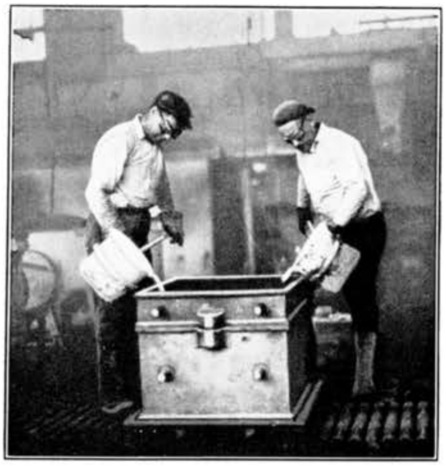
The charge of aluminum and silicon, or aluminum alloy rich in silicon (commonly termed "silicon-rich"), is melted down in furnaces ranging in capacity from a few hundred pounds to 30,000 pounds, under accurate temperature control. After the entire charge has been melted and has reached the right temperature, it is thoroughly stirred to insure chemical uniformity. The molten alloy is then "pigged," the size of the ingot depending upon the ultimate use of the alloy.

For die casting purposes, an ingot weighing approximately five pounds is generally produced, but for sand and permanent mold casting the ingots may range in size from 3 to 30 pounds. During the pigging operation, several samples are taken for chemical analysis—as a check both on the composition and on the thoroughness of the mixing.

In some handset type telephones, the transmitter and receiver cases are made of die cast aluminum alloy.

There is an unusual way of applying aluminum as a coating to quartz crystals. Aluminum wire is suspended across a chamber above the crystals to be coated. All the air is pumped from the chamber. An electric current then is passed through the aluminum wire, heating it and causing some of the aluminum to vaporize. The aluminum vapor fills the chamber. The quartz crystals are kept cool and some of the aluminum vapor condenses on the crystals. This "frosting" of aluminum forms a conducting surface for the quartz plates used in telephone filters.

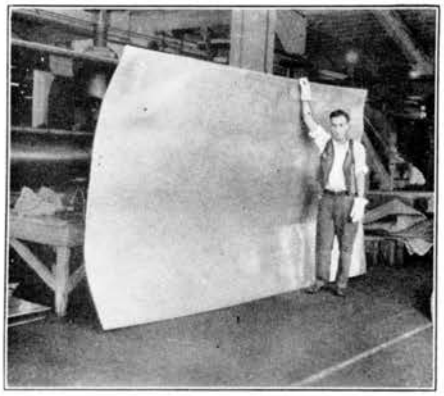
Although magnesium is a development of the twentieth century so far as commercial manufacture and applications are concerned, it was first made over 120 years ago. Commercial production was begun in Germany in 1909 and in the United States in 1914. Its early uses were as a minor part in aluminum-base alloys; as a deoxidizer or cleaner for nickel, brass and bronze and in a powdered form for the well-known photographic flashlight powder.



Pouring magnesium sand castings. Because of the great consumption of electric energy, magnesium, like aluminum, is produced where power is cheap.

During the last ten years great progress has been made, not only in reducing the cost of producing the metal and increasing its purity, but also in the development of methods for fabricating of sand castings and die castings, hammer forgings, extruded rod of all shapes and sizes, and rolled sheet.

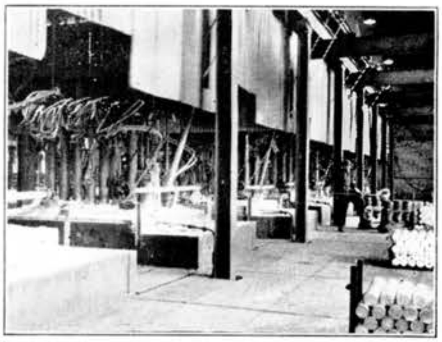
The ores of magnesium that can be profitably used constitute approximately 2% of the earth's crust, for the metal can be made from both magnesite and magnesium chloride. The former exists in enormous deposits in many parts in the world and large quantities of natural magnesium chloride occur in the United States and in Germany, in combination with potassium chloride. The metal is manufactured at present by the electrolysis of molten magnesium chloride at Bitterfeld, Germany, and at Midland, Michigan, in the United States.



Magnesium rolled sheet. Magnesium is the lightest metal used as an engineering material. It is harder than aluminum.

Magnesium is a white silver-like metal. One of its chief characteristics is its light weight, being the very lightest commercial metal. A cube measuring 2½" on a side is required to make up a pound of weight, which means that it has but two-thirds the weight of aluminum. Many of its uses are concerned with this characteristic. Because with it can be produced light-weight sand castings and forged pieces with high mechanical strength, it becomes particularly useful in the aircraft industry for engine crankcases and accessories. Magnesium is used in the alloy from which the telephone transmitter diaphragm is made. For high speed machinery, especially of the reciprocating or oscillating type, castings of magnesium are replacing iron and even aluminum, reducing inertia forces and eliminating vibration. Sand castings make excellent machine shop jigs and weigh but one quarter as much as similar parts made of cast iron. For devices which must be especially light and easily portable, die castings are used.

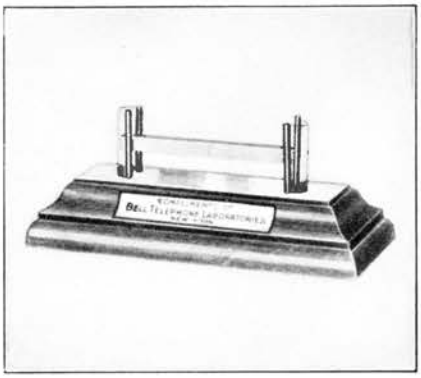
Thinly rolled aluminum sheet containing a small amount of magnesium as well as small amounts of copper and manganese is used in diaphragms for loud speakers and other sound devices, because of light weight and excellent acoustic properties.



Manufacture of magnesium by the electrolysis of molten magnesium chloride.

An interesting application for magnesium wire and rolled ribbon is in the removal of the last traces of air from radio tubes. A small piece is inserted in the tube during manufacture and after the bulk of the air has been removed by pumps the magnesium is ignited by an induced current, causing it to turn to vapor and absorb the last traces of oxygen and nitrogen.

New and unique uses for magnesium are being rapidly developed taking advantage of its excellent machining qualities, its high strength and very light weight.



"The Wobbly Bar"—When this scientific curiosity was first shown, wide-spread interest was aroused by newspaper accounts, which often inaccurately described the phenomenon as "defying the laws of gravitation," which, of course, is an impossibility.

One of the reasons people hear us so well when we use the handset type telephone is because of the use of cobalt steel alloy in the receiver magnets.

At Bell Telephone Laboratories, in New York, there is a permanent museum of original models of electrical communication apparatus; an historical collection that traces the history of the communication art from Morse's telegraph tape recorder of 1843 down to the latest type of audiphone, or hearing aid. Among these hundreds of exhibits, which illustrate the continuing progress that has been made as new ideas, materials and applications came into use, there is a device consisting of a small wooden base and two parallel bars of cobalt steel, one bar hidden within the base, the other floating in the air. The floating bar is guided by, but not attached to, vertical guides mounted at each end of the base. What holds the bar in the air?

The floating bar is merely an interesting illustration of the fundamental laws of magnetism and of the remarkable properties of cobalt steel. These two metal bars are highly magnetized and are mounted to present like magnetic poles to each other; consequently a repulsive force exists and keeps them apart. This force, which varies inversely with the square of the intervening distance, is greater than the gravitational attraction on the upper bar. Thus the free magnet bar moves upward until the repulsion just equals the gravitational pull, when it remains balanced without visible support. Bars of ordinary magnet steel, magnetized in the same way, would not act so powerfully upon each other.

Cobalt miners' homes in South Africa.

Cobalt steel alloy, in which are also small amounts of tungsten and chromium, is used in the receiver magnets of handset type telephones because of the increased magnetic power and the comparatively small magnet required, thus making the receiver lighter as well as more efficient.

Cobalt comes from South Africa. The ore from which it is obtained is mined primarily for its copper. In refining the copper an alloy is first obtained containing three metals: copper, cobalt and a small amount of iron, which are later separated. At the cobalt works in Belgium, from 600 to 700 tons of cobalt are produced yearly.

The Story of Tungsten

An African cobalt mine. Most people who have admired the blue cobalt enamels of ancient Saxony porcelains know that cobalt is one of the minerals the ceramic art has used from its beginning to obtain deep and warm blue colorations. The remarkable magnetic properties of cobalt, however, have only been known and utilized in recent years.

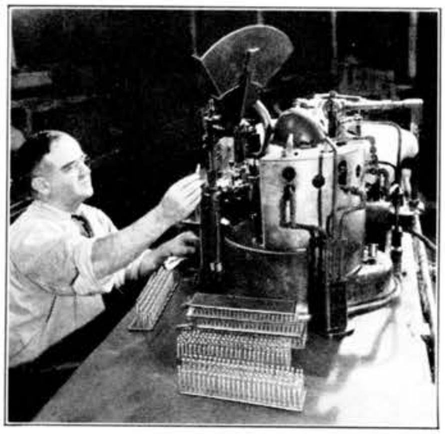
Everyone has heard of tungsten in its capacity of a "seeing-aid," so called because it is used in lamp filaments.

Tungsten is an element employed commercially in various forms, such as ferro-tungsten in steel-making; metallic tungsten in producing wire for lamp filaments and radio tubes; sheets and discs used as ignition contact points; tungsten carbide in tools, etc. It is found in various combinations of minerals. The most prevalent is wolframite, an ore containing tungsten combined with iron and manganese, mined principally in China. Another combination of minerals containing tungsten is scheelite, made up of calcium oxide and tungsten, and found in our Western States, chiefly Nevada and California, and abroad in Bolivia. Other minerals, such as ferberite and huberite, also are mined commercially, but in smaller quantities. The main source of tungsten, however, is China, which supplies the bulk of the world's demand.

Tungsten ores are smelted in electric furnaces to produce ferro-tungsten, an alloy of iron and tungsten.

The melting point of an 80% tungsten alloy is about 3,400° F., so it is not feasible to refine this metal as it is done in the case of steel or lower melting point alloys. The refining is done in intermediate steps. Each charge of ore, reducing agent, slag-forming material, etc., is reduced and refined; the slag carrying the impurities is tapped, and a fresh charge added. This is continued until the furnace is full of metal, a process requiring from two to four days. The "buttons" of metal when completed weigh about 12,000 pounds each. These are crushed to the required size for use in the industries.

Tungsten is used for filaments of telephone switchboard and resistance lamps.



This machine performs the operations of sealing and exhausting the glass bulbs of switchboard lamps. These lamps employ very small drawn tungsten wire (.004 of an inch in diameter) as filament material.

The Story of Chromium

Chromium, as an element, was discovered by Vauquelin of France, about 1800. But it is a mere youngster compared to many metals that have speeded world progress. In 1828 a young man named Tyson, while in the Farmers' Market of Baltimore, Maryland, noticed a cider barrel which a farmer had propped up with chunks of black mineral that looked like chromite. Inquiry led to the location of this ore in northern Maryland and Pennsylvania. However, the largest tonnage of chromium ore comes from Rhodesia, South Africa, with New Caledonia ranking second.

Tyson organized the chromite industry and for nearly fifty years the companies of this domestic district dominated the world supply. In those days chromium was used largely for making chemicals. Chroma is the Greek word for color, so the name was given to these chemicals because of their brilliant hues. Despite years of research no metallurgical use was made of chromium until about 1869, when the production of ferro-chromium was started by reduction in crucibles, making possible the commercial manufacture of chrome steel. Long before that, the characteristic qualities of chromium were known: hardness, resistance to tarnish, comparative freedom from oxidation when heated, and resistance to many acids.

The Eads Bridge, spanning the Mississippi at St. Louis, built in 1874, was the first in America to use alloy steel for the main members.

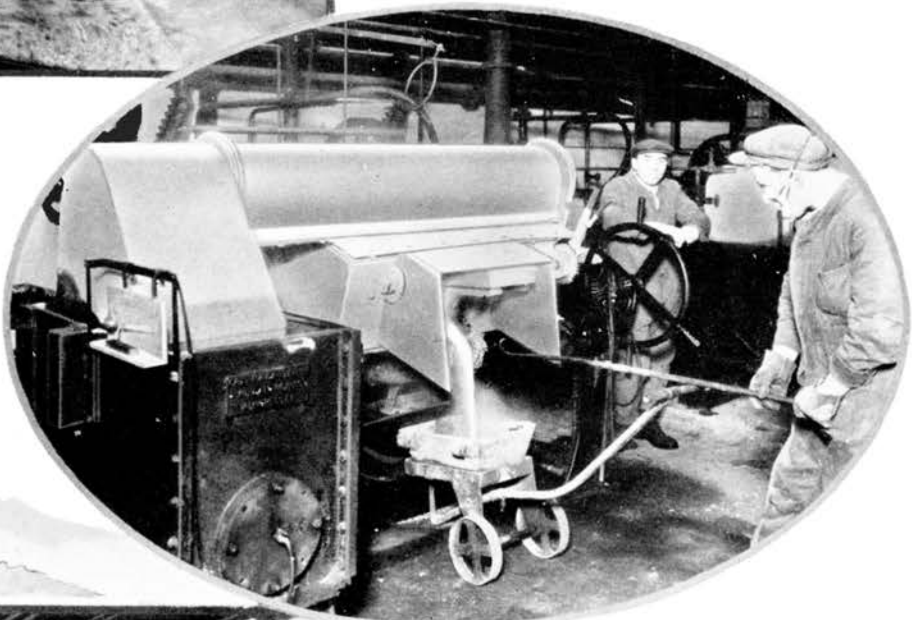
Modern high speed steels containing chromium, tungsten, and carbon retain their remarkable qualities of hardness and their cutting edges even when operating at such speeds that the tool becomes red hot.

Chromium steel is used extensively in magnets for generators, relays, receivers, polarized bells, selectors, ringers and various other pieces of telephone apparatus.

A chromium mine in Rhodesia, South Africa. Chromium is used in certain forms of permalloy and in the permanent magnets of ringers, receivers, generators, coin collectors, and other types of telephone apparatus. Alloys of iron, tungsten, chromium, and nickel with other alloy combinations, in addition to their uses in the telephone industry, are utilized in making many kinds of electrical resistances, grids, kitchenware, engine and motor parts, acid containers and rust resisting hardware. Chromium plating is widely used for automobile parts, and an almost infinite number and variety of parts where a plating better and far more lasting than ordinary nickel is desired.

