NOTES ON MINERAL WASTES

BY

CHARLES L. PARSONS
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PREFACE.

By J. A. Holmes.

During the past year, in producing 500,000,000 tons of coal we wasted or left underground, in such condition that it probably will not be recovered in the future, 250,000,000 tons of coal; we turned loose into the atmosphere a quantity of natural gas larger than the total output of artificial gas during the same period in all the towns and cities of the United States; we also wasted or lost in the mining, preparation, and treatment of other important metalliferous and non-metalliferous minerals from 10 to 50 per cent of the year's production of such minerals. These losses serve to indicate the importance of inquiries and investigations by the Federal Government for the purpose of lessening the waste of essential resources—investigations on the same general lines as those looking to a reduction in the loss of life in the mining operations of the country and the far more extensive investigations looking to the more efficient production and use of agricultural products, both of which are being conducted by the Federal Government.

In a consideration of the possible activities of the individual, the State, and the Federal Government in behalf of a less wasteful use of our mineral resources certain facts and principles should be kept clearly in mind, namely:

That the present generation has the power, and it will exercise the right, to use as much of the country's resources as it actually needs; there can and there will be no such thing as stinting the present generation by bottling up resources for the use of the future.

That the Nation's needs are not likely to be curtailed; these needs will increase with the extent and diversity of the Nation's industries, and they will increase more rapidly than population increases, for the reason that the per capita consumption of mineral products is rapidly increasing; and

That the men of this generation will not mine, extract, or use these resources at continuous financial loss to themselves in order that something may be left for the use of future generations; there can be no such thing as a mineral industry without profits.
Furthermore, it should be clearly understood that the mineral resources of this country have required long ages for their accumulation and that of these resources the Nation has but the one supply. There are no known substitutes available to meet the Nation's further needs when that supply will be exhausted and, to the best of our present knowledge, this one supply must serve as a basis for both the needs of the present and the far greater needs of the future.

In a higher way our mineral resources should be regarded as property to be used and to be held in trust with regard to both the present and the future needs of the country. It should be remembered that neither human labor nor any human agency has contributed to their origin or to their intrinsic value, and that whatever rights the individual may possess have been derived from the General Government and from the State as the original owner. The State does not surrender its right, and should not neglect its duty, to safeguard the welfare of its future citizens by preventing the wasteful use of these resources. Though the individual may claim the right to use the resources in proportion to his needs and the needs of the community, he certainly has no right to waste that which is not needed for present use but is certain to be needed hereafter.

Those in charge of the investigations of the Bureau of Mines recognize the rights and duties of the Federal Government as being limited to the carrying on of inquiries and investigations with a view to determining the nature and extent of this waste of resources, the means by which it may be diminished, and the setting forth of the facts in the case.

The present report embodies the results of certain preliminary inquiries as to the nature and extent of this waste. It will be followed by a more detailed report on the subject as soon as the necessary inquiries and investigations have been conducted and the results put in shape for publication.

In the preliminary work along these lines, the representatives of the bureau have received the cordial cooperation of the engineers and chemists associated with the varied mineral industries of this country and also of the owners and the operators of the mines and the metallurgical plants.
NOTES ON MINERAL WASTES.

By Charles L. Parsons.

INTRODUCTION.

The mineral resources, which by their abundance in favored localities have made our civilization possible, required the ages for their building. Through millions, perhaps hundreds of millions, of years their segregation into workable deposits has been going on. Their genesis may still be under way, but the rate of their formation is now infinitesimal in proportion to the rate at which they are being eroded and scattered over the earth's surface.

NEED OF PREVENTING MINERAL WASTE.

It is practically impossible to estimate the supplies of our chief ores and minerals. A few minerals, like the silicates, are inexhaustible; one or two metals, like aluminum, may become so likewise when processes are devised to utilize material not now available. Many new deposits of all will undoubtedly be found; but the ultimate exhaustion and dissipation of some of our important useful minerals of to-day, from the standpoint of the race and in the light of present knowledge, is in sight. This fact deserves serious consideration. Hence, it is of the utmost importance that these minerals be mined, concentrated, and utilized with all practical economy, and that the metals, after serving their purposes in manufactured articles, be collected for reuse wherever possible. These basic principles have all been expounded by many eminent writers, and are brought together in interesting form in the report of the National Conservation Commission, in a book of lectures by Charles R. Van Hise, and in many individual articles in the public press and in scientific and technical publications.

The mineral resources of the United States are greater than those of any other nation. In 1911 the value of the product of our mines

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a S. Doc. No. 676, 60th Cong., 2d sess.
b The conservation of natural resources in the United States, 1910, 413 pp.
and quarries exceeded $2,000,000,000 in the wealth produced by our people, being surpassed only by the value of the product of the soil. No matter of greater moment concerns us, therefore, than the proper conservation of our mineral resources for the needs of the future. This conservation can be accomplished only by avoiding waste in the mining, manufacture, and use of the mineral products that the legitimate advancement of commerce and industry may require.

The purpose of the Bureau of Mines in publishing this report is to call attention to some of the present wastes, in the hope that knowledge of the facts may lead to an increased desire to eradicate the wastes, and to a greater interest in careful, practical, and scientific investigations, through which only can they be overcome. Much has already been done, especially in the metallurgy of iron, lead, copper, and the precious metals, and there is no intention of belittling in any way the really wonderful work of the last half century or of the last decade, but time is sure to show that human accomplishment in economical mineral technology is only in its beginnings.

**VARIETY OF WASTES.**

Wastes in mineral production and treatment are of many kinds. There are wastes in mining, in concentrating or ore dressing, in smelting or manufacture, in flue dust, and in unrecovered dross and scrap. Inefficient methods are adopted through unnoted or undeveloped opportunity. Losses are caused by the use of material entirely unfitted for the use to which it is put. Air and light and moisture cause rusting and decay. Certain uses, such as that of zinc oxide and lead carbonate for paints or for the filling of rubber for automobile tires, leave no practical chance for recovery. Failure to use resources, the value of which is yet unknown, gives rise to economic inefficiency. All present wastes will be largely prevented in future, as science progresses and investigations multiply.

In the process of mining some of the material is inevitably left in the ground, being of too low grade to work with profit, or being necessary for roof supports in the form of pillars. Many ores, formerly of too low grade to pay for extraction, are now sources of wealth, and care should be taken to leave low-grade deposits in position for future development whenever conditions warrant. Improved methods of mining and timbering often permit the complete removal of pillars, and their replacement with valueless material. New forms of machinery will reduce costs, and entirely feasible precautions will lessen the danger to life and limb.

In ore dressing and ore concentration the losses are often startling, and, in spite of the advances in the last few years, this field offers broad opportunity for the investigator. Present practice should
always consider the storage of the material now wasted, in the hope that new knowledge may yet render it profitably available. Numerous instances might be cited in which the tailings from gold mines, the slags from copper smelters, and the dumps from mines and manufactories have become a source of wealth, the wastes of the past being thus converted into the dividends of the present.

The dust from stacks and chimneys of all kinds is often not only a great waste of valuable material, but is one of the great evils of modern civilization. Valuable metalliferous dusts are strewn broadcast from the stacks of our smelters; gases and poisonous solids destroy vegetable and animal life; and masses of black smoke pour from our chimneys and settle in clouds over many of our cities, rendering them exceedingly disagreeable and unsightly. Even with present knowledge, practically all dust nuisances are preventable, and legislation the country over is diminishing the dust output from smelters, from cement plants, and from smoking chimneys, often with the result that the collection of dust incident to smoke prevention becomes a source of profit. Specific instances of the wastes mentioned are cited in subsequent pages.

LOSSES THROUGH INEFFICIENT METHODS OF TREATMENT AND USE.

Losses through inefficient methods are not always realized, sometimes because proper practice has not been developed, but oftener because of ignorance resulting from lack of technical supervision, or because of prejudice against its employment. The increase in efficiency of method will surely be greater in the future than in the past, although no fable is more wonderful than the history of the development of the metallurgy of iron through the introduction of the Bessemer and the open-hearth processes, the recovery from the waste gases of heat for the blast and the driving machinery, the dehydrating of the blast, the nodularizing of the flue dust, and the utilization of the slag. The metallurgy of copper has greatly advanced in recent years, but more efficient methods, yet to be devised, will save fuel and conserve the sulphur as well as valuable accompanying metals that now go off in the slag. The methods for winning zinc, owing to the peculiar reaction of that metal, are little changed in principle from those in vogue when the metal was first commercially obtained.

The application of new scientific principles to simple manufacturing practice often brings about incalculable saving. Hess states  that the advent of tungsten-steel tools has saved hundreds of millions of dollars in the United States alone by the increased efficiency of

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over 400 per cent in metal-cutting lathes, and quotes Mr. Elwood Haynes to the effect that a certain automobile company would be obliged to add $200 to the price of each automobile now manufactured should it have to use the old carbon-steel tools instead of the tungsten-steel tools it now employs. Vanadium and molybdenum have much the same effect on steel as tungsten when used in the proportionate amounts of about 1 of vanadium to 5 of molybdenum to 18 of tungsten. The beneficial effects of these elements should not be accorded to them alone, for each must be accompanied by chromium also to give the resulting ferroalloys the properties that render them valuable.

Another good example of waste in utilization is the failure to use the latest methods in the hardening and tempering of steel. A certain large manufacturer of steel blades, making at the present time some 300,000 blades a day, has reduced his costs more than half through the services of an expert chemical engineer. He now uses some 3 tons of cold-rolled steel per week. The blades were formerly hardened by using 65 machines which, utilizing gas and blast for the heating process, ran day and night and required 15 men for their control. The company is using six electrically heated furnaces, which, in an 8-hour day, give double the old capacity and require the services of only two operators. For the tempering process the blades, 70 pounds at a time, are dipped into an electrically heated salt bath, and are held for a definite period at a temperature precisely controlled by pyrometers. On the other hand, another of our largest manufacturers of small steel articles is still employing the hand labor of blacksmiths for hardening each article, getting a much more variable result at many times the cost. The company is working up hundreds of thousands of dollars' worth of material each year, believing that its supposedly secret practice is an asset of great value. Examples of this kind of waste could be almost indefinitely multiplied.

