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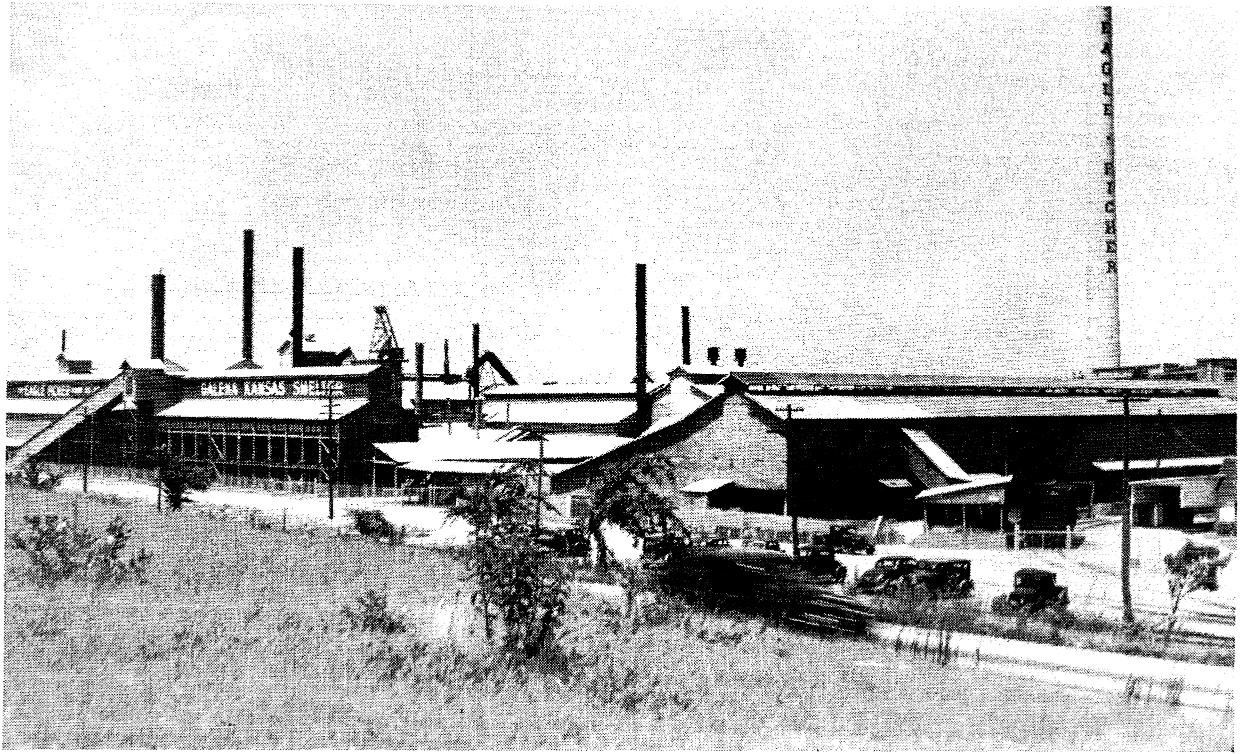

One of the largest zinc smelters in the world is located in southeast Kansas

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The Educational Leader

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The EDUCATIONAL LEADER

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How Big Is Your World?

Etelka Holt

Perhaps your world used to end at the foot of your own street. In the last few months we have seen the world contract before our eyes. We have been forced to broaden our vision and become familiar with countries and tiny islands hitherto little known. Improved methods of transportation and communication have reduced distances, have brought men in all parts of the world closer together, and have made them interdependent. Resistance to the improved concepts of international relations may be at the root of our present struggle, but whatever the cause, all nations are now being forced to realize the extent and depths of their interdependence.

A geographic background is essential for interpreting and comprehending the problems presented to us in world news. Such knowledge is vital to intelligent participation in economic and political life. If we are to be interdependent, we must have an understanding of how our neighbors live, we must know why they live as they do, and also know why we live as we do. This sympathetic concept will be essentially true in the readjustment at the close of the war. It is now admitted that many of the difficulties arising out of peace treaties following World War I were due to the imperfect geographic knowledge and conceptions of the statesmen who made the treaties; this must not happen again. More and more it is recognized that new political boundaries cannot safely cut across economic boundries based on natural environmental conditions. A region facing a waterway, down which commerce has flowed for centuries, cannot economically adjust to a new situation in which it turns about and faces a mountain barrier that has always lain at its back. The river that separated groups when transportation methods were primitive has in this later era united them with unbreakable commercial ties.

The airplane and the radio have made of our United States a single community living in constant touch with other communities all over the world. Distances are becoming shorter; contacts, more fre-

quent. A newspaper item in 1842 recorded the astonishing fact that a Chicago merchant made the trip from Chicago to New York in six days with only five changes in transportation: steamboat from Chicago to Buffalo, railroad to Lewiston, steamboat to Syracuse, railroad to Albany, and steamboat to New York. The account ended with the statement, "The trip was made without any delay. This is indeed rapid traveling." Today, one hundred years later, travelers fly from Chicago to New York in four hours. Planes now cross from Lisbon to New York in 22 hours; a hundred years ago the early steamboats required as many days.

The neighbors in our community are no longer contented with the view from their own doorways. As they travel back and forth on Main Street, from the Statue of Liberty to the Golden Gate, they will find inspiration or discouragement, opportunity or handicap, according to their equipment for seeing the world. All around them are the beauties of nature, the romance of the past. Those trained to observe can see that the streets of the community are laid out in well-defined patterns. Some were first followed by the buffaloes and the Indians who sought the easy grades and the waterways. Others, through modern engineering, have scaled high peaks and spanned broad rivers. Still others lead to cities that are interesting in their complexity or to regions that are fascinating in their simplicity. And at the end of some of the side streets are the uninhabited places, the fringe of living, where there is not even the coming and going of the dog team or the pack train. As the neighbors visit along the streets in the community, what do they see? It all depends on what they are capable of seeing. One sees a mining shaft where another sees a pile of dirt. In the mind of the first observer is aroused an intelligent appreciation of the commercial and political factors that accompany this economic activity. The second is bored or irritated by a pile of dirt.

Economic interdependence throughout the world brings about an interchange of wares and commodities, weaves a network of trade and communication that leaves out no part of the world, but relates all types of regions and all classes and races of people into one neighborhood, where every man must be more or less affected by his world neighbors. Many changes have been wrought in recent years by new discoveries and inventions. Resources that formerly went to waste are now used profitably; and further inventions and discoveries are certain to make it possible to use all our resources more completely. Nothing but an appreciation of the basic factors underlying the great commercial and industrial activities of our community can ensure intelligent citizenship. How often politicians and voters alike unwittingly insist on measures that meet immediate local needs, but eventually swing back to destroy.

What has the geographer to offer in the solution of economic prob-

lems? With a technical knowledge of the elements of the natural environment—climate, soil, relief, drainage, and mineral deposits—he is able to correlate data and predict with some degree of certainty the possibility of success or failure in establishing certain enterprises under certain conditions. The history of our great cities furnishes abundant proof of the relationship between human activity and the elements of the natural environment. Although man is not compelled to adopt any particular method of earning a living, certain elements of his environment will limit or further his plans for doing so. For example, Marietta, Ohio, was founded in 1788 as a river port for a great commercial empire to be developed in the valley of the Muskingum River. The hardheaded business men who laid out the town knew, in an era when water transportation served all commercial purposes, that the river was navigable for 250 miles and that its tributaries drained an immense territory. But they did not know that the sterile soil of the unglaciated plateau could not support an agricultural population. The Muskingum Valley was sparsely settled, and after a year or two westward immigration passed through. Marietta enjoyed a few years of prosperity, based on boat building, and then sank into relative insignificance.

Cincinnati, founded the same year, was the river port for the Miami Valley and adjoining areas underlain with limestone and limestone shales. Down the streams and roads came hogs and grain to be turned into meat and flour for the river trade. Cincinnati's population jumped from 2,500 in 1810 to 10,000 in 1820 and to 25,000 in 1830. With the advantage of this early start in commercial development, the city continued to grow.

The work patterns of our communities are interesting. Why did Chicago become overcrowded while several towns with the same soil and climate and not more than twenty-five miles from that city remain only sparsely populated? Why did the population of Leadville, Colorado, jump to 15,000 in the 1870's? The site of the town was at an elevation of 10,000 feet in a sagebrush valley that was almost inaccessible. But there were plenty of buyers eager for this property; yet at the same time real estate agents in a hundred other cities were offering lots with all improvements at bargain prices.

What men want badly enough they will find a way to get even though it is in the middle of the desert or beneath the frozen wastes. The potentialities of the polar regions and the tropics are hardly touched. Is this not why we number among our world citizens those who make daring trips to these places? Is this not why Admiral Byrd, Lincoln Ellsworth, and other explorers have made trips to Antarctica, an uninhabited continent which centers around the South Pole with an area larger than Europe. Lincoln Ellsworth in announcing plans for his seventh trip

to this polar region made this statement:

"Just three weeks ago I decided suddenly and overnight that I must go back to the Antarctic. I can sincerely say that this will be my last trip, and I mean it, but tomorrow I may have changed my mind."

Today our primary concern is not the conquest of our waste places. We have before us a twofold task—the winning of the war and the preservation of the American way of life. The news tells not of one battlefront but of several:

1. In western Europe
2. In eastern Europe
3. In the Mediterranean and northern Africa
4. In the Far East
5. In the Atlantic
6. In the Pacific

And yet this is not six wars but one. By our thoughts, our words, and our actions, we shall prove that this nation can pass through the flames of war and come forth victorious and free. Then will come the process of reconstruction for all of the world. On our American continent we have proved that all races of men—Japanese, English, Germans, Jews, and Italians—can live and work together in freedom and in peace. In the future this should also be true for the world pattern. For with contracted distances and complex industrial interactions, tyranny and freedom cannot live in peace.