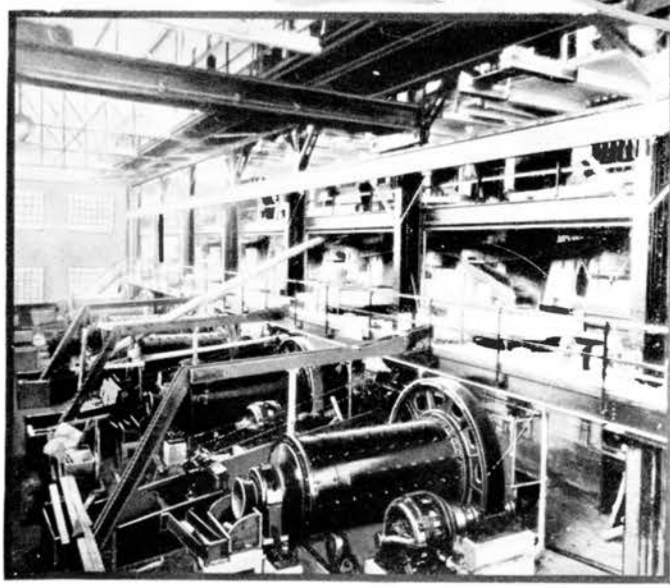
Gold, silver and platinum, the precious metals for centuries because of their purity, and use for ornaments, decorations and coins, are now more precious than before because Industry finds them more suitable than any others for certain uses.

Left—The gold ore, after being separated in a cyanide solution, is given a period of agitation in large tanks to allow the solution to dissolve as much of the gold as possible. This picture shows agitators in a mill in the Kirkland Lake gold district of Ontario.



Right—Pouring from a reverberatory furnace. Here the concentrate of platinum metals has been smelted at a temperature of 1,000 degrees centigrade.

Below — Rod mills which break up the ore and classifiers used for fine grinding, in a South Dakota mine.



Right—An Alaskan prospector washing gravel for alluvial gold. It was by this method that the California "Forty-Niners" recovered most of the precious metal that gave their commonwealth the name, Golden State.

Gold and silver have been precious metals since the time when the women of ancient Egypt and Assyria wore gold and silver jewelry and the leaders of warriors used these metals to decorate their arms and armor. Platinum, on the other hand, has been known to us only since the eighteenth century, while its close ally, palladium, was discovered about eighty years ago.

The price of platinum has fluctuated greatly in recent years. It has sold as high as one hundred and fifty-five dollars an ounce. Today it is selling at approximately thirty-five dollars per ounce, with palladium at about twenty-three dollars and fifty cents per ounce—while the market price of gold is about thirty-five dollars per troy ounce.

Today the world's gold and silver come principally from the Transvaal in South Africa; Ontario, Canada; Alaska, the Rocky Mountain States, the Dakotas, Mexico and Australia, while considerable silver is derived from the lead zinc ores of Missouri and adjacent states.

About seven centuries before Christ, a coin was made from an alloy of gold and silver. This, the oldest coin known, is called the Babylonic Stater. Not more than 200 years later in the days of the Persian king, Cyrus the Great, the King of Lydia stamped his royal insignia on lumps of gold and thus made the first gold coin that had a definite value and was used in trade.

Down through the centuries that followed, the traders who carried the names of Tyre, Carthage, Alexandria, Florence, Genoa, Venice, Flanders, and England far and wide, used gold and silver in their trading. Later with the expansion of international trade which followed the Crusades, men became possessed with such a desire for gold that the scientists of that day and age working in secret spent their lives trying to turn silver and other comparatively cheap metals into precious gold. Of course, they failed but their researches with metals and acids resulted in the so-called science of alchemy, which might be called the father of today's wonderful science of chemistry.

Then came the days when the Turks captured Constantinople. Columbus sailed west and Vasco da Gama went around Africa in search of India and the East Indies. Out of these explorations came the discovery of many new lands which have produced great wealth, but not in the form of gold or silver. Peru and Mexico turned out to be the only real El Dorados or Lands of Gold for the gold-seeking Spaniards.

The most important present source of platinum metals, including palladium, rhodium and ruthenium which are rare metallic elements of the platinum group, are the copper-nickel ores of Sudbury, Canada. Following these in order of importance, are the deposits in the U. S. S. R., South America and South Africa—South America being the first known source of platinum.

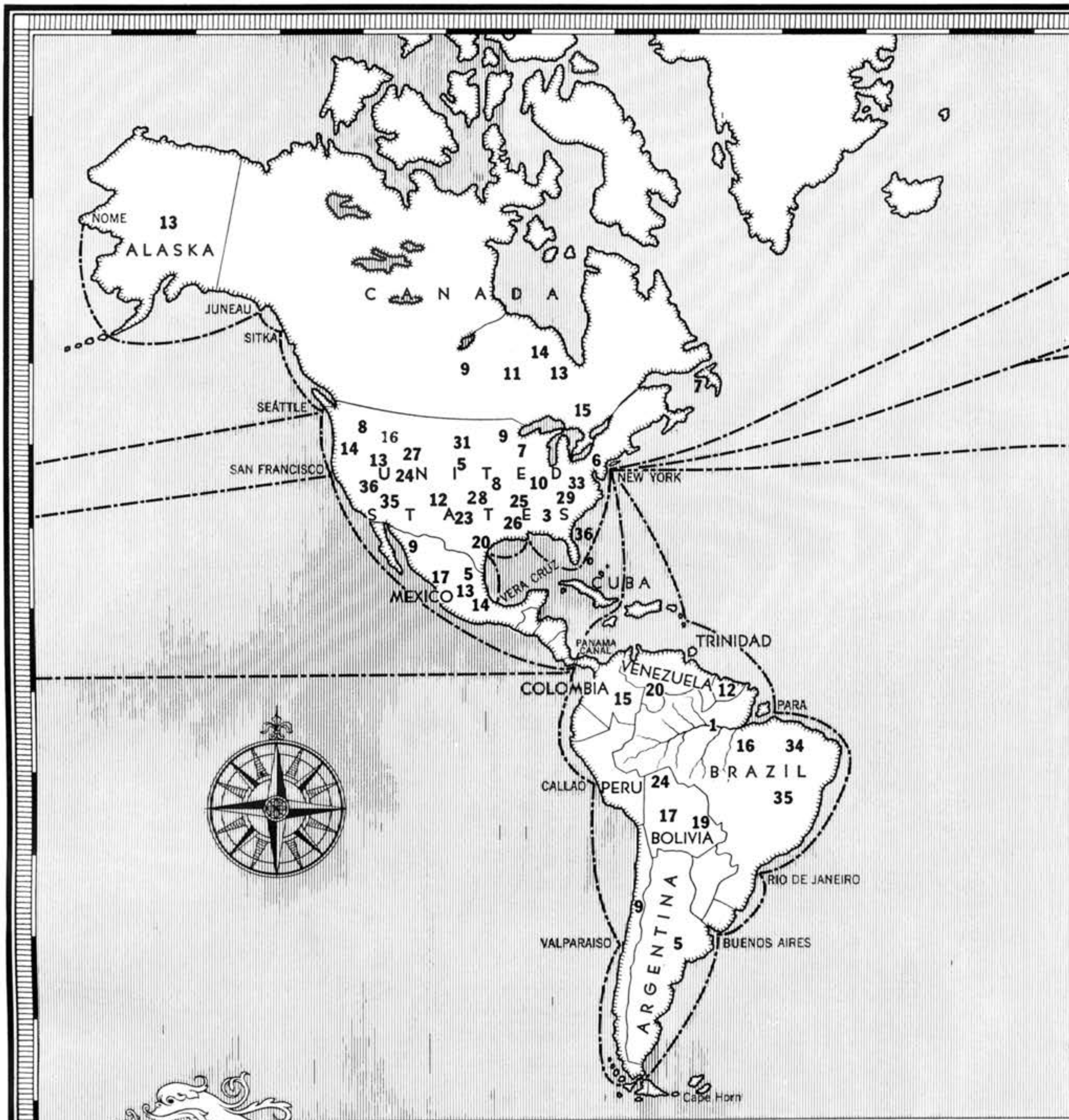
Gold is frequently found uncombined with other metals, although it usually occurs in ores also containing silver and small quantities of copper or iron. Besides being mixed with

Underground in the Homestake mine, the largest gold producer in the United States. It is at Lead, South Dakota.

Dredges are now the chief means by which alluvial gold is recovered. Here is a large unit at work in Oregon.

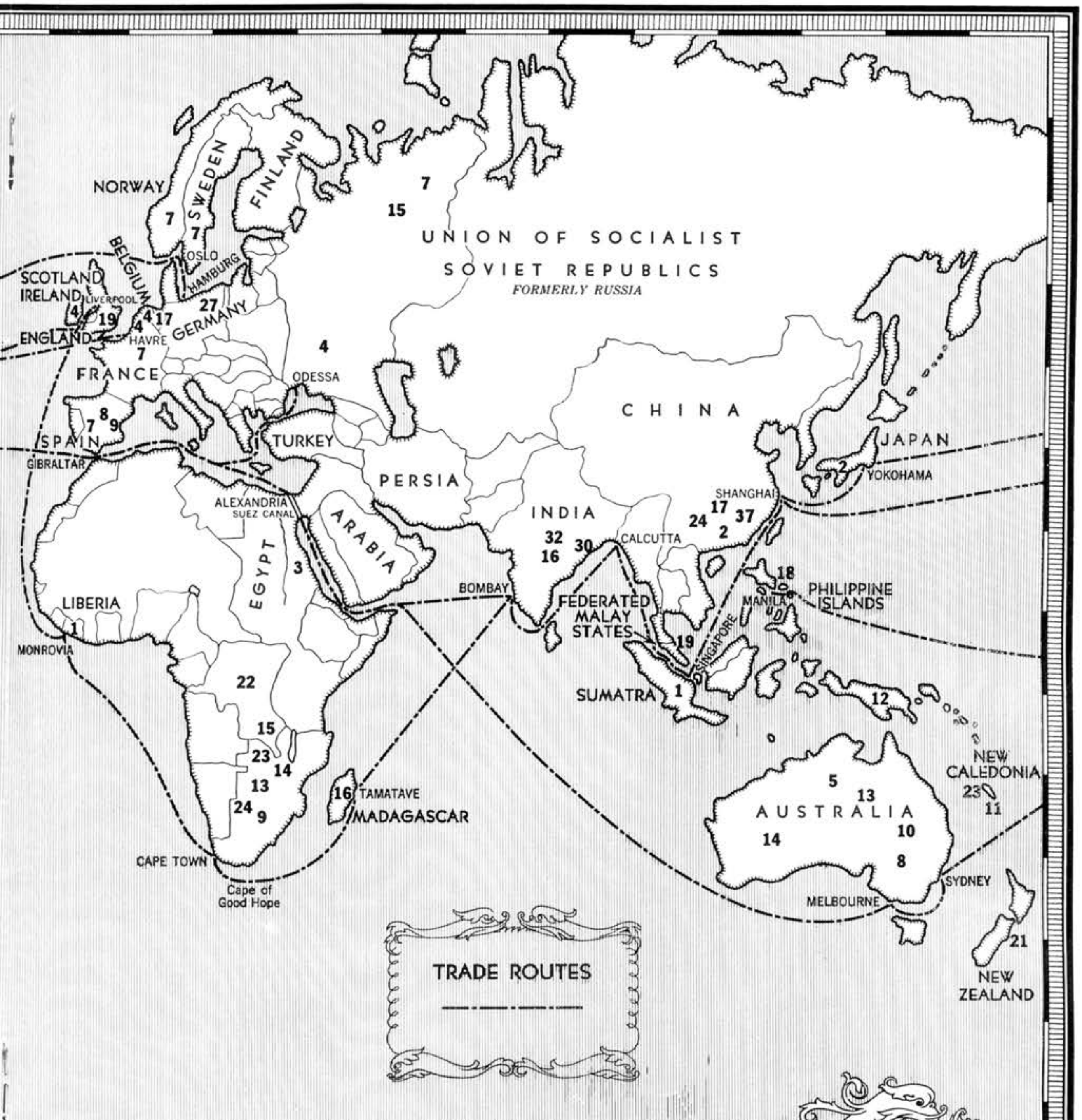
Preparation of platinum alloys for vacuum tube filaments.

Where The More Important Materials Wh



1 Rubber	*6 Coal*	*11 Nickel*	*16 Mica*
2 Silk	*7 Iron*	*12 Aluminum*	*17 Antimon*
3 Cotton	*8 Lead*	*13 Gold*	*18 Hemp*
4 Flax (linen)	*9 Copper*	*14 Silver*	*19 Tin*
5 Wool	*10 Zinc*	*15 Platinum*	*20 Asphalt*
			37 Chinawood Oi

hich Make Up Your Telephone Are Found



21 *Kauri Gum*
22 *Cobalt*
23 *Chromium*
24 *Tungsten*
25 *Cellulose Acetate*

26 *Stearin Pitch*
27 *Magnesium*
28 *Wax*
29 *Silicon*
30 *Shellac*

31 *Leather*
32 *Jute*
33 *Phenol Plastic & Fibre*
34 *Carnauba Wax*
35 *Gilsonite*
36 *Clay and Talc*

Colombian natives panning platinum.

"Sputtering" gold on the diaphragms of broadcasting transmitters. The telephone handset transmitter electrode (terminal) and the interior of the tiny carbon cup are gold plated to provide a non-tarnishing surface, which is low in electrical contact resistance.

The young woman is pointing to the "spot of gold" in the center of the transmitter diaphragm.

gold, silver is often found combined with lead and zinc and copper.

Mining gold and silver with a pick and shovel is no longer a commercial practice in the more advanced mining districts.

Most of the great gold mines of our day are many thousands of feet deep. Some gold is, however, obtained from alluvial gravel deposits, which are worked by dredging, or are attacked by powerful streams of water that "dissolve" away the landscape and carry off the mixture of sand and find particles of gold. The alluvial platinum deposits of the U. S. S. R. and of the Chaco district of South America are worked largely by dredging, although some platinum is secured by natives employing the primitive methods of their ancestors.

Silver is secured principally from minerals containing considerable quantities of lead and zinc, or sometimes cobalt. The usual mining methods are employed, and the silver is recovered in the subsequent smelting and refining operations incidental to the production of the base metals.

Platinum and palladium occurring in the copper-nickel ores of Sudbury are recovered in the course of refining the latter metals and are in a sense by-products, though very valuable ones.

Silver, in addition to its use for coinage, for sterling silver (92.5% silver, 7.5% copper), and in electroplating, is used in large quantities for the production of the light-sensitive coatings of photographic films, plates and papers, and in small quantities for a host of purposes, such as glass and metal mirrors, and certain types of chemical equipment to resist alkalies, fruit juices or dry chlorine.

Platinum has many uses in industrial equipment aside from its most important use in fine jewelry. Platinum alloy wires, or strips, are essential to the production of the long-lived thermionic amplifiers used in telephony, while alloys of platinum, particularly the platinum-iridium alloys, are widely used for electrical contacts required to function continuously and unfailingly as, for example, in certain types of telephone relays, high-tension aircraft magnetos, etc. Crucibles and electrodes for electrochemical apparatus are made of platinum to withstand the corrosive attack of the chemical re-agents employed, and are essential to the modern laboratory. Little cups with hair-fine holes and made of gold, alloyed with either platinum or palladium, are used in the Rayon industry to form the thick cellulose solution into the delicate fibres that imitate the product of the silkworm.