The prevention of waste of metals is largely a question of their preservation. Metals like copper, iron, gold, and silver tend to accumulate and add to the world's stock. Zinc and probably some other metals are dissipated each year in quantities almost as great as the amounts produced. Accordingly, any means that tends to prevent the destruction of metals, whether it be use of protective coatings of cement, enamel, or paint, or the addition of some substance that renders the metals comparatively immune, such as the addition of copper to iron, is of the utmost importance in intelligent conservation.

Less than half of the known elements of which the earth is composed are now commercially important, and some of the most abundant are the least used. Many instances are on record of valuable but little-
known minerals of the rarer elements being passed over and lost through inability of the ordinary prospector to identify them. Future investigation will certainly develop many important applications for materials now useless, and new exploration will develop resources that are now unsuspected.

The scrap heap is receiving more and more attention every day, and important results in true conservation have already been accomplished through the medium of the junk dealer. Iron by the thousands of tons is collected to be smelted in the open-hearth furnace. Lead scrap, stereotype metal, babbitt, and solder are remelted and reused; tin from tin scrap and tin dross, and zinc from zinc clippings and zinc dross are recovered. Copper from old wire, from discarded copperware, from brass scrap, from bronze scrap, from copper paint sludge, from the ashes of brass and copper furnaces, from molders' sand, etc., is separated from its accompanying metals and comes once more on the market. Gold, silver, and platinum are collected from jewelers' sweepings and dental waste. All this is the truest conservation, for it tends to keep the world's stock intact. Losses, however, are still incalculable, although often readily preventable through application of known remedies or through a little investigation and intelligent experimentation.

In a consideration of this whole question of waste, one should remember that there are many wastes that are necessary under present economic conditions. In all cases, however, every effort should be made to store up for future use material that may, as human knowledge advances, become valuable. The really important problem before the country is to investigate the extent and nature of these wastes and then to find and apply remedies in a thoroughly business-like way.

**FUEL OR CARBON WASTES AND THEIR REDUCTION.**

The wastes of carbon in our modern economy are almost incomprehensible. Only the wastes of what may be termed inorganic carbon can be considered here.

**WASTES IN THE MINING AND UTILIZATION OF COAL.**

In mining coal in this country probably one-third of the bituminous coal and one-half the anthracite are left in the mine. Better methods of mining have reduced past losses and there is prospect of further immediate improvement. The losses from pillars left to support the roof, and from coal left in beds too thin to be mined profitably are sure to continue, but can be greatly diminished. Fully 80,000,000 tons of anthracite coal is now being left behind in the mines each year, and it is estimated that since coal mining began in this country fully
2,000,000,000 tons of anthracite and 3,000,000,000 tons of bituminous coal have been left in the ground under conditions which make future recovery highly improbable.  

After coal is mined, the losses by no means cease, although some of the culm that formerly went to waste by millions of tons is now being briquetted and used. Probably not over 11 per cent of the energy in coal is effectively utilized. The remainder of the energy is lost through the inefficiency of the steam boiler, the steam engine, and the electric dynamo. It is estimated that the boiler scale in locomotives alone in this country means a loss of over 15,000,000 tons of coal annually. It has been shown that one-sixteenth of an inch of scale means a loss of 13 per cent and that one-eighth inch, an amount present in many boilers, means a loss of 25 per cent in boiler efficiency. This boiler scale not only causes a loss of energy, but its presence shortens the life of the boiler itself. Careful study of boiler practice has greatly increased boiler efficiency, but, although 80 per cent efficiency is obtained under careful chemical control in the best experiments, not above 50 per cent is obtained in average practice.

In spite of present conditions, great advancement in the utilization of fuel has been made, and greater advances will follow, although the direct utilization of the full energy of carbon through some chemical process may be the dream of the chemical engineer for decades to come.

One of the efficient methods of conserving our coal supplies is through the utilization of water power. Furthermore, the development of the gas engine, by means of which the energy of fuel can be utilized without the intermediary loss involved in generating steam, is rapid. This development has the distinct advantage that much coal, too poor in carbon content to be economically transported, can be readily burned in gas producers and its energy transmitted to a distance through the gas engine and the dynamo. The covering of pipes with asbestos and magnesia coatings and the scientific control of the combustion of coal under boilers are greatly increasing the amount of energy actually utilized, but the losses of carbon that is still pouring from our chimneys, defacing monuments, buildings, and landscape, are without valid reason.

The entirely needless and seemingly ruthless loss of the energy from carbon in the production of coke must also be mentioned. Parker states  

\[ \text{that the value of the recoverable contents of the coal made into coke in beehive ovens which was wasted in 1910 would have been between $35,000,000 and $40,000,000.} \]

If all the coke made in the United States were produced in retort ovens, these would yield from

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the carbon now wastefully consumed, no account being taken of by-products, approximately 1,000,000 horsepower.

POSSIBILITY OF UTILIZING COAL TAR.

The argument formerly made against the use of by-product coke ovens, that the output of tar could not be marketed in this country, no longer holds, for not only is there a ready outlet for the crude tar for use on roads, but indications are not lacking that we shall not always be dependent upon outsiders for needed coal-tar products. Germany already makes over four-fifths of her coke in by-product ovens, whereas five-sixths of the coal we coke has some $40,000,000 of its value dissipated into the atmosphere. This loss might be prevented by the use of modern methods.

Without entering into the details of the wonderful coal-tar industry, which, although probably the greatest example of chemical industrial progress, is only beginning to develop in this country, it is interesting to note the indirect bearing of this industry upon conservation through the synthetic preparation of alizarin, indigo, and other colors that were formerly produced from plants grown on land now devoted to other purposes. It has been stated that the synthetic indigo now prepared from coal tar is equivalent in amount to that which would be produced by over 300,000 acres of indigo plants. Furthermore, development of one industry like this always has a decided influence upon another. When the cyanide process for the extraction of gold was first proposed, potassium cyanide cost over $1 per pound. By the utilization of waste products and the perfection of methods, the price of cyanide, now chiefly used in the form of sodium cyanide, has been reduced in the chief producing countries to something like 15 cents per pound, and since a saving of 1 cent per pound of cyanide means a saving of something like $150,000 annually to the gold industry, the cheapening of this product alone means a saving to the world of some $12,000,000 a year.

WASTES IN THE PETROLEUM AND NATURAL-GAS INDUSTRIES.

The 29,000,000 metric tons of petroleum that the United States now produces is for the main part utilized. It is not always used economically, and undoubtedly large losses in lubrication might be avoided. Few people realize the immense amount of lubricating oil used, and there is probably no substance on the market more subject to the abuse of brand. For a consumer to pay more than 50 per cent of the selling price for the name on the container is not at all uncommon, and as regards the high-priced lubricants the same oil can frequently be bought on specification for one-third the price that would be paid for it under some special copyrighted name. This is an economic but not a material waste.
Formerly kerosene was the chief product sought in the distillation of petroleum, and immense quantities of the lighter and heavier fractions were thrown away. With the introduction of the electric light, of the automobile, and of the proper understanding of lubrication, almost the total output of petroleum is now utilized as gas, gasoline, naphtha, benzine, kerosene, lubricating oil, asphaltic road material, and carbon for electrical purposes. Indeed, kerosene has almost become a secondary product, and within the last few years the demand for gasoline has been so great that petroleum companies are anxious to increase the output of that fraction. Not only are investigations under way to convert the heavier products into gasoline by chemical or thermal methods, but the gases from petroleum wells and from natural-gas wells are being subjected to cold and pressure, and a light, easily volatile liquid product is being condensed therefrom, which can be used in gas engines. From some gas wells 2 to 6 gallons of liquid products may be obtained from each 1,000 cubic feet of gas. The gas itself is rendered better for illuminating purposes or for gas-engine combustion, though, of course, its volume is considerably decreased. Many thousand gallons of this kind of gasoline is now produced daily.

The wastes of carbon through the escape of natural gas into the atmosphere are, and always have been, little less than criminal in every new gas or oil field. In most of the old fields these losses have been controlled, and the gas is held stored in its natural reservoir, sometimes under tremendous pressure, until used. Formerly this pressure was utilized at some wells to run engines, the gas itself passing off into the atmosphere, but this waste has been stopped by legislation in most States. In a few cases, in which reduced pressure is desired before running gas into mains for distribution, the high pressure is still reduced through the medium of engines, thus conserving both energy and gas. Although in the more recently developed fields there are still intolerable wastes, it is pleasing to note that careful study and perfection of method are leading to a rapid decrease. Many million gallons of the lighter petroleum products, lying between true gasoline and natural gas, is annually lost by evaporation from the open mouths of petroleum wells and from open storage tanks.

In connection with the utilization of petroleum and natural gas, two problems of importance need solution and will in time be solved. First, a gas engine that will use crude petroleum efficiently will conserve to a large extent the energy that is now wasted in passing through the medium of steam, and will, accordingly, greatly enlarge the area within which ships may travel on a limited fuel-carrying

capacity, as well as greatly increase the power produced per fuel unit in all power plants using liquid fuels of this class. Second, there is a rapidly growing demand for hydrogen, both for reducing oils and fats to products of lower melting point and for the development of other processes, which, in part at least, like the proposed contact process for ammonia production, are dependent upon cheap hydrogen for successful exploitation. From petroleum products, as well as from natural gas, hydrogen can be produced and carbon, perhaps as lamblack, be simultaneously obtained.

The present process of manufacturing lamblack from natural gas is very inefficient. Not only is the heat of combustion of the hydrogen entirely lost, but a considerable portion of the lamblack actually freed and not consumed is wasted. The recent improvement in methods of dust recovery should make the conservation of this loss an easy matter. B. B. Butler states a that in a large West Virginia plant at least 25 per cent, and probably 33\(\frac{1}{3}\) per cent, of the gas burned for lamblack is wasted in the form of a dense cloud of black dust mechanically carried with the draft.

Uses are being sought also for the large quantities of the so-called solar oils of the Texas petroleums, which seem to be too good to be used for fuel but are not light enough to be distilled for kerosene.

