PHYSICS

Beyond Einstein

Thought of the "New Deal" in Physical Science Has Outstripped Even Theories of the Famous Relativitist

A "NEW DEAL" has been called in that branch of science known as physics. Those who studied their science before the World War and even those who have not looked into the field of physics in the last few years will need a guide. It has even gone beyond the relativity ideas of Einstein that created the revolution in scientific thought in the few years following 1919.

Yet strangely enough this newer deal that is puzzling scientific minds began in a large measure in the brain of Prof. Albert Einstein when in 1905 he applied the quantum theory that Prof. Max Planck had introduced earlier.

Just as the Einstein relativity theories set lay and scientific heads to buzzing, so the development of theories about the nearly infinitesimal in science, which have culminated in what is known as the "quantum wave mechanics," involve delightful paradoxes that puzzle both lay and scientific minds.

This new quantum wave mechanics is so complex that even the simplest fundamental process can not be pictured and is expressible only by means of mathematical symbols. But the many paradoxes brought out by this new treatment are mentally intriguing to examine and discuss in an approximate and unmathematical way.

Bohr Began New Deal

The new deal really grew out of the admirable adaptation by Prof. Niels Bohr, Danish Nobel prize winner, of the bare quantum theory postulates of the early twentieth century to the problem of atomic structure. The Bohr atom as further developed by Prof. Arnold Sommerfeld served the physicists as a working model with fair success until about 1925. Then the paradoxes became overwhelming. Something had to be done to the theory.

A group of young geniuses arose. The development began in Europe with Prof. Werner Heisenberg leading a new attack that in the hands of Born and Jordan led to the "matrix mechanics." Prince Louis de Broglie began an attack from the viewpoint of wave action that was carried on by Schrodinger to the "wave mechanics." Both were shown to be equivalent to one general scheme now christened the quantum mechanics. This theory has been pushed forward very vigorously by Profs. P. A. M. Dirac, W. Pauli, George Gamow and many others in Europe and by Prof. Edward U. Condon, Prof. J. Robert Oppenheimer, Prof. John C. Slater, Prof. Geo. E. Uhlenbeck, Prof. John H. Van Vleck, Prof. Paul S. Epstein and a host of others in this country.

Building Blocks

What is everything, stars, earth, plants, people, made of? In the final analysis everything consists of small bits of electricity. This is one of the latest developments of the new deal in physical science.

The most publicized electrical particle is the electron, the unit of negative electricity. Its movement constitutes an electric current. This electricity is so highly concentrated that it appears to weigh a minute amount, so small that it would take 33,000,000,000,000,000,000,000 electrons to weigh a millionth of an ounce.

The other familiar building block is the proton which carries an equal positive electrical charge but weighs about 1,850 times as much as the electron.

Older pictures of the atom were satisfied with a model having protons and electrons in the core or nucleus of this chemical entity and more electrons revolving about the outside much like the planets revolving about the sun.

To illustrate the minute dimensions of the atomic heart physicists say that if all the nuclei in a man's body could be packed together they would not be any larger than an almost invisible speck of dust, yet this mite would weigh nearly two hundred pounds. The rest of the space is "filled" with the electrons outside the nucleus, but since the old school of physicists thought that the relatively huge electron had a diameter of only one ten-thousandth of the atom the world is mostly "holes" occupied by particles that are never exactly anywhere.

The enigma of how the large electron could be squeezed into the minute nucleus has been overcome by the recent discoveries of the neutron and the positron. The neutron is the most unique building block since it has no electrical charge although it has the same weight as the proton. By assuming neutrons and positrons alone in the nucleus or atomic heart, physicists can account for the proper weight without crowding things too much.

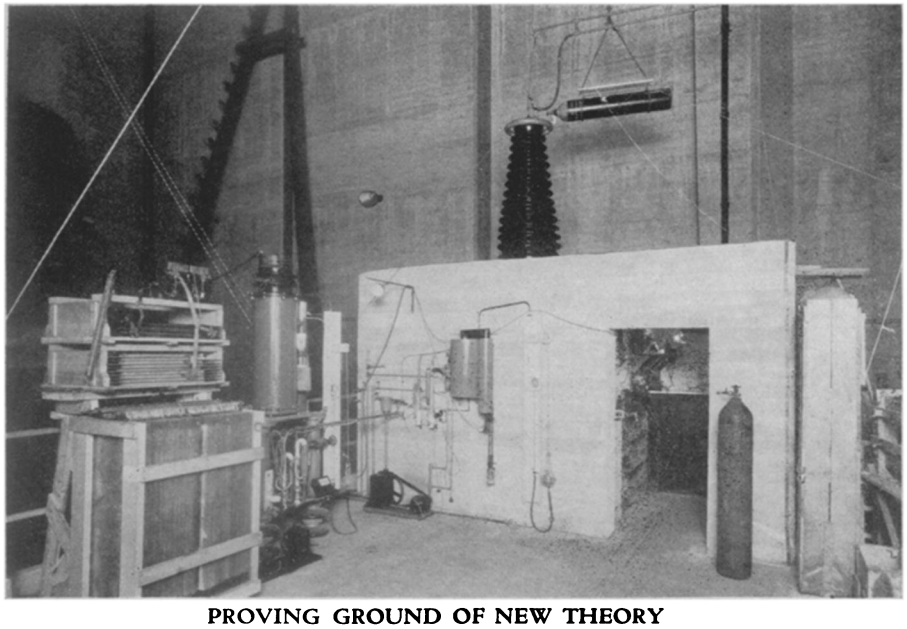
The positron is the counterpart of the long-known electron in that it seems to have the same mass but the opposite electrical charge. Physicists have no place for it in the external structure of the atom and are attempting to squeeze it in with the other nuclear constituents.