Perhaps before many centuries, people will be able to circumnavigate the globe between sunrise and sunset. Communication may be carried on without wires or instruments. Even the last frontiers of the polar regions as well as the jungles of the tropics may be conquered and made productive. In fact there may be neither polar nor tropical areas.

How big is your world? Daniel Burnham says: "Make no little plans. They have no magic to stir men's blood and probably themselves will not be realized. Make BIG plans; aim high in hope and work. . . . Remember that our sons and grandsons are going to do things that would stagger us. THINK BIG!"

Rubber for War

O. W. Chapman

The great importance of rubber to a nation involved in war is vividly portrayed by Semon:[1]

> "In these days of modern warfare the outcome of a campaign may be determined long before the first shot is fired. Passive preparation is not sufficient. The victor is the one who has prepared men, materials, and machinery to strike dynamically, aggressively, and decisively. As rubber has been one of the stays of peace, it now becomes one of the sinews of war; for in accomplishing maximum efficiency in the air, on land, on water, and under water, rubber plays an indispensable role."

In Napoleon's day it was said that an army moved on its stomach, and, no doubt, it is still true that the smooth functioning of the soldier's digestive system is important, but mechanized warfare means that an army and its supplies must move swiftly and smoothly, and that means that they must move on rubber.[2]

Although the United States now has more rubber than ever before, it must be carefully conserved. This conservation is necessary because rubber[3] is essential for movement of goods and individuals by truck, bus, and car; for the transmission of power in insulated wires, for the transport of solids by conveyor belt, and for the carrying of liquids by flexible hose. Further, anything that stimulates business creates a demand for more rubber. Preparations for defense have created an increased demand for rubber for trucks, tanks, planes, and "jeeps." Defense requirements for 1941 probably totaled 100,000 tons of crude rubber; but that is less than 20 per cent of the total requirement.

USES OF RUBBER

In peacetime about 75 per cent of the rubber consumed in America goes into highway transportation; about 10 per cent goes into mechanical goods, as belts and packing; about 6 per cent is converted into footwear, heels and soles; 4 per cent is used in the wire and cable industry; while lesser amounts are employed for waterproofing fabrics and for mountings. A large amount of rubber thus appears to be indispensable.

In World War I, rubber was used chiefly in solid and pneumatic tires, balloons and dirigibles, and for protecting men and equipment from gases and the elements. In the present conflict, the uses of rubber have been greatly extended, largely because speed is essential to the modern army. Men and equipment must move from 40 to 50 miles an hour, while in the past movement of more than 20 miles a day was considered practically impossible. Motorized units necessary for rapid

[1] W. L. Semon, *Ind Eng. Chem.*, 32, 1153. (1940).
[2] W. L. Finger, *Ind. Eng. Chem.*, 33, 1335. (1941).

transportation must have rubber tires or rubber tracks or both. They should be puncture proof or self sealing. A few of the other important uses of rubber in time of war include such items as: bullet sealing gas tanks (important to safeguard fuel supply); de-icers (pulsating rubber attachments); fire hose (important in bombed cities); pressure hose (to operate controls for submarine mines and gun turrets); storage batteries of submarines and aircraft; ship protectors against magnetic mines; pads to protect occupants of tanks; gas masks; boots and shoes, soles and heels; raincoats; surgeons' gloves; life jackets; pontoons; bouys; rafts and boats; barrage balloons; recoil mechanisms; and many others.

AMOUNT OF RUBBER REQUIRED

The amount of raw rubber used by the manufacturers of America has been growing steadily; in the early months of 1941 an average of from 50,000 to 60,000 tons were processed monthly. This is more than the amount used by all other countries combined. The added impetus of defense activities caused such a sudden increase that in the month of November, 1941, nearly 85,000 tons were consumed.[3] This means that the annual demand of 600,000 tons or more, at the present rate of increase, will soon reach fablous heights.

RESERVE STOCK

An unlimited stock pile of crude rubber cannot be accumulated without rotating at regular intervals to prevent deterioration. The rubber industry has used old government stock, replacing it with new, to prevent excessive deterioration and make possible the acquisition of an adequate reserve supply. Approximately 600,000 tons of crude, less than a year's supply, was estimated to be available at the close of 1941.

The supply of raw rubber is augmented by reclaimed rubber, the first line of defense against interruption of the supply from the East. Reclaimed rubber is now used at the approximate rate of 30 per cent of crude; within 18 months it can be used at twice this rate. The year 1941 saw 263,000 tons reclaimed in the United States, with 29,000 tons on hand at the end of the year. To insure the constant reclaiming of rubber, raw rubber must be used continually, and large quantities of caustic soda, pine oil, cotton, carbon black, and electric power must be available.[4] The product which results from these ingredients is not suitable for tire treads, but it is satisfactory for many purposes.

The demand for rubber articles is so great and the military needs so urgent that it has become necessary to place restrictions on the use of rubber goods; the rubber industry has become almost a nationally run industry. Each manufacturer is told how much raw rubber he can use, for what purpose, and even the amount of reclaimed rubber he may have. Stringent regulations are nec-

[3]E. G. Holt, *Ind. Eng. Chem.*, 33, 1339. (1941).

[4]J. P. Coe, *Ind. Eng. Chem.*, 33, 1347. (1941).

essary to prevent depletion of reserve stocks in case the sea lanes, over which come the supplies of crude rubber, should be closed.

SOURCES OF CRUDE RUBBER

The Middle East countries now furnish nearly all of the natural rubber, and they are the only ones that can supply our needs for years to come. Open sea lanes in the Pacific are just as essential as the trans-Atlantic routes. As our enemies know our need of rubber they seek to encircle, isolate, and blockade the countries from which it comes.

If the entire production of natural rubber of South America and Africa should be available in the United States, the supply would not last three weeks. To extend plantations in these continents to a point where we would be fully supplied would probably require about twelve years. It is reported that the South American supply could be greatly extended by utilizing the wild rubber available, although it is in rather inaccessible places. When it is realized that the American people move on rubber and use rubber in more than 30,000 different articles,[5] it is evident how dependent we are on the Far East.

STATUS OF SYNTHETIC RUBBER

In view of the possible severe curtailment of natural rubber, the interest of manufacturers naturally has turned to the possibilities of the so called synthetic rubbers. During the first World War, Germany produced 150 tons monthly of an inferior synthetic product, but production was abandoned at the close of the war.[6] Some years later, Germany produced a series of synthetics more nearly approaching natural rubber in properties. At least six American companies have developed methods similar to those of Germany. American manufacturers have a distinct advantage in that they have a nearly limitless supply of raw materials in petroleum, whereas Germany has to rely on more expensive methods starting with coal.

The synthetic rubbers are polymers of various unsaturated compounds, the most successful being interpolymers of butadiene with styrene or acrylic acid derivatives. The list of synthetics includes du Pont's neoprene which has been produced for several years. It is a polymer of chloroprene, which is made from vinyl acetylene and hydrogen chloride. The raw materials are coke and salt. About 550,000 pounds a month were made in 1940,[7] selling at 65 cents a pound.

Other synthetics being produced in the United States, or about to be,[5] are Buna-S, an interpolymer of butadiene and styrene; Perbunan, also known as Buna-N, an interpolymer of butadiene and acrylic nitrile; Perbunan Extra, made by using different proportions of the same materials used to make Perbunan; Ameripol, an interpolymer of butadiene and other materials not

[5] E. V. Murphree, *Ind. Eng. Chem.*, 32, 1157. (1940).

[6] C. R. Park, *News Editon*, 1393, Dec. 10, 1941.

[7] E. R. Bridgwater, *Ind. Eng. Chem.*, 32, 1155. (1940).

disclosed, but possibly butylene and isobutylene; and Butyl rubber, an interpolymer of simple olefins with small amounts of diolefins.[8] The last is a 100 per cent petroleum product and the cheapest of all to produce, with the possible exception of Buna-S. Other synthetics are suitable for a limited number of uses as hose, gaskets, wire insulation, and coated fabrics. These include the plasticized polyvinyl chlorides, Koroseal and Vinylite, and Thiokol, made from ethylenedichloride and sodium polysulfide, and Vistanex, polymerized isobutylene. A great number of polymers and interpolymers of such compounds as vinyl substituted hydrocarbons, alcohols, ethers, aldehydes, ketones, acids, esters, nitriles, and others, in addition to the compounds listed above, might be used.

In addition to the raw materials previously mentioned, substantial tonnages of other materials, such as polymerization catalysts, emulsifying agents, and stabilizers are required for all synthetics. The production of emulsifying agents requires animal and vegetable oils, of which there may be a serious shortage. Ammonia and alcohol are used to make stabilizers. Many tons of aluminum compounds are used as catalysts. Even common acids and alkalies are potential bottle necks. While the synthetics do not require the same chemicals for processing as the natural product, since some of them need no accelerators, there still remain a number of chemicals that may be difficult to obtain in sufficient quantities. Some of these are zinc oxide, aniline, carbon disulfide, formaldehyde, acetaldehyde, butyraldehyde, acetone, and naphthylamine.

