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FUTURE OF THE SCIENCE OF PHYSICS

BY ROBERT D. POTTER

LISTING the practical advances made possible by the physical discoveries of the x-ray, radioactivity and the electron in the recent past, Dr. Karl T. Compton, president of Massachusetts Institute of Technology, predicted that by the end of the twentieth century the still newer discoveries of research on atomic nuclei may yield comparable advances. Dr. Compton spoke on "What's Ahead in Physics" at the dinner session of the five societies of physics meeting in New York on October 30 to celebrate the formation five years ago of the American Institute of Physics.

"During the past third of a century the discoveries of the electron, the x-ray and radioactivity have together brought about the greatest advances which have ever been made in fundamental knowledge of the physical world and in practical applications of this knowledge to human welfare. These developments will undoubtedly continue. It may very well be that the new fields of knowledge disclosed through exploration of the atomic nucleus may bring about a new set of developments of corresponding importance before this century comes to a close. It is primarily in the groups represented by these five member societies of the American Institute of Physics that those things which are next in physics, some of which we can anticipate and some of which are certainly quite unknown to us, will come to pass."

Dr. Compton pointed out that in predicting the future one can depend only on the achievements of the past and a knowledge of present trends. Of the past he said:

"In the last fifty years physics has exerted a more powerful beneficial influence on the intellectual, economic and social life of the world than has been exerted in a comparable time by any other agency in history. Its influence has far exceeded that of wars, political alignments or social theories.

"This is a striking statement which, if true, discloses an equally striking absurdity, for the public is continually excited about this or that issue of politics, tariffs, codes or international relationships which are of far less human import than the past and future accomplishments in that body of science whose American representatives are meeting here to-day, practically unknown and unnoticed."

As justification of his claim for the past usefulness of physics, Dr. Compton showed that all the many types of engineering, civil, mechanical, radio, motion picture, aeronautical, all spring from the mother science of physics. Moreover, other scientists—astronomers, meteorologists, optometrists and others dealing with instruments—are also basically physicists. The contributions in five decades of these men bring glory to the science of physics and make its value outweigh war and politics in its effects on civilization.

Scientific research is needed on a national scale as much as on the smaller industrial scale, Dr. Compton declared, deploring the shortsightedness of research in the Federal Government agencies caused by lack of appropriations. He said:

"Irrespective of our judgment regarding the justification for large government expenditures to stimulate industry, I think that there would be agreement on the following principle by practically all scientists, engineers and progressive industrialists:

"In national, just as in industrial, expenditures, some substantial portion should be devoted to the attempt to improve the products, processes and methods of the future. Huge expenditures for construction and production only, with no provision for research and development aimed at better construction and new production in the future, are woefully short-sighted. Public policy and future industrial welfare require foundations for the future as well as production of the present."

Dr. Compton suggested that some of the most promising future developments in the usefulness of physics lie in the field of medicine. Medical application of x-rays and radium rays have already aided the treatment of such diseases as cancer. Neutrons, obtained in experiments on nuclear transformation, are now likewise found to have a differential effect on normal and malignant tissues. Moreover, artificial radioactive materials like radioactive sodium offer interesting possibilities for cancer treatment without dangerous after effects.

Use of high-frequency radiation to create artificial fever is another application of physics in medicine which is just now showing its value. There is some temperature above which no known organism can live. Recently it has been found that this temperature is lower for the organisms causing distemper in dogs than it is for the dogs themselves. Raising the temperature of the dogs above the lethal temperature for the distemper organisms frees the animal from the disease. In a similar way syphilis has been cured in monkeys, although in man the two temperatures are so close together that it is difficult to effect a possible cure by this method.

"Very recently, however, an improved technique has been developed which offers great promise for many applications and which consists of raising bodily temperature locally by means of electromagnetically produced high frequency electric currents within the body in the region to be treated while the temperature of the body as a whole is kept within the safe limit by special cooling."

THE JOSIAH WILLARD GIBBS LECTURE

BY ROBERT D. POTTER

MANY of the problems of astronomy are so big that they must be mentally simplified before astronomers can even start to try to solve them, declared Dr. Henry Norris Russell, professor of astronomy at Princeton University, at the closing sessions of the five founder societies of the American Institute of Physics. Professor Russell de-

livered the Josiah Willard Gibbs lecture of the American Mathematical Society on "Model Stars."