Knowing the Invisible

If something cannot be seen, it can be described only by how it acts. The minute particle of electricity or matter, the electron, is certainly too small to see and seems to be too small to make a showing by itself.

For these reasons physicists are in a quandary as to the exact nature of this fundamental particle. Or is it a particle? On Mondays, Wednesdays and Fridays they think of it as a tiny corpuscle and on Tuesdays, Thursdays and Saturdays it seems to be a wave. This is one of the consequences of the "new deal" in physical science.

The most modern description of an electron is that it is both, and the pic-



PROVING GROUND OF NEW THEORY

This picture shows a portion of the laboratory of the California Institute of Technology, a typical workshop of physicists of the "New Deal." Here large quantities of neutrons were obtained from the disintegration of the metal beryllium with artificial alpha rays or hearts of helium atoms. With the compact and relatively inexpensive X-ray tube made of the transformer insulator protruding above the concrete hut, helium gas escaping from the small horizontal tank above was speeded up to form the artificial alpha particles.

ture of this combine presents strange features to explain the known effects. Physicists imagine it to be like a tiny spider, which represents the point particle, that is at the center of a gossamer web which is analogous to the wave. The wind, which represents external influences, blows on the webbing and guides the energy-containing spider about with it. Thus the electron is influenced by neighboring atoms through the medium of these widespread tentacles although it may never pass very close to them.

The wave associated with an electron may be considered as a wave of probability and the places where the wave is strongest are places where the electron is likely to be.

The Uncertain World

"Meet me at the corner of 42d Street and Broadway at 8 p. m. today and jump on my auto as it runs along at 10 miles per hour."

Any agile friend could be expected to keep that date with great certainty. But not so with any fundamental particle of matter or bit of electricity as viewed in the latest theories or the "new deal" in physics.

The physicists have decided that it is impossible to know just where an electron is and at the same time to know with great precision its speed of travel. This, roughly stated, is the uncertainty principle or the principle of indeterminancy as formulated by Dr. Heisenberg, young German physicist.

This is quite upsetting to the older idea of physics. Physics professors of a few years ago taught that all was definite and measurable in their best of all mechanical worlds.

The uncertainty principle states that no physical measurements on a particle are capable of providing absolutely precise knowledge of the simultaneous values of the position and momentum which is the product of the mass and the velocity. If scientists wish to obtain a high degree of accuracy in the measurement of one of these quantities then they are forced to be content with only an approximate value of the other and vice versa.

Least Possible Work

What is the least amount of work that can be done and yet be called the using up of energy? That might be thought of as a question suggested by the drive for shorter working hours. Atoms have always operated under a minimum energy code. So physicists believe, who call the unit of energy the quantum.

An atom does work or gives off energy by shaking its parts into vibration or by having an internal explosion. The effects of this disruption travel out through space from the atom as a wave and work on the target atoms that the wave strikes.

The useful photoelectric cell that is the mechanical eye of many robot devices is one application of the working of this wave. For the excitement in the working atom is nothing more than the emission of light and the waves that spread out from the source are a beam of light. When this light falls on the photoelectric cell the work that is done is the removal of an electron from the metal plate in the cell.

But that is a definite task and requires a known amount of energy, much more than is contained in that portion of the wave front that crosses the target atom at any one instant. Physicists showed that the assumption that the target atom stored up sufficient energy for the electron's release over a long time before the escape took place is not correct and that the action is instantaneous because a feeble light will cause an immediate response.

The modern explanation of this paradox is that the energy in the light beam has a certain probability of being located at a single point on the advancing wave front and if it so happens that this amount of energy is a quantum sufficient for the release of a target electron then the photoelectric emission can occur.