SYNTHETIC RUBBER PROPERTIES

Many of the synthetic rubbers have proved superior to natural rubber in resistance to oil, gasoline, and sunlight. Since about 75 per cent of our rubber is used for tires, the question asked by the layman is: Is it satisfactory for tires? According to Bridgwater[9], a number of synthetics can be made that produce satisfactory tires provided that they are used only on good roads at moderate speeds, the cars being in good mechanical condition and accelerated and decelerated slowly. Street and Ebert[10] report that road tests on passenger car tires have shown the butadiene-styrene interpolymers, neoprene, and butadiene-acrylonitrile interpolymers to be the equal of natural rubber in tread wear. Tests have also shown that these synthetics may be superior to natural rubber for truck tires under severe conditions.

EXPANSION AND COST

The rate of production of some synthetics in long tons in America during the past three years is shown below:

Year	Neoprene	Butadiene Types	Polysulfides
1939	1750	None	500
1940	2500	60	700
1941 (est.)	6300	4000	1400

[8]R. M. Thomas, and others. *Ind. Eng. Chem.*, 32, 1283. (1940).

[9]E. R. Bridgwater, *Ind. Eng. Chem.*, 33, 1342. (1941).

[10]Street and Ebert, *Rubber Chem. Tech.*, 14, 211. (1941).

By the end of 1942 America expects to be producing monthly: 1600 tons of neoprene; 900 tons of butadiene polymer; and 3,300 tons of butadiene-styrene. This will make a total of 5,800 tons a month, greater than the present German production. In addition, 1,500 tons a month of other types will be produced. By the end of 1943 it is estimated that America will be making approximately 60,000 tons a month, sufficient for normal needs.

The cost of producing synthetic rubber in these greatly expanded plants will be perhaps 25 cents a pound, compared to the present price of 15 cents for natural crude. To accomplish the complete substitution of synthetic for natural rubber would require at least 16 plants, each producing 100 tons a day.[1] There is no such plant now. It would also require the construction of plants to make such raw materials as butadiene and styrene. The estimated cost of plants equipped to supply these materials in amounts large enough to produce 3300 tons of rubber a month would be $25,000,000. When the cost of power plants, maintenance shops, etc., is added, the total cost of building these plants would be at least one half billion dollars.[9] This estimated cost is for the production of 3300 tons monthly, but nearly 20 times this amount must be made if the supply of natural rubber is shut off.

The cost of the plants is not the only difficulty. The industry must have technical personnel trained in this field. No such group is now available. Experience in large scale production is also lacking. The time required to build the plants is another important factor. How long it would take for the necesary number of plants can only be estimated. The Dow Company built in three months a plant to produce 1,000 tons a year.[11]

The question in the minds of all Americans is, under the present emergency, regardless of cost, can synthetic rubber be substituted for crude natural rubber? The answer is yes, for du Pont, Standard Oil, and Dow alone could take care of the demands.[11]

[11]B. L. Longstreth, *Ind. Eng. Chem.*, 32, 1156, (1940).

Australia and the United States

Elsie Broome

Most Americans have little knowledge af Australia's size, population, resources, and developments or even its position in the world. If the average American were ask to give the location of Australia on the globe, the question probably would receive such an answer as, "Oh, somewhere on the other side of the world from us."

In the last few weeks one hears such questions as: "What has Australia to fear from the Japanese?" "Why don't the 'Aussies' just go up there and bomb those dirty little Japanese Islands off the map?" "Why don't the Australians go to the rescue of the British in India and the Americans in the Philippines?" The average American does not know that Australia is sadly lacking in man power. This is probably her greatest handicap in facing a country with twelve times as many people, who have been taught that their highest aim in life is to die for the state.

Australia is more vulnerable to attack than is the United States. If we can imagine the East Indies, the Philippines, and several thousand other small islands west of San Francisco, all strung out along the route to Japan, we would be in about the same strategic position as Australia. Our west coast cities would then be in much greater danger of Japanese bombs and sea raiders than they now are.

If we exclude Arkansas, Australia would then be slightly larger than the United States. For illustration, let's put half the population of New York City into six coastal cities, such as Richmond, Wilmington, New Orleans, San Diego, and Seattle. Then let's locate out of this same half of New York City's population ten thousand in Washington, D. C., and a thousand in Kansas City. The result would be a fairly good illustration of the distribution of half of Australia's people. If we would then distribute the other half of New York City in an area from the coast to two hundred miles inland in the two Carolinas, Georgia, and Louisiana, a few thousand in southeastern Texas, Portland, Oregon, and northern Idaho, our whole population would then compare in number and distribution to that of Australia. Our northern and western coastline would have only a few small settlements separated by hundreds of miles of uninhabited lands with vast areas in the interior without a single inhabitant.

Northern and central Australia have a population density of one person for every 175 square miles of land. Large numbers of small seagoing boats could land and unload their cargo of enemy troops, planes, and tanks without being observed by the inhabitants. Only one telegraph line, one railroad, and two

air routes connect the great northern area with the cities of the southeast. Since the major part of western Australia is an old worn-down plateau with low level terrain, it would be ideal for troop and tank movement as well as for the construction of airplane fields. The enemy could easily and quickly move to the south and east and overrun the entire continent, leaving the few cities, with their backs to the ocean, nothing to do except surrender or be pushed off into the ocean.

When we compare these conditions with our own, we find that we are almost twice as far from Japan as is Australia without any stepping stones between; hence we are not nearly as vulnerable to attack. When we compare 132,000,000 people with Australia's 7,000,000, it can readily be seen why the Australian Prime Minister recently appealed to the United States for protection. In peace time passenger travel from San Francisco to Sydney required 19 days over the 6,000 mile water route; from Great Britain to Sydney via the Suez Canel it took 38 days to cover the 12,000 miles; via Cape Town it took 45 days to reach Sydney from London; today more than 45 days are required over the only open route from London to Sydney.

The history of Australia is similar to that of the United States. The first permanent settlement was made in Australia near the closing year of our American Revolution. The first settlers consisted of 800 convicts and 700 soldiers sent to guard them. In the whole group only one man was a farmer by trade, and the settlement had to live by raising its own food and by coastal fishing. Many of these so called convicts were in prison because they had dared to criticize the home government or the ruling politicians; others were in prison because they could not pay their debts.

The small semi-circular area on which Sydney is located has an excellent harbor, but it is hemmed in by a rugged hinterland just as the American colonists were held to the coast by the Appalachians. It was not until several decades later that a small group of men looking for pastures for the fast growing herds of sheep followed down the western side of the mountains to the coast on the south, the present site of Melbourne.

Several reasons hindered the growth of the small settlements at Sydney and Melbourne for many decades. Early explorers had given reports in Britain exaggerating the unfavorable geographical conditions to be encountered in this new land. British farmers did not know how to raise semi-tropical crops; land owners were enclosing fields to raise sheep and provide wool for the fast growing textile industry in England, the industry which started the Industrial Revolution. As the unemployed farm laborers did not have the money to buy land and tools and pay transportation to the new colony, they moved to the cities and found employment in the factories or were taken care of under the dole system of the government.

Since the Germans, Poles, Swedes, Danes, and other peoples of western Europe who helped settle the American Colonies found good land and climate much the same as in their homeland, this semi-tropical region twice as far from their native land as was the American Colonies did not appeal even to these land hungry people.

Soon after the gold rush of California, gold was discovered in Australia and her population doubled in two decades, but even this failed to bring the needed classes of white people. The Japanese and Chinese were permitted to come into the country to work in the mines, but they came in such numbers and increased so rapidly that the Australians began to fear Oriental domination. The states passed the "White Australian Policy," which prohibits immigration of all peoples of the black and yellow races and encourages peoples of Western Europe and North America. South Europeans, particularly Italians, began pouring into the country; here they found land and a Mediterranean climate which would grow the kind of crops they raised at home. The Italians did not easily become assimilated by the British Australians, for they were clannish, worked longer hours, and were thrifty. On the other hand Australians had the care-free, luxury-loving spirit which is typical of the British people. Race riots became common occurrences, and the government had to limit the number of all south Europeans by immigration laws.

In our early history if the European immigrants did not agree with our settlers on the eastern seaboard, they could move overland by way of east-west flowing rivers to the interior of the continent, where they could build homes and become as clannish as they wished so long as they remained loyal to the Colonial government. But Australia lacks this vast system of water transportation, as she has only one river of note, the Murry-Darling, and that can compare only with one of our lesser river systems, the Rio-Grande-Pecos of Texas. Even the Murry-Darling has its source on the west side of the mountains and flows away from the centers of population. When Australian settlers found routes to the interior, they did not find a Mississippi-Ohio Basin but a semi-arid land that is best suited to grazing and supports only a sparse population.

Australia's coal, iron ore, copper, tin, lead, zinc, and large areas of good agricultural land can furnish basic raw materials for a potential manufacturing that could become a small rival for our own industrial East. The East Indies can furnish Australia with petroleum and rubber as well as a market for manufactured goods if the Indies can be kept in friendly hands. Two of Australia's handicaps in manufacturing are a scarcity of labor and a competitive market with Japan. The Japanese worker receives a mere pittance, but wages are high on the continent. However, in raw materials Australia has the distinction of being the world's greatest producer in proportion to her pop-

ulation. She also has a higher per capita foreign trade than does the United States. Her trade is mostly from the ranch and farm which in value goes first to Great Britain and second to the United States. To us she sells wool, rabbit skins, cattle hides, canned butter, gold, and tin; to Great Britain she ships not only the above named items, but also wheat, frozen and chilled beef and mutton, dairy products, and tropical and temperate fruits, both fresh and canned.