To show how astronomers simplify their intricate stellar problems, Professor Russell chose a typical example. "What would happen," he asked, "to a large mass of matter left to itself in space? If we could solve this completely, and work out the special case of our solar system in all detail, we would not have to bother with straw-votes or presidential polls. To get something we can handle mathematically, we must take a single body, forget that it is rotating, and forget that the 90 different kinds of atoms of which it may consist may be present in different proportions in various parts—or, to be polite, assume that the material is 'thoroughly mixed.' The problem can then be solved for a 'cold body' which has lost into space all the heat that could possibly be got out of it.

"For a small body of a cubic mile or less, this would be a lump of rock, ice, or solidified gas. For a very large body, as massive as the sun, the matter would be 'degenerate' and very dense. The atoms would be ionized, or deprived of their outer electrons, by the enormous internal pressure. The white dwarf stars, like the companion of Sirius (which is about 30,000 times as dense as water) represent an approach to being final condition.

"A completely cold body, whatever its mass, can not be larger than a certain size. This has been calculated by the East Indian physicists, Kothari and Majumdar, as 25,000 miles in diameter, for a mass about one two-hundredth that of the sun.

"For a body which still contains internal heat, we do not yet have data enough for an exact solution of the problem. Various assumptions lead to different 'model stars,' all of which are probably like the real stars in some ways, and none of them exactly like them."

The source of the energy which stars are continually pouring into space as radiation is now generally agreed to be caused by transmutation of light hydrogen into heavier elements; with the possibility that the newly-discovered neutrons may also share in a similar building-up process. If only we knew in full the laws which govern this process—or set of processes—we could calculate what the stars ought to be like—if we knew what sort of atoms were present in them, and in what proportions. But we know neither of these things yet.

On many fronts astronomy which studies the gigantic things in the universe—the stars, nebulae and super-galaxies—is therefore waiting, paradoxically with patience and hope, for the nuclear physicist to make discoveries of the most minute things in the universe—atoms, the cores of atoms and electrons.

Can neutrons exist in stellar interiors? There is little hope of solving this question with telescopes. The physicist is more likely to find the solution. "From one standpoint the business of building model stars may be regarded as highly successful. Starting with the most general principles of physics, models have been constructed which closely represent the properties of stars—not of one sort alone, but practically of all types—and satisfy the conditions of stability. The mass-luminosity relation, and the enigmatical white dwarfs have been explained.

"From another aspect, most of the work is still to do. The analytical problems which remain—such as those presented by zones of convection—can probably be solved, approximately at least, by ingenuity in discussion and assiduity in quadratures. But the physical problems still baffle us. From the nature of the situation no unique solution for the law of energy generation can be derived from a study of the properties of stars as a whole, even if these were known with high precision.

"There is a much better chance of being able to deduce the generation law from nuclear physics; but present knowledge indicates that this is likely to depend on the composition of material in a complicated fashion, so that the problems of steady states and possible evolution of the stars, and of the relative proportions and possible transmutations of the elements within them are likely to be intimately connected. We may not live to see the final success; but, when it comes it will enlarge our knowledge of the universe."

PSYCHOLOGICAL ACOUSTICS

PROBABLY without knowing all the reasons why, six professional musicians have been playing selections for scientists at the State University of Iowa to make possible research on the tones of violins. This was brought out by Dr. Paul C. Greene in his report to the New York meeting of the Acoustical Society of America. The purpose of the study was to see if violinists, in unaccompanied performances, played typically in the natural or equally tempered musical scales.

Actually it was found that they played in neither one when their violin tones were turned into electrical currents and made visible on an oscillograph. Musicians will wish to know "that compared with both natural and equally tempered intonation the violinists tended to expand their major seconds and thirds and perfect fourths tended to approximate the theoretical scale values for that interval."

The human ear is able to act as a radio loud speaker, converting the impulses coming in on an ordinary radio set into music, Dr. S. S. Stevens, of the Psychological Laboratory of Harvard University, said in a lecture before the Acoustical Society of America. Although the music can be heard and popular tunes readily identified, the quality is not rich but rather like "tin-pan" music. Nevertheless, there is the advantage that radio advertising is eliminated; speech can be recognized as speech, but only occasional words can be understood.

In Dr. Stevens' experiments, ordinary alternating electric currents were introduced into the ear by means of an electrode placed in the ear filled with a salt water solution. The alternating current was converted into sounds that could be heard. The theory that the basilar membrane of the ear carries a sufficient electric charge so that it is able to respond mechanically to an alternating electrical potential is regarded as a reasonable explanation of this phenomenon.

"We know that the ear behaves as a condenser micro-

phone in the sense that sound energy is transformed into electrical energy. The present hypothesis suggests merely that the ear, like all condenser microphones, is capable of the reverse process of converting electrical into mechanical energy.'' Thus the ear can be both microphone and loud speaker, transforming mechanical energy into electrical impulses and back again into sound.