One of the interesting uses of these metals in industry is in the manufacture of telephone equipment. For instance, palladium, or the older gold-silver-platinum alloy, is utilized in your telephone circuit for contact points that make and break electrical circuits when the receiver is lifted from the hook. A similar use is on the relays which open and close other pathways for electrical currents in telephone switchboards, thus governing many of the operations involved in connecting you with the party to whom you wish to talk.

The number of relays operating when a telephone call is made depends upon the type of call and the apparatus involved, whether it be operated manually by human hands or automatically, as in the case of the dial telephone. When you call a number, from a few score to several hundred relays are set in operation, many of them operating several times.

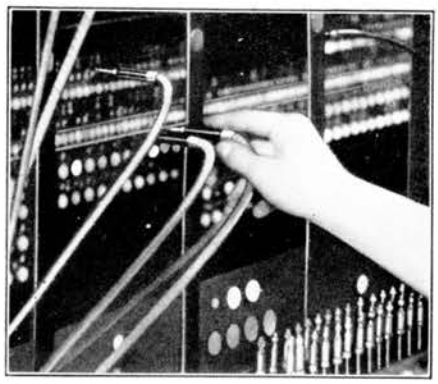
When you call a number in the same exchange as your own, you set into operation on certain calls as many as 35 relays, each of which has one or more of these precious metal contacts. If you dial your number, there may be as many as 236 relays required, each with one or more pairs of contacts, that operate one, two, three, or more times during the operation of calling the party to whom you wish to speak.

Pre-melting platinum sponge. "Sponge" is really a misnomer because at this stage of the recovery process, it is a powder which must be melted prior to casting into ingots.

Precious metals are used in telephone systems because they insure dependable and quiet operation, and possess such long life that they actually prove most economical over a long period of time; they likewise effectively combat the corrosive effect of the atmosphere, which would cause the more common metals to corrode or become rusty and make your telephone unusable. Palladium contacts remain bright and clean and always afford a good pathway for the electric currents used in telephone systems.

The contact points are securely welded to the nickel silver springs which support them, and in spite of their comparatively small size, resist the wear occasioned by the rubbing during closure, and the slight sparking on opening.

Tiny lamps flash in front of the telephone operator, advising her of incoming calls; that parties called have or have not answered, or that both parties have hung up or disconnected. Small lengths of nickel-iron wire, enclosed in a sheath of platinum, lead through the glass of these lamps and connect to the wires that support the light-giving filament.



The front of a telephone switchboard, showing the plugs, cords, jacks (into which the plugs are inserted to connect the lines) and the signal lamps, covered by glass caps.

The use of platinum in small switchboard lamps takes advantage of a different characteristic of the metal than that utilized in contact points. The wires which lead in the current through the glass to the filament must expand and contract at the same rate as the glass, so that the glass will not fracture or develop air leaks around the wires as the lamp repeatedly heats and cools in service. Furthermore, in the manufacture of the lamps it is essential that the wire does not oxidize upon heating to the melting point of the glass. Platinum and some of its alloys possess this combination of properties and, therefore, they are used as the sheath on the "lead-ins."

Radio broadcasting stations likewise make considerable use of tubes with platinum alloy filaments, which possess a life of 25,000 hours or longer. In these tubes a little twisted strip of platinum alloy is coated with a mixture of two chemicals, barium and strontium oxides, and need be heated to only a dull red in operation.

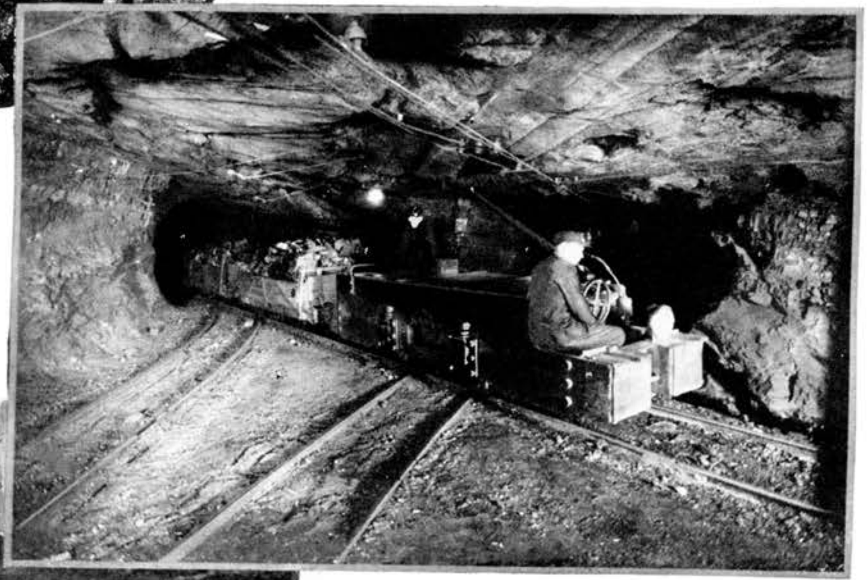
A side view of a switchboard lamp. In these lamps platinum-sheathed nickel-iron wires run through the glass. Platinum is used because heat and cold affect it to about the same degree as glass and therefore the wires do not shrink away from the glass and let air into the lamps.

The precious metals find yet another use in the telephone, protecting base metal parts from oxidation (or rusting). For instance, the new type of transmitter employed in handset telephones is equipped with a carbon container fitted with gold-plated contact elements, for it has been found that this construction results in increased reliability and quieter operation.

Though coal is found in practically every part of the world, you can almost measure the commercial importance of a country by the tonnage of coal it mines.

Left—A group of miners at a Pennsylvania colliery. The men in the foreground are breaking large chunks of coal. Larger numbers of men are employed at "the face" under modern mining conditions.

Below—Electric mine locomotives have freed the mules which used to haul out one or two cars of coal at a time



Below Left—Loading a mine car.

Right—Communication in a mine is always necessary and sometimes a matter of life and death. Therefore, mines have complete telephone systems and many use Western Electric telephones.

The widespread use of coal is comparatively recent. Although in England—probably the first country to utilize coal to any extent—the Anglo-Saxon used it as early as 852 A.D. Coal mining as a real industry did not begin until James Watt, the Scotch inventor, designed and improved the steam engine, about 1784. From then on coal did its part to change the methods of industry.

Coal was first mined in this country about twenty-five years before our Revolutionary War. Since that time coal mines have brought us untold wealth and prosperity.

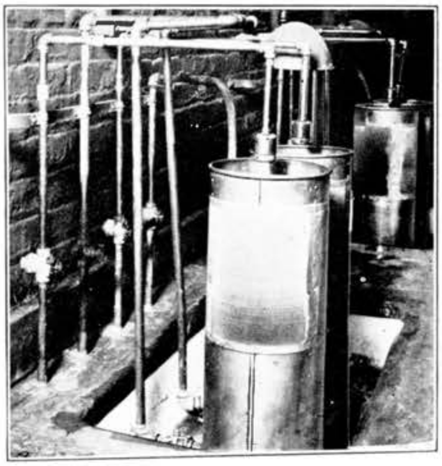
You have no doubt often read the story of how coal was formed. It is fascinating to send our minds flying back over the centuries to a time when the regions now yielding coal were swamps covered with rank luxuriant vegetation, which in time died, fell into the waters of the swamp and, as the deposit became thicker and thicker, sank below the water and gradually became covered with sand, mud and other earthy substances carried out from the shore.

Today coal is being formed in much the same way in the lower valley of the Amazon, in the Dismal Swamp of Virginia and North Carolina and in the peat bogs in Minnesota.

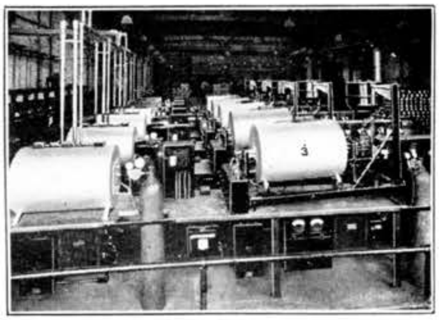
This buried vegetation has, during the ages, gone through various changes. Compare a piece of anthracite and a piece of bituminous coal. The anthracite is changed much more than the piece of soft coal, due mainly to the fact that it has been subjected to greater pressure, which squeezed out most of the moisture as well as other compounds.

Thus anthracite, containing as it does over 80% carbon, has a great heating power and burns with a smokeless flame. Bituminous is more brittle, contains more gas and burns with a smoky flame. Below bituminous in the order of usefulness of fuels is a brown colored lignite hardly deserving the name of coal. Peat, which is dried and used for fuel in Ireland, Holland, Germany and the Scandinavian countries, is not even coal, although if left long enough under pressure it would change into lignite, while that lignite in time would change into bituminous coal, and so on.

Trees help make the telephone—prehistoric trees to be sure, but the relationship between a telephone and a prehistoric tree is not so remote as one might think. A logical journey can be mapped directly back from telephone to tree, and the main stopping places are carbon and coal. Due to the action of carbon particles under change of pressure, your telephone transmitter when you speak into it, sends out varying electric currents over the wires. These currents fluctuate according to the vibrations of your voice, since the sound waves cause the transmitter diaphragm to vibrate and so change the pressure on carbon particles or granules contained in a compartment for which the diaphragm forms a flexible side (or, in some transmitters, presses against a knob on the flexible side). The varying resistance of these particles caused by the vibration of the transmitter diaphragm—the carbon being a part of the circuit—sends a varying current out on the line,

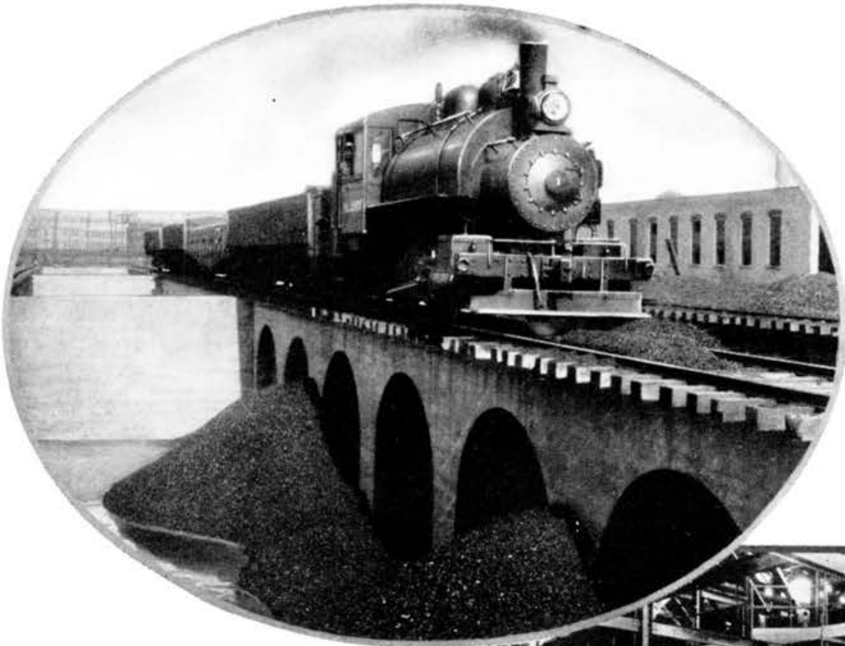


Carefully selected coal is used in the transmitter of your telephone. The operations of washing granular carbon are performed with the simple machinery shown above.



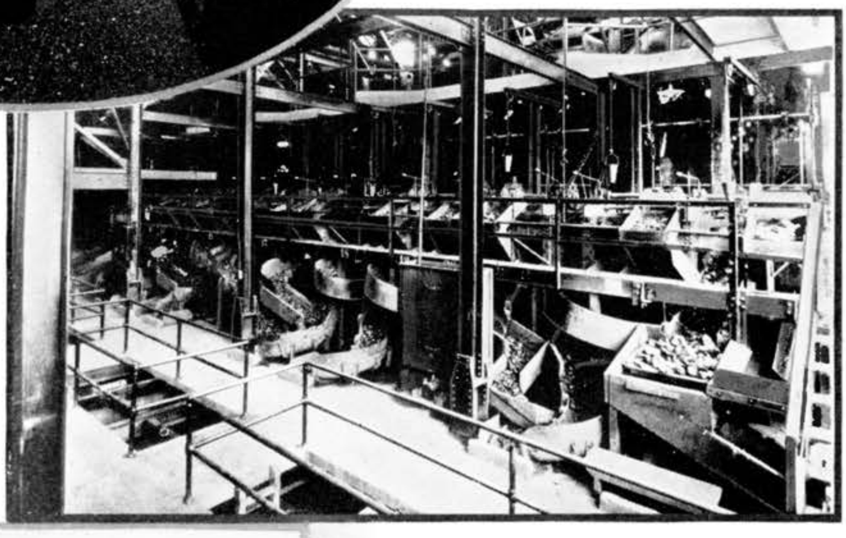
The granular carbon (coal) is roasted in these electric furnaces.

Granular carbon, greatly magnified, as used in telephone transmitters.



Coal is used not only to make the wheels of industry turn but is also important for its wide use in the processes of producing other raw materials.

Left—Huge coal piles sometimes set themselves afire through spontaneous combustion, so one of the modern ways to store coal is in water.



Right—Steel and concrete coal breaker which automatically separates the different lumps into the well known classifications such as stove, or egg coal.

At the mouth of the mine is the equipment which makes the mined coal available for use.

Coal miner and helper at work.

since each change in position of these tiny particles of carbon alters the electrical resistance of the circuit and this, of course, changes the strength of the current passing over the circuit.

As you know, the twentieth century is often called the Age of Steel. But coal is necessary to make steel and so it would also be true to say that this is the Age of Coal. In fact the greatest industrial nations are those which consume the most coal. Of these nations United States ranks first both in coal mining and the use of coal, Great Britain second, and before the World War the German Empire ranked third.

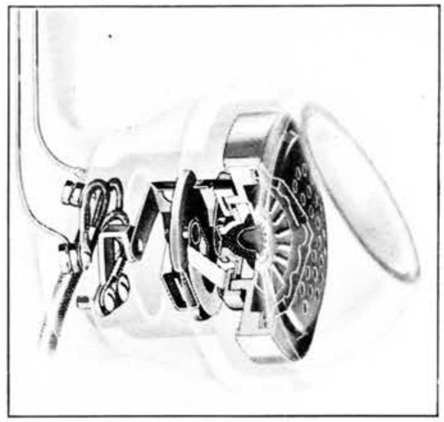
Of the two common methods of mining coal the "room and pillar" is mostly followed in this country, and machinery is used a great deal in mining operations. Shafts are sunk to the coal seams where the coal is then mined from small rooms in which pillars of coal are left to support the roof. In the "long-wall" method instead of leaving pillars of coal for support, the roof is allowed to settle as the mining goes forward. Care is taken, of course, to keep haulageways clear through the falling material.

The United States uses coal to raise steam in locomotive, marine, and stationary boilers—to heat houses and other buildings—to manufacture coke—to make gas—for smithing—and to fire furnaces, such as those used in making lime, cement, and brick; in obtaining metals from ores and in separating metals. These are about the principal uses in other countries too, though different climates and industries may vary the amount applied to each need.