Early in Australia's history a few high grade breeding sheep were acquired from the semi-arid lands of Spain and the cool temperate land of England. With this small beginning Australia has improved her flocks until she now has one-sixth of the world's sheep and produces not only one-fourth of the world's wool but also wool of the highest quality.

The general idea in the United States is that all or most of Australia is a desert with no economic possibilities. In much the same way our early forefathers thought of our Great Plains when they crossed the expanse of land from the Mississippi River to the west coast. But this was an erroneous idea because one-third of our so called desert now produces great quantities of wheat and other small grain as well as live stock. So might this "desert" of Australia be made to provide homes for thousands of agriculturally minded people as well as to produce much more food for world consumption. This oldest continent geologically has only two carniverous species of animals; all others are herbiverous. Nature seems to have aided the animals of this far away land by creating more types of vegetation which can be used for domestic animals than are found in the semi-arid lands of the United States. Five great artesian basins near the surface furnish water for cattle and sheep which thrive on native vegetation. State governments aid ranchers in the "outback" by putting down wells every 12 miles along stock routes over which cattle and sheep are driven to the southeast for overseas markets. Artesian wells on ranches provide water for stock, for domestic use, and for irrigation of both subsistence and forage crops.

In America the Australian is pictured as riding madly over vast areas after sheep or living in the wilds among native "black fellows" and kangaroos. This is not true, since 48 per cent of the nation's people live in half a dozen metropolitan cities, two of which are the third and the fifth largest cities of the British Empire. Economists give three reasons for this urbanization:

1. Importance of the wool industry which requires little labor.
2. Large scale farming machinery which permits vast acres to be cultivated with little labor.
3. High standard of living which prevents the growth of subsistence farming.

In literacy, Australia surpasses the United States by one and one-half per cent. Children of the remote interior are instructed by private or traveling tutors who are paid by the state government.

This British speaking nation patterned her legislative and judicial departments after those of the United States. She has a constitution; her senate and house of representatives are elected much the same as those of the United States. The executive branch of government is patterned after Britain which consists of a prime minister and his cabinet who remain in office only as long as they hold the confidence of the people. A governor-general is appointed by the Crown to represent the mother country, but like the British King, he has little part in the Australian government.

Generally speaking, the Australian citizens do not display a great interest in politics. In fact, this lack of interest in the political side of their national life led to the enactment, about 20 years ago, of legislation making it compulsory for every citizen over the age of 21 to vote at the election, or forfeit two pounds. The *Official Handbook* of the Australian National Publicity Association describes the attitude of the Australian toward politics as follows: "Australian democracy has come to look upon the State as a vast Public utility, whose duty it is to provide the greatest happiness for the greatest number." The same publication defines the status of the country as: "Australia and the other Dominions are now equal partners with Great Britain in the British Commonwealth of Nations. . . . the Dominions can enter into direct relationships with foreign countries and decide matters of high policy." Australia gave the world the secret ballot which helped to decrease fraud in federal and state elections. In social legislation she also led the way with pensions for old age and widows and government insurance for the unemployed.

As compared to our own great railroad systems, she is sadly lacking, having only two transcontinental roads, one from north to south and one from east to west. Her east-west railroad crosses almost two thousand miles of uninhabited lands to connect less than a million people with the more densely populated eastern side.

Australia possibly leads all other countries in the use of the radio as a means of communication. Ranchmen living outside urban centers use receiving and sending radio sets. One writer tells of several ranchmen spending a quiet evening visiting with friends in widely separated sections. They swap stories, gossip, discuss market reports, or just visit. One thing lacking is a discussion of weather, since the weather there is about the same all year. Even doctors use the receiving and sending radio to prescribe to patients in the "outback," and when it becomes necessary to see the patient the doctor travels by airplane.

The Australian soldiers are noted for their gallentry and bravery the world around. In the former world war they became the terror of the foe on every war front in which they served. One historian tells of a small company of Anzacs who captured six thousand Turks in Palestine using only empty guns, a few hand grenades, and a lot of bluff.

We remember in the past year how the Australians made the Lybian Desert ring with the words and tune of our own clever little song, "The Wizard of Oz." Many humorous incidents were cited in which the charging battle song of these Anzacs so terrified the Italians that scores of them often swarmed out of entrenchments with hands up, only to find that they had surrendered to a half dozen Australian or New Zealand soldiers.

The following story from a Kansas newspaper indicates the unbound energy of these boys from "Down Under" on a British ship enroute to North Africa. When the ship docked at Capetown for supplies, the boys swarmed ashore and caused so much excitement in the city that the British commanders put them aboard and sailed out of the harbor where supplies could be brought out to the ship in small boats. During the wee morning hours a distressing message was sent to the commander of the ship to come and rescue the city from the Australian-New Zealand troops. It was found that the boys had gone over the sides of the boat after dark and swum two or three miles to the shore. These men from the wide open spaces were not accustomed to the rigid discipline of their British comrades. The officers, not wanting to dampen the spirits of these brave lads, rushed them to the Libyan Desert where their exhuberence could be spent in dislodging the Italian's hold on North Africa.

One of our newspaper correspondents who was permitted to watch these boys in action says: "They are from two to four inches taller and twenty to forty pounds heavier than the British soldiers. When it becomes necessary for the Australians to fight, they behave with perfect discipline under fire; they are the friendliest fellows found anywhere and yet the most deadly warriors." Their casualty list in death and disability is highest, and the number of prisoners taken from among them is the lowest, of any nation in the war. At present, the New Zealanders are helping to drive out the invaders from North Africa and the Australians are helping to hold India.

Early in 1941 Australia sent several ships loaded with troops, guns, tanks, planes, ammunition, and food to Malaya. All of these were supplied by the few million Australians back home.

Australia asks the United States and Britain to send laborers and to unite with her in building war supplies in factories which are already established where ships, guns, bombers, and other supplies can be built and sent to the Eastern war zone more quickly than from either the United States or from Britain. To aid in the defence of the country Australia recently built a road from Port Darwin on her north coast to supply depots in the interior of the continent. This 836 miles of road over hot-wet jungle and hot dry desert was built in ninety-three days, showing what Australians can and will do to aid in the war. An Australian labor leader says, "A peace loving people are fighting

this war because they see the liberties, privileges, and standards of living won by political and industrial battling threatened by the triumph of Facist ideology."

Australian newspapers tell their people they expect the United States to play a larger roll in that country's future than she has in the past. Her political leaders also say, "In seeking opportunity the American slogan has always been 'Go west, young man.' Now that the western United States is so highly developed, Australia is still a western land of opportunity."

We are invited to use this vast area as large as our own country as a base for air, sea, and land operations from which we may eventually push northward until Japan herself is invaded and forced to surrender her zeal for Australian and Pacific domination.

Japan looks with hungry eyes upon Australia because there is good land upon which to settle many of her one hundred million people. Japan has two hundred times the population density of Australia. If we are to save Australia as well as ourselves from these hoards of yellow men, let us understand and not minimize the importance of Australia with her English speaking people, economic possibilities, loyalty, courage, and valor, and with an ideology similar to that of the United States. She is worth protection and help.

Use of the Electron Theory in Teaching Elementary Electricity

E. W. JONES

The classical period in the development of physical science is considered to have ended about the year 1900. The outstanding achievements of the century then closing were the kinetic theory of heat, the wave theory of light, the electromagnetic theory of matter, the discovery and application of the phenomena of electromagnetism, and the beginning of the quantum theory. During the classical period the electron was unknown and therefore could not contribute to an understanding of observed phenomena. Numerous assumptions, hypotheses, and partial theories had been offered in explanation, many of them being philosophical in character and largely unsupported by experimental evidence. There was no single basis of broad interpretation.

In 1895, X-rays were discovered, followed by the discovery of radioactivity in 1896 and the photoelectric effect in 1897. These could not be explained in terms of classical theories. They were revolutionary and served to explode the then prevalent belief that physical discoveries were completed and the facts all known. They opened up a new and very fruitful field of investigation, the clue to which was found in 1897 with the discovery of the electron. Since that time, this "building stone of the universe" has figured prominently in the interpretation of science generally and particularly in the study of things electrical.

During the next two decades, the electron theory was built up. It offered the most complete and satisfactory explanation of electrical phenomena ever formulated. It does not invalidate the observed facts of classical times but serves to integrate and explain those facts more clearly and minutely and offers experimental evidence in support. Strangely, however many authors of textbooks on elementary electricity still cling to classical theories even though certain laws and rules then formulated are known to be in error, are contradictory on some points, and are confusing to the beginner. A few examples, out of many that could be cited, will serve to illustrate the superiority of the electron theory over earlier explications.

On electrification a number of theories had been offered during classical times. Among the most prominent were the two-fluid theory, credited to Du Fay (1698-1739), a Frenchman; the one-fluid theory of our own philosopher and statesman, Benjamin Franklin (1706-1790); the ether-strain theory of Faraday (1791-1867); and

the electromagnetic theory of Maxwell (1831-1879). Although partially successful in explaining observed phenomena, these theories were based largely on conjecture unsupported by rigid experimental proof, and all failed in one or more respects.

Du Fay postulated two distinct kinds of electricity, calling them "vitreous" and "resinous." Both were indestructible. An uncharged body contained equal quantities of the two fluids, while a charged body contained an excess of one or the other. Vitreous electricity was the kind found on glass, precious stones, hair of animals, and on many other substances. Resinous electricity occurred on amber, silk, paper, and a large number of other materials. The fluids, which were considered imponderable substances, were communicated in some unexplained way to these bodies by the process of electrification, and the fluids, on account of their power of "action at a distance," were the cause of mechanical forces observed between electrified bodies. This theory seemed to explain many of the simple phenomena of static electrification (current electricity was then unknown) and was quite generally accepted up to the advent of the electron theory, although, like the one-fluid theory, it was unsatisfactory on induction, the effect of the dielectric on the behavior of charges, and the distinction between conductors and insulators.

