SCIENCE NEWS

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THE STRUCTURE OF SOLIDS

THE new theories of atomic physics—quantum and wave mechanics—are clarifying knowledge of the structure of solids and thus bringing these seemingly "impractical" playthings of the mathematical physicist into the realm of material objects which one can see and touch; objects which an engineer or layman could class as "practical."

Speaking in New York before a joint meeting of the Optical Society of America and the American Physical Society, Professor L. A. DuBridge, of the University of Rochester, described the newest advances of the attack of science on the secrets of matter. He emphasized that the nature of the structure of solids like metal crystals, or glass, or insulators, is only in its beginnings, but already the quantum and wave mechanics has interpreted —from a single starting point—many properties for which each formerly needed its own little separate theory to account. In particular, the old theory of the conduction of electricity through metals has been revised and physicists no longer picture a metal bar as containing myriads of so-called "free" electrons which could move freely about within the metal and conduct the current.

The central idea of the new picture is that a crystalline solid, like a metal, may be regarded as a single giant molecule. For a crystal of ordinary size this "molecule" will contain in the neighborhood of a million, million, million, million atoms. Or the figure 1, followed by 23 ciphers. All these millions upon millions of atoms packed into a regular array in a single crystal produce effects quite different than if they acted individually as they would in a gas. The little energy levels of the atoms between which electrons jump to absorb or release energy are no longer peculiar to the atoms singly. There are energy levels for the whole crystal. And it is the movements of electrons into these energy levels of the crystal which determine many of the properties of crystals. Crystals like those of sodium, potassium or silver are pictured by the new theory as consisting of electrons occupying the bottom of two broad bands or zones of energy. If the metals are cooled to absolute zero all the electrons are in the bottom compartment of what might be called an energy "basement."

By old theories it was predicted that solids cooled to absolute zero would possess no energy because the energy of motion of the electrons would be stopped. And without motion there was no energy. By the new theory it is predicted that even at absolute zero the electrons have motions and energies from 50 to 100 times greater than it was formerly believed they possessed at a temperature of 1,000 degrees. When an electric field is applied to metals of this group the outer electrons (or those at the top of the energy basement) will move up to the next lowest unoccupied energy levels. They move with the electric field and give rise to current. If vacant energy levels exist, to which the electrons can jump, then the metal is called a good conductor of electricity. Sodium, potassium and silver are notably good electrical conductors. If the electrons have no vacant levels to which they can go when an electric field is applied because these levels are already occupied, there is no current produced and the solid is known as a poor conductor, or a good insulator. Thus the strange situation may arise where one solid may have twice as many "free' electrons as another and yet be an insulator, while the latter is a good conductor; the reason being that the "free" electrons have no place to go.

"The new theories," said Dr. DuBridge, "offer, for the first time, a picture of why one substance is a good insulator or a good conductor. The necessary condition for conduction is that there shall be unfilled but allowed levels immediately adjacent to the occupied levels." The new theories also offer explanations of heat conduction in solids and predictions of the binding forces in crystals. Moreover, the optical properties of solids—like the photoelectric effect on which all photocell operation is based—are taking on a new understanding through analysis by the new theories. The magnetic properties of crystals are also being studied and, said Dr. DuBridge, "for the first time a satisfactory theory of ferromagnetism is being developed."

PHOTOGRAPHIC ANALYSIS OF ATOMIC COLLISIONS

BEFORE the New York meeting of the American Physical Society Professor Arthur E. Ruark, of the University of North Carolina, described a new viewing mechanism which projects in three dimensions the pictures of tracks of atomic particles taken with Wilson cloud chamber apparatus.

With almost automatic precision the cloud chamber takes literally thousands of pictures of atomic collisions. The difficulty with research in the field of subatomic particles comes not in taking the pictures but in analyzing them and correctly interpreting what is shown. Special cameras taking two views at right angles to one another give a three-dimensional picture of the tiny tracks which the invisible speeding particles cause. But to handle each separate picture of thousands is a tedious time-consuming job which means weeks and months of study and delays publication of results.

There was a time when slowness was synonymous with scientific research, but in the field of atom-smashing hundreds of laboratories throughout the world are working furiously in a literally virgin field of study. Giant cyclotron apparatus for smashing atoms, in some cases, is being operated on two eight-hour shifts a day and the whole field is one of intense activity. At one period investigators were even wiring their results into the technical journals to insure priority rights in their discovery claims.

The new North Carolina apparatus takes its pictures on rolls of film with a miniature type camera. When

developed the film is put back in the camera and the two images projected on suitable viewing screens. Special accurate, circular gradations permit the viewing screen to be turned vertically and horizontally so that the direction, in space, of the tracks can be quickly determined. As soon as a particular picture has been analyzed, the switch is thrown and the next picture pops into view. Speed, ease and several technical special uses make the new device highly valuable to an important field of science.