Only a fine grained anthracite coal, which is hand-picked at the mine for quality and purity, is used for transmitter carbon. At the factory it is put through a special treatment which fits the coal to perform its duties. There the coal is ground into fine grains, sifted and washed, after which it is roasted carefully to drive off the gas and to change it in other ways. The roasted material, which is now almost pure carbon, is improved in quality by the removal of particles containing a high percentage of iron, an operation accomplished by means of compressed air and by magnetic separation.

Coke, a by-product of coal, is used in smelters, in foundries, and to some extent as a smokeless domestic fuel. Turning coal into coke also gives us sulphate of ammonia, tar, crude light oil, and gas. The ammonia is used in refrigeration and in making high-explosives and fertilizer. From the tar are obtained many organic compounds, such as aniline dyes. What is finally left of the tar—coal tar pitch—is used in surfacing roads, in making roofing, and as a binder in fuel briquets. The crude light oil yields materials that are essential in making very powerful explosives. Another valuable product of the distillation of coal is illuminating gas. Coal tar products are used in making lacquer, phenol varnish, japan, etc.

Creosote oil for preserving telephone poles is another important product of coal tar distillation.

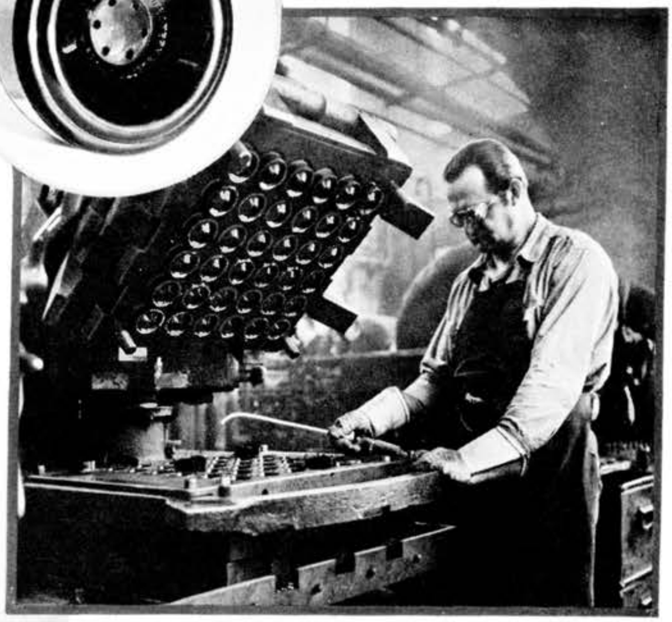


The carbon grains in your telephone are in the small receptacle just in front of the aluminum alloy diaphragm of the telephone transmitter, phantom view of which is shown above.

Diaphragms in telephone transmitters and receivers are thin discs of metal. In transmitters their vibrations, caused by sound waves, change varying voice inflections into electrical energy; while in receivers they change this same electrical energy into sound waves—voice inflections that we hear and understand. Transmitter diaphragms are made from an aluminum, chromium and magnesium alloy. Their ability (transmitter diaphragms) to control the current in your transmitter with such accuracy is largely due to the stiffness and light weight of the alloy which makes the diaphragms sensitive to slight changes in sound waves

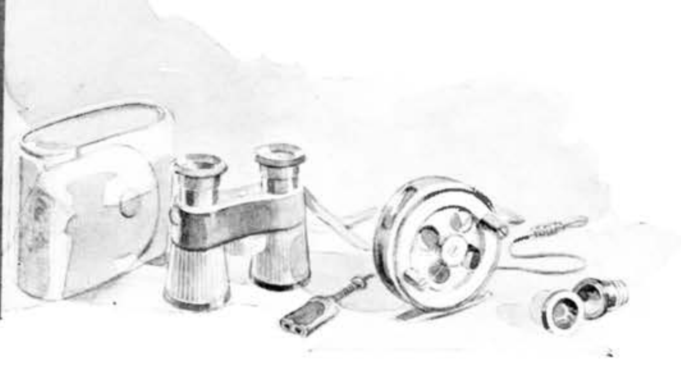
Each handset transmitter is placed in a volume testing machine, equipped with an oscillator that delivers through a telephone receiver all the sound frequencies that are essential to perfect speech transmission. The machine, in turn, indicates by means of a vacuum tube circuit the degree to which the transmitter responds to the various sound frequencies.

The powerful hydraulic presses for molding phenol plastic material take multiple dies so that as many as several dozen parts are made at once. Into each die the operator places either powdered plastic or pellets of plastic. The press is closed and in a very few minutes, the time depending on the size and type of the die, the jaws are opened and the parts, smooth surfaced as though hand-polished, emerge complete. The press at the left produces handset handles from powdered plastic.



Phenol plastic parts are very strong, odorless, retain their shape, color and gloss and are practically fire-proof. Thirty-six telephone receiver caps are produced at a time on this press. Into each die the operator places pellets or "preforms" of plastic. The operator at right is using compressed air to clean the dies.

Thousands of articles in every day use are made of phenol plastic materials.



The handset telephone—its case is made entirely of phenol plastic.

On the frontiers of science men are constantly exploring, experimenting and testing. Out of new and different combinations of old materials come newer and better materials. A comparatively few years ago laboratory workers realized that the production of the electric spark might be likened to an Aladdin's Lamp of the modern world. Uses and application of the electric current widened almost daily, reaching every branch of industry and commerce in all corners of the earth, but its masters found that this young giant, like the genii of old, required certain formulas, not only to produce but to control it.

In the control of electricity provision must be made for imprisoning a current by surrounding it with something it cannot pass through, for electricity is a wayward giant and will jump off its ordered pathway whenever it can. In laboratory, factory, power and telephone line, this unruly servant of man has to be kept on the job—held to the course it should properly go to turn wheels, light our homes or carry our voices about town or from city to city. And this guarding, protective substance is called insulation. If it was important twenty years ago, it is vastly more important today.

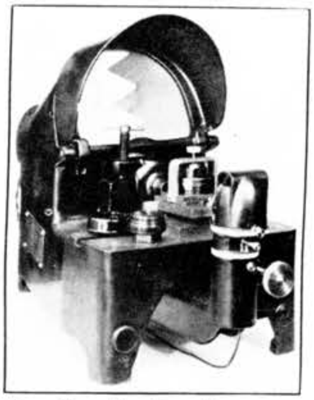
The use of phenol resin in molding phenol plastic and phenol fibre insulators, as well as the use of various enamels for wire insulating, are important improvements in the telephone and electrical industry. These products, as well as the better known forms of insulation, cotton, silk, rubber, etc., are described in the following sections.

Scientists have found that phenol resin when mixed with the proper fillers and subjected to heat and pressure, can be molded, forming a material of very high insulating quality and having extraordinary advantages in keeping all electric currents on the paths they should travel and away from contact with other things.

Phenol resin is prepared chemically by treating the proper proportions of phenol, commonly known as carbolic acid, with ordinary formaldehyde. Under certain well defined conditions these materials react to form a solid, resin-like substance. From this resin are manufactured a number of products, such as varnishes and molding materials known as phenol plastics. The latter are used in the manufacture of telephone handsets, and telephone apparatus parts, as well as a thousand other devices and articles.

Phenol Plastic materials are made by mixing phenol resin with approximately an equal portion of a suitable filler, such as wood flour and cotton flock, which adds strength and can be colored as desired. It is necessary also to add a small quantity of a chemical known as hexamethylene tetramine, to convert the fusible and soluble resin in the compound into the infusible, insoluble stage during the heat and pressure of molding. (A material is said to be fusible when it can be reduced from a solid to a fluid state by heat and it is soluble when it can be dissolved in a fluid.) After mixing, the hot, sheeted material is allowed to cool and is then ground to a fine powder, ready for the molding presses. On the opposite page is a picture of a phenol plastic press with dies for making telephone receiver caps.

A phantom view of the telephone hand-set handle—the transmitter and the receiver. As illustrated and explained on the previous page, the entire case is molded of phenol plastic compound. There are a dozen additional different insulating and moisture-proofing materials in your handset: Cotton, rubber, flax (paper), phenol fibre, clay, talc, silk, wax, hemp (paper) and shellac.



Apparatus for checking the accuracy of threads on phenol plastic receiver caps. An enlarged image of the threads is projected to make certain they are within limits. This care is necessary because telephone parts must be interchangeable.

Large rectangular ovens extending 20 feet above the floor are used in enameling wires of large diameter.

Phenol Fibre

Phenol fibre, basically a similar product, has many uses, particularly for insulators in telephone apparatus, radio equipment and other electrical devices. It is produced in sheets or special molds. In making phenol fibre, the resin previously mentioned is mixed with a suitable solvent to make it dissolve, as sugar dissolves when you put it in water.

In this case, the solvent is alcohol and the mixing of these materials forms what is known as phenol varnish. Paper or cotton fabric is impregnated with this varnish, dried, piled to the desired thickness and subjected to heat and pressure in a powerful hydraulic press, forming a hard, infusible, insoluble product, as in the case of phenol plastic molding powder.

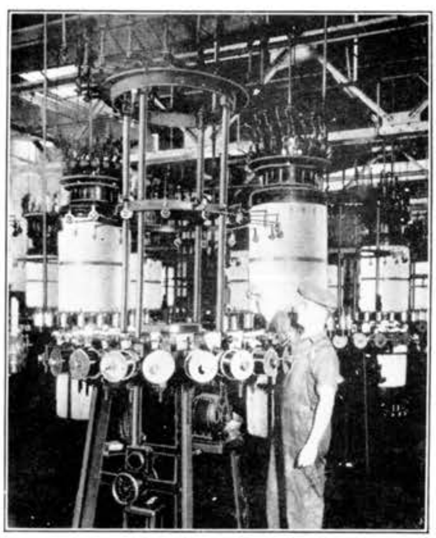
The molding characteristics of these materials require a pressure of approximately 1,200 pounds per square inch for phenol fibre sheets, at a temperature of from 300 to 360 degrees Fahrenheit, the time required depending upon the thickness of the finished molded parts or sheets.

Enamel Insulation for Wire

In recent years, to save space in coil winding and to improve the insulation for many special uses, enamel insulated wire has been developed. Its manufacture is an interesting process in which the liquid enamel is baked on the wire in successive coats. The enamel is so made by special processes that after drying it will not crack and the wire can be bent without affecting the coverings. Enameled wire is used in most types of telephone coils for connecting cables in exchanges and in some sizes of cable.

Two general classes of copper wire used in telephone manufacture are provided with enamel insulation. One of these is used to connect the various relays, coils, lamps and other apparatus in central office equipments that are exposed to relatively high operating voltages or to severe climatic conditions. The wire is first tinned to facilitate making soldered connections and is then insulated by coats of enamel. Further insulation is provided by a textile covering made of specially purified cotton or silk which in some cases is impregnated with cellulose acetate lacquer after application to the wire.

The use of castor oil and gilsonite (asphalt), resembling a thin black paint, is fast becoming obsolete due to the general change to cellulose acetate lacquer as an insulation for switchboard wire and cable. A varnish enamel is used to insulate distributing frame wires and special wires.



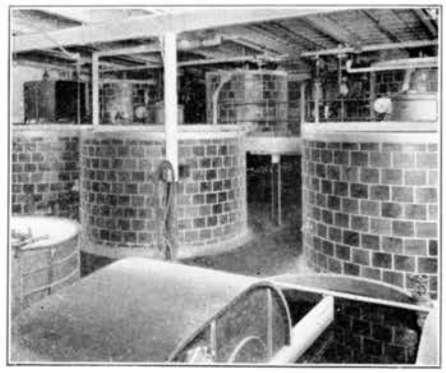
Smaller, round ovens are used for baking varnish-like enamel on magnet type wire, some of which is finer than human hair. Wire passes from three to seven times through the troughs of enamel at the base of the machines and is finally taken up on spools held in frames like the one shown in the foreground.

The other class of wire, used to wind coils, relays, and similar types of apparatus, is coated with a varnish-like enamel of different composition from that just described, and is made from the gum of the kauri tree which grows only in New Zealand. Its gum oozes from breaks in the bark, much as cherry gum appears at cracks of cherry tree bark.

The best grade of kauri from which the finest of furniture and coach varnishes, as well as wire enamel, are made, is a very light amber in color and comes from logs that have fallen and aged underground for hundreds of years.

In earlier times, the natives explored for this gum with long iron rods in the mud of swampy land. When they struck a kauri log or a lump of the gum, they dug for it, obtaining kauri gum in chunks sometimes as large as a man's head. As the value of the gum increased, men have taken to mining it like gold. Kauri, or "fossil gum," operations look something like old placer mining with men washing even very small particles of gum out of the mud. Enamel containing this gum is particularly valuable to us because it retains its flexibility and insulating qualities for a very long time.

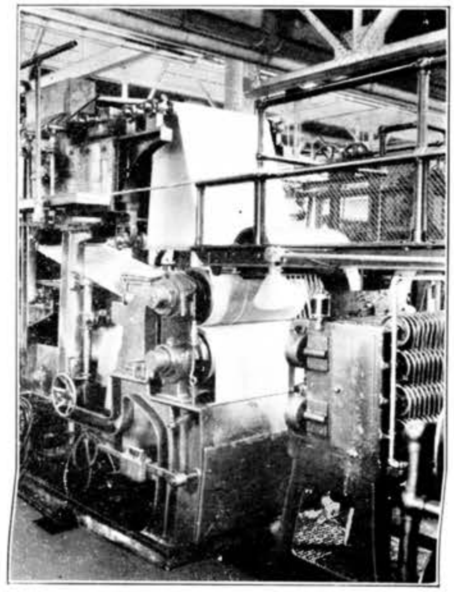
When kauri gum is used for wire insulation it is mixed with chinawood (tung) oil, linseed oil, and some other natural resins, boiled together to a thick syrupy liquid and then thinned with naphtha. From three to seven coats are applied. The enamel has excellent insulating properties and can be applied to the fine wire in very thin coats ranging from .0007 to less than .0001 of an inch in thickness, according to the size of the wire and the use to which it is to be put.



Storage tanks for pulp used in insulating cable wires.

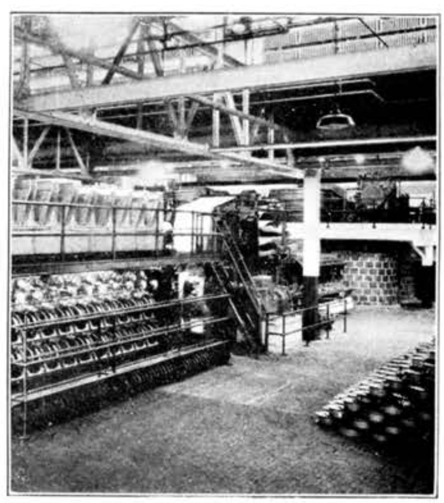
Wood Pulp Wire Insulation

Another and newer form of insulation for wires is a smooth covering of kraft wood pulp applied directly to the wire. This was perfected after several years of experimenting and after overcoming seemingly unsurmountable difficulties. Jack pine or other coniferous wood is reduced to its ultimate fibres, as in the kraft paper making process, by cooking the chips in a sulphate solution, washing and mechanically working with water. From storage tanks this material, mixed with a large volume of water, is fed continuously to a modified cylinder paper machine where it is to be formed into insulation.