**ADVANCES IN THE METALLURGY OF IRON.**

The metallurgy of iron has reached a perfection beyond that of any other metal, and wastes have been eliminated to an extent that serves as some indication of what perhaps may be done in other industries when the same amount of intelligent investigation has been applied to their development. From the mine up every possible waste has been closely watched and most of the wastes have been eliminated. The poorer ores are being reserved in a condition available for future use; the methods of the blast furnace, the steel mill, and the foundry have been rapidly attaining high efficiency; most of the waste gases and the flue dust are being utilized; and the slag is being converted into Portland cement at the rate of nearly 8,000,000 barrels a year. This advance by no means proves that the end is reached, and, indeed, the outlook for special ferrous alloys, such as those already mentioned and many more as yet undiscovered, is as wide as the future. Moreover, there are millions of tons of titaniferous iron ores not now available that are certain to be utilized by processes now unknown.

**THE EXTRACTION AND UTILIZATION OF COPPER.**

Next to the metallurgy of iron, that of copper has probably been the most developed. Losses in mining and ore dressing are large, however, particularly in the concentration of some of the low-grade

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42750—Bull. 47—12—3
ores, in which heavy metal or sulphide minerals are mixed with the lighter oxides or carbonates. In dressing these ores, a loss of 30 to 40 per cent in the tailings is by no means rare. There have been great advances in smelting, however, as well as in the utilization of ores of such low grade that their successful exploitation 10 years ago would have been deemed impossible.

The fact is that some bodies of low-grade ores are proving more profitable to work, because of their size, than some high-grade ore-bodies, and hence the cost of the metal has not increased, as might have been anticipated. Indeed, although our production of copper has increased about 1,000 per cent in the last 25 years, the annual output as well as the annual consumption is still increasing, and prices are lower than they were a few years ago, owing to the greater efficiency of method and the utilization of deposits formerly supposed to be worthless. Immense deposits of ore yielding less than 2 per cent of metal are worked with steam shovels, and the ore is concentrated in mills capable of handling some 20,000 tons per day, and is smelted by methods far more efficient than formerly. Furthermore, it is beseepered in basic-lined converters capable of handling three times the charge of the old acid form, and having a life many hundred per cent greater. These low-grade deposits, instead of causing an increase in the price of copper, are really forcing some of the high-grade mines to struggle for a continued existence. In spite of all this, it is doubtful whether there is any branch of metallurgy that would respond more quickly to scientific research by well-trained men, if they were not forced always to keep the immediate output in mind, than the metallurgy of copper. Just what lines these advances will follow, it is impossible to predict, but almost inestimable losses of sulphur, arsenic, bismuth, etc., are now taking place in the flue dusts and flue gases, and there can be little doubt that these will be controlled in time. Electrolytic or electrothermal methods, accompanied by leaching, may yet produce the copper more cheaply direct from the ores, and more efficient concentration is certain to come.

RECOVERY OF COPPER FROM SCRAP.

Here, the junk dealer is performing an especially important service, for all scrap containing copper is eagerly sought, and the copper removed. Copper-wire scrap by the thousands of tons is annually gathered, the insulation, if present, burned off, and the whole simply remelted, poled, and cast again into wire, or into bars or ingots for redrawing. Brass, bronze, cuppered tin, etc., of unknown composition, when gathered together in endless variety of kind, such as bases of electric lamps, brass and copper turnings and shavings, cartridge shells, broken and battered household goods, old pipe, brass
PRODUCTION OF NICKEL AND COBALT.

Nearly all of the nickel used in the United States is imported from Canada. Large quantities of this metal are, however, known to exist in Idaho, and an immense deposit of a low-grade, hydrous nickel-magnesium silicate occurs at Webster, N. C. The latter deposit contains millions of tons, but owing to its low-grade character no method of economically working the material has yet been found. Of course, the same statement was true of similar ores of copper ten years ago, but this nickel ore has the disadvantage that it is not amenable to ordinary methods of gravity concentration. A few tons of nickel is made from the nickel that accumulates in the electrolyte of copper refineries and one smelter in the Northwest is producing some metal. The larger part of the output is understood to be now used in the form of monel metal, an alloy obtained direct from the ore and in which the expense of first separating pure nickel has consequently been avoided. The use of nickel as a catalytic agent to bring about the absorption of hydrogen by certain oils and fats has recently become important, as valuable commercial products are obtained.

The production of cobalt in the United States is a problem connected almost solely with imported Canadian silver ores from the famous Cobalt, Ontario, district. Cobalt oxide has recently much decreased

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in price owing to the greatly increased supply, so that the old well-known uses of coloring glass and pottery blue, or of neutralizing the straw yellows of titanium in porcelain and china no longer absorb the output. A new alloy with chromium has been proposed for making cutlery. The cutlery made of the alloy holds a good edge and withstands corrosion and this use may increase the demand. The alloy could be substituted for nickel in most uses of that metal but its higher price prevents.

**LOSSES IN THE CONCENTRATION OF ZINC ORES AND IN THE UTILIZATION OF ZINC.**

In proportion to output the losses of zinc are probably greater than those of any other metal, and are especially important because there is almost no recovery of zinc from manufactured products and almost no conservation of zinc by accumulation. With the exception of the New Jersey mines, where conditions are unique, it is probable that less than 50 per cent of the zinc, even in those mines where zinc is the only product, reaches the form of spelter. Zinc mining is frequently done on a royalty basis, an arrangement that means great waste, because the lessee naturally takes out the ore paying the greatest profit and leaves the poorest ore behind without reference to its ultimate loss. There are also losses in concentration, and E. J. Ericson\(^a\) places the losses in zinc smelting at 8 to 22 per cent. It is quite certain, however, that the 8 per cent minimum is obtained only in the most efficiently managed plants and under especially favorable conditions.

The peculiar properties of zinc, its volatility, the difficulty of condensing it when mixed with inert gases, and the ease with which it reduces carbon dioxide at temperatures little above its boiling point, make losses in smelting almost inevitable. The methods now used vary only in minor detail from those employed when the metallurgy of zinc began. The losses have been greatly diminished by improvements in retorts, methods of heating, etc., but small units are still used and the labor cost is correspondingly high. It is impossible to predict what improvements in the metallurgy of zinc will come, but it seems almost inconceivable that modern science will not develop either new methods of smelting or direct electrolytic processes. The new method, used in New Jersey, of following the wastes of willemite concentration by means of ultra-violet light is of extreme interest, and the wastes, which formerly amounted to some 5 per cent, are stated to have been reduced to less than 2 per cent with the assistance of this method.

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Besides these losses in the mining and concentration of zinc ores, there are incalculable losses, which without question run into many millions of dollars and undoubtedly exceed the total value of the zinc mined, in slags and waste products from other processes. Zinc has been and in general still is considered about the worst impurity to be found in the ores of copper and lead, for it has always given trouble in their metallurgy. Accordingly, the practice has been so to run the charge that the zinc passes off in the slag and to a certain extent in the flue dust. The economical treatment of some ores has been impossible because of the high percentage of zinc that they contained and the consequent difficulty of separating the lead and copper. Much interest is being aroused in the subject and there is good reason to hope that careful investigation will in time overcome this loss and render available large deposits of ore now worthless. To make even an approximate estimate of the total loss of zinc is impossible, but it certainly exceeds many thousands of tons daily.

**RECOVERY OF ZINC FROM SCRAP.**

Owing to the comparatively low price of zinc there has not been the same interest in its recovery as in that of some of the other metals. About two-thirds of the zinc produced goes into the form of galvanized iron and a considerable proportion of the remainder into brass and other alloys. The zinc dross from the galvanizing of iron is returned to the zinc smelters and redistilled. The metal used to galvanize iron, although it greatly preserves the iron itself, is finally almost a total loss. Galvanized scrap, to be available for iron making, must first have its zinc removed, which can be done in a reverberatory furnace with oxidizing flame, the zinc passing up the stack. The zinc oxide is seldom recovered but can easily be saved when heat from oil or gas burners is used, and one plant in western Pennsylvania is recovering from clean galvanized scrap about 50 per cent of the zinc in the form of zinc oxide, which can be sold directly for paint. Almost no galvanized iron, except the clean scrap cut from the first sheets, is retreated. The quantities of this scrap have been as high as 300 tons per day, but are diminishing as the result of shaping the articles to be galvanized before the zinc coating is applied.

In order to have the iron from either tin or zinc scrap available for open-hearth steel work, the tin must be reduced to about two-tenths of 1 per cent and zinc to about three-tenths. Accordingly, from galvanized scrap some 10 to 12 per cent of zinc goes to waste. Much old scrap is smelted for sash weights, being useless for most other purposes.

A newly invented process for using some of the zinc drosses from galvanizing by treating them with still more iron and then coating
small iron articles and wire with this iron-zinc alloy has a promising field of usefulness.

Some 40,000,000 pounds of zinc oxide is used annually for a filling in automobile tires, and the remainder of the 60,000 tons now produced annually in the United States is used chiefly in paint. In neither instance is the zinc ever recovered.

WASTES IN BRASS MANUFACTURE.

W. H. Bassett a has brought out very clearly the great losses of zinc in modern methods of brass manufacture and states that there is 6 per cent of the zinc present lost in making brass castings and probably 10 per cent loss in making wrought brass. Brass furnaces are capable of great improvement, and it is certain that special forms of furnaces using an open blast cause even greater losses than those above mentioned. A careful study of the furnaces melting brass would almost certainly produce beneficial results. The problem is one of the greatest importance in the conservation of waste in alloy manufacture.

At atmospheric pressure pure zinc boils at about 930° F. When zinc is diluted with copper the boiling temperature of the mixture is, however, much higher. In present practice these zinc alloys are melted, either in crucibles with a simple charcoal cover or in open gas-fired furnaces. In the practically open containers of this kind it is not at all surprising that zinc sublimes from brass or other alloys at temperatures even below its melting point, for the vapor pressure of the zinc has no chance of ever reaching atmospheric pressure, since the vapor is continually carried away by the air currents.

