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Meetings

Atomic Clocks and Microwave Amplification

THE first Symposium concerned primarily with the application of atomic and molecular resonances to the problem of obtaining extremely stable oscillators and low-noise-figure amplifiers was held on 29 February and 1 March 1956 in Asbury Park, New Jersey, under the joint sponsorship of Army, Navy, and Air Force. In arranging this program the Signal Corps Engineering Laboratories felt that the field was still a young one, but that sufficient work had been done so that this might be a good time to compare results from different laboratories, to let the workers air their ideas in public, and to present these results and ideas to interested organizations. That there was interest was proved by the more than 250 people from universities, industrial groups, and military branches who attended.

The program was drawn up to make the most of the discussion periods which were, on the average, twice as long as the time devoted to formal presentation of papers. The programs, which were sent to registrants before the meeting, contained lists of suggested topics which were to be covered in the discussions at each session. The success of this plan, reflected in the lively participation of the audience, might lead one to recommend it as a working procedure for small meetings in which a fairly large percentage of well-informed people can be counted on. Also, a gallery of photographs was arranged to illustrate some of the important developments in atomic frequency control. Experimental models of the Maser (Microwave Amplification by Stimulated Emission of Radiation), or Ammonia Beam Oscillator, were illustrated in photographs by no fewer than seven laboratories. This indicates a great deal of interest and some pretty fast work on an idea only four years old.

The two days of the meeting were divided into nine sessions devoted to both basic ideas and practical design considerations. After introductory remarks by Dr. E. A. Gerber, Col. T. M. Hahn, and Dr. H. A. Zahl, of the Signal Corps Engineering Laboratories, Prof. M. W. P. Strandberg of MIT discussed some of the basic problems of utilizing atomic and molecular resonances for frequency stabilization. In a passive frequency control device, an external oscillator sends part of its output into a system in which the field may interact with molecules. The response of this system is then used to monitor the oscillator frequency. The

shape of the response-versus-frequency curve may depend upon many factors such as the time allowed to each molecule for interaction with the field, and the configuration of this field. The oscillator frequency can be controlled to within a small fraction of a molecular line-width by making use of the amplitude response or, better still, the phase-shift response of the system. In comparing systems in which the response is detected by counting deflected particles (such as in the atomic beam experiments) with systems which measure absorption or emission of radiation, Prof. Strandberg finds that the particle detection systems have a greater intrinsic precision by a factor of KT/hf .

The most advanced system based on these principles is the cesium beam standard, in which resonance at 9200 mc/sec is detected by counting the atoms which have undergone transitions under the influence of the external oscillator. Systems of this type were described by Prof. J. Zacharias of MIT who expects to build an oscillator whose frequency will vary by no more than a few parts in 10^{14} . This should be sufficient to measure the influence of a gravitational field upon a radiating atom, by comparing the frequency of an oscillator on a mountaintop (the present trend seems to be in favor of the Jungfrau) with an identical oscillator in the valley. Dr. Essen of the National Physical Laboratories in England described a cesium beam set-up which is now used to monitor the standard frequencies transmitted by WCBR to an accuracy of 1 part in 10^{10} . Dr. R. T. Daly described the cesium frequency standard which the National Company is building to military specifications under Signal Corps and Air Force sponsorship.

Another class of molecular resonators is represented by the work done under Signal Corps sponsorship by Prof. Dicke and his collaborators at Princeton University. The reference molecules are here in the form of a gas, usually in a microwave resonant cavity. Under some conditions, outlined by Prof. Dicke, the gas may be put into a radiative state in which the molecules will emit their resonant radiation under the influence of a small incident field. The response of this system will be highly peaked at the molecular resonance frequency and it can be utilized for frequency control purposes, as a narrow-band regenerative amplifier, or even as a stable-frequency microwave generator. Still another type of system is represented by the Maser which was described by Dr. J. P. Gordon of the Bell Telephone Laboratories. In this device, developed under a three services contract by Prof. Townes and collaborators at Columbia University, those ammonia molecules which are capable of radiating the 3,3 inversion line at 24 000 mc/sec are separated from the others in a beam, and stimulated to emit coherently. This intriguing idea, which seems, at first sight, to violate the Second Law of Thermodynamics, has captured the imagination of many people who would like to see the Maser operated with other materials to generate millimeter waves and serve as extremely low-noise amplifiers in the difficult millimeter wave regions.