Polishing equipment which turns the moist pulp ribbon down to a continuous, uniform covering.

The insulating process consists, in brief, of passing 60 wires simultaneously through this machine where they are cleaned, embedded in narrow ribbons of the moist pulp and run through a polishing machine which turns the ribbon down to a continuous, wet, uniform covering. The covered wires then pass through an electric furnace, 26 feet long, maintained at a temperature that will dry but not scorch the insulation. This rapid drying leaves the pulp covering in the flexible porous condition required for good cable insulation. The insulated wire is wound on reels; later it will be made into cable. Kraft paper is used extensively in condenser manufacture.



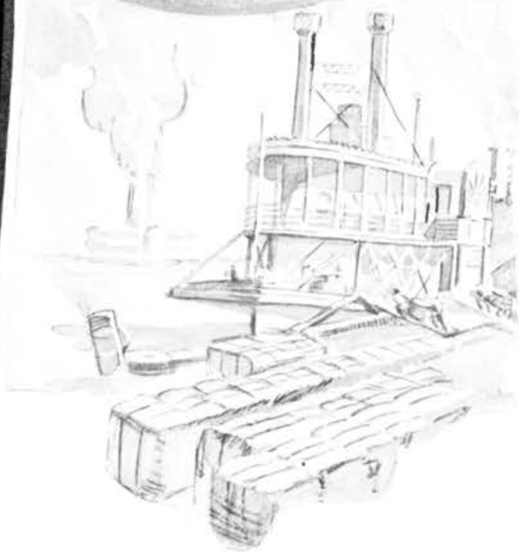
Equipment for applying paper pulp insulation to wire used in making certain types of telephone cable.

There is scarcely a nation in the world which does not use cotton for clothing. The United States is the chief producer of cotton and uses millions of bales. Yet there is enough left so that we export more of it than of any other commodity.

"Way Down South in the Land of Cotton."

Below—Waiting their turn at a cotton gin.

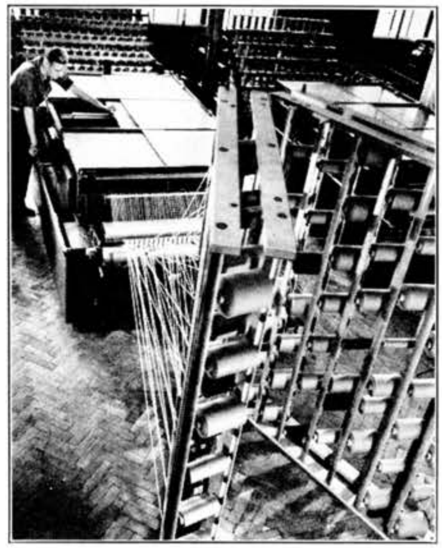
Below—Inside the ginning room where the cotton seeds and cotton fibres are separated.



On the levee at a cotton port beside the Father of Waters.

Cotton! The very word brings to mind pictures of many centuries and countries: India, land of gorgeous potentates and many religions where the white and yellow flowers and snow-white bolls of the cotton plant have colored the landscape for fifty or sixty or seventy centuries—Egypt, home of the finest cotton in the world—ancient America, land of Aztecs and Incas and of tobacco, potatoes, sunflowers—and cotton.

Cotton scenes of today are no less scattered. The sunny land of negroes, sunshine, and song calls cotton—"King." Thousands of spindles and looms continually hum in New England, New York, Pennsylvania and in southern states, transforming the fluffy down into yarns and cotton goods. Ships ply our Atlantic coast and cross the seas to England carrying cargoes of raw cotton. Ships set sail from Egyptian ports and from Calcutta and other British Indian coast towns for England and America laden with bales of cotton. And from England and our country other ships depart for all ports of the world with finished cotton cloths and goods.



This machine glazes or coats the individual cotton threads with a starch compound which by producing a smooth, hard finish imparts to the yarn increased strength and resistance to wear. Glazed cotton is used in the outer covering of switchboard cords because this class of cord is subject to very severe usage in the telephone exchange.

The first complete power-driven cotton mill in the world, manufacturing cotton cloth (by power-driven machinery) right from the raw cotton itself through carding, spinning and weaving, was set up in Waltham, Massachusetts, in 1813.

Samuel Slater set up a cotton mill in Pawtucket, Rhode Island, about 1790, but an old fulling mill in Rowley, Massachusetts, antedated that, and Samuel Greer's cotton mill, the first real cotton factory in this country, represented only a small portion of the factory industry. Slater spun the cotton by a water-power-driven frame, but the yarn went mostly to cottage industries to be woven.

Cotton has not always played so important a part in the world's commerce. The story of Eli Whitney and the invention of the cotton gin, familiar to most of us, form the last chapter in a tale which starts with one John Kay in 1733. This Englishman invented a flying shuttle which enabled the weavers to turn out goods so fast the spinners could not easily keep up with them. For thirty-seven years the spinners struggled to supply the weavers. Then Hargreaves, another Englishman, invented the spinning jenny.

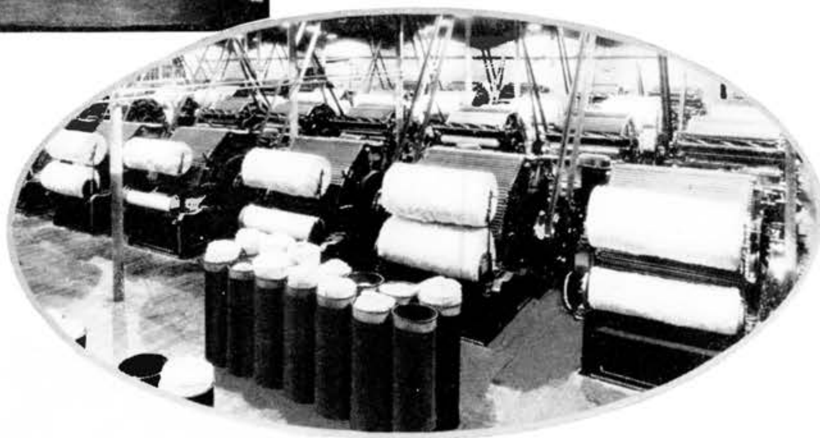
Cotton braid protects many types of telephone cords. As the insulated wires or cords come up through the center of this machine, spindles of cotton thread move round and round braiding on the protective layers.

This made the race even. The mills could furnish to the trade all the cotton goods it wanted. With this greater production the price of cotton goods dropped to a place where others than the very wealthy could buy. If the mills could have obtained all the raw cotton they needed, cotton goods would have been cheap enough for the common people to use. But there was the hitch—the cotton growers could not supply the mills with enough bales of raw cotton.

Eli Whitney solved this problem in 1793 by inventing the cotton gin, which separates the lint from the seed. Under the old methods one man would have to work two days to produce one bale of cotton. Now, a cotton gin produces fifteen bales in a day.

The plantations where cotton is picked and the towns where it is processed have grown as the cotton cloth of commerce has gone from those towns and cities further and further into the remote corners of the world.

Left—A cotton breaker which opens the bales at the mill.



Right—Carding: Raw cotton, after being mixed, cleaned and "lapped" or "rolled" is carded and combed until the fibres lie parallel to each other.

Below — Spinning: After being carded, the fibres are stretched on drawing frames, twisted and finally wound on bobbins which spin them into thread for weaving.

Below—Weighing the cotton in the field.

The cotton gin was a boon to our southern states. New plantations sprang up, old plantations grew larger and the United States took the place which it has ever since held, as the largest producer of cotton.

The mill secrets of England soon seeped into New England. Wherever there was a good waterfall a textile mill was established. Instead, however, of buying its raw cotton directly from the South, New England at first secured American raw cotton more cheaply from Liverpool by way of the West Indies.

Cotton thus did a great deal to turn the South into a prosperous agricultural section and the North into a beehive of industry—and it is still an important item of manufacture.

For anybody who has not seen cotton growing in the fields, a trip through the southern states, when the cotton plant is in full bloom, is fascinating. Then acre after acre of spreading branches are beautiful with green leaves and white and rose-tinted blossoms.

As the blossoms gradually drop off, the bolls begin to swell. Soon they burst and the white fleece shows. This is usually in August or early September.

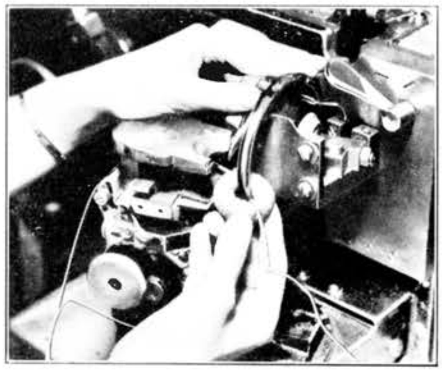
A cotton field is usually picked three times. One-fourth of the crop is gathered in the first picking, one-half in the second, and the other one-fourth in the last. Dusky cotton pickers, working under a bright sun, dot the fields full of white bolls of cotton, making a picture in contrasts not soon forgotten.

After the negroes pick the cotton, it is put into bags and taken to the gin. After the seeds are removed, the cotton is pressed into bales and shipped to wharves or to southern mills. Galveston, New Orleans, and Savannah are among the chief cotton shipping ports.

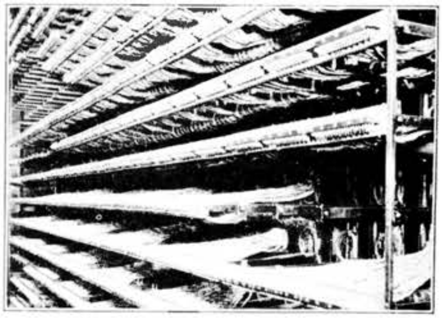
The cotton seed and the waste from the gin were formerly thrown away. Now many valuable products are made from them. Cotton seed oil has become a common substitute for olive oil. Substitutes for lard, oil cake and oil meal are also manufactured. From the waste of the gin is made celluloid and a high explosive called gun cotton.

Cotton is still used extensively in the manufacture of switchboard cables, wires and cords which are required in the telephone system. Its toughness protects the wire and it insulates one wire from another, thus preventing the electric current that carries your voice from wandering off the wire pathway and being lost.

One particularly interesting use of cotton thread is in the cords you see connected to your telephone. These cords are bent and twisted many times, as you know, and since repeated bending breaks a copper wire, flat ribbons of copper alloy no thicker than your hair are wound spirally around a cotton thread to give the cord flexibility and added strength. Several of these tinsel wrapped threads are twisted together around a center cotton thread and the whole assembly again covered with one or more protecting layers of cotton. In recent years, rubber insulation has replaced some of these cotton coverings. The completed cord is made by braiding a cover of mercerized cotton over two or three such conductors.



Winding enameled wire, further insulated with cotton, around magnetic cores—used in loading coils which play an important part in long distance telephony. Cotton used in insulating wires, is first purified by special washing processes to remove any soluble salts.



Thousands of pounds of purified cotton and silk insulation, frequently impregnated with cellulose acetate lacquer, are used on the wires and cables in the telephone exchange to connect together the switchboards and auxiliary apparatus.

The cord emerging from the handle of this telephone set, those seen inside and those connecting cords (see text) coming from the base of the stand are covered with an insulation made of cotton.

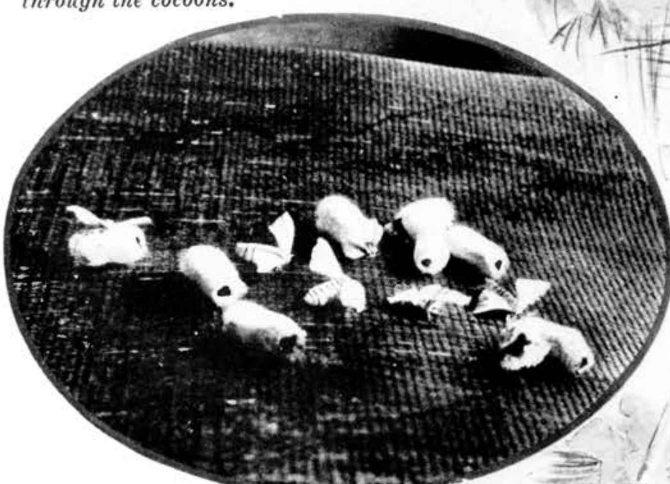
Six centuries ago the great trading cities of Venice and Genoa carried on trade in silk with the Far East, and today silk is a source of national wealth to Far Eastern countries.

Feeding silkworms with mulberry leaves.

Right—Silkworms making cocoons. Fifth week after hatched from egg.

Below—Cocoons as they appear immediately after spinning.

Below—Moths breaking through the cocoons.



A silkworm farmer in Japan.

The story of silk is a story of olden times when merchant-adventurers journeyed to the Far East for valuable woods and spices and cloths—and of modern industry which sends men to those same strange countries of the Orient for the same precious products.

The United States is the largest silk manufacturing and silk consuming country in the world. In one year recently, 549,884 bales of raw silk were imported into the country at a total value of more than $260,000,000. Pennsylvania leads all other states in the manufacture of silk products. Other important silk manufacturing states are New Jersey, New York, Rhode Island, Massachusetts and Connecticut.

Silk dresses, shirts and the many, many other products of silk that are so commonplace today, are made from what was once a long, fragile fibre spun by a tiny worm in Japan. Japanese girls wind this cobwebby, silken strand from the cocoons of the silkworm, fast ships carry the precious cargo across the Pacific Ocean, and special trains waiting at the dock, rush it across the country in shorter time than the fastest passenger trains take for the journey. To reach its destination here, silk travels more than eight thousand miles.

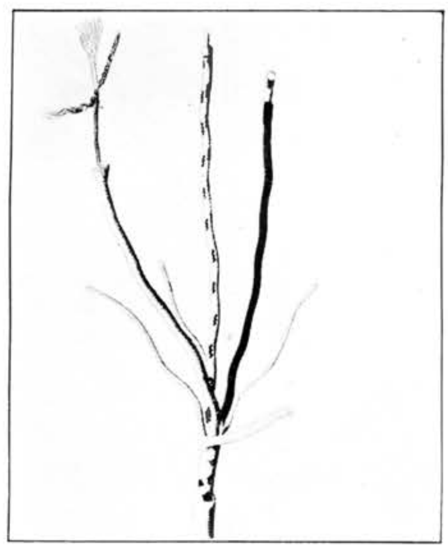
The secret of the tiny worm that produces a fibre so necessary to our everyday life was first discovered three thousand years ago in China. The fourteen year-old Empress, Sing Li Chi, watching the worms spinning their cocoons on the mulberry trees of the palace garden, discovered that the beautiful strands of which the cocoon was made could be twisted into thread and woven into beautiful fabrics. Today almost everybody wears silk, but for years after its discovery only kings and queens had silken garments. So highly prized were silk fabrics throughout China that death was the penalty which awaited anyone who revealed to foreigners the secret of the silkworm.