The solution of the problem of eliminating this loss is undoubtedly the use of a closed furnace of some kind; an electric furnace properly constructed to overcome other difficulties, of which there are many, would be ideal. The cost of current might be high, but other advantages, such as large units, easy stirring, low labor cost, nonintermittent firing, and saving of zinc, would probably more than compensate. Every theoretical consideration indicates that there should be a great field for the electric furnace in connection with zinc alloys, and that with its use the present great losses of zinc in alloys would be largely overcome. Catching the zinc oxide from the present form of furnace is easy with modern methods of dust catching; but if coal or coke be used the oxide caught is so mixed with foreign material as to be worthless, except possibly for making zinc chloride for impregnating timber. By substituting petroleum or producer gas in firing, the recovery of the zinc oxide would probably even now pay commercially, but the problem of preventing its formation would seem to be even simpler.

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CONSERVATION OF GOLD AND SILVER.

In brass manufacture large quantities of clean scrap of known composition are directly remelted, with the addition of spelter to make up for that which is carried off in the flues. It is estimated that 7,500 pounds of zinc are passing into the atmosphere daily in the form of zinc oxide from the stacks of the brass-casting shops in Waterbury, Conn., alone. Dirty scrap, as well as the concentrates from the ashes of crucible furnaces and from molders' sand, are generally worked up as previously described in the recovery of copper, the zinc contained, roughly estimated as over 2,000,000 pounds per year, being a total loss.

As already indicated, there is no broader field for research or one that offers more to the cause of conservation than zinc losses and their prevention.

CONSERVATION OF GOLD AND SILVER.

The high value of gold and silver has not only been a natural incentive for the conservation of those metals, but has made profitable the recovery of all waste in their production. The cyanide process for dissolving gold gives a very high recovery and has largely superseded chlorination. Wherever lead or copper smelters are available the ores, unless of unusual richness, are simply smelted with the lead or copper ores. The silver and the gold are recovered from the lead by the Parkes process and from the copper through the residues from the electrolytic refining. The doré obtained is almost always refined electrolytically with some recovery of platinum and palladium from the electrolyte.

Gold and silver are being gradually accumulated in the world's stock. Scrap metal is gathered from the large manufacturing firms, and even the sweepings from small jewelers' shops are saved. Sweepings are also collected from dental houses. These so-called sweepings are generally hand sorted, platinum residues going to platinum refiners. The more valuable portion of the silver and gold scrap is melted with copper into bars and sold to the refiners on an assay basis. The bars are then cast into small anodes and the copper is separated electrolytically, the gold and silver going into the sludge to be treated in the regular manner. The copper anodes produced are always remelted and passed to the regular copper refinery, this double refining being commercially profitable on account of the quick recovery of the major part of the gold and silver, and the consequent lessening of interest charges. The poorer quality of scrap is broken up in ball mills to a fine powder so as to be readily sampled, and this class of "sweeps" is briquetted with a lime binder and is used as a part of the charge of a lead or a copper blast or shaft furnace.
NEED OF PLATINUM AND PALLADIUM.

Every effort should be made to search systematically for platinum in the placer and ore deposits of the western States, for the demand has greatly increased. Owing to the popular craze for platinum in jewelry and owing to its use in dentistry the price of this metal, which is now absolutely essential to scientific research, has trebled in recent years. One producing company is now obtaining each month about 150 ounces of mixed platinum palladium, which contains about 120 ounces of palladium. The metal is being saved in the refining plants, although as a rule smelters do not as yet allow anything for it in ores.

Platinum is being sought more and more in the West. The Rambler mine, which was supposed to be worked out, has seemingly struck ore again. This ore formerly carried about $14 worth of platinum per ton.

Palladium is used in jewelry and also in making the dividing scales of delicate astronomical instruments. Its price per ounce is about the same as that of platinum, but palladium has the advantage of lower specific gravity.

Platinum is being conserved by the substitution of a wire of nickel-chromium alloy covered with platinum for the entrance wire of electric-lamp bulbs. This alloy is also being used for other purposes for which pure platinum was formerly used. Also it is probable that the alloy developed by S. W. Parr, which is extremely resistant both to heat and acids, will find application in calorimeter bombs and for other purposes for which platinum is now required.

MAINTAINING THE SUPPLY OF TIN.

Although this country leads the world in the production of many of the important metals, an output of tin has been singularly lacking. There is some indication that Alaskan deposits may add to our resources of this metal, and it is possible that a considerable output may yet come from Texas and South Dakota mines.

Tin is a comparatively high-priced metal, and a domestic source of supply is greatly needed. In spite of the detinning recovery processes a large quantity of the tin produced each year is lost. However, great advances have already been made in recovering used tin, and the tin dressings of our tin-plate manufacturers are now largely remelted both in reverberatory and in special electric furnaces. Indeed, waste heaps of dross from former years have been carefully reworked. One company that has buildings standing on old accumulations of dross has seriously considered tearing down the buildings in order to recover the tin in the former waste.

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Four detinning processes are at present in use in America. All work over tin scrap and clippings incident to the manufacture of tinware and none, in spite of a popular belief, at the present time recovers any large amount of metal from old tin cans. Tin scrap to the amount of about 150 tons per day is treated in this country with a recovery of 1.5 to 1.75 per cent of tin. One company dissolves the tin from the scrap with stannic chloride and another with sodium hydroxide, but both recover the metallic tin electrolytically. A third company produces stannic chloride by dissolving the tin with liquid chlorine, and a fourth produces tin oxide, possibly by electrolyzing the metal in a bath containing sodium nitrate.

The obtaining of tin from tin cans is so complicated by the expense of gathering the cans, dissolving off the solder, and of removing the detinning agent from the irregularly crushed metal that it has seemingly not proved a commercial success. However, large quantities of tin cans are collected from city dumps and are remelted to an impure form of iron, generally used for sash weights in so-called sash-weight factories, which use not only scrap tin but also scrap galvanized iron without attempting to remove the tin or zinc, a process that would be necessary if this iron were to be used in the open hearth. However, most of the zinc or tin present passes off by the stack or in the slag. There appears to be about 2 per cent of tin on fresh tin scrap, but only about an average of 1.25 per cent on old tin cans.

THE WASTE OF CADMIUM.

As western spelter contains an average of over 0.3 of 1 per cent of cadmium and as there was 230,169 tons of this spelter produced in 1910 a there was, accordingly, over 700 tons of cadmium sold as an impurity in zinc in that year. Cadmium is easily distilled fractionally from zinc, in which it is an undesirable impurity, especially if the zinc is to be used for the manufacture of lithophone. Flue dust from coal-fired brass furnaces carries about 1.25 to 1.5 per cent of cadmium, which is about 5.5 per cent of the zinc actually present. On this basis there is some 400 pounds of cadmium lost each day from the flues of the brass works of Waterbury, Conn.

The United States imported 4,000 pounds of cadmium in 1910 and produced about 5,300 pounds, the price varying from 60 to 70 cents per pound. It is reported that furnaces capable of producing 1,000 pounds a month are about ready to operate. New uses for cadmium are desired. At present its chief use is in glass manufacture and as a constituent of easily fusible alloys. It has also found application as a constituent of a silver-cadmium plating alloy. If cheaper, it could be used extensively as a yellow pigment. Cad-

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mimum sulphide is said to have been used formerly instead of lead chromate as a yellow paint for horse cars, its use being necessary because the cars were kept in horse barns, where hydrogen sulphide blackened the chromate. Now that trolley cars have replaced horse cars, the cheaper lead chromate can be used to paint cars yellow.

THE LOSSES OF LEAD.

Van Hise states that the losses of lead are 15 to 20 per cent in mining, 15 per cent in concentration, and 15 to 20 per cent in smelting. A large part of the lead mined is applied to uses that prevent its recovery; namely, as a pigment and as a filler for rubber. Perhaps 30,000,000 pounds of lead carbonate was used as a filling for rubber goods during the past year.

NEED OF CHEAPER METHODS OF OBTAINING ALUMINUM.

Twenty years ago aluminum sold for $5 a pound; to-day it can be bought for less than 20 cents and still is obtained from only one ore, bauxite, the deposits of which, although far from inexhaustible, are much more extensive than generally supposed. Though bauxite is still cheap a and is reasonably available, there is great need of a method that will cheaply convert it or some other material into pure aluminum oxide, since pure alumina, free from iron and silica and ready for the electrolyte, now sells for about $60 per ton. Bauxite has many other uses and is needed for the manufacture of alum and aluminum salts in the chemical industries, also for making refractory and abrasive materials.

In the manufacture of aluminum one of the chief items of expense is the preparation, from bauxite, of alumina free from iron and silica. Extensive deposits of true halloysite on the eastern slope of Taylor’s Mountain, 5 miles north of Gore, Ga., are now being exploited; large deposits of the mineral are also known to exist in Indiana." Halloysite contains 30 to 35 per cent of alumina that is claimed to be soluble in dilute sulphuric acid and to form a clear white alum cake almost entirely free from both iron and silica. There seems to be no good reason when these facts become more generally known why methods can not be devised to obtain pure alumina cheaply from this source.

Any method for producing aluminum cheaply from clay would be of inestimable advantage. Several new patents have recently been issued and experiments are under way in this country which give some promise of success. The possibility of concentrating bauxite when mixed with clay has been little studied. There are known to

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a W. C. Phalen presents figures showing that the production of bauxite in the United States in 1910 amounted to 143,932 tons valued at $716,238, or $4.81 a ton. (Mineral Resources U. S. for 1910, U. S. Geol. Survey, 1911, p. 713.)

be considerable deposits in central Georgia that may pay for further exploitation. The consumption of aluminum has grown from 83 pounds in 1883 to 47,734,000 in 1910. Both the metal and its alloys are finding new applications daily.

ANTIMONY AND ITS USES.

Some losses of antimony are taking place from the flues of our smelters, but the amount is not comparable with the arsenic given off. Antimony lithophones are stated to have been successful in Germany. The oxide itself may be used as a white paint, and sodium metantimonate is a valuable constituent of enamels. It is an important constituent of bath-tub enamels, replacing to a considerable extent the more costly tin oxide. Its use in enamels placed on cooking utensils is forbidden abroad, but so far these enamels have not been widely prohibited in the United States. Antimony is an essential constituent of some of the most important alloys, especially type and stereotype metal and the bearing metals. Type metal for the main part derives its antimony from antimonial lead. Babbitt metal is supposed to be made by mixing pure antimony, because all antimonial lead contains deleterious arsenic, but doubtless large quantities of the antimonial lead are frequently used. An alloy of pure antimony with lead is now being used in the form of pipe and tubing as a conduit for carrying telephone and telegraph wires. This alloy may entirely displace the old lead-tin compound. The United States produces little pure antimony, although the Arkansas mines are again being opened.