Franklin, in his one-fluid theory, assumed that all matter contained a single "positive" fluid which could penetrate any conductor but accumulated only on the surface of insulators. Matter took the place of the negative fluid. The particles of matter and of the fluid were self-repellant but mutually attracting. Uncharged bodies contained a normal amount of fluid, such that the attraction of matter for fluid outside the body just balanced repulsion due to the contained fluid. A body was plus, or positively charged, if it contained an excess of the fluid, and minus, or negatively charged, if it contained less than normal. Glass became electrified by friction because in being expanded by the heat it took up more than its share of the fluid, which it gave up again on cooling. The theory held that conductors could take up any amount of the fluid and store it throughout their substance, while insulators could store it only on their surfaces. Each portion of the electric fluid was supposed, for reasons unknown, to repel every other portion directly.

This theory explained quite well how opposite charges neutralize each other and why a negative charge cannot be developed without at the same time producing an equal, positive charge. It failed to explain the fundamental difference between conductors and insulators and succeeded poorly on both frictional electrification and charging by induction. It was not universally adopted. One direct and quite important result of this theory was Franklin's suggestion of the terms "positive" and "negative" to designate the kinds of charges, instead

of "vitreous" and "resinous" in previous use. This improvement in terminology was generally adopted and is in use today. However, the assumptions made in the application of the terms were most unfortunate. "Positive" was arbitrarily and without experimental proof taken to mean an excess of the electric fluid and "negative" a deficiency. Thus the fluid was naturally believed to flow from positive to negative, whereas just the opposite is true, as was learned after the discovery of the electron and the part it plays in the dynamics of electricity. But before the mistake was discovered, 150 years of prolific electrical devolopment in both scientific and industrial fields had established many of the laws of current flow and the rules of practical application. Also a vast body of the literature of electricity had accumulated in which the errors growing out of this wrong assumption were thoroughly diffused. Habits of thought and usage are hard to change. Had the interpretation of the new terms been reversed from the beginning, the present confusion in the conception of current direction and related ideas would have been avoided.

Faraday believed that electrical forces were communicated by the insulating medium, or dielectric, which separated electrified bodies, and was able to show that while the force between two charged conductors does not depend on the material used or whether they are solid or hollow, it does depend on the nature of the dielectric. This has been called the "ether-strain" theory of classical times.

Faraday found it convenient to represent the field of force about a charged body by elastic lines, which he called "lines of force." These lines indicated the direction and magnitude of the forces between charges. They extended from the surface of a positively charged body to some surface negatively charged and were rigidly attached to those surfaces. If the charges became neutralized, the lines of force disappeared. Attraction and repulsion between charges were explained by assuming that the lines of force tended to contract lengthwise, thus pulling unlike charges together, and to repel each other laterly, pushing like charges apart. Although the ether-strain theory as such, is now discredited, Faraday's conception of "lines of force" is still used by some writers to illustrate the properties of the fields of force surrounding electrified and magnetized bodies. He explained quite well the phenomena of electrostatic induction, but failed on conduction.

Maxwell later incorporated Faraday's ether-strain ideas into his electromagnetic theory, in which the mechanics of induction and the propogation of electromagnetic waves at the speed of light were mathematically predicted. Maxwell also attempted to show that the flow of electricity in a conductor is accompanied by a displacement in the surrounding dielectric which contains the electric and magnetic fields and acts as a reservoir and conveyor of energy. Faraday's and

Maxwell's theories, together with certain fundamental discoveries made by others, led directly to the electron theory and have been largely included in it.

The electron theory in elementary form and omitting neuclear structure, holds that the atoms of all matter are made up of positive and negative charges of electricity and nothing else, except the energy associated with them. According to Rutherford and Bohr a model atom consists of a neucleus, or central group, of protons having a small number of electrons associated with it and other electrons revolving in circular or elliptical orbits about the neucleus. All the atoms of any one element are alike. The atoms of different elements vary in the number and arrangement of the electrons and protons in their structure. Each electron carries a certain unvarying negative charge and each proton an equal and constant positive charge. In a normal or uncharged atom, electrons and protons are equal in number; hence the atom as a whole is neutral. The electron orbits constitute energy levels spaced at different distances from the neucleus, an outer orbit containing more energy than an inner one. By absorbing energy in quanta, corresponding to the difference in energy between levels, an electron may jump from an inner orbit to one farther out. If it absorbs sufficient energy to carry it entirely out of the atom, it becomes a free electron, or negative ion, while the remainder of the atom, now possessing an unneutralized proton, becomes a positive ion. Since this may happen simultaneously to many of the atoms of a body, under which condition the free electrons are usually transferred to remote parts or removed entirely, the body as a whole exhibits a charge. This charge is positive if the body is deficient in electrons and negative if more than the normal number of electrons have collected on it. The outer electrons of many kinds of atoms are not strongly held by the positive charge on the neucleus, and a suitable acquisition of energy serves to displace them or even drive them from the atom and make them free and roaming. Energy for such purposes may be supplied from various sources, such as friction, electric and magnetic fields, heat, light, electronic impact, and chemical action.

When ebonite or similar resinous substances is rubbed with fur, the mechanical energy supplied is partly expended in removing electrons from the fur, leaving it positive in charge and depositing them on the ebonite, making it negative. Likewise glass and other materials of the vitreous group, when rubbed with silk, lose electrons to become positive in charge, while the silk gains them to become negative. Since the number of electrons lost by one body are the same as that gained by the other, positive and negative charges are equal. Thus the phenomenon of charging by friction is simply explained.

The enormous force of repulsion existing between free electrons and

between unneutralized protons explains why like charges repel, while the equally great attraction of electrons and protons for each other accounts for attraction of opposite charges. These forces, the cause of which is undetermined at present, are equivalent to 2.275×10^{19} dynes between two free electrons one centimeter apart. They are transmitted by the electric field, which is a field of radiant energy replacing the ether of classical physics. Because of this field and within its bounds all electrical action takes place. Displaced or mobile electrons, together with the unbalanced energy conditions accompanying them, are responsible for electrical phenomena of every sort, all of which are collectively expressed in popular terminology by the one word "electricity."

Charging by induction is easily and fully explained by means of the electron theory. Use is made of the electric forces mentioned above. The effect of an approaching positive charge when brought near an insulated, neutral, conducting body is to attract free electrons to the nearer side of the body, creating there a negative charge, or surplus of electrons, and leaving at the farther side a number of positive ions, constituting a positive charge. Since electrons are not taken from or added to the body, the charges on it are not permanent but will merge and neutralize when the inducing charge is removed. If the body is grounded, or touched with the hand, while a charge is being induced upon it, the electrons necessary to establish the negative charge will not be drawn from the body itself but from the earth. No internal strain will be imposed upon the atoms of the body, and a positive charge will not appear upon it. If the grounded connection and the inducing charge are now removed, the electrons from the external source will spread uniformly over the surface of the body, giving it a negative potential throughout.

Charging by induction may occur only if the body is a conductor in which electrons are free to move and are not closely confined to the atoms. Since in an insulator, or dielectric, electrons cannot leave the atoms, a charge does not spread but remains in the region where electrification takes place. Because of electric force a displacement of the outer electrons of the atoms occurs, whereby their orbits become distorted into abnormal positions and shapes. These return to normal, however, when the force is withdrawn and becomes distorted in the opposite direction if electrification is reversed. This slight electron movement within the atoms of a dielectric was named by Maxwell a "displacement" current. It is especially useful in explaining the behavior of electrostatic condensers.

The electron theory offers the best explanation of electric current and of electrical conductors and insulators so far advanced. Much has been verified by experiment. Three kinds of current are recognized: conduction current in solids; displacement current in dielectrics, as mentioned above; and convection current in liquids and gases. All in-

volve atomic structure and the behavior of electrons and protons.

Conduction current in metals consists of the transfer or movement of free electrons from atom to atom through the conductor. Such a current may exist in any solid that contains electrons capable of escape from their parent atoms to drift or flow in a continuous stream. These electrons are called roaming, detachable, or conduction electrons. A good conductor is a material which releases and passes a large number of electrons in this manner under a slight electric force or potential difference, while a poor conductor contains fewer detachable electrons and these require a higher potential difference to detach them from their atoms and cause them to drift. The electrons of insulators are believed to be tightly bound within their atoms and are released, if at all, only under the pressure of an extremely high potential. The chief difference between conductors and insulators, whereby a list of known substances quite gradually grades off from one extreme to the other without any sharp line of demarcation, is believed to be largely, if not entirely, due to this one feature of atomic structure, detachable electrons.

Protons in solids tend to move in a direction opposite to that of electrons, but, because of their greater mass and fixed positions within atomic neuclei, movement does not occur to any extent. As they are essential to atomic structure without variation in number or arrangement, to remove them would destroy or alter the atom. Atoms of different elements are unlike, and if proton movement were appreciable it would carry whole atoms across the junctions of metallic circuits and cause the mixing of unlike substances. This has never been observed at normal temperatures and pressures.