Trade in silks, however, was carried on by China with neighboring countries as the years went by, and the Persians sold silk fabrics to the Roman Empire. Trade routes were established as the knowledge of the wonders of the Far East became known in Europe. Caravans brought cargoes of raw silk across the desert. Such explorers as Vasco Da Gama, Columbus, and others sought shorter trade routes by water to the Far East, the land of silks, spices, and jewels.

Japan discovered the secret of silk cultivation about 300 A.D. and today is our chief source of supply, about 85% of all the raw silk we consume being imported from that country. China, however, is still an important silk producing country, although some silk is produced in Europe. Attempts have been made from time to time to raise silk in the United States, but many obstacles have been encountered in its production; labor costs, high as compared to those in the Orient, being an important one.

Silk, though fragile looking on the cocoon, is the strongest and most elastic fibre known to man. That a three and a half-

Because of its superior insulating properties, silk is used in the manufacture of Audiphone (individual hearing aid) cords. The use of silk also makes for smaller over-all cord size which is a desirable feature in the cords worn with a hearing aid.



In making switchboard cords a group of strands is wound around a heavy cotton thread and then wrapped with silk and cotton insulation. This unit is waterproofed and a cotton braiding is woven around it for protection and further insulation.

Silk, the luxury of the bygone centuries, is a worker today in the electrical industry because it keeps electrical currents on their pathways.

Left—Boiling cocoons to loosen the silk fibres and reeling the fibres of raw silk.

Right—A modern silk steam filature or mill.

Testing and grading silk.

Sorting cocoons.

inch worm can produce these silken strands, which are so desired for garments and so useful in industry, is truly a remarkable phenomenon. When it hatches from the egg, the silkworm is about an eighth of an inch long. It feeds for thirty to forty days on mulberry leaves before it starts spinning its cocoon. The silk is contained in two small sacs, one at each side of the worm's body. The two strands join together at the spinneret, just below the mouth, coming out as a single strand, which hardens as soon as it is exposed to the air. The silkworm attaches these strands to a twig, or other projection, and works industriously for twenty-four hours before the task of weaving the cocoon around itself is completed.

Within the cocoon the silkworm changes into a chrysalis, and then into a moth, which breaks through the cocoon and flutters away at the end of ten or fifteen days. The moth lays eggs from which other silkworms hatch and the cycle is started all over again. If, however, the cocoons are to be unwound and prepared for weaving into fabrics, the moth is not allowed to break through the end of the cocoon and spoil the long filaments. To avoid this, the cocoon is heated to kill the chrysalis and so permit the unwinding of a continuous strand, sometimes one thousand yards in length.

The unwinding, or reeling process, takes place at factories called filatures. Here Japanese girls sit in long rows and unwind the silk from the cocoon onto reels. Strands from five or six cocoons are combined to make one thread whose fibres adhere to each other because of the natural gum in the silk. The silk is then re-reeled to produce a skein which is well formed and can be easily unwound in American mills. Twisting the raw silk into "books," packing into bales, and preparation for shipping, complete the process.

While silk has been largely replaced by rubber and purified cotton on cords used in the telephone system, it is still wrapped around miles of wire used in telephone switchboard apparatus, switchboard and audiphone cords and is especially useful in insulating fine wires, because it fits smoothly over the wires and takes up little space.

This installer is connecting up the cotton and silk covered copper conductors in the telephone switchboard.

Silk is wrapped around fine copper wire in a serving machine pictured above. The operator is adjusting the silk band to assure perfect coverage of the wire.

Old rope from riggings that have sailed the seven seas and rags of linen, cotton and other cloths find their way eventually into the paper that has been used for centuries to send written messages and to record commercial transactions.

Left—Interior of a native rope factory in the Philippines.

Right—Loosening the flax fibres from the stalks by wetting them in a river where they are in crates weighted down with stones.

Spreading flax fibres on toothed belts to convert the separate fibres into continuous even sized yarns.

Belgian flax harvesters pushing a crate of flax into the river.

Most of us think of flax and the making of fine linen as belonging to the old world. And this is as it should be. Irish linen has long been famous, while Italy and Russia and Belgium have likewise been noted for the quantity and quality of the flax they grew. The old world has always raised flax and its history goes back beyond the days of Egyptian Pharaohs. No doubt you remember reading in the newspapers about the linen curtains found in Tutankhamen's tomb.

Thus in Ireland the seed is sown by hand, the fields are weeded by hand and in the latter part of August the plants are pulled by hand, gently so as not to injure the fibre. The next step is to soak the bunches of flax in water to get rid of the gum in the straw and to make it possible to free the fibre from the useless stem. Sometimes this is done by spreading the flax over fields and allowing the dew to settle on it or by putting it under water, as is done in Belgium.

The fibre is actually separated from the stem in scutching mills by wooden blades, which strike the straw as it is pushed across a shelf, thus beating off the broken straw and leaving only the flax fibres.

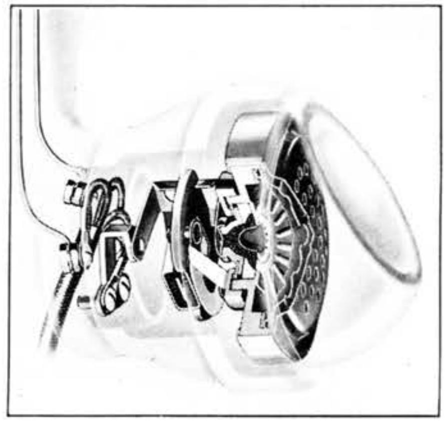
The flax then goes to a spinning mill to be made into thread. Here the short and tangled ends are removed, while the long, finely split fibres are combed out into the two used for the yarns and twines from which linen is woven.

We now have the linen cloth from which many fine things are made. But in making fine tablecloths, dress goods and other linen pieces, odd scraps are left over. And after a time the pillow cases, embroidered table pieces, the tablecloths and linen dresses wear out and are thrown away as rags.

These scraps from linen factories, and rags from everywhere find their way to mills, where they are changed into high grade linen paper.

First the rags are sorted, dusted, cut into small pieces and boiled in water containing lime. When they come out of the boiler the rags are of a brownish color. Then after being washed again they are beaten down to a pulp. When this is poured out onto a moving wire mesh, the linen fibres in the liquid crisscross and bind together. The product is then passed through heated roll after roll, which dries and presses it until it comes out at the end in large rolls as finished paper.

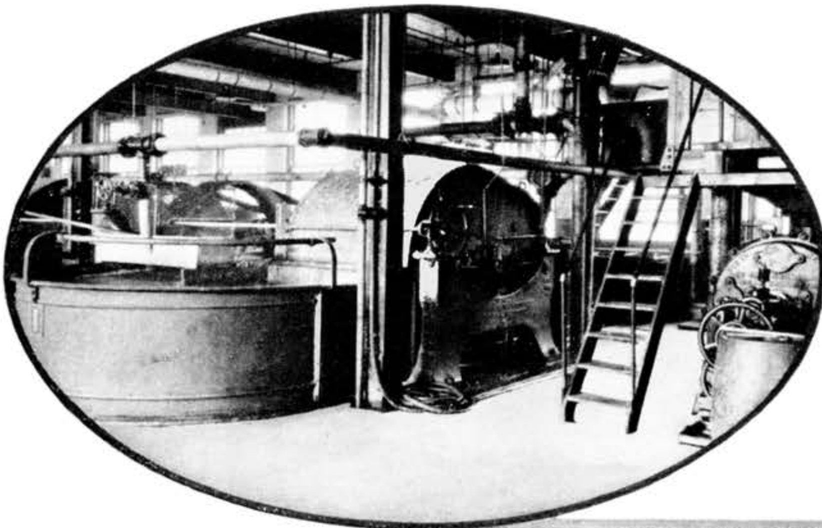
Linen paper is used in your telephone system in what is called the condenser. Now a condenser is a very simple piece of apparatus, made in its simplest form of two metallic plates insulated from each other so that the current is unable to flow directly from one to the other. The condenser is very important for this reason: a direct current is unable to flow through it, while an alternating current can pass through freely—and telephone ringing currents are alternating currents, while the energy for talking over telephone wires is direct current from storage batteries.



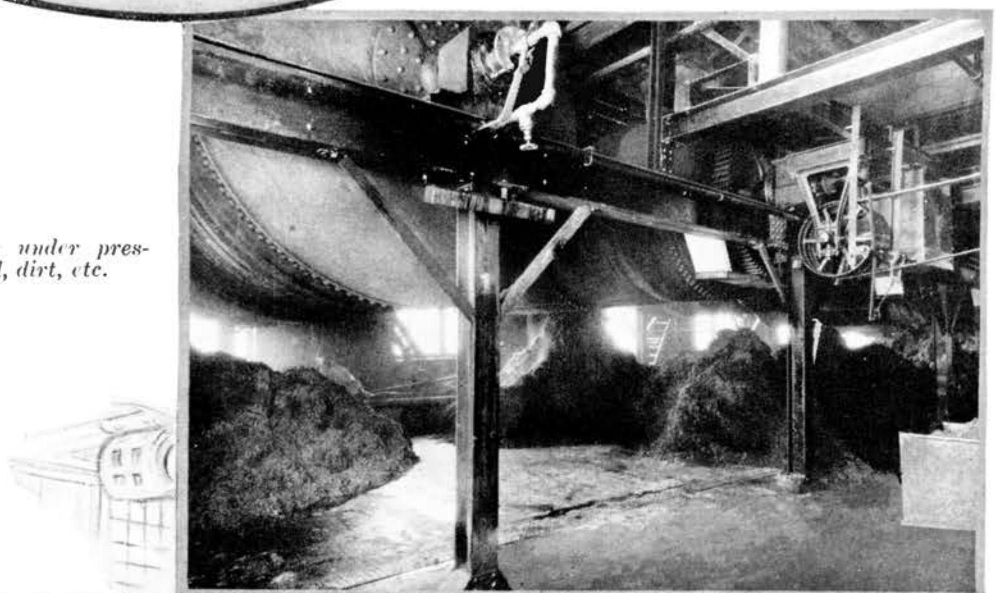
A phantom view of your handset transmitter. The dome-shaped dark mass in the center is the carbon granules. There is a paper seal between the diaphragm and the electrode to prevent the carbon granules from leaking out.

A row of paper insulating machines. The shiny copper wire shown on the spools in front of these insulators is wrapped with insulating paper much like one would tape a baseball bat, except that very close limits must be maintained.

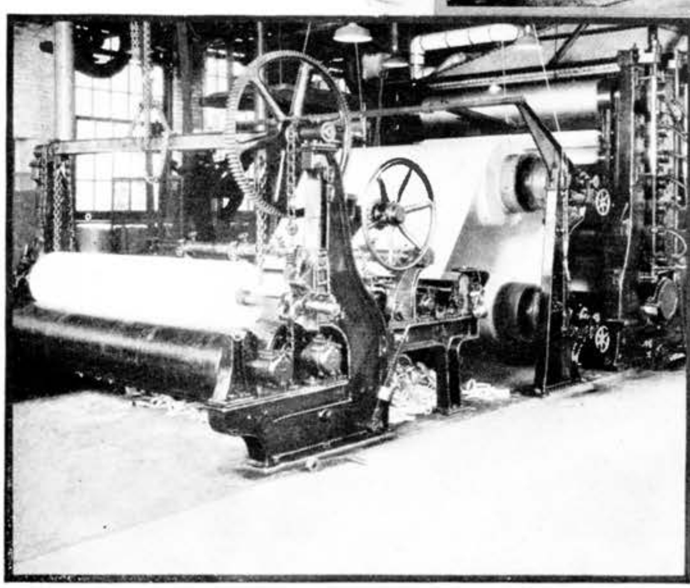
Today paper plays another part in the transmission of thought. It provides insulation for the hundreds of wires sheathed in the lead covered cables along the rural highways and under the streets in our large cities.



Left—Washing and beating rope to the proper dimensions for paper making.



Right—Cooking rope under pressure to remove oil, dirt, etc.



The dry end of a paper making machine where paper is dried, calendered and rolled.

Cutting rope and separating fibre yarns.

The Western Electric factory, in Chicago, makes millions of telephone condensers a year. Most of these are made by taking two strips of aluminum and four strips of paper and winding them together so that each foil strip is separated from the other by two paper strips. In certain types copper foil or tin foil is used. This step is followed by others, such as thoroughly drying the units, treating them with wax and sealing them in small containers filled with an asphalt mixture. In making some kinds of condensers mica is used in place of paper, since it is also a good electrical insulator.

Manila hemp is grown only on the Philippine Islands. The Filipinos cultivate the plants, weeding them when they are young. Just before the time for flowering, they cut the plant down near the roots and split it open so that the sun can dry the fibre. After this the fibre coats are scraped. Two natives can cut and scrape about twenty-five pounds of the fibre in a day.

The outer fibre, which is hard and strong, is used to make stout cord and rope. The layers next to these are made into web cloths and gauzes, while the inner fibres are woven into delicate fabrics like the "grass cloth" the French manufacture.

To make Manila hemp paper only old rope can be used. These old pieces of rope which have served their day on ships and farms make the strongest of papers. The rope is reduced to a pulp, which is treated in much the same way as the rag pulp already described.

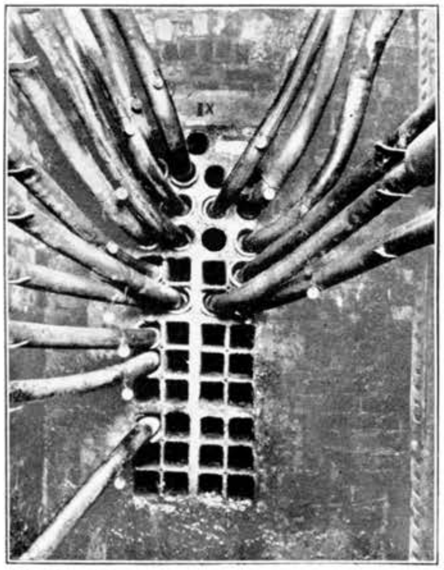
Pairs of wires for your telephone, if they form a part of certain types of lead covered cable, may be separately insulated with a strong, tough paper made of a mixture of hemp rope, cotton and wood fibre. And around the whole bundle of pairs is wrapped a layer of similar paper, over which the lead sheathing is placed. Hemp paper is also used in receiver coil insulators.

Still a third kind of paper is used in the telephone circuit. Since this page which you are now reading contains carbon (a diamond is carbon as well as the graphite in your pencils and coal has a great deal of carbon in it) it is possible by an interesting chemical process to change the cellulose in the paper into carbon filaments which glow in certain types of switchboard lamps when a current passes through.

Thus some of the switchboard lamps which signal your telephone operator that you wish a number or that you have finished talking are lighted up by filaments which were originally paper. Tungsten filaments also are used in switchboard lamps.

And lastly, a paper stock similar to that on which this page is printed, is used for another purpose. On it, is the number that appears under the cellulose acetate disc in the little holder on the front of the transmitter, or in the center of the dial on the base of your telephone.

This shows the paper wrapped wires in a cable and the paper wrapping around the entire rope-like group of wires, just as the cable core looks before it receives its sheath of lead and becomes real lead covered cable.



