electron densities as well as for observing ionospheric plasma radiation.

The final paper, by S. F. Singer, was concerned almost entirely with dynamical effects caused by the electric charge of a body which moves through an ionized plasma. He first described methods for calculating the coulomb drag and gave a simple formula which applies to particles very much smaller than the Debye length. For large bodies, the coulomb drag is usually a small effect; however, for large bodies made out of screens, the coulomb drag can become very important in relation to radiation pressure drag and aerodynamic drag. For example, it can produce measurable torques on space vehicles with complicated antenna configurations. Conversely, the coulomb drag effect can be utilized to orient vehicles in a direction parallel to the direction of motion.

For very small bodies, whether they are natural dust particles or artificial particles, such as the dipoles used in the West Ford project, the coulomb drag can produce important dynamical effects on the trajectory and orbits. Some of the applications are related to the capture of very small particles as they traverse the earth's magnetosphere; their hyperbolic orbits are changed into elliptic orbits which eventually contract into the earth's atmosphere. Other applications are related to the behavior of dust particles on the surface of the moon under the influence of the lunar electric field. A particularly interesting application establishes the maximum lifetime of dust particles in the earth's magnetosphere. It can be shown in this way that particles ejected from the surface of the moon cannot form an appreciable component of gravitationally trapped material in the earth's vicinity.

The symposium was sponsored jointly by the International Academy of Astronautics, the International Astronautical Federation, and UNESCO. It was regrettable that many workers from the Soviet Union and the United States who are interested in this field were unable to attend. Nevertheless, this first international symposium was indicative of the great interest which exists among scientists everywhere in discussing a subject which has both fundamentally interesting aspects and widely ranging applications. The proceedings will be published by Springer Verlag, Vienna.

S. FRED SINGER

University of Miami, Coral Gables, Florida 33124

Radio Meteorology

A conference covering radio meteorology and weather radar was held at the National Bureau of Standards Boulder (Colorado) Laboratories 14–18 September 1964. It was organized somewhat differently from the usual conference; a proceedings volume containing all accepted papers was printed in advance, and the papers were not presented orally at the conference. Instead, it was expected that the papers would be studied before the meeting so that they could be discussed during their scheduled session. By this method the Conference Committee sought to encourage the free presentation of ideas and more effective communication between scientists, leading to constructive discussions of radio meteorological problems. Lead speakers at each of the sessions presented review papers and introduced the discussion of new developments reported in the contributed papers. In this way, the new ideas contained in the papers were digested and presented in a short period of time, leaving most of the session for the discussion of the topics under consideration. This method of operation for the most part worked extremely well and, except for a few instances in which the conference participants had not done their homework, resulted in participation in the discussions of almost the entire assembly of over 300 scientists and engineers, 32 of whom were from outside the western hemisphere.

Discussions on anomalous echoes and angels centered on the controversy which has raged for some years as to whether unidentifiable radar targets (angels) may arise from inhomogeneities in the atmosphere or from birds or insects. It is suggested that certain atmospheric regions associated with angels are attractive to birds or attractive to insects which in turn can attract birds. At the same time much of the evidence for the absence of wildlife from angel targets has been weak. J. S. Marshall (McGill University) suspects that a great majority of the debated targets are biological. Only a minority of the meeting appeared to hold that extreme view; most would agree that some measure of confusion exists. The majority found merit in David Atlas's thesis picturing an angel as a marked refractive index gradient across an extensive near-spherical surface.

Quite apart from arguments about angels, bird watching by radar was discussed as an important item for scientific observation which can be reasonably undertaken by radio meteorologists. Bird migration is related to the weather and a great and important opportunity offers itself to learn more about that relation. The importance to aviation of a knowledge of where and when the birds fly can provide practical justification for studies in this area. This was pointed up during the regular session and additionally by William W. H. Gunn, Canadian ornithologist, who provided the commentary for the showing of the Marconi Company's time lapse film of birds on a PPI radar display. This information was greatly extended by E. W. Houghton (Royal Radar Establishment, United Kingdom) in his paper in the *Proceedings*.