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6-A-61

Prof. N. F. Ramsey of Harvard offered some insight into the split-cavity method for obtaining narrow lines in atomic beam experiments. Techniques for frequency measurements and frequency control instrumentation were discussed by Dr. M. Peter of MIT and by Mr. J. H. Shoaf of the National Bureau of Standards.

Just how will the advent of dependable atomic frequency standards affect our systems of timekeeping? Dr. W. Markowitz of the US Naval Observatory outlined the method by which the crystal-resonator clocks are now calibrated against the motion of the moon in relation to the stars. Such comparisons have already shown important irregularities in the rotation of the earth. The atomic clocks should bring more light to bear on this and other astronomical matters. After a very careful calibration of some convenient atomic frequency, such as Dr. Essen is performing with the cesium resonance, we will probably shift to an atomic time standard, at least for some purposes. There also remains the very interesting question relating to how the various time scales may differ from each other. Newtonian time, which depends on gravity and inertia, is measured by astronomy and the pendulum. Coulomb time involves electric interactions and might be determined by the frequency of crystals and some molecular transitions. In addition, frequencies such as the cesium resonance, which involve a nuclear magnetic moment, might be considered to define a nuclear time since they depend upon nucleon interactions. Will it be possible to measure relative deviations among these time scales? Time (?) will tell.

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International Acoustical Congress

THE second International Congress on Acoustics is to be held June 17-23 in Cambridge, Massachusetts, in conjunction with the 51st meeting of the Acoustical Society of America. The first Congress was held three years ago in Delft. Sessions will be held both at Harvard University and at the Massachusetts Institute of Technology, and it is anticipated that the attendance will break all previous records for a gathering of specialists in acoustical science. The program is organized around three major symposia (on bioacoustics and noise control, architectural and musical acoustics, and physical acoustics and sonics) and will include some twenty-seven additional sessions of contributed papers that will deal with a variety of topics in modern acoustics, ranging from speech analysis and synthesis to jet aircraft noise. International standards for acoustics will be considered at a round-table discussion during the afternoon of June 21st.

More than one hundred scientists from abroad will attend the meeting, including representatives from Argentina, Belgium, Canada, Denmark, England, France, Germany, Hungary, India, Italy, Japan, The Netherlands, Norway, Russia, the Saar, Sweden, and Turkey.

The Congress will open with a reception on Sunday evening, June 17th, and a convocation Monday morning. A banquet is to take place on Friday evening, June 22nd. An exhibit of acoustical materials and instrumentation will be an event of interest.

The Congress has been organized by a planning committee headed by Richard H. Bolt, director of the MIT Acoustics Laboratory. John A. Kessler, also of the Laboratory, is Congress secretary. Local committees of the Acoustical Society are handling arrangements for the meeting. They include representatives of both host institutions (Harvard and MIT) and of other scientific and industrial organizations in New England. The technical program committee for the Congress is headed by Frederick V. Hunt of Harvard.

APS West Coast Summer Meeting

A PROGRAM of fifty-nine contributed papers and sixteen invited papers has been arranged for the American Physical Society's 1956 Pacific Coast summer meeting, to be held June 21-23 in the Science Building of the University of Oregon in Eugene. The program, which has been compressed into seven longer than normal sessions in order to avoid the need for parallel meetings, has been organized under the following topic headings: electron physics and spectroscopy; nuclear structure; neutron and reactor physics; sound and general physics; high-energy physics; nuclear energy levels; and solid-state physics. The banquet of the Society (preceded by a cocktail hour in the Colonnade Room of the Eugene Hotel) will be held on Friday evening, June 22, in the Erb Memorial Union on the University of Oregon campus. The principal speaker will be Professor A. C. Helmholz on "The Responsibility of Physicists as Educators". Since banquet tickets will not be sold after 1 p.m. on Thursday, June 21, those who expect to arrive in Eugene after that hour are urged to order their tickets in advance by sending \$2.50 per person to Dr. B. Crasemann, Physics Department, University of Oregon, Eugene, Oregon.

High-Temperature Techniques

A THREE-DAY symposium on the methods, materials, and processes involved in the uses of high temperature in science and industry is to take place June 25-27 on the Berkeley campus of the University of California. Sponsored jointly by Stanford Research Institute and the University of California, the symposium program will include panel discussions devoted to the following topics: methods of reaching high temperatures; materials for containing high temperatures; and processes occurring at high temperatures. Theodore von Karman, chairman of NATO's Advisory Group for Aeronautical Research and Development, will deliver the keynote address at a luncheon to be held on June 26th. The program for the symposium has been organized with the cooperation of the Air Office of Scientific Research of the US Air Research and Development