THE PRODUCTION OF BISMUTH.

The uses of bismuth are growing and if the metal could be obtained more cheaply, these uses would be greatly increased. Inquiries have recently been made for alloys of bismuth and lead which were wanted by the ton if they could be had at a low enough price. Large quantities of bismuth are being wasted in this country. Probably 4,000 pounds per day is going out of the stacks of the smelters in the Western States, and it is understood that one or two smelting companies are already installing processes for obtaining the metal and placing greater amounts of it on the American market. In 1911 nearly three-fourths of the domestic consumption was imported. Bismuth is not a desirable constituent in lead, and it must be separated from lead that is to be used for many purposes. The bismuth now produced in this country is obtained as a by-product in refining lead. The lead is melted and allowed to crystallize, and the mother liquors become richer and richer in bismuth. Finally these mother liquors are refined electrolytically and the bismuth is recovered from the slimes.

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NEW USES FOR TUNGSTEN, VANADIUM, MOLYBDENUM, AND TITANIUM.

Among the comparatively rare elements that are becoming more and more prominent in industry may be mentioned tungsten, the ores of which to the extent of some 6,000 tons per annum are now mined and treated for use chiefly in the production of tungsten-chrome steel and the filaments of electric lamps. A moderate quantity of the metal is now being obtained from Colorado ores.

There seem to be opportunities in the metallurgy of pure tungsten which have not yet been completely developed. A few years ago tungsten was regarded as unobtainable except as a brittle metal, but by one of the most remarkable of the many investigations dealing with the application of science to industry the pure metal, although melting at a temperature above 3,100° C., is now being drawn into wire and molded into forms. More than a million feet a day of such wire is being drawn in this country for electric lamps, and hammered pieces of the metal are being utilized for the targets of unusually effective Crookes tubes for production of the X-ray. Tungsten ribbon is used in electric resistance furnaces in an atmosphere of hydrogen to produce temperatures heretofore impossible, except in the electric arc. The development of other uses for the metal is certain.

Vanadium is employed in the preparation of vanadium steel, which is supposed to have special toughness and resistance to shock. This element when added with chromium to steel can replace tungsten for the manufacture of tools capable of cutting when hot. Much less vanadium is required than tungsten, but because of price there is no present prospect of vanadium replacing tungsten for this use.

Vanadium ores occur in some quantity in Colorado and other parts of the West, but the known deposits there probably can not withstand strong competition, if such should develop, from the ores obtained in Peru, which are of very much higher grade and are found in that country in seemingly great quantities in one particular deposit.

The preparation of ferrovanadium is comparatively simple and the methods used are essentially the same as one used in the preparation of ferrotungsten. Although little information is at hand in regard to the methods for the preparation of ferrovanadium, the separation of the metal from the ores probably comprises treatment with sulphuric acid, evaporation of the solution, ignition, and reduction of the concentrate with the mixture of iron oxide and aluminum known as thermit.

In Maine and in the West occur large molybdenite deposits which have been useless for the reason that methods of separating this min-
eral from the gangue have not been successful until recently. Molybdenite in this country generally occurs disseminated in small particles through a large amount of siliceous material, from which it must be separated before chemical treatment. Accordingly, the only molybdenum used has been derived from imported molybdenite, chiefly from Australia and Ceylon, and more recently from Canada, in which countries masses of some size can be picked from the gangue by hand. Manufacturers have been willing to pay as high as $700 per ton for small lots of good hand-sorted molybdenite, but the market has not been extensive. Two new methods, one a flotation method and the other an electrostatic method, are now advocated for separation of the material, giving grounds for hope that American deposits of this mineral may soon be utilized.

Molybdenum has almost exactly the same effect on steel as has tungsten, and 5 parts by weight of molybdenum can replace approximately 18 parts of tungsten, but it is not used extensively in steel because tungsten is cheaper, and especially because molybdenum has the disadvantage of volatilizing out of steel rather easily even under the blacksmith's hammer. There seems to be little prospect that it will replace tungsten in ferroalloys, but there is a considerable demand for its salts in chemical laboratories and in certain blue pigments used in the manufacture of porcelain and for dyeing silks and woolens. It is of special value in steel used in the manufacture of permanent magnets. It can be obtained in the form of ribbon for electrical heating purposes. On account of its ductility and high melting point it is used as a support for the tungsten wire in incandescent electric lamps.

There is a growing demand for the mineral rutile, from which titanium is most readily prepared. The uses of this metal have greatly increased in the last few years. In its alloy with iron it is now used in practically all rails made of Bessemer steel, its function seeming to be to deoxidize and to denitrogenize the ingot so that the rails are sounder and stronger. There is also a considerable demand for the preparation of titanium carbide to be used in arc lamps of exceptionally high efficiency.

Immense quantities of titanium occur in this country in the form of titaniiferous magnetites, many deposits of which are now next to useless as iron ores on account of the titanium content. Some of these ores may perhaps be used in the manufacture of ferroalloys, but they are not used as yet for the making of the pure metal. Titanium is so widely distributed that it can be found in most rocks, although only in traces in some. In practically all secondary kaolins the element is a real nuisance on account of the yellow color it gives to wares.
POSSIBLE SOURCES OF RADIUM.

Radium is of value in the treatment of certain diseases and a larger supply is greatly desired by the medical fraternity. Foreign governments have undertaken its production, but nothing has been done in the United States, although two companies are now experimenting on its production. Large deposits of carnitite, a low-grade uranium ore, occur in Colorado, others have recently been found in Oregon, and there is every reason to suppose that exploitation of two mines known to contain pitchblende would produce an output of this wonderful but very rare substance. Investigations of methods of mining and concentrating the ore and of recovering the substance might well be undertaken with the hope of improving these methods and of increasing the stock of this truly marvelous substance. The price of radium is now about $80 per milligram of 2,000,000 power. The production in 1910 was 1.92 grams, which sold for about $150,000.a

NEED OF NEW ALLOYS.

No field for investigation offers more promising returns at the present time than that including a continued study of the properties of various known alloys and a search for new alloys for specific purposes. This fact has been clearly brought out in articles by W. H. Bassett,b by W. R. Whitney,c and by numerous publications of the American Society of Mechanical Engineers, the American Institute of Metals, the Institute of Metals of Great Britain, and the National Physical Laboratory of England. Wonderful results with reference to the ferrous alloys have already been attained, but work on the nonferrous alloys has not received so much scientific attention. The effect of comparatively few elements on brass, for instance, is known except of those, such as iron, which have a strikingly deleterious effect.

Alloy manufacturers have found out through sad experience some of the things that they must keep out of their alloys, but there is every reason to believe that the addition of other substances, also in small proportions, may be found to be as desirable in the making of alloys as in the manufacture of steel. If, for example, there could be found some substance that added to brass would greatly retard the growth of its crystals so that the cast metal would have a finely crystalline rather than a coarsely crystalline structure, the tensile strength of brass could certainly be increased at least 50 per cent. That a small proportion of copper added to iron almost eliminates the corrosive effect of weak acids or acid salts on the iron was discovered a short time ago, but the discovery is already of far-reaching importance.

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a Met. and Chem. Eng., vol. 9, April, 1911, p. 201.
The element boron has only recently become available through the researches of Weintraub, who has shown that the addition of a small proportion greatly increases the ease and perfection with which copper castings can be made. Such castings can now be obtained having a conductivity formerly impossible. Other instances might be given, but certainly in this field almost nothing is known compared with the results that intelligent research is certain to bring forth.

THE SEARCH FOR POTASH.

At present the United States is more dependent upon a foreign country for potash salts than for any other one commodity except coal-tar colors, which, like potash, come almost solely from Germany. The public press and the technical journals for some months past have contained article after article upon the subject.\(^a\)

In combined but unfortunately in relatively insoluble form there are unlimited supplies of potash in this country. Because no methods are known for economically obtaining the potash we are obliged to import from Germany about $15,000,000 worth each year. Potash is absolutely essential, and unless methods can be found for obtaining it from domestic supplies, we shall be obliged to continue to purchase it from Germany at a price at least 400 per cent more than the cost of delivery in New York.

The feldspars in the granite, as well as in the dikes or veins of pegmatite in this country, contain billions of tons of potash; the rocks of the leucite hills of Wyoming carry over 8 per cent; the alunite veins of the West contain some 10 per cent; and the giant kelps on the seacoast of California annually gather within their structure an amount of the valuable chloride that from analyses and estimates seems to exceed 8,000,000 tons. Yet in spite of the immense quantities of potash within the United States no method for producing the substance in quantity is yet developed.

The soluble potash of the German deposits, which are mainly in the region around Stassfurt, was gathered together by nature in enormous quantity in the bed of an ancient inland sea from which the supplies are now drawn. The material is in soluble form, and needs simply to be mined, being sold either without other treatment than simple grinding or after having been concentrated by evaporation and fractional crystallization. No like deposits are known in this country, although if a large number of widely separated bore holes could be sunk in selected areas it is by no means improbable that beds would

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be found. The ordinary bitterns from our salt wells, although invariably containing potash, carry too small a quantity to pay for evaporation. Chemical methods have been proposed for treating our feldspars, and one or two of these have some prospects of a limited success. Moreover, it is greatly to be hoped that the immense masses of seaweed, referred to as giant kelps, growing upon the Pacific coast may be utilized. Their dried substance carries in potash and iodine, according to D. M. Balch, who first described them, material worth about $20 per ton. Whether this material can be profitably extracted depends solely upon the cost of gathering and drying. The alunite deposits could certainly be worked commercially if they were only nearer the markets for their products, and they may be developed under present conditions. There is also a possibility, which seems well worth thought and experiment, that no little potash may be obtained as a by-product in cement manufacture, as suggested on page 39. Authoritative announcement has been made by the United States Geological Survey of the discovery of deposits of potash in the brines of Searles Lake, San Bernardino County, Cal. These deposits are estimated to contain 4,000,000 to 10,000,000 tons of potash. The discovery is of the utmost importance and is probably only a presage of the future. Confident prediction can be made that in time this country will be able to produce its own potash supplies. How soon depends largely on the energy and money expended in the necessary investigations.