Discussions on radio climatology and meteorological effects on propagation were concerned with attempts to establish quantitative correlations of radio signal strengths and fading frequencies over a variety of paths with meteorological conditions as observed by radiosonde and refractometer. No new principles were disclosed, but some hope appeared that a useful degree of forecasting of transmission conditions could be achieved with easily observed meteorological parameters. The importance of performing radio meteorological experiments in well understood radio meteorological conditions and the inadequacy of simple meteorological models on a great majority of occasions were pointed out.

Reports on the relative merits of various systems for locating sferics positions dealt with the later stages of thunderstorms and, in particular, the existence of lightning in the decaying stage of a thunderstorm. The interrelation of source, propagation, and frequency factors in the radio noise observed from a thunderstorm was also discussed. It was pointed out that the observed distribution with frequency of radio noise did not necessarily imply a corresponding distribution at the source.

Certain physical facts, which impose limitations on the measurement by radar of rainfall and drop-size distribution, include the presence of a bright band, beam filling factors, and, particularly, the uncertainty of the radar reflectivity of rainfall. The last, the Z/R relationship, continues to be studied as described in some of the papers. Much of the uncertainty in current attempts to relate rainfall to radar

echoes is due to radar calibration problems and the inadequacy of conventional rain gauges and networks.

The lead speaker of the session on scattering and attenuation, Paul Smith, Jr. (McGill University), divided his review between the theoretical and experimental aspects of the problem. Although emphasis was placed on the theoretical papers, several were of the "let's compute it, since we can" class. One of the papers was a careful restatement for the 1960's of Lord Rayleigh's classical problem of the phase addition of signals from many scatterers. It drew fire since it focused on the smouldering controversy over whether cloud droplets are by any chance more ordered in position than random in Rayleigh's original sense. While heated, the discussion was inconclusive. However, if a vote had been taken the defenders of Rayleigh's randomness would have carried the day. This situation clearly points to the necessity of direct and clever experiments in which lasers might well help. The discussion of the attenuation of radar signals by rain confirms more indirect and theoretical assessments made earlier at McGill and at the Massachusetts Institute of Technology. It was shown that the attenuaion by rain, as observed in seven very different geographical locations around the world, was much the same for a given rainfall rate despite differences in drop-size distribution.

The discussion of tropospheric and terrain noise radiation indicated that such radiation limits the sensitivity of radio receivers at frequencies in the microwave region and above. The possibility of using the thermal radiation properties of the atmosphere as a means of determining the thermal structure as a function of altitude was also discussed.

Experimental investigations have included the use of microwave refractometers for determining the radio refractive index of the atmosphere as a function of time and space. Of particular interest was the discussion concerning the paper by Gunther Büll (East Germany) in which he reported measurements of the three-dimensional structure of the refractive index made near the surface of the earth. A confirmation of the anisotropic nature of refractive index was indicated.

Discussions on techniques and instrumentation dealt mainly with the use of Doppler radars and devices for remoting weather radar information. Although coherent pulse radar techniques now seem well established, problems still remain in finding the most appropriate means for processing and storing Doppler information in such a way that it is suitable for meteorological analysis. The need was emphasized for a Doppler signal processing scheme capable of fast Doppler velocity-range presentation. There are also requirements to observe the distribution of the motion of the particles inside storms by scanning the radar beam and the radar range in order to explore the region of interest. Examples of improved sensitivity in radar receivers using a maser amplifier were described.

Reports on hurricanes and storm structure brought out the point that electrical activity remains strong for a considerable length of time after active convection has ceased. It was argued that this strong activity indicates a source of electrical activity not directly connected with strong vertical motions. The discussion that followed noted that much work is needed before the electrical activity generated in stormy weather is fully understood. Premonsoon squall lines were discussed in some detail by authors from India. Others presented statistics of cell characteristics and gave relative heights, widths, and spacings of thunderstorm cells in north central India. Such statistics should be developed by objective means when possible. An explanation was offered for the ring of high pressure observed around the center of a tornado cyclone, relating this to the deceleration of the low-level inflow velocity and acceleration in the rising column.