Ordinary conduction current then, as from a battery, is a flow of free electrons through the wires and other parts of the circuit which extends from one battery terminal to the other. The cause of the flow is the chemical action of the battery which serves to carry electrons away from the positive side of the battery and deliver them to the negative. The natural and powerful force of repulsion between the free electrons thus accumulated drives them out along the wires connected to the negative terminal while the attraction for electrons exerted by unneutralized protons at the positive terminal pulls electrons strongly from that end of the circuit. Both forces are in the same direction and they combine to form what is known as potential difference, electromotive force, or voltage. The electrons, on their way around the circuit give up the electric energy imparted to them by the battery, this energy being transformed by the circuit into heat, light, magnetism and other forms of energy that do the work we obtain from electric circuits.

The direction of current flow is, therefore, seen to be from negative to positive in the external part of a circuit, which is opposite to the

classical direction, positive to negative. This contradiction is due, as previously mentioned, to a mistaken choice made arbitrarily without experimental proof before the electron was discovered and the process of conduction understood. Several electrical laws and practical rules where direction of flow is involved were formulated during the classical period and are now known to be in error. In certain elementary work of a practical nature, direction of current is not highly important, but in the study of electron tubes, electro-chemical reactions, and conduction through gasses, where electron behavior is the very basis of things, the direction of current flow must be understood and duly considered.

This record of the superiority of the electron theory over those preceding could be greatly extended. It is simple, more complete, and checks with experiment; it is the only theory acceptable today. Does it not seem advisable, therefore, to use this modern theory, plainly and fully stated, in elementary textbooks and other electrical literature, abandoning the old as being outgrown, inadequate, and confusing? This procedure would simplify the subject matter, create confidence in the accuracy of treatment, and integrate thinking on the part of both teacher and student.

Military Explosives

Edwin O. Price

An explosive is any gas, liquid, or solid which is capable of very rapid decomposition into more stable substances, usually gases. This decomposition is accompained by a loud noise or "detonation" and the evolution of large quantities of gases and smoke. A great amount of energy is also liberated, and it is this released energy which brings about useful work, demolition, fragmentation, and concussion.

Explosives may be classified in several ways. Commercial explosives are those which are fundamentally used in mining, excavation, or construction. Military explosives are those which are used in military operations, and this group includes many which are also classified in the former group. Another classification may be made on the basis of sensitivity or ease of initiation of the decomposition. Some substances are too sensitive for safe use, while other explosives are very difficult to detonate.

Military explosives are conveniently divided into propellants and high explosives. A propellant is used for propelling bullets or shells from the barrel of a gun or cannon. The explosion rate is 'slow'; that is, it develops its power much more slowly than that of the high explosive. The high explosive, used in shells, detonates so rapidly that it has great power of demolition and brisance.

The oldest explosive is 'black powder.' European history contains references to this substance as early as 1250 A. D., and it was used as a propelling charge for firearms in the fourteenth century. Probably the Chinese used black powder much earlier than the European nations. It is no longer commonly used as a propellant, but is still used in coal mining, fireworks, primers, and fuses. Black powder is a mixture of about 75 per cent potassium nitrate or sodium nitrate, 15 per cent charcoal, and 10 per cent sulphur. It is not explosive unless confined; then the large volume of heated gases generated by its combustion causes it to develop its power.

The potassium nitrate in the mixture produces the oxygen necessary for the combustion of the other materials. Potassium nitrate is not plentiful; hence, quite often the more abundant sodium nitrate is substituted. The latter has the disadvantage of being hygroscopic. The charcoal in this preparation is usually a carefully made soft-wood variety. The sulfur used is the ordinary "brimstone." The main art in making black powder is to get the material finely pulverized and perfectly mixed.

As a propellant black powder has been superseded almost entirely by smokeless powder. This is due to the fact that upon combustion black

powder gives off great volumes of smoke, causes a gun barrel to erode rapidly, and rapidly deteriorates under atmospheric conditions because of its great hygroscopicity. The term "smokeless powder" is a misnomer because the substance is neither smokeless nor is it a powder. It has no close chemical relationship with black powder as it is organic in nature, and black powder is inorganic. Smokeless powder is considered the greatest of all propellants.

Smokeless powder is a nitrated cellulose. It is interesting to observe that such substances as photograph film, automobile lacquers, and collodion contain nitrated cellulose. The main difference between these substances and smokeless powder is that the powder is nitrated to a higher degree.

Nitrocotton has been used for a propellant since the beginning of this century. French, German, and British chemists were first to develop the material. Its manufacture is now so highly developed that a product with uniform ballistic properties is assured. When cellulose in the form of cotton or wood pulp (usually cotton in the U. S. A.) is added to a 'mixed acid,' containing nitric and sulfuric acids, a chemical reaction takes place. Since the exact formula for cellulose is not known, it it difficult to write a chemical reaction for this process, but the following equation is probably fairly accurate qualitatively:

$$\underset{\text{cellulose}}{C_{24}H_{40}O_{20}} + \underset{\text{nitric acid}}{11HNO_3} \rightarrow \underset{\text{cellulose nitrate}}{C_{24}H_{29}O_9(NO_3)_{11}} + 11H_2O$$

The cellulose nitrate here produced would contain theoretically 13.47 per cent nitrogen, but the usual product contains less.

One of the features of the purification of nitrocotton is the great amount of washing required. Many gallons of water are required for each pound of smokeless powder produced. The finished product when dried should show 12.6 per cent nitrogen and should pass several heat surveillance tests for stability. About one per cent of diphenylamine is incorporated with the powder to make the substance remain stable. Since cellulose nitrate is insoluble in water, the material is colloided with ether and alcohol and pressed into grains. These grains vary in size from very small squares used in small arms up to the cylindrical grains more than an inch long and half an inch in diameter used in cannon powder. All these cylindrical grains are perforated, the large ones having seven perforations running lengthwise of the cylinder. The science of gunnery requires that great attention be paid to the size of the grain and the "web thickness." This web thickness is the average thickness of the grain between perforations. If it were not for the holes in the grain, the powder would burn from the outside only with ever decreasing surface area. The actual condition is that the powder burns from both sides of the web with increasing surface area.

The most important high explosives used for military purposes are ammonium nitrate and trinitrotol-

uene (TNT). The former is a white crystalline substance, melting at 170 degrees, and very soluble in water. The difficulty with which it is detonated may be illustrated by the fact that a common experiment in elementary chemistry is to have students prepare nitrous oxide by heating the pure ammonium nitrate with a burner. No accidents have been reported from this source, although the nitrate melts and decomposes. When explosion is initiated in the mass (usually by means of another high explosive), the energy released is little less than that by dynamite or TNT. Ammonium nitrate is prepared by the action of ammonia or ammonium hydroxide with nitric acid. Ammonia can be made by direct synthesis, the nitrogen coming from air and the hydrogen from water or natural gas. The necessary nitric acid is made by oxidation of ammonia.

Many nitrated aromatic compounds have proved to be good explosives, but trinitrotoluene is most commonly used because of its ease of manufacture and its desirable properties. Toluene, a by-product of the coke oven, is nitrated in a three-stage process by the addition of mixed nitric and sulfuric acids. The total reaction is given by the equation:

$$\underset{\text{toluene}}{C_6H_5CH_3} + \underset{\text{nitric acid}}{3HNO_3} \rightarrow \underset{\text{trinitrotoluene}}{C_6H_2(NO_2)_3CH_3} + [3H_2O$$

The purified TNT somewhat resembles brown sugar in appearance. Its melting point is 80.2° C. which makes it easy to melt and pour into shells. It is so stable that it can withstand shock of being fired from a cannon, which is not possible with nitroglycerine.

TNT has been an important military explosive only since 1904. In the first World War great quantities of TNT were used by all the warring nations. It can be used commercially anywhere dynamite can be used, but it is considerably more expensive. Consequently, TNT is used for military purposes only.

Since the supply of toluene is limited, the usual plan is to mix ammonium nitrate with TNT. This mixture is called "amatol," the more popular mixtures being the 50/50 and the 80/20, the first number referring to parts ammonium nitrate. The 50/50 mixture has as much power at pure TNT, the 80/20 being slightly less powerful.

Another high explosive formerly much more commonly used than now is picric acid. This is trinitrophenol. It is a very powerful explosive, but it has a higher melting point than TNT, and while it is very stable in itself, it is likely to form very sensitive picrates when in contact with shell cases or other metals. The ammonium salt of picric acid, however, is very insensitive. This is often called Explosive D and is used in armor-piercing shell.

Two compounds, mercury fulminate and lead azide, are such sensitive high explosives that they find use as detonators. A spark will set them off, but they in turn cause less sensitive explosives to detonate in a cartridge or shell. Many times

in the large charges of a shell or bomb the detonation is also aided by a booster. Mercury fulminate has the chemical formula $Hg(ONC)_2$ and is made by adding metallic mercury to nitric acid and the subsequent addition of ethyl alcohol. It is a heavy crystalline solid, and when pure, is white. Lead azide has the formula PbN_6. It is made by the addition of lead acetate to sodium azide. It is sensitive to flame, but is too insensitive to be used alone where initiation is by impact of a firing pin.

One of the commonest boosters is tetryl or trinitrophenylnitramine. This can be made by the nitration of dimethylaniline, produced in great quantity as a dye intermediate. Tetryl is a fine crystalline powder of yellow color, practically insoluble in water. It has a higher nitrogen content than any other military explosive. Although it is too sensitive for use as a shell filler, it is safe when compressed into a booster.