WASTES OF ROCK PHOSPHATE.

The fact that the supplies of high-grade phosphate rock within our borders are sufficient for our needs for many hundreds of years to come is no good reason for the losses that are still taking place in Florida. According to Cameron the tonnage wasted in the Florida pebble field is two or three times the tonnage of rock saved, mainly because of washing away of fine particles by the water used to mine and clean the larger aggregates. In the Tennessee field the wastes appear to be fairly well in hand and reduced as much as could reasonably be expected. Mining has not begun to any extent in the immense fields of Wyoming, Montana, Utah, and Idaho. Exports of this material are falling off owing to competition arising from the unusually rich deposits that have been discovered on Christmas Island in the Pacific.

WASTE AND RECOVERY OF NITROGEN.

Ages ago there were stored up, chiefly through the influence of plant life, immense deposits of nitrogen. Although some of this nitrogen may have been brought into combination by means of electri-
cal discharges through the atmosphere, a highly probable assumption is that the larger portion of it was fixed through the same form of bacterial action that is now known to take place in the tubercles growing upon the roots of the *Leguminosae*. Certainly it appears to be true that the 500,000,000 tons, more or less, of sodium nitrate that is known to have been deposited in the desert of Atacama, Chile, is probably of organic origin; that is, animal refuse was oxidized and the nitrate was collected under peculiar conditions of high temperature and scanty water supply. Bituminous coal contains 1 to 2 percent of nitrogen, a small fraction of which can be recovered by proper methods. From these sources, except for the comparatively small amounts that have been conserved by saving animal and plant refuse and returning it to the soil, we have until recently drawn our total supply of nitrogen, that element which is absolutely essential for both plant and animal food. Our explosives, upon which depends our whole mineral industry, have also necessitated a large use of nitrogen obtained from the Chile deposits.

Our wastes of nitrogen, worth in combined form about 15 cents per pound, are almost inconceivable, and no calculation can give us a real idea of what these losses mean. Their immensity has so impressed the human mind that the daily press for years has contained article after article, now known to be needlessly alarming, in regard to the starvation of man through the inability of the earth to support plant life on account of a coming lack of nitrogen. Two million six hundred thousand tons of sodium nitrate is being produced each year in Chile, a rate of production which means that the exhaustion of these deposits is probably less than a century ahead.

WASTE OF THE NITROGEN IN COAL.

Although we produced last year over 406,000,000 tons of bituminous coal, we recovered only $3,800,000 worth of the $160,000,000 worth of recoverable nitrogen contained in the coal. Of course, it is entirely impracticable under present conditions to recover as ammonia all of the nitrogen that might be obtained, but it does seem most regretable that of 63,000,000 tons of coal converted into coke in 1910, containing $22,000,000 worth of recoverable nitrogen, only about one-sixth was treated in ovens or retorts which could make that recovery possible. The rest of the nitrogen in the coal went off as free nitrogen in the air.

Pennock, in an excellent article on "Losses of combined nitrogen," states that between 1893, when the first by-product coke oven was built in this country, at Syracuse, and 1910, "the coke coked in beehive ovens, where the volatile nitrogen was ruthlessly wasted in

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fire, amounted to about $10,000,000 tons. Had this been coked in by-product ovens the volatile nitrogen of the coal would have yielded 23 pounds of ammonium sulphate per ton, or a total of 9,315,000 tons, which at $60 per ton would have had a value of $558,900,000. But this would not be all. Had this ammonia been recovered, it would have been used on the soil as a fertilizer, and the crops would have been increased fully 20 per cent and the saving would have been many millions more."

It certainly is startling to realize, if the total nitrogen content of bituminous coal is taken into consideration, that last year we saved less than $4,000,000 worth of combined nitrogen from this source, whereas more than $2,000,000,000 worth of that stored up for us ages ago was dissipated into the atmosphere in the uncombined condition. Of course, the recovery of even 10 per cent of this amount is with present knowledge impossible, but it is interesting to note that the public and the manufacturers themselves are being aroused to the loss, that by-product coke ovens are being employed more and more, and that the question of producing combined nitrogen from the atmosphere is making a real beginning. Here again Germany shows her pre-eminence in chemical economics, as four-fifths of all her coke is made in by-product ovens.

FIXATION AND RECOVERY OF NITROGEN.

As an offset to this great waste of nitrogen there are at present five different methods for bringing this element into combination, and a sixth has been proposed. Four, and perhaps five, of these processes have already reached commercial success, but the tremendous amount of energy at present required for their prosecution raises an effective barrier against ever really offsetting the wastes that are taking place.

It is scarcely necessary to present details of the processes for obtaining nitrogen in the form of cyanamide as practised at Niagara Falls and abroad, or to describe the processes of Birkeland and Eyde, of Pauling, or of Schoenhof (Badische Anilin und Soda-fabrik process) which obtain nitric acid from the air by means of the high temperature of the electric arc, and absorb the acid in lime to be sold as calcium nitrate; or to repeat the published statements in regard to the Serpek patents for converting kaolin or bauxite into nitrides and then into ammonia, or in regard to the Haber method for the direct union of nitrogen and hydrogen under the influence of pressure and a catalytic agent.

It may be well to state that cyanamide is obtained by the action of nitrogen on calcium carbide heated to 1,200° C., a temperature at which it rapidly absorbs the gas and forms cyanamide. It is necessary, however, first to produce calcium carbide and to obtain
pure, dry nitrogen free from oxygen, which is done by liquefying air. The cost of these operations is the chief limitation of the process. It is true that there are now large wastes of almost pure nitrogen from the carbonating towers of soda plants, amounting to 2,940 tons per day, and in the air residues in the production of sodium peroxide, but these wastes are not yet available for cyanamide plants, owing to conditions of transportation and power.

Of the three processes for the union of nitrogen and oxygen at the elevated temperature of the electric arc the Birkeland and Eyde process at Notodden, Norway, has been so far the most successful perhaps because of cheap electric power and the use of many large furnaces. In 1910 the Notodden plant utilized some 50,000 kilowatts of electricity throughout the year, an amount that has probably been increased to 200,000 kilowatts. The output approximates 70 grams of HNO₃ per kilowatt hour. The furnace has the great advantage of being capable of use in large units, some of which are of 4,000 horsepower. It produces nitric acid as calcium nitrate, which commands a ready market. The Pauling process is being used near Briançon, France, and appears to be in successful operation. An American plant using this process has recently begun operations at Nitrolee, S. C. The Schoenhof process is to be installed in new works in Norway, together with the Birkeland and Eyde process, and it is estimated that the two processes will shortly be using 250,000 horsepower in that country. Even this tremendous expenditure of energy can, however, supply only a fraction of the world’s requirements for combined nitrogen, as one kilowatt year is required to produce 1 ton of 13 per cent calcium nitrate.

The success of the above-named processes at the present time is dependent almost solely on the factor of cheap energy. The principle of all is the same, namely, the utilization of the intense heat of the electric arc to bring about a reaction between nitrogen and oxygen and the quick cooling of the gases in order that the reaction may not reverse itself. In the Birkeland and Eyde process the electric arc is branched out by means of an electric field; in the Schoenhof process a similar active surface is obtained by producing in tubes long arcs up to 22 feet in length. In the Pauling process the arc is enlarged by means of a blast of hot air under pressure. Patents recently issued in Germany indicate that an entirely new method may soon be used, depending upon the reaction between nitrogen and hydrogen under pressure with the reaction hastened by uranium or some catalytic agent, the ammonia being absorbed as fast as produced. An inestimable advantage will be gained by procuring some
method by which nitrogen can be fixed without the tremendous loss of energy involved in heating it to 3,500° C., the temperature required in the electric processes.

The Serpek process, which is operating in France, treats a mixture of bauxite and excess carbon with air at high temperatures, resulting in the formation of nitrides, which, when treated with water or caustic soda, yield ammonia and oxides or hydroxides. The process was started with the idea of producing pure alumina as the main product and ammonia as a by-product, but the nitrides of impurities, especially of titanium and iron, have not been removed as easily as anticipated. A similar process employing the medium of aluminum nitride is being developed in this country, but no information has been published relative thereto. There is every reason to expect the success of a method using nitrides. Such a method is especially desirable because it will probably require much less energy than the direct-combustion methods.

It would seem that if bacteria can bring about the fixation of nitrogen on the roots of legumes, man also must sooner or later succeed in bringing about this reaction at moderately low temperatures and perhaps in time imitate the process through the use of catalytic agents.

WASTE AND UTILIZATION OF SULPHUR.

The waste and the utilization of sulphur are both enormous and depend largely on local conditions. We produce sulphur cheaper than any other country in the world, sell it at perhaps the highest price, and in the form of sulphur dioxide discharge it into the air from the stack of a single smelter in quantities almost as large as those utilized throughout the country from sulphur and domestic pyrite put together. If the sulphur discharged into the air from this one smelter were converted into sulphuric acid it would furnish more than enough sulphuric acid for the total fertilizer industry of the United States. This country is producing annually about 3,000,000 tons of sulphuric acid—the basis of all chemical industry—of which approximately one-half is used in the manufacture of fertilizers. The total amount of sulphur dioxide discharged into the air in this country would unquestionably suffice to make more than 8,000,000 tons of sulphuric acid. That the sulphur dioxide from smelter smoke can be recovered has been proved at zinc smelters and by the copper smelters of Tennessee, but the question of economical recovery is so closely connected with the question of transportation and markets that at present the idea of converting sulphur dioxide into sulphuric acid in sufficient quantity to fully utilize the waste gases seems almost hopeless for the western smelters. Indeed, if the total output were made into sulphuric acid it would probably at present
become a worse nuisance than the gases themselves, although the growth of the fertilizer industry in the West may largely solve the problem.

In the South, where the major part of the fertilizers made in this country is used, the sulphur fumes from two large smelters, which are near the phosphate markets, are being successfully utilized. At the present time probably 200,000 tons is recovered as a by-product in the roasting of zinc sulphide in regions where the sulphuric acid can find market, and probably 300,000 tons is recovered as a by-product in the smelting of copper; at the same time a great nuisance to the surrounding country has been largely mitigated. The smelting plants of the West are fortunate in having, comparatively near, immense deposits of phosphate rock which can be used for making phosphates as soon as a western market for the product is developed. Since, however, the western smelting plants are meeting much legislation against the passage of smelter fume into the air, and since the production of sulphuric acid can at best be only a partial remedy, other methods of disposing of their sulphur and waste material seem at least temporarily necessary.