OTHER PAPERS READ AT THE NEW YORK MEETING OF PHYSICISTS

PROFESSOR VLADIMIR KARAPETOFF, of Cornell University, showed a compact little device which can be set up on a table of elements to show the results of an impact upon any element or isotope by any one of several different kinds of sub-atomic "bullets" used in experiment. By properly reading the scale the theoretically possible resulting products of this atom smashing and the ejected particles that should come off, can be read. The work of forecasting disintegrations and transmutations has become increasingly complex, and yet more and more scientists and amateurs are becoming interested in it, said Professor Karapetoff. Nearly all the stable elements have been made radioactive by bombardment experiments and the number of possible forms of matter now runs into the hundreds instead of the simple 92 forms found in the old tables of the chemical elements. Moreover, the number of possible kinds of bombarding particles has been increased to nine, in Professor Karapetoff's scale, so that the varieties of the various impacts which can occur set up a great mass of data. Professor Karapetoff's new scale brings order out of this drudgery and forms a convenient tool for the experimental and theoretical physicist in his nuclear research. The scale gives all the theoretically possible transmutations of elements; quantum-mechanical computations and the experiment are necessary to decide on those which can actually take place.

DR. S. E. FORBUSH, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, reported that a study of data on cosmic ray intensities, as they varied with sidereal, or star, time through the 24 hours of the day showed that the tiny variations can not be real. Two years ago, Dr. Arthur H. Compton, of the University of Chicago, suggested that if cosmic rays did originate outside the earth's galaxy of stars then, because of the galactic rotation, there should be times when the earth was moving "against the current" of the oncoming cosmic ray stream, and other times when it was moving "with the stream." This movement with, or against, the possible cosmic ray "current" would produce changes in cosmic ray intensity varying with sidereal time. Since this suggestion was made, careful checks have been kept on cosmic ray intensities in Europe, South America and the United States. Data for 595 days are now at hand and were analyzed by Dr. Forbush as the basis of his report. Using less powerful methods of statistical analysis other investigators have announced "real" variations of about .05 (five one-hundredths) per cent. Dr. Forbush, with his more penetrating methods, now announces that the variations suspected can not be considered real on the basis of the present amount of data. More data, now being accumulated, may answer the point at some future time and give a final check to the Compton theory of the origin of cosmic rays.

DR. DAVID I. MACHT, of Hynson, Westcott and Dunning, Inc., Baltimore, stated that pharmacological studies are seeking to learn the causes of x-ray sickness which not infrequently occurs in patients undergoing x-ray therapy. Studies show that the blood of irradiated animals contains toxic substances which appear from 12 to 24 hours after the treatment and do not disappear for several days. The amount of toxin varies with the region of the body irradiated with the x-rays. Studies of brain tissue in animals irradiated with x-rays shows that there is some impairment of enzymatic activity, said Dr. Macht. Recovery comes if the dosage is not excessive. Clinical studies on human blood are now in progress. A search is also being made for drugs which may counteract the toxicity created by x-rays.

THE last steps in the explanation of the extremely slow "death" of the longest-lived beta-radioactive element known, were announced. The puzzling element was the rubidium isotope 87, which requires 100,000,000,000 years for its radium-like activity to decrease by half. The several varieties of radium itself have "lives" of only a few minutes to at most 300,000 years. Reporting to the meeting of the American Physical Society, Dr. E. J. Konopinski and Professor H. A. Bethe, of Cornell University, described the calculations which confirmed an ingenious explanation of rubidium's longevity. Recent experiments by Kopfermann in Europe have determined the spin of the final decay product of the radioactive disintegration. This spin turned out to be considerably different for the final product than for the radioactive parent from which it originated. Professor Bethe and Dr. Konopinski showed the feasibility of the explanation that the extremely long life comes about because the decay process is slowed up by the difficulty the atom has in changing its gyroscopic spin. In analogy, at least, the tiny spinning gyroscope within the atom slows up the decay in the same way that a gyroscope on a boat slows up the roll of the ship in rough water and thus makes a smoother ride.

TO maintain the existing radiation pouring out from the sun it is necessary that each one of the trillions upon trillions of protons and neutrons contained in it must give out a photon of light every 20,000 years. Calculations of the sun's energy and estimates of its radiation production were presented by Dr. Arthur E. Haas, mathematical physicist, of the University of Notre Dame. Every second the sun liberates photons represented by an enormous number consisting of 2×10^{45} or the figure 2 followed by 45 ciphers, photons a second. The total number of particles in the sun (the protons and neutrons)

Dr. Haas estimates as consisting of 1.2×10^{67} particles, or a number represented by 12 followed by 56 ciphers. It takes the sun about 20,000 years to liberate a number of photons equal to the number of particles it contains. "We must therefore assume," said Dr. Haas, "that each primordial particle contained in the sun experiences, at least in intervals of about 20,000 years, some reaction leading to the emission of a photon, or we must assume that extremely 'hard' primary photons produced in the interior of the sun split into a variety of softer photons on the way to the surface of the sun, or perhaps we must combine both assumptions."