The session on tropospheric propagation, super-refraction, and scatter propagation was primarily concerned with the relationship between propagation and meteorology and, in particular, beyond-the-horizon scatter propagation and the microstructure of the refractive index of the troposphere on which it depends. This mode of propagation has now been the subject of much study and intense debate for more than a decade. At first it was widely thought that scattering due to refractive index fluctuations caused by turbulence was the dominant mechanism. However, in recent years more and more support has been given to the view that partial reflections at layers—large and small, rough and smooth—are of greater significance. Recent work at the NBS Boulder Laboratories has strengthened this point of view. Considerable interest was also provoked by an account of recent investigations in Norway in which a beam-swinging experiment, under conditions of scatter propagation, was designed to yield information concerning the degree of isotropy of the atmospheric, refractive index fluctuations. There was, however, much argument—and not complete agreement—as to how the results should be interpreted. The discussion indicated that any further major progress in the understanding of tropospheric radio wave propagation is dependent upon our first learning more about the detailed nature of refractive index variations in space and time.

The conference ended with a session on a relatively new topic in the field of the radio meteorologist, "Measurements at Optical Wavelengths—Lasers." Myron Ligda and his colleagues (Stanford Research Institute) demonstrated how atmospheric structure can be revealed by using a laser radar to study the distribution of aerosol in "clear" air. It is reasonable to hope that one element of structure that may be revealed directly or indirectly is clear air turbulence. The meeting was reminded by Ligda's colleague, Collis, that the official subject of the session was not clear air turbulence but more generally the use of lasers in studying the atmosphere. It continued to be the main subject of discussion, however, once Peter A. Franken (University of Michigan) had gone from a shrewd analysis of the elementary properties of lasers to talk about his own recent work with them. He had taken a laser radar aloft in a light aircraft and had obtained strong returns from the clear-air wakes of aircraft. Such returns were obtained on those occasions when the temperature at the height of the observation was colder than the ice-point. For attenuation and scattering studies, the narrower beam available from a laser can be used to advantage. Hogg (Bell Telephone Laboratories) gave evidence for this theory based on a 2-km path through turbulence, fog, rain, and snow. On the other hand, actual measurements of attenuation by precipitation, which were reported earlier, had been made with a less narrow beam and without a laser.

The conference was sponsored by the Inter-Union Committee on Radio Meteorology, the International Scientific Radio Union, the International Union of Geodesy and Geophysics, the

American Meteorological Society, the Central Radio Propagation Laboratory of the National Bureau of Standards, and the U.S. Weather Bureau. It was organized under the general chairmanship of J. S. Marshall (McGill University and chairman of the Joint Committee of the URSI-UGGI on Radio Meteorology). Members of the Program Committee were John A. Saxton, chairman (United Kingdom Scientific Attache to the United States and vice chairman of Commission II, URSI), Stuart Bigler (U.S. Weather Bureau), David Atlas (Air Force Cambridge Research Laboratory), Jack W. Herbstreit (Central Radio Propagation Laboratory and secretary of Commission II, URSI), and J. S. Marshall. It is believed that the objective of the conference, to strengthen the community of interest among the many specialized fields in radio meteorology, was realized. A limited number of copies of the proceedings volume are available from the American Meteorological Society, 40 Beacon St., Boston, Massachusetts.

JACK W. HERBSTREIT
Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado

Forthcoming Events

January

5–8. **Solid State Physics**, 2nd annual conf., H. H. Wills Physics Laboratory, University of Bristol, England. (Administrative Assistant, Inst. of Physics and Physical Soc., 47 Belgrave Sq., London S.W.1, England)

6–8. **Industrial Electronics and Control Instrumentation**, 13th annual conf., Philadelphia, Pa. (E. Weiss, Sun Oil Co., Marcus Hook, Pa.)

6–9. **Psychopharmacological** Conf., Czechoslovak Medical Soc., Psychiatry Section, Jesenik Spa. (M. Vojtechovsky, Budejovicka 800, Pavilion A1, Prague, Czechoslovakia)

8–9. **Orthopaedic** Research Society, New York, N.Y. (R. A. Calandruccio, 869 Madison Ave., Memphis, Tenn.)

9–14. American Acad. of **Orthopedic Surgeons**, annual, New York, N.Y. (H. K. Hart, AAOS, 29 E. Madison, Chicago 2, Ill.)