Under the streets from manhole to manhole the lead covered cable carrying hundreds of pairs of wires lies in clay conduit, either square or round.

Today, rubber touches our daily lives in telephone communication, transportation, production of the garments we wear, the foods we eat, the games we play and in a hundred other ways.

Left—A nursery of young rubber trees on a rubber plantation in Liberia.

Left—A mature rubber plantation. Overseer inspecting tree tapping.

Right—Native rubber tappers bringing latex to the factory which prepares sheet rubber.

Below—Washing latex.

Tapping for rubber in Liberia. Each morning the natives cut channels in the Hevea trees, from which the latex exudes into little cups at the foot.

Four nationalities have played an important part in the history of rubber—an Italian discovered it, an Englishman gave it its name, a Scotchman put it to commercial use, while an American discovered how to vulcanize it.

On his second voyage, Columbus found the natives of Hispaniola (Haiti) playing with balls of an elastic substance. It was one of the many strange sights experienced by the discoverer of the New World and made him also the discoverer of rubber.

Spanish explorers found it in Mexico also, about the year 1521.

In a recent book, "Columbus Came Late", the author travels in Mayan lands, telling of the many fascinating secrets of Chichen Itza. His discoveries show that rubber was known to that ancient and wonderful American civilization and, in fact, that Toltecs played a kind of basketball with balls of rubber.

The Spaniards soon learned to waterproof their canvas cloaks with the fluid from the rubber trees, and also made shoes of it.

Some of the crude rubber in time found its way to England, where it was considered a curiosity and a plaything with no commercial value. But about the time of our Revolutionary War a famous scientist in England by the name of Priestly, who also discovered oxygen, found that this curious material would rub out lead pencil marks. From that time on English speaking people called the queer substance "rubber". Other nations have imitated the word used by the natives for the tree, the French spelling of which is caoutchouc (koochook).

Little more was learned about rubber for more than fifty years, but about that time a Scotchman named Mackintosh found a way to use rubber for waterproofing cloth and started to manufacture rubber-treated clothing. The word "Mackintosh" is still sometimes used in speaking of raincoats.

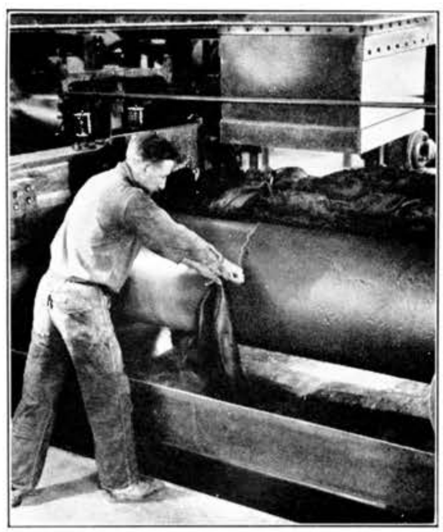
But the rubber overalls and coats made by the firm of Mackintosh did not make ideal wearing apparel. Even the best qualities of rubber get soft and sticky in hot weather and stiff in cold weather. Indeed, little rubber would be used today if some one had not discovered a way to treat it so that ordinary changes in temperature would not affect it.

The year Charles Goodyear was born the first rubber was brought into this country. Thirty-nine years later, Goodyear, almost despairing of finding a secret he had worked on for many years, accidentally discovered the process which made possible the huge rubber industry of today.

The process, which he afterwards developed, and which he called vulcanizing, after the Roman god of fire, is a necessary step in turning rubber into tires, conveyor belts, rubber belts and practically everything made from rubber or having rubber in it.

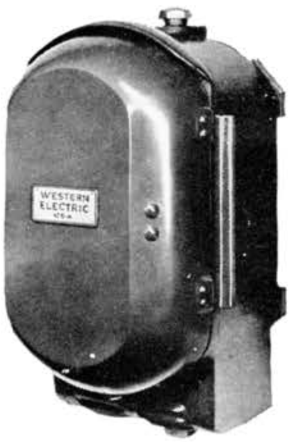
The best known of the rubber trees in South America is the Hevea (Heè-ve-uh) tree. This tree growing from 60 to 100 feet high is found in the warm, damp jungles of Bolivia and Brazil.

Sheet rubber baked and vulcanized is used for the receiver of the desk stand telephone and molded rubber dust is used to form the cap of the receiver.



This heavy duty roller mill is used in processing various rubber insulating compounds for the manufacture of rubber covered wire. This operator is removing a batch of insulating compound preliminary to straining it through a fine screen to remove foreign particles.

Rubber dust is poured into molds like the one the operator has before him and dies are inserted in powerful presses. When heat and pressure have vulcanized the rubber contents of the mold, receiver caps result, ready to be smoothed to the glass-like surface you have so often felt against your ear.



Rubber is used as insulation on the wires in mine, police, and railway telephones installed out of doors and on wires and connecting cords in damp localities. Marine and aircraft cables and cords are rubber insulated. Rubber is also used in many places throughout the equipment that goes to make up the telephone system—insulators, bushings, the tops of switchboard keys, key shelves, and number plates used on switchboards.

These special insulating and vulcanizing machines take bare wire and a ribbon of rubber and in one operation produce rubber insulated wire.

There is a rubber-producing tree found in Mexico, the Castilloa Elastica, and in Africa a vine, Landolphia, as well as the tree Funtumia Elastica, which has a high rubber content. They are not, however, commercial sources of rubber, for they will not stand repeated tapping as will the Hevea.

The Hevea has been transplanted and cultivated in the Dutch East Indies, Liberia and other parts of the world. The plantations of the east now produce nearly 800,000 tons annually.

While Brazil is the original source of our rubber supply and for years furnished the world from its wild rubber trees, of recent years plantations in the East have been supplying most of the world's raw rubber.

The juice from which rubber is made flows from the tree and is coagulated. This latex, as the juice is called, is a milk-like fluid circulating just beneath the outer bark. It is distinct from the sap. To collect it from the trees, gashes are cut in the bark, through which the liquid drips into dishes.

In the Amazon region the latex is smoked in a smudge made from palm nuts. The smoke of the palm nuts is a chemical agent which transforms the latex into the crude rubber of commerce.

On rubber plantations the rubber part of the latex—which is composed of rubber and resin—is made to curdle by chemicals. The curds are washed, sheeted and after being dried are smoked in hardwood fumes to prevent possible spoiling.

To make this crude rubber of use to industries it must be mixed with sulphur and other substances and heated to a certain temperature for a definite length of time. Ebonite or hard rubber is made by adding about 30 to 35% sulphur to the ordinary mixture.

The shell of your desk stand telephone receiver, the part you grasp to place at your ear, is of sheet rubber, while the cap at the end which actually touches your ear is molded of rubber dust. There are hundreds of telephone parts used in different places in the vast equipment that makes up a telephone system produced from sheet rubber. On cords for telephone handsets, for police, aircraft and marine radio equipment, and for public address and railway telephone systems rubber insulated conductors are used. For added protection on cords used with telephones installed out of doors and cords used in damp localities, a completely rubber-covered cord is now being made.

In making rubber covered wire, smoked sheets of crude rubber from the East Indies, sulphur from the Gulf States, whiting and other products are combined in a mixer weighing some thirty-five tons. The compound is then strained through a fine mesh screen after which it is formed into a ribbon about 3″ wide and 3/4″ thick, and wound on a reel.

These reels are conveyed to special insulating and vulcanizing machines which take the bare wire and a ribbon of rubber and in one operation produce rubber insulated wire.

Several kinds of waxes are used in insulating and moisture-proofing compounds on wires and various telephone parts. Superla wax, a high melting paraffin, is used in moisture-proofing the condenser in the handset type telephone transmitter. Beeswax is used for the same purpose in some types of handset receivers. Carnauba wax is used in the compound for moisture-proofing certain types of switchboard wires. This wax comes from the leaves of a palm tree (Copernicia Cerifera) that grows only in northern Brazil. During the hot season this wax exudes from and hardens on the leaves. The latter are cut off and dried when the wax becomes powdery and is easily removed, melted, and formed into blocks for shipment.

The Brazilian palm tree, Copernicia Cerifera, from the leaves of which Carnauba wax is obtained.

The use of Shellac dates back to Sanskrit, being recorded among the oldest products of the ancient Hindus. There are few products which have more uses than shellac. Yet, so very little is known about shellac that nine men in ten who use it do not even know what it is.

As the science of electricity developed, it became absolutely necessary to find an insulator that would be a total non-conductor of electricity and an effective bar to dampness. Shellac answered the problem, and there is scarcely an electrical device—from telephones to huge generators, simple switch cabinets to intricate radio circuits—in which shellac is not used as an insulator.

Shellac is given to the world by a tiny red insect no larger than an apple seed, which drinks the sap of trees in India and Siam.

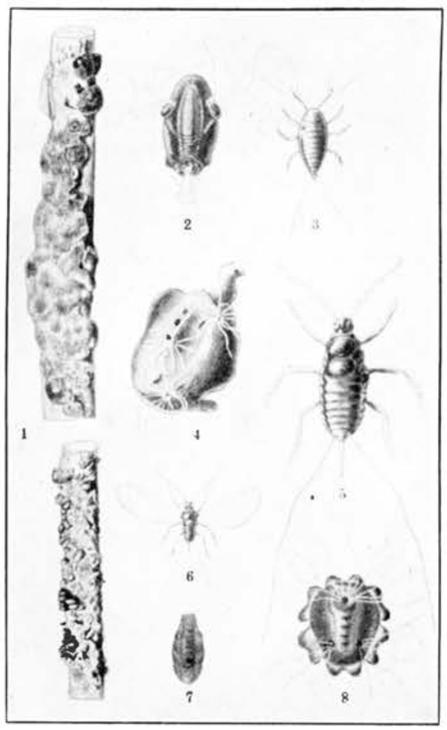
Thousands of millions of these little bugs swarm upon the branches of certain types of trees in these countries; they feed, they propagate, they die.

And, in doing so, they produce a gum that all the famous laboratories in the world cannot copy. These tiny red insects contain within themselves the ability to take tree sap within their bodies and subject it to chemical changes that are still a mystery to science.

First the swarm of little bugs picks out the tree or trees to be used for feeding purposes. Then each bug inserts a stinger-like proboscis through the bark into the wood of the tree. Each female produces about a thousand eggs before dying. All the bugs eat continuously from the sap of the tree. This sap undergoes the mystifying chemical transformation and is then exuded by the bugs and forms a hard, shell-like covering over the body. Gradually the exudation from each bug meets and joins the exudation of the neighboring insects and finally all are a part of one complete crust.

The male and female bugs both become inactive under this crust and then die. Their bodies have become a tomb and at the same time, an incubator for the next generation.

In the sixth or seventh month the young begin to break through the crust and swarm to new feeding grounds.



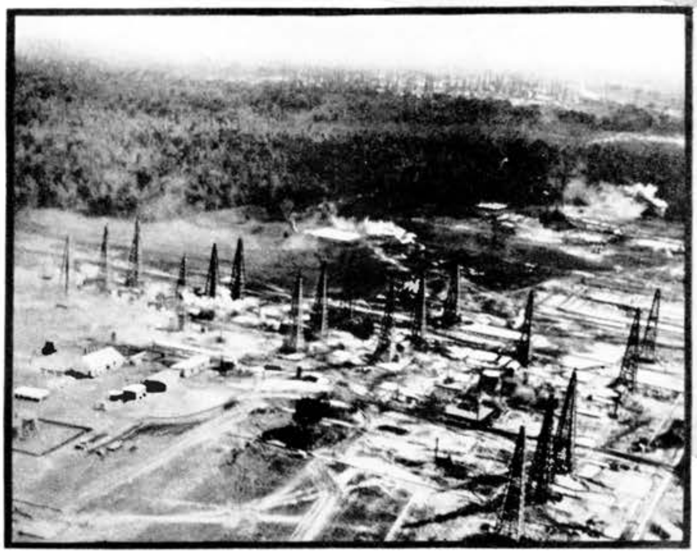
The life cycle of the Lac Bug

1—Insects attached to the branch of a tree
2—A female Lac insect four weeks old
3—Young Lac insect
4—Young Lac insect emerging from a female cell
5—Wingless male
6—Winged male
7—Male cell thirteen weeks old
8—A female thirteen weeks old

Through the centuries asphalt has followed human needs. It started as an aid to the defense of the great Mesopotamian cities and today under the world wide rule of Commerce, asphalt provides good roads and streets.

Left—The Bermudez Asphalt Lake in Venezuela is like a swamp with earth and pools of water scattered about. Here the natives are digging out asphalt and loading it into small cars for transport.

Right—The Trinidad Lake of Asphalt is very different in appearance from the Bermudez Lake. It is practically an uninterrupted sheet of asphalt. Here, too, light railroads that are moved as the surface of the lake moves, transport the asphalt.



In the United States most asphalt is distilled from petroleum and here is a section of an oil field showing the derricks used to drill for oil.

Digging asphalt from a Venezuelan asphalt lake.

Today most of the so-called natural asphalt used in the United States comes from the well-known asphalt lake on the Island of Trinidad in the British West Indies and a somewhat similar lake in Venezuela.

About 90% of the asphalt used in the United States is produced in American oil refineries by distilling asphaltic petroleum obtained in Mexico, California, and the Gulf Coast States.

At both lakes crude asphalt is dug out in heavy lumps with picks, and thrown into small cars which run on rails chained to palm tree ties to keep the railway line together as the movement of the lake twists the tracks about. On these cars the asphalt is transported to the shore from whence it goes to the piers and thence away to Europe or America where it is refined and used.

In making telephone condensers the units of paper and foil which have been rolled, pressed and treated with wax are sealed in a container with an asphalt preparation, a special mixture which does not become soft and crawl in warm climates nor become brittle and crack in cold regions.

Waterproof coils are also dipped in an asphalt preparation and wires in the central office which are open to the atmosphere are coated with it to protect them from moisture.

Tape armored cable is so prepared that it may be buried in a trench, thus doing away with the use of expensive conduit. To produce it, lead covered cable is coated successively with coverings of asphalt, paper, jute, steel tape, and whiting. The whiting is added to keep the turns of cable from sticking together on the reel, and to deflect the rays of the sun. Jute, a vegetable fibre that grows as a grass-like shrub in India, forms a durable coating for the cable.

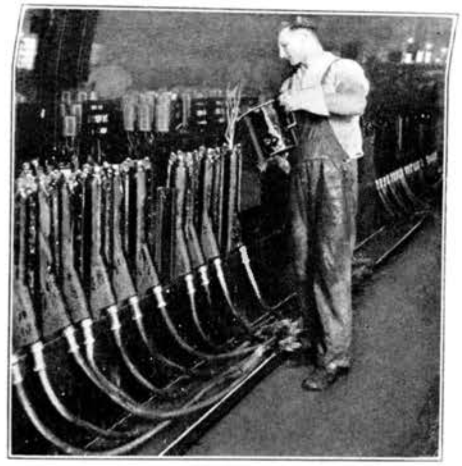
The inner layers of jute form a bedding for the steel tapes and keep them from cutting the lead sheath, while the outer layers, impregnated with asphalt, provide further water-proofing and protection from corrosion, or rusting.