It is possible for an individual to listen to a tone and then to regulate the frequency of a second tone until it is just half the pitch of the first, according to a report by Dr. Stevens in collaboration with Dr. J. Volkmann, of Harvard, and Dr. E. B. Newman, of Swarthmore College. Although several of those taking part in the experiment declared that the feat was impossible, they all found that they were able to make this judgment of a tone just half as high as another and a numerical scale of psychological pitch was made up in this way. Further experiments indicated that the apparent size of just perceptible increases in pitch remains constant regardless of their location on the scale. This is just the reverse of the way sound intensifiers are heard. The smallest loudness difference that can be perceived depends upon their intensity of the first sound heard.

It would seem that pitch and intensity are not perceived by the same type of physiological mechanism. Loudness appears to depend upon the total number of fibers stimulated in the auditory nerve. Pitch depends upon the location of that stimulation on the basilar membrane. When an individual picks out a tone he feels is just half as high in pitch as another, he picks one that stimulates a portion of the membrane just halfway between that stimulated by the first tone and the end of the membrane.

ITEMS

A BAND of disease fighters at the University of Cincinnati is being specially trained to combat tropical diseases in the event of epidemics imported into the United States by air. While officers of the U. S. Public Health Service are developing new methods of quarantine needed to protect the nation's health since speedy air travel has brought the tropics dangerously close, the department of preventive medicine of the University of Cincinnati is teaching doctors and medical students to diagnose, treat and control tropical diseases, such as yellow fever, malaria and various forms of dysentery. A party of doctors and medical students under the leadership of Dr. T. J. LeBlanc, of the university, has returned from a summer spent in a first-hand study of tropical diseases at the School of Tropical Medicine at San Juan, Puerto Rico.

EVERY state health department should employ a nutritionist to aid and advise the personnel of the health services in small communities, Dr. Wilson G. Smillie, of the Harvard School of Public Health told the American Dietetic Association meeting in Boston. Such dietitians can be of ''inestimable service in recognizing nutritional defects as a factor in health conditions and their influence will often persuade prospective patients to seek advice from physicians.'' Their most important function will be the promotion of normal nutrition through advice in the selection of a well balanced yet economical diet. Larger cities were advised to create an entire department devoted to the efficient solution of nutrition problems. Such a program would be in keeping with the comparatively recent realization of importance of nutrition in preventing disease and promoting general health.

EVIDENCE that plants migrated across the Northern Pacific Ocean nearly 200,000,000 years ago in the epoch of time that geologists call Lower Permian has been unearthed in Texas by Harvard explorers. The discovery of two new species of Tingia, a genus of long extinct plants hitherto unknown in America but found in China, was announced by the Harvard University Botanical Museum where the specimens were studied. Tingia are plants like cycads, a group that flourished for about a hundred million years (during the Mesozoic era) after the age of the discovery just made in Texas. Cycads living to-day in various parts of the world look like palms or ferns, with root-like trunks rising 20 to 60 feet crowned with leaves. ''This new discovery results in a much better understanding of international geological correlations in the Pacific provinces,'' according to Dr. William C. Darrah in commenting on the discovery. The Tingia fossils occur beneath beds in which Gigantopteris plants were found and they were accompanied by plants known as Callipteris and Walchia. Finding the same fossils in both Western America and Eastern Asia is proof that there was free migration of them between the two continents. The party collected other fossil plants from a number of new localities in the Southwest.

LEG-BONES of rats have been grown in the animals' brains by Dr. R. A. Willis, pathologist at Alfred Hospital, in Melbourne, Australia, in an effort to solve a problem of growth and development. Details of the research were reported to the Royal Society. Dr. Willis was interested in what makes bones grow up to be bones. There have been two schools of thought on the subject. One believed that it was the surrounding tissues that made the beginnings of bones in embryonic animals, where those beginnings look like anything but bone, grow into the completed structure. Another held that whatever it is that organizes the primitive cartilage of the embryo into bones was to be found in the cartilage itself. Dr. Willis, confirming the indications of an earlier experimenter who used a different method, proves the second line of thought is correct. He took the one-twenty-fifth-inch-long beginnings of foreleg bones from the very young embryos of rats, and thrust them, by a simple operation, into the brains of adult rats. There, nourished by the surrounding brain tissue, they grew. If it had been the surrounding tissue juices that determine what a tissue shall be, the bones would have changed into brain tissue. This did not occur. The implants grew into almost full-size bones, just as they would normally have done. X-rays and microscope examinations show no difference between these bones grown in the brain, and ordinary bones which grew in the forelegs of rats.