The substances mentioned here include the commonly used military explosives. It can be seen that the manufacture of these explosives includes no complicated chemical operations and that any nation which has adequate supplies of cellulose and coal can produce all the explosives it may require. This condition was not always true, however, because until 1914 no one was able to use nitrogen of the air because of its inert character. In that year Fritz Haber learned the proper conditions and learned the proper catalyst for the combination of nitrogen and hydrogen. Before that Chile exported thousands of tons of nitrates which occur naturally in that country. These nitrates could be readily changed into nitric acid and all its derivatives. Now, any blockaded country is independent of Chilean nitrates; as a matter of fact, all advanced nations make use of the Haber synthesis of ammonia, which is the starting compound for all explosives manufactured.

Balancing Chemical Equations

W. B. PARKS

All chemists are agreed that chemical reactions are of prime importance. Through them, as aids, we are enabled to gather facts, to construct theories, and to deduce laws. The value attached to the balancing of chemical equations is attested by the many articles on the subject appearing in our current chemical literature during the last few years.

While we take pride in our ability to express the results of reactions with mathematical exactness, it is well to remember that chemical history tells us we passed from the mythical, through the obscure, to the certain. We are convinced it will do our students no harm to be reminded, even today, that chemistry is not a completely developed science. One of the foundation stones of the new chemistry, we are told in Venable's[1] *History of Chemistry,* was laid by Lavoisier in the following dictum:

> In the chemical reactions, only the form changes, the quantity remains the same. The substances used and the products formed can be brought into an algebraic equation, by means of which any one unknown may be calculated.

While chemical equations enable us to state our results with the exactness vouch-safed by mathematical terms, we find J. W. Mellor[2] quoting the following words by H. C. Bolton:

> In his calculations, the chemist relies on the supposed numerical relations of the invisible, intangible, immeasurable particles he calls atoms. These relations have been determined by others in whom he has confidence, and the accuracy of these relations has to be accepted on faith.

The equation is merely the shorthand method of representing facts. The facts involved in the reaction must be known. The existence of the facts opens the way to their representation.

Reactions of inorganic chemistry, W. T. Hall[3] reminds us, are those of metathesis or oxidation-reduction. Metathesis commonly includes those reactions involving the formation of a precipitate, a gas, a slightly ionized substance, or a complex. Oxidation-reduction includes those reactions involving a change of valence (or polarity) of a constituent. Long strides were taken in passing from the idea of chemical affinity to saturated capacity and then to valence. We read[4] in chemical history that Wurtz introduced the idea of valence into the science in three steps:

1. There was the discovery of the polyatomic combinations.
2. The polyatomicity was referred to the state of saturation of the radicals.

[1]Venable, *History of Chemistry.* p. 84

[2]Mellor, *A Comprehensive Treatise on Inorganic and Theoretical Chemistry.* Vol. II, p. 202.

[3]Hall, Oxidation-Reduction Reactions. *J. Chem. Ed.,* Vol. 6, p. 479.

[4]Reference (1) above; see p. 130.

3. The notion of saturation was extended to the elements themselves, which had first been applied to the radicals, and from this their atomicity was deduced.

In the light of the facts cited, it is not surprising that the concept of valence should be found lacking in clearness in recent times. The failure of textbook writers for beginning students of chemistry to agree on the definition of the term valence was pointed out by J. O. Frank in an article appearing in the *Journal of Chemical Education* not many years ago. Today we speak of valence number and distinguish between the two types as positive valence and negative valence. We also recognize electrovalent and covalent compounds.

It is usually agreed that oxidation does not necessarily have anything to do with the element oxygen. However, in dealing with co-valent compounds, it is claimed[5] that the "Oxidations of a compound or element is the addition to it of oxygen or the removal of hydrogen. Reduction is the reverse process: the removal of oxygen or the addition of hydrogen."

We are indebted to J. J. Berzelius for the idea that valence is of an electrical nature. In the Berzelian theory[6] it was claimed that every atom (as the term was then used) had a definite quantity of electricity belonging to it, partly positive and partly negative. The changes gave polarity to the atoms. When these atoms united the product (molecules) formed still retained polarity. Hence, even in the compound atom polarity remained. Every substance was made up of two parts, one positive, the other negative, hence the dualistic theory. A base was regarded as an electro-positive oxide and an acid as an electro-negative oxide; the two combined to form a salt. When the analyst reports his results of mineral analysis in terms of oxides, he is harking back to the dualistic theory.

The "dualistic theory" is looked upon as the forerunner of the present day electro-chemical theory. The chapter in our first year college courses of chemistry too often does not receive the consideration it deserves because of its location in the textbook or for lack of time.

In the article of Dr. Hall referred to above, credit is given to Ottice C. Johnson for the idea abolishing the dualistic method of writing oxidation-reduction equations, and for balancing by the change of valence. Dr. Johnson emphasized negative bonds, but what he said of them may also be said of what we now call electrons. Polarity is preferred to the term valence, and oxidation is represented as being an increase in polarity in the negative to the positive direction; reduction is a change in polarity in the position to the negative direction. The equations involved in writing non-oxidation-reduction reactions and the simpler oxidation-reduction reactions are usually easily balanced by inspection. The oxidation-reductions involving co-valent, or

[5]McPherson, Henderson, Fernelius and Mack, *Chemistry A Textbook for Colleges.* p. 183.

[6]Reference (1) above; see p. 105.

non-polar compounds, call for more careful consideration.

The structure of the atom as set forth in modern theories makes it possible for us to form a mental picture of what is taking place in the transfer of electrons (or readjustments) during the oxidation-reduction process. The picture is helpful but its use has limitations; we should not expect too much of the picture. It is important to recognize in the atom a nucleus and a valence shell, and also a positive and a negative change, e.g., a proton and an electron. With the foregoing granted we are in position to use either the valence-change method or the ion-electron method in balancing equations. It is pointed out by Professors Jette and LaMer[7] that there are cases in which the valence-change method is quite satisfactory, e.g., when dry interact, others in which the ion-electron method is greatly to be preferred, e.g., aqueous solutions.

Among the substances usually taking part in the most commonly occurring oxidation-reduction reactions are found both elements and compounds. The state of oxidation of all free elements is zero. Those which most readily accept electrons (suggested by their structure and position in the periodic table) are classed as oxidizing agents; while those most readily losing electrons are classed as reducing agents. Those compounds containing a constituent which may readily accept electrons and thus pass into a lower state of oxidation are classed as oxidizing agents, while those containing a constituent oppositely affected are classed as reducing agents.

In an article entitled "Typical Oxidation-Reduction Reactions for College Chemistry,"[8] Dr. Brinkley of Yale reminds us that large numbers of reactions involve non-polar compounds. In such cases the positive valence number is decreased and may be considered as being equivalent to the gain of electrons. The equations may be derived by either the valence-change method or the ion-electron method. Many oxidation-reduction reactions are carried out in anhydrous media; others in aqueous solutions. A third substance may be added to increase the activity of one or the other of the reacting substances, and this third substance is usually an acid or a base, depending upon the nature of the reactants. When the reaction involves the presence of a third significant medium in which it takes place, Dr. Brinkley recognizes four distinct classes as follows:

1. Anhydrous substances fused in a basic medium.
2. Anhydrous substances fused in an acid medium.
3. Solution reactions in the presence of an acid.
4. Solution reactions in the presence of a base.

In the article cited in reference 8 the authors express a most decided preference for the ion-electron method where the reactions take place in aqueous solutions. They

[7]Jette and LaMer, The Balancing of Oxidation-Reduction Reactions, *J. Chem. Ed.,* Vol. 4, pp. 1021 and 1158.

[8]Brinkley, Typical Oxidation-Reductions in General Chemistry, *J. Chem. Ed.,* Vol. 6, p. 1894.

emphasize the idea that this method rests upon a sound experimental basis. The method, it is pointed out, is based upon the fact that practically all the reactions can be carried out in such a way as to secure an electric current from them; these are called "cell reactions." We are enabled, therefore, to write equations for "half cell" reactions. The further claim is made that not only are the reactants and the products involved in the reaction shown, but only those substances, the amounts of which are changed in a significant manner during the course of the reaction, are included in the equation. No assumption is made as to the presence of some hypothetical ions such as the Mn^7 or Cr^6.

In dealing with oxidation-reduction reactions the following rules have been found helpful in balancing the equations according to the valence-change method:

1. Write the skeleton equation representing all reactants and products molecularly.
2. Indicate the valence in both oxidizing and reducing agents.
3. Write for the coefficient of the oxidizing agent that number representing the number of electrons lost by one mole of the reducing agent, and for the coefficient of the reducing agent that number representing the number of electrons gained by one mole of the oxidizing agent.
4. Balance the equation in accordance with the law of the conservation of mass.