Clay and Talc

From Florida and California come, respectively, clay and talc, which go into the making of the ceramic barriers or insulators which separate current carrying parts in handset telephone transmitters.

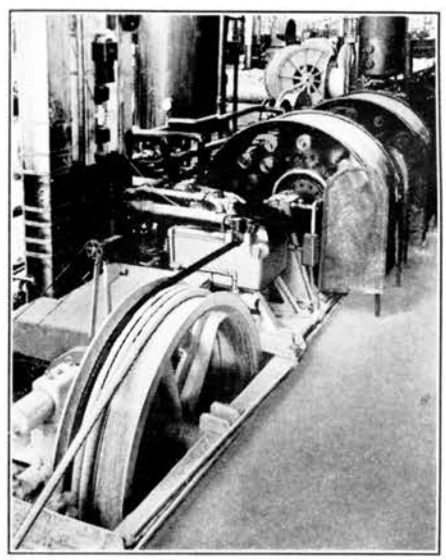
Stearin Pitch in Japanning

Japanning, as the term is generally used in industry, means the application to metal of a varnish that dries hard with a glossy finish. Stearin pitch is added to japan because it has the property of making the japan insoluble and resistant to weather, when baked. The film of pitch is not brittle, although it is very hard. Usually stearin pitch is made from animal fats, the fatty acids being separated and distilled under vacuum. The residue, after distillation, is stearin pitch. Until recently telephone mountings (handset and desk type stands) were japanned black, as were all subscribers' metal telephone boxes. Synthetic enamels are now rapidly replacing japan for these purposes.



Asphalt in cable terminals, used when telephone wires are joined to a lead covered cable, prevents moisture working in among the wires.

A condenser "potting" operation in which the condenser cans are filled with asphalt compound, and the units, composed of wound alternate layers of aluminum foil and paper, are inserted.



Tape armoring machine showing jute serving heads and application of whiting to the armored cable on the take-up capstan.

Mica, the window glass and lantern lenses of centuries ago, still plays a part in bringing us light and heat for it is an insulation in many different kinds of electrical machinery, providing light and heat and in addition it finds a place in electrical communication by telephone.

Left—A mica mine in India.

Right—Indians splitting and cutting mica.

Indian mica cutters trimming books of mica.

East Indians carrying mica.

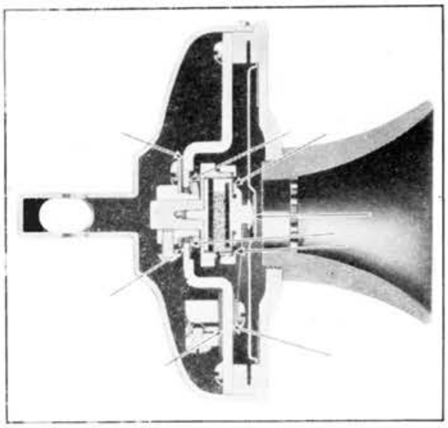
American Indians had a novel way of securing mica. They built a great fire close by a rock containing pieces of the sparkling mineral. When the stone was red-hot they withdrew the fire and cooled the rock by pouring water over it. This sudden change of temperature split the rock and the Indians could then extract the treasured mineral, which they used for mirrors and for burying with their dead.

Practically all peoples have sought out mica for its transparency. The ancients greatly valued this shimmering mineral and talked a great deal about its wonders. The Roman General, Agricola, wrote that many call it a metal on account of its glitter and others name it cat's silver. Our name for the mineral comes from the old Latin verb, micare, to shimmer or sparkle.

Thumb-nail or small knives are generally used by the workers in India to split the sheets of mica and since a delicate touch is required most of the workers are women and children. India, Brazil, and the United States produce about 95% of the world's sheet mica. It is also found in Madagascar.

The most extensive and valuable use of mica is for insulation in dynamos, electric light sockets, telephones and other electrical appliances.

Mica is in your desk stand type of telephone instrument and there it is used in thin strips and round pieces in the carbon transmitter button. It is this button which helps to transform the sound waves of your voice into the electric waves which pass over the wires to the receiver of the listening party. Besides insulating the instrument, this mica protects the powdered coal from the effects of heat and atmosphere. Another use of mica in telephone systems is in certain types of condensers, where thin sheets are used by the thousands.



Mica is used as an insulator in the transmitter of your desk stand telephone.

A round piece of mica forms one end of the carbon transmitter button of your desk stand type telephone instrument.

Cellulose Acetate Aids in Insulating

Cellulose acetate is a synthetic material—not highly inflammable as is celluloid, which is another product made from cellulose. It can be produced in the form of transparent sheets, yarn, fabric, extruded tubing, lacquers, and molding powders.

Due to these desirable characteristics, numerous applications have been found in the telephone industry. Sheet material, only 0.0007 of an inch thick, is used as insulation between layers of wire in the ringer and induction coils used in each subscriber's station. The many relay coils used in central offices also are insulated and protected with cellulose acetate.

A cellulose acetate lacquer is used to coat the cotton covered wires of one type of terminating (interior) cable. This lacquer smoothes the cotton coating of each wire, prevents fraying, and is impervious to moisture.

Cellulose acetate lacquer is used on telephone dial number plates to protect the numbers when we make a call. It is also used when hand telephone cradles and boxes are enameled in colors. Cellulose acetate lacquer also is used as a coating over cotton or cotton and silk on switchboard wire, distributing frame wire, and switchboard cable.

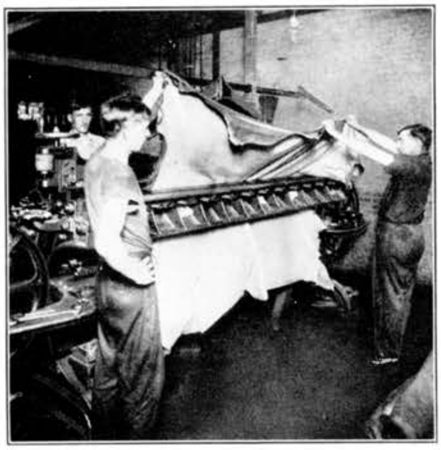
Thin sheets of mica are assembled for the condensers used in certain special telephone circuits which carry several messages at once over the same pair of wires.

Leather, its Preparation and Use

Leather in the tanning process. A weak tanning liquor is used for the first bath, followed by stronger solutions.

Raw material for American leathers, while largely domestic, comes also from several foreign countries. The leather industry in 1937 used approximately 21,000,000 cattle hides, 19,000,000 of which were home grown. There were 10,000,000 domestic calf skins and 17,000,000 sheepskins made into various leathers in the same time. We used 50,000,000 goatskins which, however, were practically all imported from India, Brazil and also China. Most of the cattle hides imported come from Argentine, Brazil and Canada.

Leather is used to cover the bases of handset telephones because, when dialing, its surface holds the telephone to the table more firmly. The raw material comes from hides of yearling cattle of the northern part of the United States. These hides are smaller and finer than those of the large cattle used in the making of sole leather, patent leather and work shoe upper leather, and are used principally in the manufacture of so called "elk," the soft, light colored leather used in the manufacture of sport shoes. Even these fine light hides, however, are about twice too heavy for use in shoes or on telephone bases, and after the first tanning process, are split into two layers by a band knife, moving at high speed. The outer or hair side is made into "elk" finish or other types of leather made from cattle hides, while the splits, or flesh side, is used extensively in the general shoe trade. Some of these splits are given an artificial coating and made into slippers. Others are sueded on the emery wheel and used for the quarter linings of men's shoes.



Splitting the hide. This delicate and interesting operation separates the grain which carries the hair from the hide and also splits the hide into various thicknesses.

Leather for telephone bases must be quite uniform. They cannot be too heavy, too thin and weak, or too imperfect. The tannage is pure chrome made from compounds of the mineral chromium, potassium dichromate, and aniline dyes that are almost unfadable. The leather must withstand a boiling test as well as meet a number of requirements for tensile strength and resistance to abrasion.

Determining thickness of sueded leather used for base of telephone handsets.

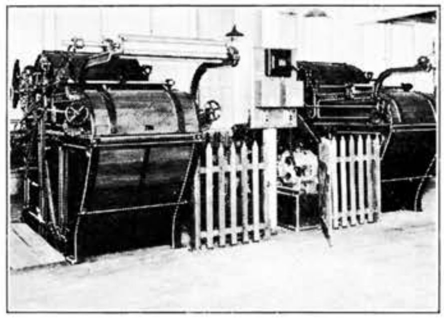
Sueding of leather consists simply of loosening the ends of the skin fibres just enough to give a short uniform nap. It is done on a fine emery wheel, first before and again after the splits are colored. The tanning and coloring are done in large revolving drums, at about 110° to 180° temperature, each drum holding enough splits to make about five thousand bases. The splits are cut with a heavy steel die. The cutting is accurate and permits the careful inspection and placing of each pattern to avoid defects, weak spots, or irregularities of thickness. After cutting, the bases are inspected with a micrometer gauge before being mounted on the bases of handset type telephones.

Wool on Some Telephone Bases

Wool has become one of the staple products of the world, not only because it is useful as a fibre to spin and weave into cloth but because it—unlike cotton, flax and silk—can also be matted or felted.

The reason why a fabric can be made this way was probably not known until centuries after the first felt was made. It is possible because each fibre of wool is covered with minute teeth or barbs pointing toward its tip. By pressing a number of these fibres together, those which lie in opposite directions to each other and in contact will interlock at those barbs and stay attached.

The fabric made by this ancient method is called pressed felt. There is still another kind of felt made today by weaving soft wool yarn into a fabric, which is then passed, while in a moist condition, through heavy rollers. This product, called woven felt, is extremely durable and was used to make the pad on the base of your desk stand telephone.



This fulling mill is the modern method of felting. It succeeds through several mechanical and machine improvements over a long period of years the old-time method of stamping the cloth with the feet. In the fulling mill heat, friction and moisture combine to make one fibre interlock with another. Felt is used for washers in the machinery which makes various telephone parts. Another interesting use of wool is for covering telephone conductors as a protection against the effect of the climate in tropical countries.

The Place of Wood

Wood is extensively used in making switchboard cabinets and telephone booths. Two high-grade woods which are used mostly are Cuban mahogany from the West Indies and Peruvian mahogany from Peru and other South American countries. Oak from the North American continent also has an important place in telephone equipment. Many magneto telephone cabinets and bell boxes are made of this wood.

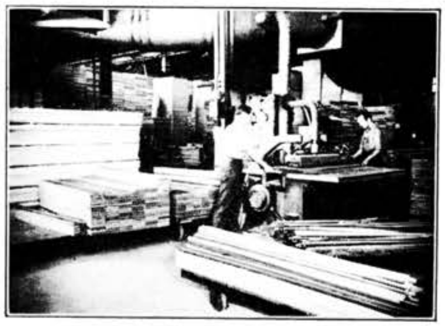
Only the most suitable logs of a variety of woods are selected to be cut into very thin sheets called "veneer." These sheets are then used for the face side of built-up ply wood. India supplies teak to the telephone industry because it is a wood that is immune to wood-eating ants. Cabinets for export to countries subject to these insect attacks are made from this particular kind of wood which finishes to a rather light walnut appearance.

Prospective telephone poles are carefully inspected in a concentration yard for any possible flaws.

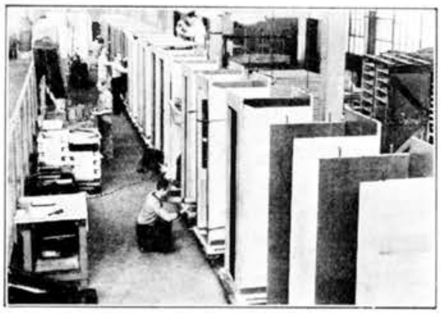
In the telephone industry as many as thirty varieties of wood are used. Including those already mentioned, they are:

Cuban, Peruvian and African mahoganies, birch, maple, hickory, walnut, holly, basswood, red and white oak, ash, chestnut, gum, lignum-vitae, cypress, beech, teak, poplar, Northern white pine, Western yellow pine, Norway pine, sugar pine, Southern yellow pine, tamarack, Douglas fir, West Coast hemlock, balsa wood, white spruce and red cedar.

Telephone poles, crossarms and insulator pins are of wood. Crossarms are made of Douglas fir from the west coast of North America or of yellow pine from the southern states. Pins are made of straight grain, yellow or black locust or oak, because each of these woods, for the particular job it has to do, serves the purpose best.



A corner in one of Western Electric's large wood-working shops where experienced cabinetmakers use only fine selected woods for switchboards and other equipment.



In another wood-working shop scientifically prepared woods are used to construct telephone booths.

In a quartz mine in Brazil an inspector is engaged in a test to insure delivery of only the most suitable quartz crystals for use in radio and telephone voice transmission.

With this polariscope the trained worker determines exactly the axis of the quartz crystals before they are diamond sawed and then ground within extremely small tolerances.

The selection of trees of just the right height, girth and quality to make telephone poles is one of the most interesting activities of the telephone equipment suppliers. From the woods the tree is transported to a concentrating yard where it is seasoned, cut to the exact length, bolt holes bored, and treated as required and as inspection indicates.

Among the woods suitable for telephone poles are: Southern pine from the South; Northern white cedar from the Lake States; Western red cedar from the Northwest; Lodgepole pine from the Rocky Mountains; and Douglas fir from the Northwest.

Some reels on which the familiar lead covered cable is shipped are made of spruce and pine. Giant fir and hemlock are used for cable reel lags and structural maintenance material.

The Qualities of Quartz

Today quartz has many uses. One of these is the making of ornaments. The ancient Greeks found quartz crystals in the Alps and thought they were a form of ice made permanently hard by intense cold. They gave them the name of "krystallos," meaning clear ice, from which we have the word crystals.

One of the important modern uses of quartz crystal is its application to telephone circuits. For this purpose the mineral has a peculiar characteristic. When cut with precision to a prescribed thickness and area, depending upon requirements, and then made to vibrate, electrical charges are generated on its surfaces that keep in step with its vibrations. The charges can be led to vacuum tube amplifiers and made into a strong current that alternates in direction many times a second. This characteristic makes quartz crystals useful in long distance telephony. As many as 480 separate voices can be carried over a single pair of conductors at the same time with the help of these accurately cut quartz plates which keep each voice on its own frequency.

The same characteristics of quartz crystal are used to control and maintain the prescribed frequency of radio transmitters.

Plates used in radio receivers and transmitters are made as small as ½″ square by 1/100″ thick and as large as 1½″ square by ⅛″ thick.

Plates for telephone filters vary in size from a tiny bar 1/16″ square by ¼″ long to a plate the shape and size of a pocket mirror.

Great accuracy is required in cutting and grinding the plates and some dimensions must be precise to within 1/100,000 of an inch.

Most of the quartz for this purpose comes from Brazil or from far away Madagascar because large, clear, perfect crystals are required, and not the small particles or small masses found in seashore sand and in other silicon deposits.

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