Cosmic Ray Uncertainties

In celestial space, millions of light years from the earth, cosmic rays are the chief source of energy. From 30 to 300 times as much energy would fall on a body at that almost imaginary point in the form of this mysterious radiation as would come from all the stars in the universe.

What is it that makes them so mysterious and why should it be necessary to climb the Andes and float to the stratosphere to measure them?

There are two distinct theories of the nature of this most penetrating radiation. Dr. Robert A. Millikan, Nobel prize winner at the California Institute of Technology, believes that they are largely bullets of waves similar to ordinary light but of an enormous frequency; whereas Prof. A. H. Compton, Nobelist at the University of Chicago, believes that they are largely electrically charged particles moving with enormous velocities. Dr. Millikan's theory proposes that these photons or light wave bullets were emitted by the for-

mation of heavy atomic hearts from the hearts of lighter atoms. Another theory, stated by Abbé Georges Lemaitre, the Belgian physicist, attributes them to the original explosion of the universe, and he postulates that the original fragments of this explosion that are still flying about may be the cosmic rays.

Balloon flights, both manned and unmanned, study the effects of the cosmic rays and see if they increase with altitude. Physicists have thought that if the primary cosmic rays are photons these effects should reach a maximum intensity and then fall off to zero as the surface of the atmosphere is reached. However if they are electrically charged particles the effects will increase steadily and approach a maximum at the top.

Measurements up to the present have shown definitely that charged particles are present but they do not exclude absolutely the photon hypothesis. It is the hope of scientists that a successful high altitude flight will decide this question and that is the chief reason for all the effort expanded on these ventures.

New Ideas on Reducing

A champion may lose five pounds in a Davis Cup tennis match but atoms lose very little weight when they dissipate energy. Strangely enough if they move fast enough they appear to gain weight.

Physicists believe that weight or mass and work or energy may be one and the same thing. When atomic hearts are broken down or built up mass may disappear with the emission of enormous amounts of energy. Conversely energy exerted in causing the change may appear in the form of a heavier atom core. First it is work and then it is weight, or perhaps work again.

The simplest relativity theory predicted that if an elementary particle such as the electron were speeded up to velocities approaching the velocity of light, 186,000 miles per second, it would become heavier and heavier. If it could be made to go at just that speed, which is the maximum speed limit in the universe, it would become infinitely heavy. This is just another way of saying that it is impossible to break that ultimate speed record, more than seven times around the world in less than a second.

Trick Mountain Climbers

Why not slip through a mountain instead of climbing over it, and then pull the hole shut after you?

This sounds impossible for any human to do, but physicists struggling with the "new deal" in their science have decided that this is an approximate picture of the way captive particles escape from the valleys that are the centers of all atoms. It would take about 25,000,000,000,000 of these hollows and ridges placed side by side to cover only one inch. The captive particles do not have enough energy to climb over the barrier but they do get out. The only conclusion is that they must have found a tunnel that existed for only an instant and were clever enough to seize the opportunity.

The cores or hearts of all atoms are pictured by mathematical physicists on the basis of energy considerations and to help visualize their abstract symbols they draw a picture of this nucleus that looks like a valley between two mountain peaks. The constituents of the atom heart are trapped in this depression and are held captive for all time if the atom is stable.

Some atoms, such as radium, do break up and these fragments come flying out of the valleys with enormous speeds. But they have to be shot back at the mountain with much higher speeds in order to return to the core.

This return speed determines the height of the mountain.

These valleys and mountains are called potential energy functions and the new theory interprets the leakage of particles from within as due to a finite probability of escape from the zero energy state at the bottom of the valley to a slightly higher energy state at the outside foot of the potential barrier.

Science News Letter, October 14, 1933

OPTICS

Metallurgist Devises New High Precision Microscope

AN AMERICAN metallurgist whose skill with the microscope has won world acclaim has just announced another of his triumphs over the invisible. Francis F. Lucas of Bell Telephone Laboratories has reported on his newest invention, a microscope capable of the highest precision at magnifications of 5,000 times, before a congress of metallurgists.

The microscope and its accessories for the examination of metals required four years to build in the Zeiss works of Germany. The chief feature of the microscope is its rigidity which eliminates vibration. Three long benches suitably mounted on wheels and with shock absorbers galore support the apparatus. Refinements never before attempted are built into the instrument.

Among the refinements which have been made available in this equipment for regular use are: absolutely pure monochromatic light, mono-bromnaphthalene for a principal lens, specially rugged and accurate focusing mechanism, and the suppression of distracting noise from the spark gap.

The equipment is installed in a light-tight laboratory having an enameled interior reflecting only definite wavelengths of light not detrimental to the use of the microscope.

Science News Letter, October 14, 1933