The raising of manganese from the tetravalent to heptavalent state of oxidation is effected in the preparation of potassium permanganate from manganese dioxide. The change may be carried out in two stages or steps. The first step calls for an anhydrous fusion in a basic medium resulting in the formation of a manganate; the second step involves the conversion of the manganate, by self oxidation, to the permanganate. An application of the fore-going rules in balancing the equation for each of the reactions noted above is made. The balancing of the equation for the first step follows:

1. Skeleton equation—

$$MnO_2 + KClO_3 + KOH \rightarrow K_2MnO_4 + KCl + H_2O.$$

2. Valence change—

Oxidizing agent

$Cl^{5+} + 6e \rightarrow Cl^{1-}$

Reducing Agent

$Mn^{4+} - 2e \rightarrow Mn^{6+}$

3. Coefficients—oxidizing agent 6 and reducing agent 2.

4. Balanced equation—

$$6MnO_2 + 2KClO_3 + 12\ KOH \rightarrow 6K_2MnO_4 + 2KCl + 6H_2O.$$

The solution obtained from the fusion in the first step, indicated above, is acidified giving manganic acid. The equation for the self oxidation-reduction follows:

1. Skeleton equation—
H_2MnO_4 oxidizing agent + H_2MnO_4 reducing agent → $HMnO_4 + MnO_2 + H_2O$.

2. Valence change—
Oxidizing agent
$Mn^{6+} - e \rightarrow Mn^{7+}$

3. Coefficients—oxidizing agent 2 and reducing agent 1.

4. Balanced equation—
$$2H_2MnO_4 + H_2MnO_4 = 3H_2MnO_4 \rightarrow 2HMnO_4 + MnO_2 + 2H_2O$$

The following is a set of rules for balancing the oxidation-reduction equations of reactions when the ion-electron method is used:

1. Write the skeleton equation representing reactants and products as ions, when possible.
2. Set up a partial (half cell) equation for the oxidizing agent. Balance this both as to mass and as to electrical changes.
3. In like manner set up a partial (half cell) for the reducing agent balancing both as to mass and as to electrical changes.
4. Add the two partial equations after multiplying each by a factor which will make possible the cancellation of all electrical changes. This should be the final equation.
5. Check the final equation in accordance with the law of the conservation of mass.

In quantitative analysis one of our most common oxidizing solutions is that of potassium permanganates. On the addition of this solution to an acidified water solution of an oxalate, oxidation-reduction results. The balanced equation for this reaction, obtained by using the ion-electron method in accordance with the rules last given, follows:

1. Skeleton equation—
$$MnO_4^- + C_2O_4^{2-} + H^+ \rightarrow Mn^{2+} + CO_2 + H_2O$$

2. Partial (half cell) equation for oxidizing agent
$$2(MnO_4^- + 8H^+ + 7e \rightarrow Mn^{2+} + 4H_2O + 2e)$$

3. Partial (half cell) equation for the reducing agent
$$5(C_2O_4^{2-} - 2e \rightarrow 2CO_2)$$

4. Completed partials added give final equation
$$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 10\ CO_2$$

5. Check final equation by inspection.

Some years ago Mr. A. W. S. Endslow[9] wrote to the Journal of Chemical Education inquiring as to the origin of the algebraic method of balancing chemical equations. This led to an extensive and interesting discussion (correspondence) not only as to the inquiry made but also as to the merits of the method. Diverse answers to the questions were given, and conflicting opinions regarding the merits of the methods were expressed. A letter[10] written by Dr. James Kendall suggested that the method was probably derived from Sir James Walker's textbook, *Introduction to Physical Chemistry.* He states that the method works with certain reactions but that Walker is careful to add: "The student is not recommended to make use of the algebraic process as it is purely mechanical and affords little insight into the nature of the chemical reactions considered." The method is rarely used at the present time.

[9] *Ibid.,* Vol. 8, p. 2453.
[10] *Ibid.,* Vol. 9, p. 30.

CAMPUS ACTIVITIES

Miss B. Lillian Nelson of the Home Economics staff attended the Leadership Conference at Topeka, Jan. 23-24. Plans were made for the spring conferences for teachers of homemaking.

On March 7 the all-day spring conference for the teachers of homemaking in southeastern Kansas was held on the campus under the leadership of Miss B. Lillian Nelson of the college staff. The program consisted of reports of work accomplished since the autumn conference, and a demonstration on teacher-pupil planning of class work.

On Staurday, March 7, Dr. and Mrs. W. T. Bawden were hosts to the faculty members of the Industrial Education department, their wives, graduating seniors, and other guests. This was the seventh annual dinner which is held to make reports of conferences and meetings which cannot be attended by all staff members. E. W. Baxter told of his trip through the defense special train which he visited at Springfield, Mo. Walter L. Friley reported the thirty-second annual meeting of the Manual Arts conference of the Mississippi Valley, and Dr. Bawden told of the meeting of the American Vocational Association held in Boston.

The Graphic Arts Club of the College held its second annual printing dinner at the College Cafeteria on Tuesday evening, January 13 in observance of national printing education week. Mr. George Ortleb, former deputy Public Printer gave the principal address. President Rees H. Hughes was toastmaster for the dinner. More than eighty editors, printers, printing instructors and students from the four-state area were in attendance.

Dr. William T. Bawden represented the College at a conference on pre-induction military training held at the University of Chicago February 20 to 22, 1942, called for the purpose to help universities and colleges over the country to cope with situations arising from the war. Prior to this conference Dr. Bawden as chairman of the College committee on defense training reported to the student body in Assembly and other committee members made recommendations to students concerning their enrollments until such time as they are called to service.

At the thirty-second annual meeting of the Manual Arts Conference of the Mississippi Valley held in Minneapolis, Minn. in October, Dr. William T. Bawden tendered his resignation as chairman of the Con-

ference, having served in that capacity for twenty-seven years. In voting to accept the resignation of Dr. Bawden a committee was appointed to name the successor and the committee submitted resolutions which read in part:

> "Be it resolved, Therefore that we thank him sincerely for long, arduous, and efficient assistance to us in the work of our great interest;
>
> "That we take special note of the professional spirit, fairness, and informality that have characterized his conduct of our affairs, and that have been engendered and strengthened in us: . .

Dr. Verne Fryklund of the University of Minnesota was named as successor to Dr. Bawden.

Student teachers in homemaking are receiving training in teaching from the defense angle. The classwork at the Frontenac homemaking cottage this semester, thus far, has consisted of First Aid, victory gardening, nutrition, and Red Cross sewing.

FIELD NOTES

William Lawrence, major in Social Science, now with the Royal Canadian Air Force, was visiting friends on the campus March 6.

Virgil M. Hardin, a former student in Kansas State Teachers College and now principal of Pipkin junior high school, Springfield, Missouri, was elected president of the National Association of Secondary School Principals at its annual meeting in San Francisco in February.

Don Musser, a junior in the history department won the local oratorical contest with the subject "From Prehistoric Man to Superman." First place in this contest carries with it a prize of $20 from the Don Gray Drug Store.

Kenneth McFarland, B. S. in History in 1922, and for the past several years superintendent of schools in Coffeyville, Kansas, has been elected superintendent of the Topeka school system for the coming year.

Col. G. G. Naudain, B. S. in 1927 and Ph. D from Iowa State in 1939, and for several years head of the Chemistry Department at Winthrop College, Rock Hill, South Carolina, is now serving in the Chemistry Warfare at Edgewood Arsenal in Maryland.

Richard Schiefelbusch, B. S. in Social Science in 1940, was a visitor on the campus March 5 and 6. Mr. Schiefelbusch is now training in the Army Air Corps at Corsicana, Texas.

Dr. James E. Mendenhall, Director of the Institute for Consumer Education at Stevens College, Columbia, Mo., was called to Washington, D. C. in January to assist the Consumer Division, Office of Price Administration, as head of the Program Planning and Program Materials Unit. Dr. Mendenhall, who is the son of Professor and Mrs. Edgar Mendenhall, received his B. S. degree at K. S. T. C. in 1924 and his Ph. D. at Columbia University in 1930.

Contributors to This Number

Edwin O. Price, assistant professor of chemistry, is a graduate of the University of Colorado, A. B., 1926, and of Ohio State University, M. Sc., 1933, and Ph. D., 1938. He was a member of the staff of the department of chemistry at Iowa Wesleyan College for six years, and came to Kansas State Teachers College in September, 1940.

W. B. Parks is a graduate of Texas Christian University, with degree B. S., 1886, M. A., 1892, and Ph. D., 1894. He also holds the degree of M. S., University of Chicago, 1920. He served as professor of chemistry, Texas Christian University from 1887 to 1899 and from 1904 to 1917, and Dean of the College from 1910 to 1917. He was head of the department of chemistry, Southwest Oklahoma State Teachers College, Weatherford, 1918-21, and professor of chemistry, Oklahoma A .& M. College, Stillwater, 1921-23. In 1923 he was appointed professor of chemistry at Kansas State Teacherss College, Pittsburg, and in 1940 was placed on the unassigned list.

Etelka Holt (M. S., University of Chicago) was appointed assistant professor of geography in 1930. Her teaching experience includes service at Pennsylvania State College and at Western Kentucky State Teachers College, Bowling Green. She is a member of Sigma Xi and of the board of directors, Kansas Council of Geography Teachers.

Oliver W. Chapman (Ph. D., Iowa State College) has been a member of the College staff since 1928, and was appointed professor of organic and bio-chemistry in 1930. His teaching experience includes ten years in the department of dairy chemistry, Iowa State College. He is a member of the American Chemical Society and Secretary of the Southeast Kansas Section.

Elsie M. Broome (M. S., Kansas State Teachers College, Pittsburg) has been on the staff of the College since 1933, and was appointed to her present position in the department of geography in 1937. She served as member of the board of directors, Kansas Council of Geography Teachers for six years, and as editor of the Bulletin and secretary for two years.

E. W. Jones (M. S., Kansas State College, Manhattan) is a native of Kansas. He graduated from Kansas State College in 1909, with B. S. degree, and later earned the E. E. degree, 1923, and M. S., 1936. After

eight years of practice as an electrical engineer, he taught advanced electricity at Lathrop Trade School, Kansas City, Missouri, from 1917 to 1921, then came to Kansas State Teachers College as assistant professor of physics, and in 1926 was promoted to his present position, associate professor. He is author of two widely used textbooks, *Essentials of Applied Electricity*, and *General Electricity*.