Prof. Cottrell, whose process for the precipitation of solids from gases has recently been turned over to a research corporation under the auspices of the Smithsonian Institution, takes up this question in an interesting manner in an article on "Mineral losses in gases and fumes." He refers not only to the outlet through superphosphates, but also to a process for fixing the sulphur in harmless compounds by utilizing the fumes to decompose finely granulated and moistened basic slag and simultaneously to leach out any metal values that the slag contains. Prof. Cottrell also refers to a second process, now attracting much attention, in which the sulphur dioxide is reduced to elemental sulphur, which can be stored indefinitely, and he suggests that this sulphur might be utilized as a binding material for sand in the manufacture of drainage tile or for other uses of a like character to which it is not now applied on account of its price. Indeed, at the present time sulphur is being used in Philadelphia as a cementing material in which to set the trolley posts of the street-car lines. These trolley posts were formerly greatly corroded by electric currents and electrolytes in soil moisture, but the sulphur, being itself an insulator and being waterproof, appears to protect the iron and makes an excellent cementing material. Indeed, sulphur may possibly find much more extended use to preserve iron from the effects of electrolysis than has heretofore been imagined.

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c Young, S. W., Thioegen process for reduction of sulphur dioxide in smelter fume. Min. and Sci. Press, vol. 103, 1911, p. 386.
Prof. Cottrell also hopes that the pyritic smelting of copper in the blast furnace may be found to be possible with a smaller consumption of oxygen, in order that a considerable percentage of the sulphur may be sublimed without oxidation. If this result could be accompanied by the utilization in part of superheated steam in the copper converter so that there, too, some of the sulphur might be recovered without oxidation the problem would be a long way toward solution. Certainly the necessity of importing nearly $3,000,000 worth of pyrite each year is greatly to be regretted while these immense sulphur wastes continue.

**LOSSES IN THE UTILIZATION OF MATERIALS FOR POTTERY ENAMELS AND CEMENT.**

The cause of conservation can not be forwarded by any other one agency in a degree comparable with the influence that the various products of our silicate industries bring to bear. Bleininger has brought out this fact clearly. The chief raw materials that enter into the manufacture of clay products are absolutely inexhaustible. The deposits of clay, limestone, sand, feldspar, soda, and other basic material are unlimited and the minor materials, such as fluorspar, cryolite, niter, borax, and the various colors and opacifiers, can probably always be manufactured in sufficient quantity or substitutes can be found. The more these materials are used the greater will the saving be. These products are of the utmost importance in conserving fire risks through fireproof construction, in sanitation, in drainage, in bridges, culverts, and buildings, in the construction of permanent roadways and waterways, and in beautifying our homes and villages.

**POTTERY.**

One of the largest of our imports is pottery, the import value of which in 1910 amounted to $11,027,405, an increase of 40.73 per cent in 10 years. At the same time we produce in this country a still larger amount, chiefly of the coarser and less expensive kind, although potteries producing the very highest class of ware are developing rapidly. For our best ware much of the clay is imported, although there is little doubt that a careful study of our own deposits and methods of preparation would enable us to utilize domestic material more extensively than is done at the present time. This utilization is especially necessary, as some foreign countries threaten to prohibit the exportation of their special clays in the hope that thereby their own pottery industry will be protected.

The chief wastes appear to be in this use of more expensive foreign material when systematic study would undoubtedly enable our pot-

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teries to obtain all of their clays at home, just as they now obtain all of their feldspar and quartz. It is undoubtedly further true that intelligent management would enable potteries to use material that is not now available, especially the semikaolinized feldspars of the southern Appalachian region. Investigations now under way by the Bureau of Mines seem to indicate that there is no question that an immense tonnage of this material, heretofore considered of no value, may be readily utilized. Much of this material, with little additional expense, can be obtained in the same pits or mines from which kaolin is now taken. These semikaolinized feldspars are simply mixtures of kaolin and feldspar and are some of the purest known, being as free from impurities and yielding as white products as any found in the world. If the potteries could obtain this feldspar and this kaolin separate, they would themselves mix the materials according to their formulas to produce the highest class of ware. There seems no good reason why the materials should not be utilized by adding pure kaolin or pure feldspar to bring the mixture to the desired composition. Careful technical control is all that is necessary. Probably 200,000 tons of the purest material, which now goes to waste, can be utilized under scientific management, with advantage both to the producer and to the consumer.

Prof. Bleininger states that the chief loss in the ceramic industry at present is a loss of heat efficiency, and calls attention to the fact that in Germany special continuous kilns are used that effect a saving of heat of 50 to 70 per cent, whereas in this country periodic kilns are still used almost exclusively. He notes further that less than 20 pounds of coal out of every 100 used was actually applied to heat the ware.

ENAMELS AND GlaZES.

Glazed ware and enameled ware have a direct bearing upon proper sanitation and public health and their use should be encouraged in every way. They also serve as protective material for conserving metals, and they afford a ready market for such substances as antimony oxide, zirconium oxide, and borax. They are easily produced, and more general information in regard to them and their manufacture should be published, so as to make possible a cheaper production of enameled articles. Furthermore, enamel brick and tile, which are becoming more and more important from a standpoint of beauty as well as utility, can still be greatly improved, and much of the work now done by hand can be done by machine.

CEMENT.

The wonderful effect of the growth of the Portland-cement industry on the wastes of other materials can not be overestimated. In 15 years the output of Portland cement in this country alone has devel-
oped from less than 1,000,000 to nearly 80,000,000 barrels per year. The industry has supplied a cheap material which not only replaces iron and steel in much structural work but also is used as a coating for them, greatly increasing the life of the metal by protecting it from rust. Cement in the form of concrete has taken the place of millions of feet of lumber and gives a permanency to our structures that wood can not give. Not only is it used in our large engineering structures, but it is used for hundreds of minor purposes around the farm and the village. Indeed the concrete dwelling is becoming more and more in vogue, and with its comparative fireproof and weatherproof qualities, together with new methods for coloring and decorating, it promises to supplant the ordinary wooden house.

The development of the cement industry has been accompanied by keen competition and careful attention to detail, so that, fortunately for the people, the price of the product has been brought down to the low rate at which it can be obtained to-day.

The kilns have been gradually increased in size until a kiln 100 to 140 feet long is the rule rather than the exception, and much larger output and saving of heat has undoubtedly accompanied each increase in length and size. Still, to the ordinary observer there appear to be heat losses that ought to be prevented by some regenerative process. In most cement works the raw rock before being ground is dried in a separate kiln, while from the main kiln incandescent gases escape into the stack. The white-hot clinker falling from the front end of the kiln has to be raised to towers through which it slowly falls to be cooled, and here again there are immense losses of heat for which no practical method of utilization has yet been found.

Another loss which is much more serious than is generally realized is the flue dust that passes from the end of the kiln into the stacks and away. Actual measurement indicates that this flue dust is probably never less than 4 per cent of the raw material used and that in some plants it is more than 10 per cent. The loss is of particular importance because the material has been ground. Schott* states that this dust is being caught and recharged with profit in some of the German plants. In this country some of the cement manufacturers are threatened with restrictive legislation, and three plants at least have been ordered to shut down or put in dust catchers to eliminate a nuisance. A plant at Riverside, Cal., has already installed the Cottrell process for catching its dust, which was injuring the surrounding orchards so seriously that the plant had no choice but to catch the dust or to shut down. In this plant the raw material carries a small amount of feldspathic rock, and as a

consequence the alkali that it contains is volatilized and caught with the dust in the collectors. This dust averages about 2 per cent soluble potash, but certain samples obtained under peculiar working conditions have analyzed as high as 35 per cent soluble alkali, of which about one-half was potash. These figures show plainly, as indeed has been known for some time, that in the cement kiln the alcalis are for the main part volatilized. Moreover, it would certainly seem possible to increase the amount of potash-bearing material in the mix by the addition of either potash feldspar or such potash-bearing silicates as the green sands of New Jersey, without injuring the quality of the cement obtained and without adding to the cost of manufacture. With the catching of the dust it would then seem possible to obtain a by-product rich in potash, the value of which might cover wholly or in part the cost of eliminating a dust nuisance.

**UTILIZATION OF FULLER'S EARTH.**

The imports of English fuller's earth are regularly increasing in spite of the duty. Domestic production is still used chiefly for petroleum, whereas imported earth is used for edible oils. The deposits of fuller's earth in the South, especially in Georgia, South Carolina, and Alabama, are immense, and there is no good reason why any foreign earth should be imported. Deposits in Arkansas and Texas are also being exploited. Domestic earth could be easily produced at a profit at the present price if a sufficient output could be maintained. Several of the domestic earths bleach edible oils much better than the English. Lack of knowledge of methods of preparation for the market is one of the chief reasons why the domestic earths are not now used; also some manufacturers do not yet successfully remove from edible products the slight taste these earths are apt to impart. At least one large producer of edible oils now uses only American material.

**INFUSORIAL EARTH.**

Probably the largest deposit of fuller's earth in the world is at Lompoc, Cal. It is almost inexhaustible and is remarkably free from iron and other impurities. The earth is used in making light terracotta brick; in the beet-sugar industry it is used to assist in filtration, and it is also used as a boiler covering. The pure earth has been rather hard to obtain in the past, but the immense deposit at Lompoc, much of which is still open to exploitation, should encourage new uses for the material. Like many other deposits in the West, the cost of transportation is the chief obstacle to its present development. If it could be delivered at a low enough price on the Atlantic
seaboard, it would undoubtedly find extensive use as an insulating material, and be an effective agent in preventing heat losses.

NEW USES FOR ASBESTOS.