10–16. The **New Science**, symp., Colorado Springs, Colo. (F. A. Sondermann, Colorado College, Colorado Springs)

11–14. **Civilian and Military Uses of Aerospace**, conf., New York, N.Y. (I. B. Laskowitz, New York Acad. of Sciences, 2 E. 63 St., New York)

12–14. **Reliability and Quality Control**, symp., Miami, Fla. (H. D. Hulme, Westinghouse R&D Center, Bldg. 601-1346, Churchill Boro, Pittsburgh, Pa.)

12–15. **Crustacea**, symp., Cochin, India. (Marine Biological Assoc. of India, Marine Fisheries P.O., Mandapam Camp, South India)

14. American **Genetic** Assoc., Washington, D.C. (W. R. Singleton, Biology Bldg., Univ. of Virginia, Charlottesville)

18–20. **Solar Radiation Simulation**, intern. conf., Los Angeles, Calif. (H. F. Sander, Inst. of Environmental Science, 34 S. Main St., Mount Prospect, Ill.)

19. American Inst. of **Mining, Metallurgical**, and **Petroleum** Engineers, Metallurgical Soc., 7th mechanical working conf., Pittsburgh, Pa. (R. W. Shearman, Secretary, Metallurgical Soc. of AIME, 345 E. 47 St., New York 10017)

19. **Cor Pulmonale**, New York Heart Assoc., New York, N.Y. (NYHA, 10 Columbus Circle, New York 10019)

19–20. **Die Design and Press Tooling** Conf., American Soc. of Tool and Manufacturing Engineers, Hartford, Conn. (M. Zapico, Asst. Conf. Director, ASTME, 10700 Puritan Ave., Detroit 38, Mich.)

20–22. **Instrumentation**, College Station, Tex. (P. T. Eubank, Chemical Engineering Dept., Texas A&M Univ., College Station)

20–23. National Soc. of **Professional Engineers**, New Orleans, La. (P. H. Robbins, 2029 K St., NW, Washington, D.C.)

22. **Bibliographical** Soc. of America, New York, N.Y. (Mrs. H. C. Ralph, P.O. Box 397, Grand Central Station, New York 10017)

22–1. **Earthquake Engineering**, 3rd world conf., Auckland and Wellington, New Zealand. (Administrative Secretary, Third World Conf. on Earthquake Engineering, P.O. Box 5180, Wellington)

22–23. **Blood**, annual symp., Detroit, Mich. (W. H. Seegers, Dept. of Physiology and Pharmacology, Wayne State Univ. College of Medicine, Detroit)

22–23. **Hydrocarbon Analysis**, symp., American Soc. for Testing and Materials, Houston, Tex. (ASTM, 1916 Race St., Philadelphia 3, Pa.)

25–26. **Fundamental Phenomena in the Material Sciences**, 3rd annual symp., Boston, Mass. (D. B. Fay, Ilikon Corp., Natick Industrial Centre, Natick, Mass.)

25–26. **Viruses of Laboratory Rodents**, symp., Atlanta, Ga. (R. Holdenried, Natl. Cancer Inst., NIH, Bethesda, Md. 20014)

25–27. American Inst. of **Aeronautics and Astronautics**, New York, N.Y. (J. Bidwell, AIAA, 1290 Avenue of the Americas, New York 10019)

25–28. American **Meteorological** Soc., annual, New York, N.Y. (K. Spengler, AMS, 45 Beacon St., Boston 8, Mass.)

25–28. American Society of **Heating, Refrigerating and Air-Conditioning Engineers**, Chicago, Ill. (R. C. Cross, 345 E. 47 St., New York 10017)

25–28. Modern Methods of **Analytical Chemistry**, 18th annual intern. symp., Baton Rouge, La. (P. W. West, Dept. of Chemistry, Louisiana State Univ., Baton Rouge)

25–28. **Cardiovascular Diseases**, 2nd natl. conf., Washington, D.C. (C. H. Maxwell, 9650 Wisconsin Ave., NW, Washington, D.C. 20014)

25–29. American **Mathematical** Soc., Denver, Colo. (G. L. Walker, AMS, 190 Hope St., Providence, R.I.)

25–29. American Soc. for **Testing and Materials**, steel meeting, Mexico City, Mexico. (H. H. Hamilton, Public Rela-