COSMIC RAYS may be the most piercing and powerful of all radiation, but one modern steam generating plant develops about the same amount of energy as do all the cosmic rays incident on the surface of the earth. Dr. Thomas H. Johnson, of the Bartol Research Foundation of the Franklin Institute, estimated that the total cosmic ray energy striking the earth comes out to be about a million kilowatts. This is the same energy rating as the new steam generator plants of the South Philadelphia Electric Utility Company. The total number of rays striking the earth per second, said Dr. Johnson, is 8×10^{17}. This makes the cosmic ray current to the earth .13 amperes. The average energy per ray is about 160,000,000,000 electron volts.—ROBERT D. POTTER.

NEW OIL DISCOVERIES

FOR the first time in a decade the 1937 discovery of new oil reserves has exceeded annual production in the rich California petroleum fields, according to a report to the meeting of the American Institute of Mining and Metallurgical Engineers by V. H. Wilhelm, chief petroleum engineer of The Texas Company (California), Los Angeles, Calif. The major discovery of the year was the field in San Joaquin Valley where a well came in at 11,302 feet deep with a production of 1,400 barrels of oil daily. During the year an estimated 238,000,000 barrels of oil were withdrawn from reserves, but new discoveries will amount to almost twice this amount. In South Louisiana 14 new oil fields were discovered during 1937. In the main, production is coming from the 10,000 foot levels in Miocene sands. In Mississippi drilling in the state's two fields continued to decline and 1938 is expected to be a year of great activity in the search for new reserves. About 20 geophysical prospecting parties worked in Mississippi during 1937 and located salt domes and other types of oil-bearing structures which will, in 1938, be definitely tested by drilling operations. In Missouri the state witnessed the best year in its history in the discovery of gas wells. The 49 completed gas wells showed an initial flow each averaging 1,000,000 cubic feet per day. Eight of these wells also showed oil. In the Texas Panhandle region 663 oil wells were drilled in 1937 having a daily initial production of 322,332 barrels. The total proved production area in the state is now 118,050 acres or the equivalent of 184 square miles. One hundred and sixty-eight gas wells were also drilled with a combined opening flow of over six billion cubic feet of gas. Forty-six gasoline-extraction plants in the state during the year processed 273,318,108 gallons of gasoline from gas.

ITEMS

LABYRINTHIC passages comprising a cave about one fourth as large as Carlsbad Cavern, discovered only a few days ago, were explored immediately by government rangers. The entrance is nine miles from Carlsbad, on government land, outside the Carlsbad Cavern National Park, but inside the withdrawn area. The newly-discovered cavern is "quite dingy, containing only three sizable formations," reports Colonel Thomas Bowles, superintendent of Carlsbad Caverns. The National Park Service declined to comment on the geologically possible underground connection between these caves and Carlsbad Cavern.

DR. R. A. FOSHAG, curator of minerals at the National Museum, points out that "recent diamond finds at Cherokee Flats, near Camino, Calif., do not justify any rush to the area in search of easily-gotten glittering stones." One diamond from the Cherokee Flats region is received at the museum every three or four years. Perhaps two hundred diamonds have been found in California since the gold rush days, the largest reported being about seven carats. The Cherokee Flats diamonds are perfectly good stones, their rarity, rather than any defect in them, making the placer gold deposits unprofitable as diamond mines.

GREEN fodder for winter feeding to livestock is made from seeds in only six days in a device of British invention now being demonstrated at the New York Museum of Science and Industry at Rockefeller Center, New York City. The "fodder factory" consists of an insulated cabinet containing a series of perforated trays. In these are placed quantities of grain, legumes, or other seeds, after soaking for 24 hours. The trays are kept at constant temperature, and watered from the top. At the end of six days, when the sprouts have reached a height of six inches, the entire contents of the trays—sprouts, soft seeds, and roots—are fed to the livestock, which relish the succulent fodder. A larger cabinet than the one on display here is being tried out on a working scale at a large dairy farm in Connecticut. The "fodder factory" is an invention of Captain H. H. B. Lund, of England.

STRENUOUS athletic activities have no bad effect on the heart, in the opinion of Dr. E. L. Cooper, Dr. J. O'Sullivan and E. Hughes, of the University of Sydney, Australia. They examined a series of oarsmen from universities and colleges before going into training, after training and before and after racing. They investigated the heart by means of the measurements of the pulse, x-ray photographs and by means of the electrocardiograph. In addition, observations on blood pressure measurements and body temperature were made. The investigation was also extended to men playing squash rackets and pedalling a fixed bicycle against a brake. They could find no evidence of any permanent change to the heart as a result of training for and taking part in athletic sports. Their final conclusions were that even extreme physical effort on the part of an athlete such as the final dozen at the end of an exhausting two-mile rowing race does not result in damage to the heart.