The uses of asbestos are rapidly increasing. They afford protection against fire and are effecting a real conservation of lumber. Asbestos shingles, asbestos plaster, and asbestos lumber are of the utmost importance, and their use should be encouraged. They are much less easily destroyed by atmospheric agencies than is wood and they are noncombustible. In building operations asbestos products have the advantage over ceramic products in that they can be sawed and nailed. With the aid of asbestos lumber it is now possible to erect and even to decorate a complete building without having wood or any combustible material in its structure. This country, however, produces at the present time a very small proportion of the asbestos it uses, although extensive deposits are known to exist in Wyoming. Recently new deposits have been opened up in Texas, and some of the best asbestos known for electrical purposes is said to occur within the Government reservation of the Grand Canyon.

POSSIBLE PROGRESS IN THE MANUFACTURE OF REFRUCTORY MATERIALS.

The industry of producing refractory materials offers an especially promising field of research. Many metallurgical furnaces have to be relined much more frequently than should be necessary, and while this relining is being done their operation must be suspended for weeks. A specific instance was recently reported in which the regular life of the furnace in an important industry was increased from six months to over two years simply by a careful study of the texture of the refractory bricks used and by the development of methods for decreasing their porosity. Great improvements have taken place in the past few years, but few careful scientific investigators have attacked the problem. Bauxite bricks offer an especially promising field if their cracking under contraction and expansion can be controlled—a result by no means improbable, for already one producer claims to have accomplished it. Furthermore, by the addition of alumina to the clay from which they are made it is quite possible that the best fire clays can be greatly improved and brick be made from them approaching in composition bauxite brick. There are also large quantities of highly aluminous clays in the bauxite regions of Georgia and Arkansas, which on investigation may prove to be highly valuable for refractory purposes. Some recent work by thoroughly competent experimenters\(^a\) indicates an awakening

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interest in the subject. The need for special refractories has been forced home by the much higher temperatures demanded in the chemical and ceramic industries. Indeed, the field of the electric furnace is limited chiefly by the ability of the furnace walls to resist heat. According to FitzGerald\(a\) brick made from special forms of silicon carbide and from electrically calcined magnesia have shown most excellent resistant properties. In this connection, there is a growing demand for zirconia, and an abundant and cheap supply of this material, or of any of the cerium group of earths, would prove highly important to electric-furnace development.

THE WASTE OF ARSENIC.

According to Harkins and Swain,\(^{b}\) about 30 tons of arsenic trioxide goes out of the stack of the Washoe smelter daily. This quantity means perhaps 80 to 90 per cent of the total arsenic coming into the plant, and, if correct, amounts to over 10,000 tons a year that is being thrown into the atmosphere by this smelter alone. Similar losses are taking place in almost every smelting plant in the country, and there is no doubt that over 25,000 tons of arsenic goes to waste each year. The output in 1911 increased nearly 300 per cent over that of 1910, chiefly because of the requirement put upon smelters for the collection of the arsenic formerly allowed to escape. Although the price has been greatly reduced, the oversupply is not being easily marketed.

Arsenic is used in large quantities in combination with lead as an insecticide, and experiments would seem warranted to determine whether arsenic sulphide or calcium sulpharsenite, both of which are probably quite harmless to plants, may not be substituted for lead arsenate, giving a much cheaper insecticide that uses more arsenic and conserves lead. Obviously, any proposed insecticide must not only be effective as a poison, but also must not injure the foliage of the plant upon which it is placed.

THE SUPPLY OF BROMINE AND CHLORINE AND THE NEED OF NEW USES.

There is apparently an overproduction of both bromine and chlorine in this country, and new uses are desired as an outlet for these elements. Bromates are incidentally made in the production of bromides and so far have had little market. Potassium bromate, however, is an excellent oxydizing agent, and its use for this purpose would seem possible of great extension. One to two pounds of potassium bromate added to each ton of solution of potassium cyanide in the cyanide process for gold is said to keep the bath "sweet," provided the bath is kept alkaline with lime. Any sulphides, sulfo-

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\(a\) Loc. cit.

cyanides, or ferrocyanides tending to reduce the value of the dis-
solved oxygen are seemingly prevented from forming by the presence
of potassium bromate.

Chlorine can now be obtained very cheaply in liquid form and can
be supplied either in regular cylinders, in cheap cylinders that do not
have to be returned, or even in tank cars. Processes are also being
exploited which produce the chlorine on the ground electrolytically.
These processes, although cheapening the application, tend also to re-
duce the market for the chlorine manufactured as a regular product.
A possible use for chlorine is for chlorinating certain pyroligneous
tars to be used in the preservation of wood. It may be possible also
to make cheap, noncombustible solvents by chlorinating certain
petroleum residues, like the cheap solar oil of Texas, which can now
be disposed of for only about 2 cents a gallon. Such solvents, espe-
cially if they do not attack metals, are greatly needed. Immense
quantities of chlorine in the form of calcium chloride are being run
off as a waste from the ammonia soda process works of the country.
One plant alone now produces daily 280 metric tons of calcium chlo-
ride, 90 per cent of which is a total waste. Ten per cent is, however,
evaporated and used in granulated form, chiefly in refrigerating
plants and on roads to lay dust. This material is also found to be of
great advantage if sprinkled in coal mines, as it tends to keep the coal
dust moist, and thereby greatly diminishes the danger of explosions.
Any nonhydroscopic substance added to water used to sprinkle coal
dust in mines has little more effect than that of a diluent. Water
itself quickly evaporates from coal dust in dry mines, and is carried
away by the ventilating currents. If calcium chloride be added, the
moisture is, of course, retained.

RARE EARTHS AND THEIR USES.

Comparatively little is known about a large number of the rarer
elements of which the earth is composed. Even the minerals that
contain them are little known and it is impossible to state how
extensively they occur in the West, for they may have been over-
looked as worthless. This assumption is especially true of such
elements as tungsten, vanadium, titanium, tantalum, columbium,
thallium, thorium, beryllium, and the 20 or more elements of the
cerium and yttrium earths. No one can say what an exploitation of
this field might lead to, but it is through pure scientific investigation
of such problems as these that many industries have been developed,
perhaps the most noteworthy being that of the Welsbach gas-light
mantle. In the production of thorium from monazite, by far the
larger part of the associated materials go to waste. About 30 per
cent of this waste is cerium and the remainder lanthanum, neodymium,
praseodymium, and other rarer elements of the rare earths. There is
every prospect that the cerium will soon be utilized and bring a fair price. The separation of the element from the other earths is no longer difficult and, once the element is in solution, can be brought about in a single operation. The properties of the metal in alloys some of which have most remarkable pyrophoric properties, are now well known and the metal can be readily reduced by the electric current. It is also probable that cerium oxide, lanthanum oxide, and the oxides of other rare earths that occur in these waste materials will become of special value as refractories, for they are among the most infusible materials known. Cerium is also finding use in the form of cerium fluoride in the flaming arc, and there is little doubt that this use may be greatly extended. The properties of some of the compounds of cerium to act as perhaps the strongest oxidizing compounds known may open up new uses for this metal.

Large and extensive deposits of barite occur in Missouri, California, and Nevada, but transportation costs make possible large imports of this valuable mineral. It is used in large quantities in the production of lithophone and in paints, and should be made to supply at least a goodly portion of the western demand for these materials. Recently opened deposits in central Kentucky are already entering into active competition with the foreign article, and as these, together with other deposits being mined in Tennessee, North Carolina, Virginia, and Georgia, can obtain lower freight rates to the eastern markets it is to be hoped that they may be able to supply all the needs of those markets. Large amounts of barite occur in some of the metalliferous ores of the West. The mineral has a high specific gravity, is difficult to separate, and has to be fluxed off; consequently it passes into the slag pile.

Apatite is associated with the magnetite iron ores of New York, and is left behind by the magnetic separators. Hundreds of thousands of tons of such waste have accumulated, containing about 30 per cent of phosphoric acid in the form of apatite mixed with hornblende and quartz. No economical method of further concentration has yet been found.

Mica is always in demand, especially in large sheets, or in scrap with low iron content. Mica scrap heaps at the exits of old mines have all been carefully reworked on account of the excellent insulating material they contain, as well as for the production of other products in which scrap mica has been utilized.

Immense deposits of graphite have not been available, on account of the impossibility of separating the mineral from the gangue, but it has been found that in many cases simple pulverizing and sifting

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through sieves will separate the fine granular gangue from the more flaky graphite. Also, both of the new processes mentioned (p. 27) as being used for the separation of molybdenite are claimed to be equally effective in separating graphite from its accompanying impurities.

Calcium also can be readily and cheaply obtained whenever a use for this metal is found. The available resources are absolutely inexhaustible, but only in recent years could the element be separated electrolytically.

Lithium carbonate is now a comparatively cheap substance, which could be produced in much greater quantities if more extended use were found. At present it is used only in medicine and in one of the latest forms of storage batteries which is now becoming prominent in the market.

Selenium and tellurium can be obtained in much greater quantities than is generally supposed. From our copper refineries and sulphuric-acid plants at least 300,000 pounds of selenium is going to waste each year. Up to a year or two ago no important use for selenium was known, although for some three or four years it had been secretly used in the glass industry. It is now known to be used to color glass red, and in small amounts to decolorize glass by neutralizing the green of ferrous iron. It is obtained as a by-product in the refining of copper. Probably about 20 tons per year now finds place in the arts. Selenium is the only known element having an electrical conductivity that varies with exposure to light. This property will undoubtedly give the metal especial prominence in the future, as its applications are developed. It is now used in automatic gas-light apparatus, especially on gas buoys, in a new selenium photometer, and in devices by the use of which the transmission of pictures by wire is proposed.

Tellurium is also going to waste in quantities comparable with the waste of selenium. No use of importance is known for the element, although it is obtainable at a low price and many tons a year could be furnished.

Silicon, next to oxygen, is the most abundant of all elements, and until recently has been obtained only as a chemical curiosity. It has wonderful powers of resistance to all ordinary weathering agencies, and if it could be applied as an impervious coating to rigid perishable materials, should greatly prolong their life. It has also some wonderful properties of resistance to chemical agents, is easily made, and except for its brittleness would probably find extensive use. Even now, however, uses are gradually developing, one of the most interesting of which is for the shoes of plows in certain acid or pyrite furnaces in which iron rapidly goes to pieces. Many tons of this element is used in alloy with iron, especially in electrical transformers. It reduces hysteresis losses and increases resistance.